# Exploring the ontological links between Human Ecodynamics and field Archaeology through the integration of archaeological reports into DataARC's landscape ontology

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A mi abuelo,

*Álvaro Vaquero*

## Abstract

This research focuses on the processes of knowledge creation within a framework of Big Data. Concretely, my project focus on grey archaeological data and their underlying ontologies, and how to interlink such type of data with other data in a Computational Ontology. This research was carried out within the dataARC Project, which tries to represent Human Ecodynamics for the North Atlantic context using data generated over 25 years by NABO (North Atlantic Biocultural Organisation). The project has been developing a cyberinfrastructure whose main tool is a computational ontology. We try to include in this ontology diverse conceptual models (from archaeological and historical, to ecological or geological data) from different grey sources.

In my case, the main issue is the creation of knowledge using multiple datasets that comes from grey literature sources. Said another way, my thesis explores how to create a dataset by extracting data and their underlying ontologies from grey-archaeological reports with the final aim of interlinking them with other datasets. For so doing, these reports are transformed into a dataset, which in turn is mapped to the interdisciplinary ontology. This thesis, therefore, presents a prototype dataset and the process of conceptual mappings. In so doing, I explore how to decompose archaeological reports that are in Open Access to make their data FAIRer and (inter)linked.

Human Ecodynamics are of special importance for NABO and, consequently, for the DataARC project. Our computational ontology, therefore, had to be developed for representing Human Ecodynamics in a rigorous and efficient way, yet capable of engaging a broad audience. This, along the use multiple, interconnected, datasets in a concrete relational manner, forces us to develop an ontology capable of representing very abstract themes while representing small details that affect these ecodynamics. This led me to try to develop a theoretical framework which could allow me to contextualise DataARC's ontology and my own method. The theoretical framework blends Latourian Actor-Network-Theory and some basic ontological principles (in the theoretical-philosophical sense) drawn from Human Ecodynamics. This might arguably open new avenues for developing powerful ontologies capable of representing complex knowledge. Problems such as overlappings or identifying the right number of hierarchical levels will be discussed, as well as some procedures that might help in rethinking computational ontologies.

Digital Archaeology's ethical challenges is a final interesting point touched by this thesis. Here it is argued that Digital Archaeology, specifically if we convey inter/transdisciplinary

knowledge such as Human Ecodynamics or Local and Traditional Knowledge, carries quite an important ethical responsibility. This leads me to offer new possible pathways by openly engaging theoretical critical schools of thought such as Social Ecology -which, in turn, might shed light on problems related to Climate Change and similar current issues.

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## Acknowledgement

It is said that one does not work alone. This is beyond truth for my case. In one year, I have produced an MPhil thesis which now is set to be submitted. But the thesis, of course, is not only the fruit of my own work; these brief lines are dedicated to those who, in one way or another, helped me with it.

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## Introduction

This work sits between the practice of assembling archaeological reports, the subfields of Public and Digital Archaeology, the ambition for enhancing Archaeo-Historical Knowledge, and the broad theorical inquiry of ontology. It concentrates on processes of knowledge creation with special focus on interlinked archaeological data, and consequently some of the reflections and proposals might be applicable to other fields. Finally, the thesis emerges from the DataARC (https://www.data-arc.org/) Project's efforts in resolving some of the challenges in Archaeo-Historical Studies:

- How to interlink multiple and diverse datasets in a meaningful way.
- How to develop a computational ontology capable of representing, and even enhancing, knowledge about Human Ecodynamics.
- How to deal with Grey Literature and Legacy Data in the development of a computational ontology.

These challenges are addressed using the research context of the North Atlantic -with a special focus on the Viking Age. DataARC, as part of NABO's scholarship for the North Atlantic, is guided by principles drawn from the *paradigm* of Human Ecodynamics (henceforth, HE). As such, this work is also guided by this vision.

The core of this thesis addresses the challenges of dealing with archaeological data when archaeologists attempt to integrate their data -and their underlying ontologies- with allied disciplines working in a Big Data framework. The problems are not only in the plain and strict sense of dealing with the mechanics of data cleaning, archival preparation, or general knowledge. Rather, the main issue is the creation of knowledge using multiple datasets. Research data can be twofold: 1. newly generated from primary field/archival, etc. work; or 2. previously generated and used in new research. Since DataARC works with datasets generated over 25 years of research, this thesis deals with the second type of data. The issues linked to this are well recognised and have generated a healthy wide range of scholarship (Richards, 2002; Schöpfel, 2006; 2010; Aitchison, 2010; Lawrence, 2012; Kansa and Kansa, 2013; Huggett, 2012a; 2015a and b; 2018; Moore and Richards, 2015). Understanding what has been said and proposed is fundamental for appreciating this work.

For the sake of clarity, I provide here a brief overview of this thesis. In Chapter I, I review the main developments regarding how to integrate Grey Literature and Legacy Data and the problems they pose. I later zoom in into the main problems for the North Atlantic and

specifically for the NABO research community. In Chapter 2, I develop the theoretical framework which serves to contextualise and make up the rest of the thesis. Of special importance here is Latourian Actor-Network Theory (ANT), Bookchin's Social Ecology, HE, Landscape Archaeology and applied ethics. Chapters 3 and 4 are the main contribution of this thesis. In the former, I develop my case of study: the creation of a dataset from 8 archaeological reports, and how this is integrated into the project's computational ontology following principles drawn from the theoretical framework developed in Chapter 2. Equally, in this chapter I try to detect previous theoretical frameworks which might have influenced my own work. Chapter 4 is a theoretical reflection about the previous chapter. Here are important some ideas regarding how computational ontologies, if well developed, might offer new possibilities for enhancing our knowledge; or how these cyber-tools might yield better answers to the question of how to think of data whilst offering real Open Access. Moreover, I offer some arguments for openly engaging theory in our praxis within Digital Archaeology. Finally, Chapter 4 frames this thesis within a wider social context. Chapter 5 presents the conclusions of the thesis. The main argument here is that Digital Archaeology, mainly its theory, can inform other disciplines -opening up the space for research beyond interdisciplinarity.

Contemporary research is concerned with quite complex issues in an effort to create broader and useful narratives. This normally takes the shape of research themes which need the combination of multiple disciplines. Moreover, these themes are located in different places, and chronologically situated at different temporal scales (e.g. Harrison and Maher, 2014; Riede, Andersen and Price, 2016). Undoubtedly, this means making use of multiple datasets (Marchetti *et al.* 2018). Further, new attention has been given to the way these datasets are stored, managed and made open, with the final aim of creating a community-oriented research. With the advent of digital technologies, the landscape has evolved quite drastically, offering possibilities for crossing disciplinary boundaries whilst reaching a wider audience (Kansa and Kansa, 2013). Nonetheless, we are far from reaching a consensus on how to enhance the integration of disciplines. Similarly, the questions regarding what to do with Grey Literature and Legacy Data or how to interlink data in a meaningful way remain open. Finally, these issues affect our efforts for engaging the public with our research. All the above justifies the work and ideas here presented.

# Chapter I. Of Grey Literature and Legacy Data in Archaeology: problematising archaeological reports, their data, and their interlinkages

This chapter offers a review of the various issues regarding Grey Literature and Legacy Data. This is done by firstly giving an overview of the general concerns with this literature. Afterwards, I will close my discussion of this topic stressing its importance for Archaeology. Equally, I present some of the main issues that arise from our praxis, as well as from archaeological data if intended for creating complex narratives. The discussion is followed by some of the approaches, mainly from Digital Archaeology, which have sought to resolve such issues. Ethics and its application to these topics involve the majority of the narrative, especially where the concept of Human Ecodynamics is introduced.

## 1.1 Grey Literature and Legacy Data: a world archaeological problem

As previously mentioned, the thesis' main quandary is how to deal with already generated data for enhancing Archaeo-Historical Knowledge. However, to reach an answer we must start looking at the real face of the problem. In practice, this means *defining* the type of literature and data which create the problem. This exercise will conceptualise and frame the research.

### 1.1.1 Grey Literature and Legacy Data

This thesis uses archaeological reports, generally referred to as 'Grey Literature' (*cf.* Evans, 2015), as the primary source of its data. While there is no exact definition of Grey Literature, the limits of what conforms it are quite clear. In a broad sense, it can be defined as the literature "produced on all levels of governments, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" (McKenzie Owen, 1997; Schöpfel, 2006, p. 1). Amanda Lawrence (Lawrence, 2012) has proposed to narrow in the definition by focussing on three factors: 1. The nature of the documents; 2. The type of producers; and 3. The means of dissemination. Following this, Grey Literature is a category which includes:

1. Technical and project reports or manuals, spreadsheets/statistical files, working and discussion papers, non-published conference proceedings, thesis, blogs, social media content, etc. (Childress and Jul, 2003; Schöpfel, 2006, p. 1; Lawrence, 2012, p. 2; Vaska, 2010, pp. 13-14).

2. Produced by governmental and non-governmental institutions.
3. And that it is not published following the standard for each case (e.g. Governmental Reports, Journal publications, etc.).

As for Legacy Data, it can be defined as the data stuck/preserved in the pages of the different formats mentioned above (Allison, 2008, 6-7).

The definition means that Grey Literature is ubiquitous and, in some cases, not easily accessible (Schöpfel, 2006, p. 1). Indeed, Grey Literature from non-western countries is less accessible, and governments usually have access to this literature when it is not available to other people (Corlett, 2011, pp. 3-4). The definition also means that it is not controlled by academic quality standards -e.g. peer-reviewed (Vaska, 2010; Papas and Williams, 2011, p. 229; Lawrence, 2012, p. 2). The latter represents an important problem as this literature contains the data and information, the cornerstone, on which many publications are built. The importance of showing the data used for creating knowledge highlights the ethical imperative embedded in this topic. Further, it is ethical because it "can simplify difficult ideas for a nonspecialist audience" (Papas and Williams, 2011, p. 234) -albeit this is contingent on good presentation.

For purposes of this thesis, the subject of study is related only to academic activities; in this case, archaeological research. More concretely, the formats I am referring to enter into the categories of "technical and project reports and spreadsheets", that is, archaeological reports (Aitchison, 2010, 290-292). Nonetheless, the problem of dealing with Grey Literature and Data affects many other academic fields (Papas and Williams, 2011; Corlett, 2011; Lawrence, 2012).

Grey or invisible literature has gained attention in recent decades, especially with the introduction of new technologies (Schöpfel, 2006; Vaska, 2010, p. 11). Nonetheless, there are issues which remain unresolved (Schöpfel, 2010). In the 21st Century, the main people who deal with this topic are Library and Information scientists, seeking sharing, retrieval and long-term preservation (Schöpfel, 2010; Evans and Moore, 2014).

Renewed attention and new (digital) technologies have given rise to movements such as Open Access or Open Data (Schöpfel, 2006; Richards and Hardman, 2008; Vaska, 2010; Schöpfel, 2010; Lawrence, 2012; Coble, Potvin and Shirazi, 2014; Moore and Richards, 2015; Crossick, 2016). Yet, as I discuss in Section 1.2.3, there are problems impeding us from achieving 'real' Open Data as we would like. As Schöpfel (2010, p. 28) points out, the notion of openness focus on "selection, dissemination, access, not on preservation and

organization". This showcases to some extent where the problem is, namely: a lack of thorough understanding of data's constitution and meaning. This leads to an uneven sphere where things are freely available, but are not truly open (Faniel, Kansa *et al.* 2013; Huggett, 2018). Not even cutting-edge technologies seem to completely resolve the issues we face with Grey Literature/Data (see sections 1.2.3-1.2.4 and Chapters 3 and 4).

Some of the issues faced in Grey Literature/Data are a lack of meta- and para- data, lack of standardisations (data, bibliographic oversight, structure, written presentation), non-interoperable formats, lack of indexes, etc. (Childress and Jul, 2003; Richards, 2004; Schöpfel, 2006; Corlett, 2011; Huggett, 2012a, 2015a, 2018). This reality clashes with our efforts for Open Data. In light of this, we may conclude that Free Access is not Open Access.

No doubt, Grey Literature and Legacy Data's importance vary from discipline to discipline (Schöpfel, 2006), but, as I have argued here, it is always important. It is fundamental, hence, to ponder its role and weight in Archaeology to later understand why we should care about it.

### 1.1.2 A world archaeological problem

The concept of grey literature entered the archaeological sphere soon after its first uses. For Archaeology, Evans (2015) proposed that the concept might had its roots on the split between archives and publications. The term of 'grey literature', however, only gained traction with the turn of the new millennium. It was in the period of 2000-2006 where the term started to be a vernacular one, connotating not only unpublished works but also their quality and availability -albeit it is sometimes misused (Evans, 2015).

The debate about 'grey literature' in Archaeology covers a wide range of sources. In recent years, however, it is associated with the question of how to better integrate unpublished field-reports into "curatorial and research practice" (Evans, 2015). One might question if this matter is of real concern within our field. Some researchers (Stevens, 1997; or Evans and Moore, 2014 after considering the change provided by different system for managing and accessing to these data) question its importance. The answer to the first is that this issue is well recognised and controversial in our field (Sinclair, 1989a and b; Boivin, 1997; Fellinger and Philpot (eds.), 2014; Moore and Richards, 2015; Evans, 2015; Opitz, 2018a; Marchetti e*t al.* 2018). The latter question has a conclusive answer: since the primary goal of archaeology is to "spread a generated knowledge of the past" (Boivin, 1997, citing Tilley, 1989), and since the primary and main source of this narrative -that is, archaeological

reports- are boring, "painfully and unbearably dull […] uninspiring, inhuman" (Boivin, 1997, p. 105-106; a concern also found in Hodder, 1989, 1997; Jones, MacSween, Jeffrey *et al*. 2003; Bradley, 2006; Opitz, 2018a), we are dealing here with a huge problem.

If the above argument is not enough, maybe it is more compelling for some if we look at the problem through methodological and ethical lenses: Lucas (2001, p. 35) has said that the data justifies the excavation. This is so because the excavation event implies at the same time the destruction of the site and the loss of information. However, not all data justify the excavation if the data does not do justice to it -be it due to fieldwork inconsistency or *report preservation*. The latter implies the loss of data in unreadable and dull archaeological reports that will not be extensively and immediately read -which is a well-recognised problem (Hardman and Richards, 2003; Marchetti *et al.* 2018). This loss of data, indeed, implies the loss of the excavation. Recalling Lucas' words and our ethical duties, and since we cannot just stop excavating (Demoule, 2011), the issue, thus, is unjustifiable. This reason has motivated archaeologists to find new ways of preserving and disseminating their results (Coble, Potvin and Shirazi, 2014; Moore and Richards, 2015; Early-Spadoni, 2017). I will return to this point in the following section.

For now, I will consider the way in which archaeological reports are written and the troubles entailed by this practice. The topic is of primary importance here; indeed, it is the elephant in the room. Some of the causes of this trouble are pointed out by Boivin (Boivin, 1997, pp. 106-109):

A. The dehumanisation of the past reality researched.

B. Texts' expressionlessness, or inability to transmitting the interest of what it is presented.

C. Dry writing, or texts' lifelessness.

The above three points can be summed up by acknowledging the failure of communicating what it is of interest (Boivin, 1997, p. 110). This writing failure is unacceptable -albeit not insurmountable- once we realise the importance of spreading knowledge beyond project's teams and academic peers.

Another fair comment made by Boivin is that overspecialisation within Archaeology poses difficulties in understanding reports: jargons and narratives only fully comprehensible by sub-specialists appear here and there, all over reports (Boivin, 1997, p. 113-114). This can arguably be perceived as a mechanism of power (e.g. intelligentsia vs the Public; Western

vs non-Western/non-anglophone people, etc.). As some authors highlight, the way we write represents a relationship of power between writer and reader. For example, Tilley (1989), following Foucault (1981), considers that this is the manifestation of a tension between desire (will) and power (through institutions and regulations). Such tension happens through the creative process of knowledge production, structuration, contextualisation and delivery (Sinclair, 1989a, pp. 160-161; Tilley, 1989). As such, discourse is shaped by both, desire and power; and, therefore, contains power.

Following this, we can argue that there is power in our (chosen) words -which are subject to nuances in their written form (Sinclair, 1989b). This means, interpretation process aside, that a text is written from the perspective of the author, who conveys knowledge and meaning in a concrete, discursive, and hierarchical way (Tilley, 1989; Sinclair, 1989b, p. 214). As such, texts represent a concrete theoretical and political position (Sinclair, 1989a). The latter means that we are doing an active political activity by writing (the act of creating a narrative or discourse). Our writings are thus contingent and situated, and consequently, have an active role in different social settings (Tilley, 1989). Regarding the former aspect, theoretical position, is an interesting topic for this thesis which will take a concrete shape in Chapter 3.

As for now, though, I will focus on other implications entailed by texts' power in archaeological reports. For some, say Sinclair (1989b), archaeological reports are thought to be a synonym of objective archives but, in fact, they are nothing but subjective: "discourses embrace certain objects of concern or knowledge […always…] situated and positioned" (Tilley, 1989). And in so doing, they cast aside other concerns depending on the social context. Think, for example, in archaeological reports: their structure, acceptable ways of writing and expressing knowledge, etc. is given by accepted disciplinary procedures. As such, the archaeologist must adapt her/himself and the knowledge s/he wants to express to some accepted codes of practice. Following different guidelines might bring opposition and/or reluctance. The transmission of knowledge, therefore, depends upon institutional power. Even this critique is sustained and shaped by power: without a scholarship, I would not be writing this piece of text. Moreover, my review here follows some specific guidelines according to what it is a normal standard regarding MPhil thesis structures for the University of Glasgow.

Power, thus, sets the conditions to create, maintain or break social divisions (Tilley, 1989). As such, our archaeological reports can create social divisions: expected to be read by specialists, not by a non-academic interested reader. As a consequence, reports (and their data), do not normally reach a wide audience -creating misinterpretations and scepticism

(science and knowledge denial) to non-academics. Following traditional guidelines, I argue, serves to reify and maintain such social divisions and misinterpretations. The final consequences of this mechanism of power (Foucault, 1981) are a lack of possible criticism, a persistent dynamic of overspecialisation and inapprehensibility, and the reaffirmation of self-esteem (Boivin, 1997). A critique to standard procedures, therefore, might also open new possibilities for dissolving these issues.

Another problem highlighted by some authors (Hodder, 1989; Bradley, 2006; Aitchison, 2010; Evans and Moore, 2014), is a complete disentanglement between data and interpretation. This is a reverberation of our praxis and writing approach. Even more important is the disentanglement between the natural kingdoms in archaeological reports: animal, vegetal, and mineral kingdoms are normally treated separately (Bradley, 2006). Needless to say, such split worsens our understanding of Human Ecodynamics. See, for example, Clarke and Popescu's (2014) Best Practice Users' Guide for Cambridgeshire: there is a complete disentanglement between methodology, results, discussion/conclusion, the supporting data and figures. There is some irony here, because they acknowledge that summaries, discussions and conclusions are "often the only sections that prospective readers/researchers will actually look at [reason why you should] try to make it relevant and interesting" (Clarke and Popescu, 2014, p. 10). Moreover, they separate environmental and findings reports from other types of reports; as if they were somehow different from the rest.

Paradoxically, the problem sometimes is overlooked by archaeologists dealing with Legacy Data (Evans and Moore, 2014). The issue is methodological insofar as it makes the reuse and research of data difficult. However, and that is maybe more important, is epistemological because it favours a narrative where facts are different from their interpretations (*ibid*.). This distorts our narratives about the past, dubiously shaping the past in itself. This is ironic because such a practice opposes some guidelines which emphasise the importance of good, engaging and simple narratives, defending research "against misrepresentation" and vague messages (Fischhoff and Scheufele, 2014). Consequently, I argue that such way of writing poses difficulties in overcoming problems related to scientific communication (Fischhoff and Scheufele, 2014). This ultimately leads to research's futility inasmuch as we cannot accomplish our efforts for outreaching a wider audience.

Other complaints about archaeological reports, in this case exclusively concerning data, are lack of meta- and paradata (Faniel, Kansa *et al.* 2013; Kansa and Kansa, 2013). This is an important issue because such information is seen as a sign of consistency (Kansa and Kansa, 2013). Without this, it is difficult to trust and reuse the data contained in archaeological

reports. As I will show below, this lack also affects the archival and preservation of the data. Another common complaint about data is the lack of linkages between data of different character (Kansa and Kansa, 2013) -which, in turn, negates interoperability and a wider understanding.

The above clearly points to two main problems: A) the act of writing; and B) the way data is thought of and managed. It is possible to argue that digital technologies -faster and prepare for managing big quantities of data- are more capable of dealing, and potentially resolving, both issues. Here is where Digital Archaeology enters into "our game".

### 1.2 Digital Archaeology

For some archaeologists (Daly and Evans, 2006a and b), Digital Archaeology is not a specialism or theoretical school but an approach to better utilise computers in Archaeology. This comes after understanding information technology, which in turn might answer "how technology [and data] is, can and should be used" (Backhouse, 2006, p. 44). The latter, no doubt, forces us to consider theory as equally important as the application of these technologies. Yet, as Zubrow (2006) shows, some archaeologists see this field as anti-theoretical. Nonetheless, in this thesis I aim to discuss the importance of understanding how theory is embedded in basic data praxis, particularly for work that engages with (interlinked) legacy data.

This archaeological subfield is not new. Jean-Claude Gardin is arguably the founder of this field. As early as 1956, drawing on structural linguistics and semiotics, he founded what today is considered the theoretical and methodological basis of Digital Archaeology (Dallas, 2016). His efforts in using computation as a form to create documentary applications capable of organising, sorting and openly sharing data are of importance for this thesis. Equally useful are his theoretical reasoning about data, the concepts to which link data, and a degree of compromise between both levels. Inspirational to this thesis are also his ideas regarding the importance of explanations over other archaeological constructs, or his logicist approach schematising archaeological knowledge through a symbolical lexicon (Syntol). Moreover, his emphasis on detecting the individuals' reasonings behind our epistemologies are of great aid for the development of this thesis (Gardin, 1980; Gardin and Peebles, 1992; Dallas, 2016). These ideas are clearly the prelude of our ontologies (Dallas, 2016). Not in vain, Dallas (2016) considers Gardin one of the leading figures who have given rise to some of the most important projects in Digital Archaeology. The AKEOTEK Project (Gardin and

Roux, 2004) is the most important one for us here because it is one of the first attempts in publishing, organising and interlinking archaeological data through the Internet.

Since them, Digital Archaeology has been in a continual development creating an important path. To gauge it, we can list some implications of the coming of digital technologies. Among other things, now it is possible the use of complex statistical operations, to model, simulate and visualise new "spaces/-scapes", to understand complex interacting processes of humans in their environments, to create virtual worlds, or to develop approaches to cognitive and sensorial inferences (Zubrow, 2006). Equally important is the way digital technology has transformed how we record and develop fieldwork (Bradley, 2006). Not to mention research: from isolated scholars to a networked community; from strong community boundaries between academics and the public to fuzzy social boundaries (Zubrow, 2006).

For this thesis, Digital technologies' most important implications are related to archaeological reports and data. Digital technology has sought to solve some problems regarding archaeological reports, data management, and knowledge representation. As I will show, this has been attempted through the implementation of new formats for archaeological reports, as well as through the sharing-storing-shorting-retrieval of data. I will review some of the most important projects in this respect in due time. In the next section, however, I discuss the most fundamental ethical considerations entailed by these new approaches. The reason for discussing ethics is because there are some ethical imperatives underpinning the use of certain theoretical approaches to legacy data for making it open. Not in vain, discussions about Open Data are inherently ethical. Further, I argue that HE-research carries an important ethical imperative due to its special focus on indigenous communities and the wider public. As I will show, this means that we need better writing and data practices.

### 1.2.1 Applied ethics in Digital Archaeology and Human Ecodynamics: data openness, epistemology and ethics

It is a truism that sharing data is beneficial. Yet, some archaeologists remain suspicious about sharing their data (Atici *et al.* 2012). Moore and Richards (2015) listed some of the main arguments against sharing data: discredit in the benefits of sharing, afraid of peer-criticism, lost control of their "symbolic and economic `capital´", data misuse, etc. Most of them seemingly voice a fearful and fragile discipline, rather than one committed to openness and outreach activities. More complicated, however, are some epistemological arguments

against data-sharing (Jones, Alexander et al. 2018, p. 11), or some financial-sustainability problems (Alexander, 2013; Pratt, 2013; *cf.* Kansa and Kansa, 2013).

It is necessary, therefore, in the context of this thesis' core arguments, to re-emphasize why making Open our data (see section 1.2.3 for a definition) and grey production is important. I will use two main interlaced arguments here which concern our methodologies and their ethics. In reality, I have already presented before (section 1.1.2) a brief argument in favour of sharing data and changing the act of writing for justifying the excavation event. If this argument is not enough, I can continue by citing Moore and Richards (2015, p. 35), who blend both aspects (methods + ethics):

> Open data offers researchers a mechanism to improve disciplinary interaction and, as a consequence, enhance research [and understandings]. The unrestricted accessibility presented by open data also presents […] opportunities to use, and reuse data. […It also provides] transparency and repeatability [because] it allow[s] others to test the validity of our interpretations; allowing them to examine and reanalyse the original data.

Here are the two fundamental things: transparency and interaction (reuse, communication) between researchers, and between the public. Not for nothing, data is a public good (Porter, 2013). In addition, transparency promotes scientific rigour (Kansa and Kansa, 2013; Marchetti *et al.* 2018). Marchetti *et al.* (2018) also argue the importance of Open Data for epistemological reasons (impossibility of singling out and answer diverse research questions) and operational issues (slow and expensive publishing dynamics). This means that our current dynamics slow down the pace of knowledge production, and what is more, bias our knowledge due to partial data accessibility (Marchetti *et al.* 2018). In light of this, some researchers (Atici *et al.* 2012; Kansa and Kansa, 2013) argue that data-sharing allows for better confronting biases whilst reinforcing informed research. In so doing, Open Data also helps in surpassing knowledge/research consensus denial (Fischhoff and Scheufele, 2014)

Moreover, Open Data in a Big Data framework strengthens the creation of knowledge, challenge our imperfect working-closed-access-publication culture, promotes a better public engagement, can enhance the way we teach and learn, and favours networking and research communication across disciplines (Pearce *et al*. 2011). The latter is quite important for archaeological research, let alone HE, which seeks to probe and shed light into the anthropogenic impact on climatic dynamics.

Ethics are also affected by the act of archiving (Zwitter, 2014). This is especially true for ideas regarding Public Archaeology. Ideas from Public Archaeology contrast with some overspecialised modes of archiving -either by museums/institutions or individuals- that neglect access to the wider public (Merriman and Swain, 1999, p. 249). This affects digital archives too. Ethically speaking, we should create new avenues capable of engaging with a wider public -although this goes in hand with new legal and ethical challenges (Kansa and Kansa, 2013 Richardson, 2018). The same is true for the way we write and present our outcomes.

It is important to preserve data and archaeological reports along the lines of long-term preservation and free access (Merriman and Swain, 1999). In that respect, some traditional practices are not only unethical because negate access to the public, but also because neglect the use of archives (Merriman and Swain, 1999). In my view, Open Data is also ethical insofar as it allows us to break dynamics of monopolistic information-hoarding by some publishers (Marchetti *et al.* 2018) or researchers (Wright and Richards, 2018). Therefore, promoting access, use, reuse and stewardship of Grey Literature and Data is fundamental.

This raises the question of data accessibility based on their properties. As already noted by some researchers, accessing and reusing data is not an easy thing due to a lack of standardisation on what to record and how, denominations, etc. (Merriman and Swain, 1999; Baines and Brophy, 2006; Huggett, 2012a; Atici *et al.* 2012; Faniel *et al* 2013; Kansa and Kansa, 2013; Evans and Moore, 2014; Huggett 2018). This is both an epistemological and ethical issue (Atici *et al.* 2012; Kansa and Kansa, 2013; Zwitter, 2014; Richardson and Almansa-Sánchez, 2015; González-Ruibal, Alonso González and Criado-Boado, 2018; Milek, 2018). Therefore, considering ethics, we need better practices and networked research communities capable of creating reusable and accessible data. An interesting venue in this respect is the FAIR data framework (Wilkinson *et al*., 2016), which stresses the importance to create findable, accessible, interoperable and reusable data and metadata.

These four principles are fundamental for studying Human Ecodynamics because it needs to make use of diverse interlinked data. Here it is important to highlight the methodological and ethical importance of sharing and making available data for the sake of studying and tackling climate change within and beyond academia (Pulsifer, Gearheard, Huntington *et al*., 2012; Pulsifer, Huntington, Pecl, 2014; Barnes and Dove, 2015; Yager, 2015; Halperin, 2017; Jones, Alexander *et al.* 2017; Marchetti e*t al.* 2018). This is in line with recent efforts in cooperation, collaboration, engagement and consensus within the archaeological community, and in its interaction with different communities (Atici *et al.* 2012; Dalgish,

2013; Halperin, 2017; Milek, 2018; Wright and Richards, 2018; Kosiba, 2019). In a more general term, all this can be encompassed within very recent movements in Archaeology which seeks Open Science (Open Access, Data and Method) (Marwick *et al.* 2017). Therefore, openness normally happens at different levels (Academia and the general public) in different stages (Access + Data + Method), and, I argue, reinforce a political-engaged cultural research (Ang, 2006).

In sum, the way data is managed and made open is fundamental in our attempts to achieve a more open and engaging research. This collaborative and open *ethos* especially emphasises the use of digital technologies as the most productive source for achieving better, more open, collaborative, and combative outcomes (Atici *et al.* 2012; Halperin, 2017; Marwick *et al.* 2017; Marchetti *et al.* 2018; Wright and Richards, 2018; Jensen, 2018; Galeazzi and Richards-Rissetto, 2018; Romero Pellitero, Delgado Anés and Martín Civantos, 2018; Díaz-Guardamino and Morgan, 2019). Nonetheless, this approach does not come without ethical challenges, mainly in respect to the epistemological inclusion of Traditional Knowledge within Big Data research (Jones, Alexander et al. 2018; Huggett, 2018). As such, I notice a strong correlation between Digital Archaeology, Public Archaeology, Human Ecodynamics, and ethics. This demonstrates the ubiquity of the latter.

Considering all the above, we can conclude that the problems regarding our writing practices are an ethical problem too. In this sense, it worth to consider some proposals which aim at resolving these issues.

### 1.2.2 Approaching solutions I: new formats for Archaeological Reports

It is necessary to problematise our writing practices because, as we have seen before, our praxis produces dull archaeological reports. As already mentioned, this means the death of the data, and, by extension, of knowledge. The earliest answers to this issue focused on changing those writing dynamics (Hodder, 1989; Sinclair, 1989a and b; Boivin, 1997). This was an aesthetics or "creative turn" (Beale and Reilly, 2017). On the other hand, several critical voices argued against the publication of vast tomes of archaeological reports, mainly due to the unsustainability and unsuitability for reaching many readerships:

> Archaeological publications in general may be very worthy, but they cost a fortune to create and have a very small readership […] A site may be excavated in six months, but the results appear six years later in a 600-

> page book that a maximum of 500 people will read (Backhouse, 2006, pp. 46-47).

With the advent of digital technologies, some approaches have attempted to convey new and more attractive ways of publication, communication, and dissemination (Backhouse, 2006; Richards, 2006). This effort is in line with the broader field of Humanities (Coble, Potvin and Shirazi, 2014). The criticism and answers which I have hitherto mentioned are part of a wider context within the archaeological discipline. They form part of an epistemological debate with over 30 years of longevity. Since it is almost impossible to understand how the answers are given without the questions that caused them, I will summarise the debate in the next few pages; the solutions will be presented afterwards.

Several years ago (1975 [Frere Report]), mainly in Britain, archaeologists realised the unsustainability of traditional archaeological publications and the impossibility of handling its associated data -let alone its understanding in broad themes (Thomas, 1991; Powlesland; 1997; Richards, 2002; Backhouse, 2006; Evans and Moore, 2014; Moore and Richards, 2015). The Frere Report (1975) was the first of its kind in many things: done by a state heritage body, aimed at giving some wide-applicable answers to the unfolding publication crisis in British and Irish archaeology (Cunliffe, 1990; Richards, 2004). In trying to resolve the issue, the report divided the different stages of publication and archiving by offering a fourfold layered solution (Frere, 1975, p. 3). Notwithstanding it was a useful and much needed alternative, especially because it reorganised the storage of data and the "what/where to publish" question (Richards, 2004), it also purported some problems. From my point of view, the main issue created by the report is an epistemological disjunctive vision: it was the first official and professional publication which advocated for the disentanglement of the "whole" (Frere, 1975; Richards, 2004). This is not trivial, as it was to become paramount due to its importance and officiality. Indeed, the report ended up being a best-practice standard. To sum, the Frere gave necessary answers for the time but it also gave birth to a problematic decoupling approach which still continue today.

In spite of its influence and archival advocacy, it is not clear the real impact of the Frere Report in resolving the publication crisis from which it emerged (Richards, 2004). Eight years after the Frere, another commission, led by Barry Cunliffe, published a new report known as the Cunliffe Report (1983). This report had a great impact, but its implementation was quite difficult due to the available technology at the time (Richards, 2004). The report kept the division initiated by the Frere report between facts and descriptions as the standard

to follow. The latter issue was soon to be highlighted and critisised by Hodder (1989), among others (Richards, 2004).

By the beginning of the 1990's the situation was slowly, but steadily, changing. Both, the Frere and the Cunliffe reports, were followed to some extent by a limited number of archaeological firms and units (Cunliffe, 1990). At that time, the main discussion balanced between the degree of data to be included in archaeological publications and archives, and their fuzziness (Cunliffe, 1990). But the problem of "for who to publish" (i.e. outreaching) was still limited in scope: publications and archives were mainly thought of for academics, students, and agencies (as can be deduced from Cunliffe, 1990). In 1992 the Society of Antiquaries convened yet another committee capable of correcting some of the problems from the two previous reports, not least that assessing new tendencies in a moment where developing-funding excavations gained traction (Richards, 2004). This new meeting took the shape of another publication: *Archaeological Publication, Archives and Collections: towards a national policy* (Carver, Chapman, Cunliffe *et al*. 1992). As Richards (2004) effectively summarizes, the latter deepened on some of the recommendations made by the Cunliffe report, among which was the assertion of separating synthesis from archives.

Almost a decade later, the publication of the PUNS (Jones, MacSween, Jeffrey *et al*. 2001), and its subsequent summary (Jones, MacSween, Jeffrey *et al*. 2003), offered interesting results. As a general trend, grey literature was already a problem. Besides, there were many internal problems if unfolding the concept of grey literature. I will comment on some of them due to their relevance for this thesis.

Looking through our present theoretical framework, one of the main problems highlighted by these two publications was a patchy ethos. With this, I refer to the practice of publishing different types and amounts of data in a plethora of documents (e.g. fieldwork monographs, journal publications, fieldwork publications in grey literature, synthesis publications, etc.). As a consequence, different readers, depending on their constituency, were more likely to read a limited amount of these publications -normally focusing on just the very same type over and over (Jones, MacSween, Jeffrey *et al*. 2003). The survey additionally demonstrates that the most read publications were those that presented synthesized knowledge about an excavation whilst grey literature was the least read. Indeed, the latter was almost exclusively used by contractors and curators, not archaeologists. This represented a great problem, considering that grey literature presents the full data from our activities. Another problem emphasised was a complete disentanglement between the data, its interpretation, and the synthesis of knowledge. The disjunction was present not only within archaeological reports.

Most importantly, the problem was perpetuated because data, interpretations, and synthesis were commonly published in different mediums. This created the sensation that there was an inadequate relationship between fieldwork and research publications (Jones, MacSween, Jeffrey *et al*. 2003). Unfortunately, the problem persists today.

The issue was more acute even if exclusively focusing on fieldwork reports, as readers tended to privilege introductions, conclusions, and discussions over pure data. As for very concrete sections (ecofacts, artefacts, etc.), these were normally used by specialists (Jones, MacSween, Jeffrey *et al*. 2003). I think there is no need to stress again the great error of this and instead will refer to Boivin's words (1997, p. 113-114) cited above. Consequently, most of the time these reports were/are used as mines for gold diggers. The problem of thinking of archaeological reports as minesweepers is that you can find the specific data you are looking for, but you left aside the rest of the data and the whole context. The lack of synthesis in archaeological reports, as pointed out by many respondents, helps not to solve the problem. All of these ultimately backfires our efforts for outreaching a wider, lay, audience.

The survey also demonstrated a need for enhancing the format and purpose of archaeological reports and archives. It was clear that reports needed to change in length and format for suiting different audiences (Jones, MacSween, Jeffrey *et al*. 2003). But it also showed different approaches or needs depending on the sector. In other words, different users have different needs and preferences. At that time, this problem was a challenge. Today, technology allows to overcome the issue (see, for example, the cases of Gabii or Diana Arcaizante cited below [p. 32]).

One of the main problems stressed by the PUNS -archives' dissatisfactions (Jones, MacSween, Jeffrey *et al*. 2003)- was soon to be overcome by the development of efficient online archives. As shown below, a non-negligible number of projects have been developing procedures and approaches with efficient results. Yet, many of the problems highlighted almost 20 years ago by the PUNS are still present. This should not come as a surprise, though. Changing a traditional professional ethos is neither easy nor quick. Funding, moreover, is normally necessary to accomplish these changes. As highlighted above, power and desire are always in play, and normally slow the pace of changes in academia.

The start of the new millennium brought a renovated interest on digital archival preservation. Most importantly, this shift also meant a change of attitude towards common, high quality, frameworks for storage (Richards, 2004). With this, it also exploded a theoretical debate of over twenty years: whether to preserve by context or in a more selective way. The novelty

was now what data was worth of digitisation (Richards, 2004). It is in this context where online archives, such as OASIS or ADS should be placed (see below for a brief analysis of these). On the other hand, online archives meant a change of mindset: they were also valuable for their dissemination usefulness. The potential user changed from being someone related to the discipline to anyone with Internet access and some degree of knowledge regarding where to find online archaeological archives.

The landscape, at least for the British case, has evolved in the last decade and a half. Evans (2015) identified a trend to standardisation of field reports and an inner (from the archaeological community) perception of renovated quality. The general picture, as normally happens, is nuanced when the focus is placed on different regions -i.e. unevenness of quality and quantity. The most common and recent criticism has been related to some aspects of metadata and interpretation quality (Evans, 2015). Both things are of interest as they signal quite important aspects to be amended. The flagrant problem a decade ago was, however, the seemingly lack of self-awareness regarding the problems entail by 'grey literature'. The trend amongst many archaeologists was an acceptance of the validity of this kind of publications (Evans, 2015). This acceptance, should be noted, happened in spite of digital archives showing the importance of making data readable and accessible.

There is a bitter irony here. These sources are valuable because they contain critical data and information. Yet, they are in a grey format impeding a full circulation and interconnection of their data. It is clear that, on the one hand, archaeologists were in favour of these kind of publications for the valuable information they carry in, and that on the other, there is a need for this literature to stop being grey. To say it clear, these sources need to change their grey format for their usefulness. This reality is more critical considering modern community-based research groups. The latter generate an important amount of information which is seemingly more "elusive and ephemeral" than that from academic and contract archaeology (Evans, 2015).

The debate has always been propelled by the advent of new technologies. This means that if the epistemological arguments moved around how, what, and where to publish/archive, the development of ever-advanced technologies have offered new mediums for testing different theories. Preservation and accessibility, as might be inferred from previous lines, have been the two main goals to be achieved. Interoperability/*linkability* has been a recent goal too. Open Access and Open Sciences have also been important motto in this respect. It is not surprising, hence, that digital technologies haven been used to this end. It might be of some use an overview of how the digital have changed the field.

Micro-fiche for storing data asides, DVDs and CDs were arguably the first new formats for archaeological reports, followed by WEB-CDs (Powlesland, 1997; Gardin and Roux, 2004; Backhouse, 2006; Richards, 2006). These formats had some downsides, especially regarding long-term preservation and free access (Richards, 2006). With the development of new technologies, CDs were "outdated", and this approach is now out of game.

In any case, it was surpassed by electronic publications that make use of Internet (Richards, 2006). Albeit this approach presents problems regarding trustability and accessibility (Powlesland, 1997; Richards, 2006), is one of the favourites due to its many advantages. To name just a few: economic and capable of presenting much more (varied) material; "availability" of the data; hypertexts which break traditional narratives ("multivocality"); long-term preservation; discipline interaction, etc. (Powlesland, 1997; Richards, 2006). No doubt, many of such advantages have fostered an intensive use of this format, especially by online journals (e.g. *Internet Archaeology*). Its adoption, however, has been pretty slow for fieldwork publications (Richards, 2006).

Boiling down to archaeological reports, some of the first proposals (e.g. the publication of the Anglo-Saxon settlement at West Heslerton, in North Yorkshire) were done by using web-based tools (e.g. SGML, HTML and XML languages) which allow for semantic-web tagging connections (Powlesland, 1997; Richards, 2006). Now, over 20 years later, the landscape has gradually changed towards new reports publications which make use of Internet for linking data. This moreover serves for making more attractive and comprehensible the visualising of these reports thanks to the effectiveness, pace, and accuracy of these tools (Clarke, 2016).

In sum, this represents a challenge to traditional ways of publishing archaeological reports. New formats do not only represent a way forward for their capability in engaging with the wider public. They offer alternatives to traditional publications inasmuch as they open the possibility up for modifying how they structure data and interpretation (hyperlinks, deep mappings, etc.). The latter might destabilise scholars' authority (Sayers, 2012). They also serve for changing inappropriate dynamics where traditional techniques for recording data hamper the availability of the data (Marchetti *et al*. 2018), providing, therefore, new venues for recording and making accessible that information.

The electronic publication of the Anglian and Anglo-Scandinavian farmstead at Cottam was one of the first examples of a layered excavation-publication (Richards, 2004). Its main value

was the combination of different detailed layers without losing the narrative. In the last decade, new projects have followed a similar vein, but with much more refined results.

Projects which have implemented new ways of publishing reports are the Opolontis Project (Clarke and Muntasser, 2014 [https://quod.lib.umich.edu/cgi/t/text/text-idx?c=acls;idno=heb90048.0001.001]; Clarke, 2016), Digital Karnak (Sullivan and Snyder, 2017), or Diana Arcaizante (Luzón and Alonso, 2017 [dianaarcaizante.com]). Arguably, the Gabii Project (Opitz, 2018a) deserves a special mention. This is not only because it offers some innovations in comparison to the former cases (e.g. adaptability to different users), but because it offers a diversification and interlinkages between different levels of data and interpretation. In so doing, this publication breaks down the artificial divide between data-interpretation/data-information-knowledge. Moreover, it opens new possibilities for mapping data's ontological properties.

These new approaches to the act of writing archaeological reports represent not only a revolution in how to write depending on what content they have. Rather, they challenge our traditional approaches to the act of writing inasmuch as they change how data and its interpretation is presented in an interlinked manner, favouring interdisciplinary connections. Such an approach, indeed, overcomes some of the difficulties posed by synthesis (e.g. data or interpretation shadowing). They moreover allow data-reuse by digitising it. These points help in tackling the whishes reported by the PUNS (Jones, MacSween, Jeffrey *et al*. 2003) on achieving a more synthetical, archival-integrated, and detail-balanced, publication. Narratively speaking, another important point is that they can provide a better approach to non-academic communication (e.g. deep maps [Early-Spadoni, 2017]). All of this represent a step-forward in our narratology: less as scientists in our ivory tower and more as storytellers of compelling knowledge because of its scientific content (Fitzpatrick and San Filippo, 2017). Even if the latter poses some problems (Huggett, 2015b, p. 92), I think that some experiments (e.g. Early-Spadoni, 2017; Opitz, 2018a), are quite useful in achieving the subversion of the author, bridging some divides (Huggett, 2015b, p. 92).

In sum, these new approaches, which change the way we present our outcomes to the public and other scientists, are quite useful for new-born data. But then, what happens with the Grey Literature and its Legacy Data? It is difficult to actively include that into these new formats because of the very nature of the data. As Richards and Hardman (2008) put it, the problem extends "beyond report production to the ways in which archives and reports could be used and reused". Most importantly, however, is the question of how not to drown in data. Here

I argue that a thorough approach to data might better resolve some of these issues (Moore and Richards, 2015). We need to go deeper into the core of the legacy data's problem.

### 1.2.3 Approaching solutions II: digital archives and Open Data

In the previous section I have shown that the Frere Report and subsequent reports pointed out to the unsustainability of archaeological publications, the difficulty of handling data, and a scant of synthesis. We have seen that since that tipping point until now, several projects, normally taking the form of digital archives or repositories, have sought to solve this issue (Baines and Brophy, 2006). However, as I will argue, we are not still reaching our concrete goals.

At first, the main response was to limit publications and rely on the archiving of data, but at the expenses of accessibility: these methods lacked linkages between the archive and the publication (Moore and Richards, 2015). This situation reified an artificial divide between the record and its interpretation, and between field archaeology and curation -which lessens archaeology's purpose (Merriman and Swain, 1999; Andrews, Barrett and Lewis, 2000). This was to change with the advent of digital technologies and the web (Moore and Richards, 2015). Cyberinfrastructures are the key here. They are new research environments and tools "that support data storage, management, integration, mining, and visualisation over the Internet" (Richards and Hardman, 2008). Now, many projects make use of these tools.

These projects aim at storing and reusing data in a sustainable way, at the same time that opening that information within and beyond Academia. Some people might think of electronic Open Access literature as a solution (Evans and Moore, 2014). Indeed, some governmental institutions have prioritised research aiming to be made publicly available (see, for example, Richards, 2002 for the DAPPER Project; Coble, Potvin and Shirazi, 2014; Moore and Richards, 2015). However, that is not enough because the content is sometimes highly complex and specialised (Childress and Jul, 2003, p. 5). This, I argue, is quite true for Archaeology. To resolve problems regarding flaws linking disparate data, researchers (Childress and Jul, 2003; Richards, 2004; Huggett, 2014; Jones, Alexander *et al.* 2017) have proposed to include metadata and provenance data along with the data. This could resolve the "openness issue". But is Open Access the same as Open Data? Huggett (2015a, pp. 7-8) gives an enlighten answer by dividing data base on increasing openness:

> 1. Open access data provides online access to view datasets, limited only by a presumption of Internet access and the requirement for a modern web

> browser. Use of the data beyond viewing and searching online is restricted [2.] Open access data which returns summary geographical information as a downloadable output of a search query or via Web Feature Services (WFS). This can then be further analysed using GIS software as if the data were held locally. [3.] Open access data consisting of entire datasets which can be downloaded but where restrictions apply to the use and reuse of data and hence is not truly open data in the technical sense [and 4] Open data which has no exclusions or restrictions on use, and conforms to the Open Definition or the most permissive Creative Commons licenses. In general these datasets relate to specific projects, sites, or collections.

We can conclude, therefore, that many projects sought to be fully "open" but in reality, achieving this is neither easy nor common. Among other things, this means that new frameworks -such as the FAIR Data Principles (Wilkinson *et al*., 2016)- need to be followed and implemented. Once this has been understood, we can delve into what has been done up until now and what is left to do. For doing so, I will divide different projects into two main categories: those which seek data archival-storing-retrieval, and those whose main aim is the sharing and linkage of Open Data. I must warm, however, that this review is limited, as it only includes Western projects.

In the first category, we find projects such as *The Archaeology Data Service* (ADS), the *Designated Archaeology Collections Programme*, OASIS (Online Access to the Index of Archaeological Investigations), or the AREA (ARchives of European Archaeology) network (Barratt, 2000; Richards, 2002; Hardman and Richards, 2003; Schlanger, 2004; Richards and Hardman, 2008; Green, 2014, pp. 214-215; Evans and Moore, 2014; Moore and Richards, 2015). These projects are either digital archives or systems/guidelines/forms which seek long-term preservation and (meta)data sharing and reuse, along the lines of free, high-quality data. Some of them are more focused on digital data, while others work mainly with Legacy Data. Some of them (e.g. OASIS) collaborate with other projects seeking similar results, or unite different institutions seeking similar principles (Schlanger, 2004: Hardman and Richards, 2003).

Nonetheless, they are not free of limitations (e.g. narrow scope, epistemological flaws, etc.). OASIS or ADS did not break with the disentanglement of data, interpretation, and synthesis proposed by the Frere or Cunliffe reports. Instead, they followed through similar lines on both reports -in spite of the awareness for reintegration (Richards, 2004). This is comprehensible to some extent; their developers were trying to create a rationale capable of

managing the profound interconnection of these different parts in an easy-to-handle way. Another way to say this is that they were cautious not to create an archive of "raw undigested material" (Richards, 2004). Another fair issue is the act of archiving, which is not trivial. Archived data or knowledge of any sort have their own narrative systems. The way they are archived define their narrative's limits, as well as the possibilities of transmitting, shaping and reshaping knowledge (Fellinger and Philpot, 2014; Baird and McFadyen, 2014).

But there are some nuances in this critic that stress some of the greatest point in favour of these archives. The digital world opened new paths -helping in resolving the 'disentanglement issue'. In effect, the main advantage of digital archives -that is, their capability for linking data and files within the semantic web - served to counteracting the problem. It is arguable the degree to which these linkages helped in re-joining the different parts of an excavation record, but there is no doubt that it was a step forward. These archives moreover empahsised the importance of including meta- and paradata, and of developing interoperable standards to this end (Richards, 2004). Overall, online archives were/are a very important step forward in the way archaeological reports, grey literature, and legacy data were handled. The best proof of their importance is the fact that they have become almost fundamental.

In the second category, we find projects such as ARENA, LEAP, DAPPER, NEARCHOS, ARIADNE, tDAR, DANS, Open Context, or Pelagios (Richards, 2002; Kansa and Kansa, 2013; Faniel, Kansa *et al.* 2013; Moore and Richards, 2015; Meghini *et al.*, 2017; Marchetti *et al.* 2018; Wright and Richards, 2018; http://commons.pelagios.org/; https://www.tdar.org/about/). Dallas (2016) also mentions other projects of similar purpose. They all seek to interlink either digital data with field-publications (bridging the divide), or data with other data. These projects follow principles based on Open and FAIR Data, long-term preservation, interoperability and knowledge modelling. Normally, this is achieved by using cyber-infrastructures and other digital tools. These tools are of great aid as they allow for Linked Open Data, a method of openly publishing, sharing and connecting data, information, and knowledge online based on the concept of the "semantic web" (Green, 2014, p. 224). Projects such as NEARCHOS sought to resolve some problems faced in Open (and interlinked) research in Archaeology (Marchetti *et al.* 2018). No doubt, such an approach is useful, especially considering other proposals (Holm *et al.* 2013; Hartman, *et al.* 2018) which seeks to unite different disciplines through synergetic collaborations.

ARIADNE (https://ariadne-infrastructure.eu/) deserves a special mention. It is one of the biggest cyberinfrastructures which gathers data from a wide range of European research

whilst offering data-best-practice advices (Wright and Richards, 2018). Making use of a mega infrastructure, it serves for aggregating, storing, curating and disseminating data from different partners -promoting equity and stewardship among its different partners (Wright and Richards, 2018). Further, it offers the opportunity of recognising authorships' metadata (Marchetti *et al.* 2018), which in turn favours data aggregation from other archives (Wright and Richards, 2018).

In sum, many of these projects aims at "storing, curating, and preserving digital datasets and also broadening their access" (Marchetti *et al.* 2018). Others seeks to change the way field recordings and dissemination of primary datasets take place by making use of digital technologies capable of creating collaborative networks (Marchetti *et al.* 2018). Notwithstanding that these solutions are fair, they have problems regarding meta- and para-data development, or data shadowing (Huggett, 2012a; Moore and Richards, 2015). This problem seems to persist even though some models, such as Dublin Core metadata (https://dublincore.org/), have paved a useful way to follow (*cf.* Richards and Hardman, 2008 for some issues related to standardisation).

These issues illustrate, or make the case for argue, that Linked Open Data in a semantic web does not necessarily equates to Open Data (Moore and Richards, 2015; *cf.* Kansa and Kansa, 2013). In addition, many data are still preserved in PDF formats, a mechanism that present some problems regarding accessibility and reusability (Evans and Moore, 2014). This forces us to develop new venues for resolving all these limitations. Moreover, it goes without saying that knowledge is not data by itself alone. The latter is fundamental and allow us to consider that Open Data is not enough. Why? I argue that at the end of the day what matters is not an open, standardised, manageable, and reusable bulk of different datasets. They are quite useful; indeed, many times they are the bare bones from which to create knowledge. Nonetheless, preservation and dissemination must not neglect, or make us sloppy in, the need for enhancing interoperability and enhanced knowledge representations:

> A principle focus solely on the preservation and dissemination of grey literature, and a continued neglect of the data that facilitated the creation of this synthesis, is short-sighted (Evans and Moore, 2014, p. 238).

If not, we risk replicating the same problems here discussed. If these datasets are not interconnected in meaningful ways, they probably will not enhance our narratives. Another issue to include here is how to deal with "secondary data": the information created after analysing "primary data" (Atici *et al.* 2012). Research questions which aim at creating more

complex narratives require of disciplines better connected between them. In the case of Human Ecodynamics, for example, this is quite clear. If we are to achieve this, we must find new ways for interlinking disparate datasets in a meaningful manner. This means looking at their ontological properties within a broad story.

I am not discrediting previous efforts. They have been quite useful and have resolved many problems posed by data since their inception in the last decade of the 20th century. Many ideas and solutions offered by these projects represent the advances of our research and go in hand with new issues which arose after others were resolved. However, considering the point we are now, our collective past effort is insufficient. We may have reached a point where data is rightly preserved. However, I argue that this is not enough because we do not know yet what are the ultimate properties of such data; neither we know how to "squeeze" all the information they carry in an interlink manner. This means that we are facing new challenges, which are probably related to the "ontological turn" Archaeology is experiencing (Caraher, 2016; Díaz-Guardamino and Morgan, 2019). For this reason, Digital Archaeology is arguably in a good position for going through that "turn" and, at the same time, this may resolve the problems mentioned here. A good opportunity for doing so is by questioning data's ontological properties and the interlaces between data. I consider that computational ontologies might be the most appropriate digital tool for tackling such complicate task.

### 1.2.4 Computational ontologies

Computational ontologies have a recent implementation within the archaeological discipline. One of the earliest, if not the earliest, uses in Archaeology is from 2003 (Missikoff, 2004). As Huggett (2012a, p. 542) says:

> an ontology is 'a systematic representation of all categories of objects or concepts that exist in the specified domain and the relationship between them' [they] provide a shared and common understanding which allows the mapping of concepts to information. They are designed to produce semantic interoperability between different datasets by representing the information contained within them using a formal standardized, structured syntax for describing and capturing the concepts and contexts of information, and the relationships between them.

Besides this, ontologies allow us to map metadata to existing integrated conceptual frameworks. This achieves greater semantic interoperability and, in turn, "offers a more

effective use of both grey literature and grey data" (Evans and Moore, 2014, pp. 235-236). Moreover, ontologies have promoted good data-creation practices (Moore and Richards, 2015, p. 35). For example, the STELLAR Project (Evans and Moore, 2014) sought to preserve and disseminate, as well as to standardise and represent, disparate datasets and knowledge. In addition, they seek to enhance or create meaningful conclusions.

As already mentioned, ontologies use different semantic languages for mapping and interlinking data. Here I will focus on the CIDOC Conceptual Reference Model (CRM) -which is mainly use in the heritage management sector. CIDOC CRM is a semantic framework, a language, which "provides definitions and a formal structure for describing the implicit and explicit concepts and relationships used in cultural heritage documentation" (http://www.cidoc-crm.org/). It is intended to "promote a shared understanding of cultural heritage information" using a common language capable of mapping (conceptual modelling) any cultural heritage information (http://www.cidoc-crm.org/). It has different implementations and extensions, (e.g. CRMsci for integrating metadata by description of semantic relationships; or CRMgeo for adding spatiotemporal information) which aid in mapping different data's properties using semantics (http://www.cidoc-crm.org/collaborations; http://www.cidoc-crm.org/crmsci/; http://www.cidoc-crm.org/crmgeo/). Even though this language offers a wide range of functionalities, it is not extensively used in archaeological-laden ontologies -with some notable exceptions, such as the STAR Project, using it in archaeology (Tudhope, Binding, Jeffrey, *et. al* 2011).

Unfortunately, this tool is not a panacea. Huggett (2012a, 2014, 2015a and b) exposes some of the most common problems posed by these ontologies. Moreover, they may resolve issues at the moment of creating data, but do not resolve by themselves the problems of Legacy Data. Indeed, ontologies present some issues regarding data integration even in seemingly *easy and common* data such as that of zooarchaeological composition (Atici *et al.* 2012). This means that data cannot be integrated at face value without firstly developing some common frameworks. That is to say that we need a forward-thinking approach within a research network. On the other hand, as Atici *et al.* (2012) highlight, there are problems regarding data mapping and integration. This is related to the issue regarding variability within the conceptual hierarchical ordination (see Section 3.2.2 for discussion). Importantly, as Huggett (2012a) or Atici *et al.* (2012) stress, another great problem to be taken into account is how implicit theoretical frameworks might influence ontological development (see Section 3.3).

Moreover, as I discuss through Chapter 3, many of these ontologies fail in understanding this tool's potential. In so doing, they do not fully resolve the problems they sought to address. For example, in Archaeology many ontologies sought classification and semantic inference (Faniel, Kansa *et al.* 2013). However, as discussed in Chapters 3 and 4, both things, classification and inference, have some flaws regarding how they are thought of and developed.

Ontologies might be fundamental in the near future for researching complex and broad issues that, as happens in HE, need the integration of a huge quantity of diverse data (Marchetti e*t al.* 2018). Human Ecodynamics, therefore, make the case for working within a Big Data framework. In HE, the integration of multiple disciplines is fundamental in order to understand climate dynamics -which operate at different spatiotemporal and systemic levels (Moore, Mankin and Becker, 2015). However, the question of how to better achieve such (transdisciplinary) approaches in order to create grand narratives remains open. This is the main concern of my thesis: how to create a dataset using Grey Literature and Legacy Data capable of being interlinked in a meaningful way with other datasets, in an ontology which aims to represent narratives about historical Human Ecodynamics.

As I show in the next section, the North Atlantic is an ideal "laboratory" for such an interesting exercise. In this contexts, NABO's archaeological reports provide a source of great interest due to their "grey" condition, and the contradictions that arise between these reports and the targets that the NABO community sought to address.

### 1.3 NABO and North Atlantic research's problems

This thesis focuses on the North Atlantic, with a special interest on the Viking and Medieval periods. However, the Project is diachronic in scope, and integrates evidence from the modern and contemporary periods. As mentioned earlier, the DataARC Project draws substantially on the work of the NABO (North Atlantic Biocultural Organization: http://www.nabohome.org) research network. NABO plays an important role in the North Atlantic research community, and its research agenda form part of the context for this thesis project. This section provides an introduction to NABO and its research, as well as to the main issues generated by their praxis.

NABO is an international, interdisciplinary research and education cooperative formed in 1992 by Thomas H. McGovern[1], Andrew J. Dugmore[2], and other members (Maher and Harrison, 2014, p. 5). It was formed to cross-cut national and disciplinary boundaries by creating a common forum for regular meetings and exchange of ideas. During more than 25 years, it has helped North Atlantic scholars from a broad range of disciplines with shared common interests to make the most of the huge research potential of this area (https://www.nabohome.org/). NABO's initial focus was upon the archaeology and paleoecology of Viking Age colonization from Scandinavia and the British Isles. In this context, its strongest focus is on Zooarchaeology and the integration of faunal research into multi-disciplinary projects, both in the field and laboratory. Its team's expertise ranges over different areas, from Landscape and Environmental Archaeology, touching themes of human bioarchaeology and artefacts studies, through climate research and policy-making based on sustainability (McGovern, 2014, p. 213; Maher and Harrison, 2014, p. 5). Equally, NABO has progressively expanded in temporal scope -from Prehistory through the Modern/Contemporary Period- and geographic extent -ranging from Labrador to Finnmark (https://www.nabohome.org/history.html).

As such, NABO is strongly interdisciplinary as well as international, with an overall focus on Human-Environment interactions. This makes the cooperative ideal for creating wide ranging collaborative investigations of humans, landscape, seascape, and climate change in the region (https://www.nabohome.org/history.html) with the aim of understanding human adaptions within dynamics of natural resources' uses. In sum, its participants have been recognized for including a *long-durée* perspective to contemporary problems of global change whilst incorporating Crumley's concept of "longitudinal research strategy" (McGovern, 2014, p. 214). These lines are summarised in three main research points (*ibid*):

1) Human impact on island ecosystems through processes of settlement, and their long-term consequences.

2) Climate change impacts on biotic elements and among them in the eco-social landscapes and seascapes.

3) Micro and macro scales human interactions (economies, markets, and interactions).

[1] Professor at the Department of Anthropology of the City University of New York (CUNY).
[2] Professor at the School of GeoSciences of the University of Edinburgh.

The final goal is the understanding of past conditions and actions for the creation of sustainable policies in the future (Maher and Harrison, 2014, pp. 5-6). In the next chapter, I will discuss some implications of this scope.

NABO also has a strong commitment to *outreach* activities. This is achieved by promoting better communication dynamics with the general public, something manifested in two main activities (McGovern, 2011, p. 302):

A) The creation of kids training schools in Iceland (*Fornleifaskóli barnanna*), Greenland, Orkney and Barbuda.

B) Initiatives which seek to enhance active local participation in research and heritage conservation.

More important from the perspective of this project is its interest in better communicating its findings to other scholars and funding agencies. Indeed, this commitment is arguably their strongest characteristic, and the key of NABO's success. The cooperative has worked to aid in improving basic data comparability and in assisting practical fieldwork. The former is done by cooperating and sharing data and results across the North Atlantic. Through this, they have developed a broad picture of the North Atlantic's past, present and future (Maher and Harrison, 2014, p. 5). It has also led to the creation of a strong research network (see McGovern, 2014, p. 218).

This broad network, along with their goal of sharing data, has produced a large body of work. For example, the tight collaboration with FSÍ (*Fornleifastofnun Íslands*) has led to the creation of a database (https://www.nabohome.org/cgi-bin/projects.pl?coverage=iceland for the Icelandic case), combining data and archaeological reports obtained or done by both entities. This is substantiated in over 300 survey and excavation reports in downloadable PDF format.

Equally important is the creation of a recording manual for the Zooarchaeology Working Group Data Records: NABONE, a bone recording and data management package, or a coding manual whose main form is a spreadsheet in Open Access (freely downloadable at https://www.nabohome.org/products/manuals/fishbone/manual/1.htm). It was developed for creating or introducing zooarchaeological data with a fair degree of standardisation and consistency (McGovern *et al.*, 2017).

A final important contribution of this network is the development of three different simulation models (https://www.nabohome.org/products/models/models.html):

1. PLACE (https://www.nabohome.org/products/models/place/place.html), developed by Andy Casely from his PhD (2006).
2. Búmodel (http://www.sbes.stir.ac.uk/research/environmental_modelling/), developed by Amanda Thomson for her PhD (2003; see also Thomson, 2004 and Thomson and Simpson, 2006).
3. Farmpact06 (https://www.nabohome.org/products/models/farmpact/farmpact.html), developed by McGovern (2006).

The three models are important for understanding North Atlantic Human Ecodynamics. Nonetheless, not all of them are equally accessible, and in some cases, it is hard to understand their metadata. Both issues foreshadow some of NABO's problems.

Without diminishing the value of NABO's work, we can see important weaknesses in their approach. As recognized by the group, these issues notably appear when they are unable to back up their broad narratives robustly with their data (McGovern, 2018). Highlighting this challenge is not criticism, but reflects a much-needed self-realisation on the part of the group if NABO is to lead the future of research in the region as it has been doing for many years. Indeed, this self-realisation motivated the creation of DataARC (see section 1.4).

NABO's main issue, the gap between overarching narrative and data, is mainly due to the way archaeological reports are written (data separated from interpretation). In this situation, it is quite difficult to understand HE or similar themes where different datasets need interlinkages. The ethical issues explained a couple of sections before (1.2.1) are of importance here too.

What are NABO's main weaknesses? First, almost all the available data is in Legacy format. This is arguably one of the main problems for NABO: a cooperative whose main goal is sharing data must not fall into the trap of not digitising and sharing open and freely the data generated. While it is true that some data is open, free and digitised (e.g. Thomson, 2004; McGovern, 2006), the bulk of the datasets are not digitised (as is the case of the archaeological reports or some of the theses done under the auspices of NABO: https://www.nabohome.org/postgraduates/postgraduates.html), or not even open and free (e.g. Casely, 2006). Moreover, some data are not even on the archaeological reports, appearing in specific publications -in most cases without further references to where to find the dataset used. Finally, there is a lack of metadata and provenance data. In practice, this means that no serious research can be done using previous data. This is also negative for research clarity and fairness.

These issues are quite serious. As explained previously, the current situation makes necessary not only to strive for Open Access but rather also for Open Data. If not, NABO and all of us will fail in our role as researchers who have an ethical duty towards our *guild* -to use the historical term-, and towards the general public.

Concrete examples of these issues are found in a wide range of datasets, even for their strongest expertise (zooarchaeology). If the focus is placed on material studies (pottery, spindle whorls, etc.), which includes an abundant bulk of data, the reader will only find A) long tables (Fig. 1), or B) dully, fragmented, and over-specialised descriptions of some of these objects with little -if any- explanation of the significance of them (Fig. 2). The same issue is applicable to data concerning zooarchaeology, entomology, etc.

It is also important to notice the fact that explanations and descriptions of artefacts, bones, etc. are normally devoid of almost any image. In most of the cases, the text is only backed up with photos of important finds. Moreover, NABO's reports are mainly divided between three different axes: text-tables-images. Consequently, although the text is not completely devoid from photos, the most important ones for understanding descriptions are in different places. The exception that confirms the rule are the images from trenches and from the site, which are in a good place accompanying and backing the narrative up.

These problems replicate those issues pinpointed by Boivin (see section 1.1.2): NABO's archaeological reports are dull and unorganised. Consequently, they are difficult to understand, and even to read. This makes difficult for everyone -either specialist or an interested non-academic reader- to read and go through these texts. On the other hand, the knowledge contained in these reports is fragmented: text and explanations normally in one place, tables and images apart in other places. This split achieves a weak, distort knowledge where facts and narratives are apparently different things. The final consequences of this are:

A) A dense-opaque research *product* at its best -sometimes is unreadable at all, especially for the non-academic reader.

B) A certain difficulty of proving what it is said -especially in political and climatic claims where data is the keystone.

C) A greater distortion of the past.

The main danger of such a problem is that knowledge is not accessible. As I will explain in the next chapter, such a danger should concern us for its consequences.

## Finds register

| Finds number | Area | Context number | Phase | Type | Material type |
|---|---|---|---|---|---|
| 600 | | cleaning finds | III | pottery fragments | ceramic |
| 601 | H | 203 | III | nail | metal |
| 602 | H | 203 | III | pottery fragments | ceramic |
| 603 | H | 203 | III | pipe stem | ceramic |
| 604 | H | 201 | III | fragments | glass and ceramic |
| 605 | H | 201 | III | fragments of sheet metal, fish hook, nails | Fe |
| 606 | | topsoil | | fragment whetstone | stone |
| 607 | E3 | 200 | III | buttons | Glass |
| 608 | E3 | 200 | III | fragments | glass and ceramic |
| 609 | E3 | 200 | III | Nails and other objects | Fe |
| 610 | E3 | 200 | III | small fragments | coal |
| 611 | H | 207 | III | | Fe |
| 612 | H | 207 | III | | ceramic |
| 613 | H | 208 | III | | Fe |
| 614 | H | 208 | III | | Stone? |
| 615 | H | 207 | III | | stone? |
| 616 | H | 207 | III | flint | stone |
| 617 | E3 | 206 | II | flint? | stone |
| 618 | H | 209 | III | | Fe objects |
| 619 | H | 203 | III | vessel fragments | glass |
| 620 | E3 | 205 | III | bead?, ceramic pipe stem? | bone? |
| 621 | H | 203 | III | | Fe |
| 622 | H | 210 | III | Pipe stem | Kaolin |
| 623 | H | 210 | III | Nails | Fe |
| 624 | H | 210 | III | Vessel base | Ceramic |
| 625 | H | 212 | III | Button | glass? |
| 626 | H | 214 | II | Pipe stem | Ceramic |
| 627 | H | 214 | II | Nails | Fe |
| 628 | H | 214 | II | | Ceramic |
| 629 | H | 214 | II | Knife | Fe |
| 630 | H | 214 | II | | Fe |
| 631 | E3 | 211 | II | Nails | Fe |
| 632 | H | 214 | II | ? | Fe |
| 633 | H | 214 | II | | Glass |
| 634 | H | 214 | II | Hook | Fe |
| 635 | H | 214 | II | | Glass |
| 636 | H | 214 | II | Hook/Loop | Fe |
| 637 | H | 214 | II | | Ceramic? |
| 638 | H | 214 | II | Loom | Stone |
| 639 | H | 214 | II | | Stone |
| 640 | H | 214 | II | | Ceramic |
| 641 | H | 214 | II | Nail | Fe |
| 642 | H | 214 | II | | Fe |
| 643 | H | 214 | II | | Glass |
| 644 | H | 214 | II | Whetstone | Stone |
| 645 | H | 214 | II | Nails | Fe |
| 646 | H | 214 | II | | Glass |
| 647 | H | 214 | II | | Ceramic |
| 648 | H | 214 | II | | Fe |
| 649 | E3 | 217 | I | Bone comb frag? | Bone |
| 650 | H | 219 | II | | Cu |
| 651 | E3 | 217 | I | Hook? | Fe |
| 652 | E3 | 217 | I | Hook? | Fe |
| 653 | E3 | 217 | I | Bead | Bone |
| 654 | E3 | 217 | I | Nail? | Fe |
| 655 | E3 | 217 | I | ? | Fe |
| 656 | E3 | 217 | I | Nail | Fe |
| 657 | E3 | 217 | I | ? | Cu |
| 658 | E3 | 217 | I | ? | Fe |
| 659 | H | 221 | II | Pipe stem | Ceramic |
| 660 | H | 221 | II | Worked object | Bone |
| 661 | H | 221 | II | | Bone |
| 662 | H | 221 | II | Pipe stem | Ceramic |
| 663 | H | 221 | II | ? | Fe |
| 664 | H | 229 | II | | Ceramic |
| 665 | H | 229 | II | | Glass |
| 666 | H | 221 | II | ? | Stone |
| 667 | H | 221 | II | Many | Metal |
| 668 | H | 221 | II | Worked (toggle) | Bone |
| 669 | H | 221 | II | | Glass |
| 670 | H | 221 | II | Thimble | Cu alloy |
| 671 | H | 221 | II | Pipe | Clay |
| 672 | H | 221 | II | Pipe stem | Clay |
| 673 | H | 221 | II | Pipe stem | Clay |
| 674 | H | 221 | II | Pot sherd | Ceramic |
| 675 | H | 221 | II | Pot sherd | Ceramic |
| 676 | H | 221 | II | | Bone |
| 677 | H | 221 | II | Dice | Bone |
| 678 | H | 221 | II | | Bone |
| 679 | E3 | 223 | I | Knife | Bone+Fe |
| 680 | E3 | 223 | I | Sheet fragment | Cu |
| 681 | H | 221 | II | Indeterminate | Cu |
| 682 | H | 221 | II | Wire | Cu |
| 683 | H | 221 | II | Sheet metal loop | Cu |
| 684 | H | 221 | II | Knife blade | Fe |
| 685 | H | 221 | II | Unknown | Ceramic |
| 686 | E3 | 222 | I | Nail | Fe |
| 687 | H | 221 | II | Unknown | Wood |
| 688 | H | 221 | II | Clay pipe fragments | Ceramic |
| 689 | H | 221 | II | Indeterminate Glass fragments | Glass |
| 690 | H | 221 | II | pottery fragments | Ceramic |
| 691 | H | 221 | II | Manuport | Stone |
| 692 | H | 221 | II | Composite tool? | Bone+Fe |
| 693 | H | 221 | II | Nail | Fe |
| 694 | H | 221 | II | Unidentified objects | Fe |
| 695 | H | 221 | II | Sheet fragment | Cu |
| 696 | H | 221 | II | Manuports | Stone |
| 697 | H | 221 | II | Pipe stem fragments | Clay |
| 698 | H | 221 | II | Unidentified fragments | Ceramic |
| 699 | H | 221 | II | Unidentified fragments | Fe |
| 700 | H | 221 | II | Sheet with rivet | Cu |
| 701 | H | 221 | II | Fragments | Glass |
| 702 | H | 221 | II | Worked | Bone |
| 703 | E3 | 223 | I | Nail | Fe |
| 704 | E3 | 223 | I | Nail | Fe |

Fig. 1. Example of "Findings table" from Hicks and Björk Pálsdóttir (eds.), 2011. This is a ubiquitous example.

| | |
|---|---|
| SKU13-61-084 | 33 fragments, the largest 55x55x5 mm, whiteware, glazed |
| SKU13-61-089 | small fragment from whiteware, glaze missing |
| SKU13-61-092 | small fragment of glazed whiteware |
| SKU13-61-093 | 5 fragments of whiteware, glazed, the largest 30x19x5mm |
| SKU13-61-094 | 3 plate fragments,the largest 50x37x3mm, whiteware, glazed, blue decoration |
| SKU13-61-095 | 2 small fragm., larger 12x7x1mm, yellow glaze on one side missing on other |
| SKU13-61-096 | small white fragment, porcelain? |
| SKU13-61-102 | 30 small fragm., largest 22x19x5mm, 3 stoneware, 27 whiteware |
| SKU13-61-103 | 19 fragments, largest 42x22x5mm, whiteware, glazed, blue decoration |
| SKU13-61-106 | MISSING 2014. Discarded? Listed as 2 fragments of pottery. |
| SKU13-61-107 | 15 fragments,the largest 16x14x2mm, mainly whiteware |
| SKU13-61-110 | 2 fragments, 1 whiteware, 1 stoneware, the larger 15x9x3mm |
| SKU13-61-115 | 11 fragments, the largest 35x26x6mm, whiteware, glazed |
| SKU13-61-119 | 2 small fragments, whiteware, glaze missing, larger fragm 22x10x2mm |
| SKU13-61-125 | 36 fragments, the largest 31x26x3mm, whiteware, glazed, blue decoration |
| SKU13-61-134 | 37 fragments, whiteware,glazed, blue decoration |
| SKU13-61-135 | 54 fragments, the largest 73x45x5 mm, whiteware, glazed |
| SKU13-61-136 | 31 fragments, the largest 30x25x5 mm, whiteware, glazed |
| SKU13-61-137 | 15 fragm, the largest 23x22x3mm, whiteware, glazed |
| SKU13-61-158 | 2 fragm., the larger 16x5x5mm, whiteware, glazed |
| SKU13-61-173 | 2 small fragm.of whiteware, the larger 12x10x2mm |

Pottery is an import to Iceland. As far as we know objects of pottery were first made in Iceland in the 20th century (Guðrún Sveinbjarnardóttir 1996, 29; 85-6).
The value of the imported tableware of pottery can i.a. be seen from those instances where a broken object has been carefully mended by drilling holes in the fragments and sewing or tying the object together with thread. To make the mend waterproof the object was then boiled in milk. Drilled holes, presumably for such reparation, can be observed on two of the Skútustaðir 2013 finds.

**Clay pipes**

Three of the ceramic finds from 2013 were fragments of clay pipes, all three undecorated stem fragments.

| | |
|---|---|
| SKU13-61-036 | stem fragment, no decoration, l. 33 mm, diam. 9 mm |
| SKU13-61-038 | stem fragment, no decoration, l. 20 mm, diam. 7 mm |
| SKU13-61-056 | stem fragment, no decoration, l. 22 mm, diam. 8mm |

Tobacco pipes of clay are known from the late 16th century (Mehler 2004, 131).
Clay tobacco pipes are frequently found in excavations in Iceland, in deposits from the early 17th century onwards (Mehler 2004, 133) e.g. from Bessastaðir, Skálholt, Hólar, Stóraborg, Viðey and Reykjavík, an indeed at most Icelandic sites where post-medieval remains have been uncovered. The oldest documentary evidence for the use of tobacco in Iceland is from the earlier half of the 17th century (Jón Ólafsson 1946, 15).
The pipes found in Iceland where the countries of origin could be determined are from the Netherlands, Germany, England and Scandinavia (Mehler 2004, 137).

**Bone artifacts**



7 artifacts or fragments of artifacts of bone are among the Skútustaðir finds from 2013.

| | |
|---|---|
| SKU13-61-023 | worked bone, broken across a drilled hole |
| SKU13-61-025 | worked bone, a wedge (?) |
| SKU13-61-078 | fragment of worked (?) bone |
| SKU13-61-117 | a bone dice |
| SKU13-61-118 | a bone dice |
| SKU13-61-151 | a button, about half |
| SKU13-61-167 | fragment of bone object |
| SKU13-61-179 | worked bone, fragment |

Among the bone artifacts there were two bone dice, SKU13-61-117 and SKU13-61-118. They are square (as dice later than the Viking Age usually are). The eyes that indicate numbers are placed in such manner that eyes on opposite sides always add up to the number seven. That is how modern dice are made, but in medieval times eyes could be placed differently. The eyes are made of a sort of „ring and dot", an outer ring, an inner double ring and a dot in the middle.
The Skútustaðir dice were both found in the same context, and may be from a set of *kotra* (backgammon), in which game a pair of dice is used. In his *book Íslenzkar gátur, skemtanir, vikivakar og þulur* from the late 19th century Ólafur Davíðsson describes different games played with dice, among them *kotra,* which obviously has been known in Iceland for a long time. The author has the impression that this game has become somewhat unfashionable in thin times (see p. 306-307).
Dice are not always easy to date. Several dice can be found in the collection of the National Museum of Iceland (see Sarpur, culture history database, www.sarpur.is). Some of these are comparable to the Skútustaðir dice, but they are often without a secure dating, being stray finds or coming from private collections.
A pair of dice was recently found during an excavation of a religious house at Skriðuklaustur in eastern Iceland, that was established close to the end of the 15th century and was in function until mid-16th c. These dice resemble the Skútustaðir ones, although it seems that the eyes are arranged differently. (Steinunn Kristjánsdóttir 2012, photo on page 292).
Another pair in the collection of the National Museum of Iceland, thought to be made as late as the 1830-s, supposedly of walrus bone (tusk?) by the poet Sigurður Breiðfjörð (1798-1846), is also rather similar to the ones found at Skútustaðir.

The bone artifact SKU13-61-179 is flat, the edges on three sides are whole, one end is broken. On one side of the object there are marks made by a knife or a saw, the other side is polished. It is not obvious what this artifact may have been used for. No traces of wear can be seen, so it is possible that the artifact was not completed.

Another bone object, SKU13-61-025, has one flat side, and is likely to be a wedge that was used to fix or stabilize the joint of two wooden pieces, e.g. in a wooden box used e.g. for hay or wool (Icelandic: *meis*).

SKU13-61-023 is a piece of worked bone, that has broken across a drilled hole. This object could possibly have been intended to be part of a knife handle but unfinished.



NABO's archaeological reports represent another important problem for today's research. Here we are entering into the realm of data quality. To contextualize NABO's outputs in

Fig. 2. It expresses quite well the dullness and difficulty of understanding the real implications of the findings. From Hicks, 2013, pp. 44-45.

relation to data quality, it is necessary to note that NABO, and Icelandic archaeology in general, tend to focus their fieldwork on farms or farmsteads. This means that surveys tend to be planned from a specific farm around which different trenches are opened up. Only in a few rare cases, when a specific feature is investigated (earthworks, cairns, built features, etc.), this methodology changes and the report is built up around those elements. For the former case, albeit applicable also to the latter, coordinate references are arguably fundamental. For the second case, drawings, sketches, etc. are essential. Both things in our case, however, can be classified as "non geo-referenced Geographical Source Data" (Allison, 2008, p. 7). Too often, specific coordinates are lacking, and in some reports, there is no mention at all to any coordinate system or geographical references (*cf.* Lárusdóttir, Roberts and Þorgeirsdóttir (eds.), 2012). As for specific features, the problem is twofold:

A) Sometimes there are no drawings. Albeit not entirely ubiquitous (to cite some reports that contains drawings: Vésteinsson *et al.* 2003; Edvarsson *et al.* 2003; Vésteinsson ed., 2004; Aldred, Woollett and Batey, 2004; Friðriksson *et al*, 2005; Milek *et al.*, 2007, 2008, 2009, 2010, 2011, 2012; Vésteinsson *et al.*, 2011), it is a shocking problem.

B) On the other hand, when there are drawings, these are not digitised. Needless to say, this is not Open Data.

Another issue is that an important number of the archaeological reports are written -either entirely or partly- in Icelandic (e.g. Vésteinsson, 2004b; Lárusdóttir *et al.*, 2008, etc.). This makes impossible to collect and understand valuable data contained in these texts to anyone who cannot read Icelandic. These data, therefore, are non-accessible. Here it is possible to argue that someone working in Icelandic archaeology should read Icelandic. Claiming this is however not to look at the problem's root. While I recognise the responsibility of preserving minority languages (Romaine, 2007), this should not be used as an excuse for producing everything in just one language. There are much more useful mechanisms that can resolve the problem (e.g. bilingual editions). It is necessary to start thinking about who might be interested in reading our research. My position here is clear: a wider scope is more ethical. We should think of our reports as literature valuable not only for the Icelandic archaeologist or for a specific agency/funding body, but also for the non-specialist.

An ultimate consequence of these problems is the impossibility of understanding the enormous and diverse contribution done by NABO and its collaborators for the North Atlantic. In effect, it is (almost) impossible to understand a broad picture of the historical

dynamics of the North Atlantic despite the large amount of information generated. Unless the interested researcher chooses to immerse him/herself into a wide range of different studies, it is impossible to understand the historical, archaeological, ecological, and even ontological connections provided by these vast datasets. In practice, this leads to a serious situation, namely: sub-specialists unable of working outside their framework. Such situation prevents from an inter-, trans-, etc. disciplinary research. The situation worsens if we think beyond academia: the general public will not read all these documents, nor will they take the time and effort in questioning the ideas for understanding the broader picture of the North Atlantic's past. This is of real concern if we are to achieve an ethical trans-disciplinarity (Milek, 2018), and therefore I will deal with this problem more thoroughly in the second chapter. The problems that the NABO community faces regarding data management, however, have also an epistemic value. Considering their goals, it is urgent to resolve these issues.

## 1.4 A solution for the North Atlantic: the DataARC Project

NABO is well aware of these problems. Indeed, the "Traffic light system" they have implemented (https://www.nabohome.org/cgi-bin/traffic.pl) demonstrates that they do care about the quality of their record currently hold in the database. However, the assumption that quality is achieved just by the "provision of adequate amounts of information" is somehow misleading. Quality is not a synonym of quantity whatsoever.

NABO's concerns with Open Data, and in an attempt to enhance broad narratives for the whole North Atlantic, led to the development of DataARC. The project had an antecedent in CyberNABO (National Science Foundation Grant (SMA – 1439389)), whose main focus was on Iceland with foresight for the rest of the North Atlantic (Strawhacker *et al.* 2015).

DataARC's main goal was clear from its inception -as denoted by the Project's award abstract for NSF (https://www.nsf.gov/awardsearch/showAward?AWD_ID=1637076):

> This project will produce online tools and infrastructure to enable researchers from a broad range of disciplines to study human ecodynamics in the North Atlantic context.

The main problem the project tries to address is how to better construct datasets in a meaningful way to answers important questions in our today. These inquiries are specially related, among other concerns, to rapid climate change -which affects equally local people

and their heritage (*ibid*). This stresses the importance of knowing the past for addressing current problems:

> Data from archaeology, historic documents, climate science, and the humanities in the North Atlantic indicate that this is not the first time humans in the region of the world have faced this challenge (*ibid*).

As can be inferred from this, answering these profound questions require using data "from over thousands of square miles, hundreds of years, and multiple disciplines, from climatology to archaeology to the humanities" (*ibid*). In other words, holism is necessary. However, in the current state of data management, it is almost impossible to make real contributions:

> Datasets often exist to be able to address these questions, but it remains difficult to find these data, make them interoperable, and analyze and visualize them in new and meaningful ways (*ibid*).

This implies the collaboration of different specialist and local communities across a wide network, as well as a collaborative work with organisations specialised on datasets curation and visualisation (Strawhacker et al. 2015).

Another challenge is to resolve the divide between not only different specialists but also between academia and the public. In this sense, a cyberinfrastructure is arguably the most useful tool for engaging "other users, including students and Indigenous northern communities" (*ibid*.). Nonetheless, it is important to bear in mind that not all kinds of cyberinfrastructures are useful per se. Designing an impactful, user-friendly, and intuitive tool is necessary to fully understand the complexity of long-term human ecodynamics. This cyberinfrastructure must therefore be an interrelation between different computer systems, data, instrument and the different actors of a research network, all in a comprehensive manner (Strawhacker et al., 2015). With this in mind, the ultimate goal is "to transform the discoverability and utility of data collected over multiple decades by multiple disciplines." (*ibid*). This is manifested in four main outputs (*ibid*):

1. Discovering and visualization of the data through digital tools. This enables the combination of multiple datasets, and as by-product the combination of disciplines.

2. A system that resolves not only the existent problems. Harvesting and transforming already generated data is praiseworthy, but it is even better to

create a cyberinfrastructure which allows the aggregation of new datasets. This prevents the generation of new problems with the same old roots.

3. Encouraging researchers and stakeholders-institutions to follow the path of modernisation in terms of data practices.
4. Achieving real outreach whilst not losing scientific rigour.

DataARC, therefore, tries to create the material conditions for the transformation of how we collaborate between different disciplines and different social strata. This is done by using a theme and narrative which addresses the cultural-environmental drivers that interplay in the Ecodynamics of the North Atlantic -with a long-term perspective (Pálsson, Opitz, Strawhacker et al., 2017).

Citing Evans (2015), "the new generation of academic syntheses should be to engage with the gaps to identify what we don't know, as well as what we do […] in order for this to happen it is imperative that the results of these syntheses and analyses, including lacunae, are disseminated as widely as possible". This is indeed a good definition for one of the main roles of the DataARC Project: to create a synthesis of what we know, and don't, about the Human Ecodynamics of the North Atlantic, while reaching out as many people as possible. In sum, the project enhances the contributions of digital and environmental humanities within a framework of interdisciplinary scholarship (Lethbridge and Hartman, 2016).

In technical terms, the project uses CIDOC CRM as the central standard for integrating data (Pálsson, Opitz, Strawhacker et al., 2017). As mentioned in section 1.2.4, this language is not normally used for archaeological projects -apart from some notable exceptions such as the STAR, STELLAR, and Tracing Networks Projects (Tudhope, Binding, Jeffrey, *et. al* 2011; Foxhall, Rebay-Salisbury, Brysbaert *et al.* 2015). However, CIDOC is quite useful if we consider its applicability to different types of data besides cultural heritage, plus its ability to incorporate paleoclimatic, paleobiological and zooarchaeological observations using extensions such as CRMsci (Pálsson, Opitz, Strawhacker et al., 2017). As such, CIDOC is capable of linking disparate elements and their properties in a relational, simple manner. DataARC uses CRMgeo too (Pálsson, Opitz, Strawhacker et al., 2017), for its applicability to historical studies where spatiotemporal references are one of the main frameworks.

The key element in this maremagnum of datasets is a shared ontology that enables the organisation of different data, linking one with another. It was firstly developed by Pálsson and Madsen (Strawhacker *et al*. 2015) and later improved by Opitz. The main feature is the so-called Combinators, which map and link different datasets in a relational manner to the

ontology. Combinators work as the clock's engine that moves the hands in specific ways. These connections between terms and datasets are organised in a hierarchical relationship based on ontological and semantic proximity, generality and importance. The final product is a computational ontology based on interlinked classes and subclasses, which connects the data via the Combinators. In the third chapter, I will expand the information regarding how this ontology works.

Summing up, we might see the same problems in the North Atlantic research community as in the rest of the archaeological community. They fail in conveying knowledge in an appropriate form (dull archaeological reports, narratives vs data, and difficulties with data-management/curation). May DataARC's cyber-tool aid in resolving some of these problems? Are computational ontologies in an insurmountable deadlock when representing complex knowledge? Shall the recodification of archaeological reports into a computational ontology contribute to addressing the problems outlined here? How can archaeological data be satisfactorily combined with other kind of data? I aim to address these questions in the following chapters through my own work (the creation of a dataset from archaeological reports that can be englobed into the general project's ontology) as an example. In so doing, I will firstly develop a theoretical framework capable of guiding the rest of the project. My contribution, a theory which draws on strands from Actor-Network-Theory, Human Ecodynamics theory, and Object-Oriented Ontologies, is essential because working through theory is arguably the only possible manner to understand the implications of using a concrete type of technology for a specific purpose.

# Chapter 2: Theoretical framework

In this chapter, I will introduce my own views related to Human Ecodynamics and the studies of the past, as well as the epistemological and ontic consequences that HE entails. This will also lead me to propose new fieldwork approaches for Iceland, arguing in favour of expanding our visions of what a landscape is after considering HE. Equally, I argue that HE and its ontological considerations carry important social implications which, in turn, can be used in our contemporary world if integrated within Social Ecological theory. To end this chapter, I discuss at length some theoretical foundations that, I argue, underlies DataARC's methodology, and which I have adapted for this thesis.

This chapter, therefore, brings together multiple theoretical arguments and perspectives to create an original theoretical framework for the thesis. The development of a theoretical framework is a challenging exercise, still more if some of these theories have never been connected between them before -as is the case here. Moreover, some of the implications of the reasoning laid out here cannot be fully discussed within the scope of this thesis for obvious reasons.

## 2.1 Epistemology, Archaeo-historical Studies, Human Ecodynamics, and Ontology

### 2.1.1 Reconciling epistemologies in the Studies of the Past

Following different authors (Malpica Cuello, 1993; Zori, 2010; Moreland, 2010; Lucas, 2010), I argue that we should reconsider the epistemologies and ontologies behind Archaeo-Historical Studies. The term, however, is not closed and can be used for referring to any other discipline whose main goals are the *study* of past cultures. In so doing, we soon realise that there is an epistemological error in considering History just as the study of written records, or Archaeology as solely the study of the archaeological record. The division is artificial.

If we accept Bloch's motto "History is the study of men [human beings] in time" (Bloch, 2001 [1968], p. 58), then it follows that any human fact, process, object, thought-mentality, or symbol in the past is susceptible to its study. The knowledge developed after researching all the above is what creates the so-called "Historical Knowledge" (Barceló, 1988, p. 11;

Malpica, 2003, p. 27; 2009, p. 10) -albeit it is arguably more accurate to include the word "Archaeology" in that term. Moreover, following Moreland's thinking (Moreland, 2010, p. 43), it is an error to infer into the past as we understand it today; that is: full of disciplinary divisions, because "there was no archaeology, no history, no architectural history [in the past]" (*Ibid*). It would be impossible to comprehend in the past what we take for granted today. If we keep following artificial divisions, we would do so at the peril of perishing what we study:

> "We must move beyond the disciplinary boundaries which are the fossilised product of nineteenth-century debates on the nature of knowledge. If we do not […] then we miss the point -and the past." (*Ibid*).

Instead, I do believe that we must "break down the disciplinary barriers" (Moreland, 2010, p. 61). Nonetheless, going from X (the actual state of our epistemological division) to Y (the new stage towards I propose to move) cannot be done at the expenses of risking everything. As I will show, we must be cautious and follow a concrete path. Firstly, we should accept that human beings manifest themselves through diversity (written, material and oral manifestations). If we are to assume this, them it is necessary to accept that we must use an approach as per to it. If that is the case, hence, History and Archaeology, as disciplines, turn into those that study human beings and all their manifestations in time through a method prone to break disciplinary barriers. I hope, therefore, to have dismissed the core epistemological error of dividing History and Archaeology. The division that entails the former as the discipline which studies written sources alone, whilst the latter as the one which studies the archaeological record alone must be overcome (similar to Gardin, 1980, pp. 3-5; Plutniak, 2017, pp. 14-15). In place of it, I propose a convergence of disciplines to better study humans' past.

While arguing for disciplinary integration, I put forward an important caveat: the nature of these records is different -at least in essence. Not to mention the complexities of digital data (Huggett, 2020). Precisely for this reason, I argue against a wholehearted leap into the space of post-disciplinarity. Yet, converging disciplines in new meaningful ways is fundamental if we are to create new, enhanced, and broader narratives. The core idea here is not so much to conclude that our epistemologies are wrong *per se*, but rather that it is the absence of an ontological vision what makes us fall into a disciplinary trap.

In sum, I can claim that History and Archaeology have such a broad scope that it is quite difficult to distinguish its fringes. Gardin (1980, p. 3) is of great aid here, as he fails to give a closed frontier to Archaeology; he makes fluid its borderland. Indeed, what really matters is not to respect boundaries but to generate Archaeo-historical Knowledge – of exponentially better quality. In this "journey to a deeper Knowledge" we realise of this key principle: the more profound we go, the more fluid are the disciplinary divisions. Think in Archaeology and History; both use a huge amount of *aid disciplines* for studying different records and processes (Kristiansen, 2017). As a consequence, this blurs disciplinary divisions. But, in turn, this also enhance our knowledge about the past. In this state of affairs, I claim the necessity of holism in our studies.

Now think about the study of human-environment embedded in History and Archaeology. The breadth of the scope is considerable, and traditional studies that focus on just a few things cannot understand the whole picture. From this, it follows that we now need to ask broader questions in our research. It is here where I want to introduce the Human Ecodynamics *paradigm*, as it can offer broader lines of inquiry (Costanza *et al*. 2012).

### 2.1.2 Human Ecodynamics

Human Ecodynamics represent a new *paradigm* or trend introduced in anthropological and archaeological studies. To my knowledge, the first real mention to it appears in 1995, arguably coined by James McGlade (1995). Now, over 20 years later, the concept has been successfully developed for the North Atlantic context, as clearly demonstrate Harrison and Maher ed. (2014) as well as other references uses henceforward. Yet, HE has not a closed definition (Holm, 2015; Roigé Oliver, 2019). Although that might be an important issue, I am not going to pay real attention to its uses and definitions (see Fitzhugh *et al.* 2018 for a long, comprehensive historiographical study). Instead, I will offer a straightforward definition for later casting attention to some of its epistemological and ontological implications.

Human Ecodynamics is the historical and long-term study of the interrelationships between humans and environment through both space and time, assessing the agency that both these entities have on each other –the study of the human-natural system(s) (Maher and Harrison, 2014). It is important to stress how this trend uses Actor-Network Theory's vision (Latour, 2007) on how humans/non-humans both have agency: "structures are maintained only by constant energy/matter and entropy exchange, in which the action of positive feedbacks of environmental and cultural processes drive the system to new evolutionary states, which in

turn provide the conditions for renewal of higher entropy production." (McGlade, 1995). Therefore, it integrates a non-partialised vision where humans are not portrayed as superior/different from their environments; seeking the study of synergies between both entities (Maher and Harrison, 2014, pp. 2-3). As an example of this for the North Atlantic, I can point out to some studies done for understanding the landscape of Iceland (McGovern *et al*. 2007; Dugmore, McGovern and Streeter, 2014) or the modelling of specific identities in Northern Norway (Amundsen, 2014).

The concept moreover introduces the vision of non-linear dynamics of causality (uncertain number of agents) and of hierarchical scales (diversity of agents affecting in different time-spaces at diverse rates):

> Ecosystem structure is viewed as a series of weakly coupled sets within a hierarchy of process rates involving biotic interaction (competition, predation, mutualism etc.) and abiotic factors (climate, edaphic and historical constraints). The non-linear couplings in these processes are further complicated by human action- whether as the result of uncoordinated stochastic events or by a series of policy-directed interventions. From the perspective of archaeology, and for human systems in general, what is of interest is that since different levels in the organizational hierarchy of the natural world and its human component involve different dynamical processes, these can usefully be isolated for analytical purposes. (McGlade, 1995, p. 121)

As Maher and Harrison (2014, p. 2) or McGlade (1995) put it, this means to break the simplistic models of cause-effect.

In sum, HE is the *paradigm* which claims that we need an integrated history of Human and Environment as a coupled system to achieve an in-depth Knowledge of the Past (Maher and Harrison, 2014; Dockrill and Bond, 2014; Amundsen, 2014; Dugmore, McGovern and Steeter, 2014; Fitzhugh *et al*. 2018). HE, therefore, advocates that human past -normally divided in the triad "society, economy and political dynamics"- is a coevolution between different human/non-human agents. As I will explain in section 2.1.4, following Crumley (2017), this realisation might force us to better study Human Ecodynamics in an extensive landscape-scale.

Further, it is important to add that these studies seek not only to understand and interpret the past. Its practitioners and allies advocate for using this knowledge in the present. This is substantiated through two different actions:

1. Policy-making or active action into our present conditions. This is done by understanding past ecodynamics for detecting resilience or dangerous practices that led to stories of environmental adaption/destruction. This knowledge can be applied to current situations.

2. Implementing ancient practices by recording them from local communities especially prone to climate disasters. This is done by following the Local and Traditional Ecological Knowledge (LTK) framework, a bi-directional learning dynamic.

Therefore, there is an ethical attitude that lies at the core of Human Ecodynamics and the work of allied researchers (Dugmore, Keller and McGovern, 2007; Costanza *et al*. 2007; McGovern, 2011; Dugmore *et al*, 2013; Maher and Harrison, 2014, McGovern, 2014; Nelson *et al.* 2015; Martín Civantos and Bonet García, 2015; Holm *et al.* 2015; Brewington *et al.* 2015; Martín Civantos and Delgado Anés, 2016; Hicks *et al.* 2016; Crumley, 2017; Jackson *et al*. 2018; Fitzhugh *et al.* 2018). I will return to these ethical grounds in section 2.4.

What it is of concern here, however, is the epistemological implications of this trend. On the one hand, it represents a sort of holism, because it entangles multiple disciplines from a wide spectrum of fields: Ecological History, Historical Ecology, Environmental and Landscape Archaeology, Environmental Anthropology, Environmental Humanities, Ecology, Geology, Computational Sciences, etc. (McGlade, 1995; McGovern *et al.* 2007; Constanza *et. al.* 2007; Ortega Santos, 2007; Ortega Santos and Molina, 2009; Buckland, 2013; Acosta Naranjo y Domínguez Gregorio, 2014; Martín Civantos, 2018). However, in my opinion, these different tendencies, more than divergencies, reflect a common path: holism, a convergence of disciplines. Hence, as Constanza *et al.* (2012) argue, synthesis must take place in our research.

On the other hand, in a world-system, socioenvironmental changes and impacts in local scale may affect extensive areas. Historical-cultural-ecodynamics, therefore, are almost impossible to fully comprehend without a comparative, long-scale gaze (Maher and Harrison, 2014; McGovern, 2014; Crumley, 2017; Fitzhugh *et al*. 2018; Contreras, 2018).

Both things, holistic and long-scale approaches, create a framework where multiple datasets are necessary. A data driven approach forces us to enter the realm of Big Data (Fitzhugh *et al*. 2018). Drawing on large and heterogeneous datasets becomes essential inasmuch as it allows for aggregation, archiving, utilisation and synthetisation of knowledge (Travis and Holm, 2016; Fitzhugh *et al*. 2018). This is specially compelling for HE which, as explained above, makes use of a wide range of datasets from diverse research-fields.

There are some perils that must be highlighted, though. Heretofore, the archaeological study of Human-environment interactions has some important limitations (Contreras, 2018). This has led to the development of a research framework where studies normally use data in very limited fashion: creation of some data from different, and sometimes random, proxies and making correlations among these datasets in order to offer some weak conclusions. This is a problem inasmuch as finding some correlations do not serve for explaining the real complexities of the human-natural systems, at least in the way HE aims at. Correlation is not enough (Contreras, 2018). Instead, as Contreras (2018) or Huggett (2020) point out, we should aim for creating compelling explanations about complex interactions by making a correct use of the data. Linking multiple datasets in a meaningful manner is therefore fundamental for deploying Human Ecodynamics in all its potential. At this point, it is possible to understand how important DataARC is for the North Atlantic research. Its ontology appears as the most useful tool for researching within this *paradigm*, presenting solutions to long-standing problems and arranging the future of our research.

Recent studies consistently show the importance of combining different methods, and even theories, in an operational way for researching human-environmental interactions (Contreras, 2018). Human Ecodynamics offers us the opportunity of asking broader questions where traditional disciplines alone, or in constrained collaboration between them, fail. In a methodological sphere, this makes necessary proposals similar to trans- or post-disciplinarity (Acosta Naranjo y Domínguez Gregorio, 2014; Lethbridge and Hartman, 2016). I am afraid I can only give a nuanced answer to this problematic: following Crumley's proposal (2002), I agree that depending on the question we might propose, we can have at our disposal several methods and theories from different disciplines. It is up to us whether we decide to go as far as questioning historical/archaeological, etc. inquiries closely related to ontology or if we decide to follow more traditional paths. However, if we decide to go forward, it is fundamental to bear in mind that there is a horizon from which disciplinary divisions lose their importance. Henceforth, a heterarchical organisation must lead a process where all the theories and methods might be equally valuable: they all compound a toolbox

(Crumley, 2005). Once again, DataARC's ontology aids in the use of a great diversity of disciplines and datasets in a quite heterarchical order.

A final but brief point to make is the ontological implications of Human Ecodynamics. It unites a divide between human/non-humans, giving agency to both. This opens new ontological questions in terms of how we define our world and the beings that inhabit it. In a specific sense, Human Ecodynamics forces us to think firstly in ontological terms rather than in the epistemological aspects of our research. This will be the next point in this narrative: an ontological reflection. For now, I can conclude by saying that HE opens the possibility of trans-/post-disciplinarity if, and only if, we arrange our different datasets for thinking in ontological terms.

### 2.1.3 Ontologies and beings

I argue that many of the problems stemming from our epistemologies do not have their roots in the way our epistemologies are constructed. The core of these issues, rather, lies in ontology: we must firstly understand what the object of our study is, not just define it (humans in the past). To understand something or someone in its most fundamental form implies thinking in ontological terms. In this case, for example, the problem may be not exactly that the reports are dull and disconnect data from interpretation. Maybe, the reason behind our *ethos* is that we do not understand the importance of our data regarding our object of study. Therefore, we must first think ontologically and later define our epistemologies, casting aside possible contradictions.

Human Ecodynamics forces us to rethink our ontologies. In so doing, it offers the opportunity of resolving some problems regarding Ontology. For example, HE deals equally with human/non-human *beings*. Moreover, HE's focus is on the past. In turn, Ontology is the bare bone of the questions about *beings* and the being (*Dasein*) in the (past) world (*in-der-Welt*) (González-Ruibal, 2001). Ontology, therefore, is fundamental in Archaeo-Historical studies -and by inclusion, in HE (González-Ruibal, 2001; Harrison, 2015; Fahlander, 2017). Nonetheless, there are some greatly divergent pathways regarding some of the most abstract themes. It is sensible, therefore, to be aware of such contradictions. These can be clearly seen in the debate that exists between:

a) Anthropocene advocates who pay excessive attention to human agency.

b) Posthumanists who assign agency to humans and non-humans, shifting away human exceptionalism (Díaz-Guardamino and Morgan, 2019).

c) Dualists who inexorably divide humans from non-humans or things. They do not align with terms such as "co-evolution" or with ANT's disentanglement of close categories.

d) Monists who tend to see no ontic distinction between humans/non-humans. Everything is Nature/Environment (Urquijo Torres and Barrera-Bassols, 2009).

The debate is closely related to Archaeology, History, Ecology, etc. but its implications are well beyond that, representing ontological problems. For example, anthropocentrism presents an ontological division between an ideal "natureness" Earth-state where humans were not a harmful-environmental-factor, and an Earth completely devastated by humans in the last two centuries. This intrinsically divides "Nature", almost as a sacred thing, from Humans. Additionally, it fails to understand historical human actions in the environment (Bauer 2015, 2018; Lane, 2015; Bauer and Ellis, 2018). Consequently, it does not consider the entanglement between things and beings, nor recognises the fluid agency possessed by different beings and things (or between entities). As it fails in understanding the previous points, its ecological praxis negates the goals that seemingly seeks, and its theory clashes with Political Ecology (Bauer, 2018).

Regarding dualism, it presents problems in aligning with well-stablished terms such as "co-evolution", or with ANT's disentanglement of close categories. Monism is an interesting vision as long as it presents no essential hierarchical difference among beings. However, it is incompatible with Heideggerian ontological theory (González-Ruibal, 2001). It also risks the possibility of using agency as deploy by ANT: we might be equal and we all arguably have agency, but that is quite relative to the own *state of affairs*.

Posthumanism might be the most accurate one. However, it is not problems-free. As Bauer (2018) exposed, posthumanism perils to lose the point of co-evolution. Sometimes its fixation on seeking environmental agency/or a lack of it if compared to human actions, misunderstands the ontological implications of Political Ecology. The same is applicable within humankind, assessing equal agency (guilt) to all humanity when in many cases this is missing the point (González-Ruibal, 2018). Consequently, it randomly divides again different entities. The latter is an important issue because even though humans modify non-humans and vice versa, this happens at different ratios, scales, spaces-times and biocultures.

These contradictions are critical for assessing the past, not least for a full understanding of Human Ecodynamics. From these perspectives, it is not known if there is a coupled humans-nature assemblage or not. This is problematic and must be overcome as soon as possible on behalf of arguments based on data. The implications of this topic are, however, beyond knowledge; it has an evident political (and ethical) implication(s) (Bauer, 2018; González-Ruibal, 2018; see also section 2.4).

In sum, we need to reassess our Political Ecologies' narratives. I consider that in doing so we might reconstruct our ontologies without contradictions as those abovementioned. In practice, this means to move beyond epistemological barriers to answer more profound, ontological question of importance for enhancing our knowledge. The key problem lies in how to do it. I consider that a good possibility is by strong arguments based on multiple datasets used towards the creation of ontological narratives. If this is the case, first we must reorganise our data in a new meaningful way -as DataARC proposes, especially with the *Combinators*. Our ontology might be a plausible solution because, in some way, it links epistemological and ontological procedures.

On the other hand, if we consider landscapes, we might get a more accurate understanding of these themes. Analysing a landscape gives us new glimpses into ontology and HE. Equally, considering HE can enhance our understandings and study of landscapes. For this reason, landscapes will be of importance during Chapters 3 and 4 for the development of our ontology. This is not a trivial point and, therefore, I expand on it below.

### 2.1.4 Landscapes: towards a wider definition based on HE and ontology

Ontologically, a landscape must be understood as a space (be it land or sea) which englobes as a sole unit Nature (environment and non-human entities), settlements, productive places, ways of movement, and the symbolic perception of all these features (Martín Civantos, 2008, pp. 26-35; Moreland, 2010; David and Thomas, 2016, pp. 38-40; Knapp, 2018). The latter aspect can be broadened: it is symbolic not only in its perception and apprehensiveness -sky/sound-scapes (Silva, 2015; Scarre, 2006; Cross and Watson, 2006); but also because it is a by-product of traditional ecological knowledge -LTK (Ruiz-Ruiz and Martín Civantos, 2017; Martín Civantos, 2018). Therefore, a landscape is material and immaterial (Criado-Boado, 2017). This definition, however, must be expanded if we are to fully understand its implications.

On the one hand, landscapes are social and cultural: "The fact is that the space is in itself a cultural entity, defined by social practice"[3] (Giacomorra, 2006, p. 34). In other words, people, either in the past or present, lived in a given landscape. Consequently, their actions -and beliefs- left traces (footprints) on the landscape (similar to what Binford, 1982 foresaw). As such, different material and human remains are inserted into the landscape (Malpica Cuello, 2009, p. 12). Therefore, every social relation and process has an impact and is reflected in settlement (Trigger, 1967, p. 158) -and by extension, on the landscape. In sum, landscapes are historical, cultural, and socioeconomic (Martín Civantos, 2008; Criado-Boado, 2017).

Human Ecodynamics highlights that humans evolved in constant dialogue with Nature (environment + non-humans). In this context, Andrew Bauer argues the impossibility of understanding such an interrelationship without giving mutual agency to both ontological domains (Bauer, 2018; also, Bauer and Ellis, 2018; and in similar lines: Lane, 2015; Knapp, 2018, p. 32). This relationship has the landscape as its main arena. Landscapes are therefore sociohistorical ecosystems, or socioecosystems (Martín Civantos, 2018) -and its historical analysis brings up the notion of socioecological history (García-Contreras, 2019, p. 221). This means that, during the course of their lives, people shape and are shaped by their environment, and vice versa (Opitz, Nuninger and Fruchart, 2012). This conceptualisation links us again with ANT.

The visions of the landscape I have hitherto explained are quantitative (multiple and successive transformations) and qualitative (different properties throughout history). Notwithstanding these visions, the phenomenological properties of landscapes are equally fundamental. The phenomenological approach arguably came from the introduction of post-processualist symbolism in Archaeology (Hodder, 1987). However, Tilley (1994) is the first in popularising the idea that a landscape is not just used and transformed, but also sensed and experienced. This, along with the ideas of "seen and lived a landscape", or "dwelling-in it" are all important in Archaeology (Tilley, 1994; Malpica Cuello, 1996; Bruck, 2005; Van Dyke, 2014; Prendergast, 2015; Darvill, 2015 David and Thomas, 2016; Criado-Boado, 2017). Going back to ontology, phenomenology adds interesting nuances in how we understand a landscape.

In a methodological lens, a landscape could be conceived as a huge and measurable archaeological site which can be decoded and interpreted (Martín Civantos, 2007b).

[3] Translation by my own. Original: "Il fatto è che quella di spazio è in sé una entità culturale, definita dalla pratica sociale"

However, this does not mean that a landscape is just a usual archaeological site in terms of stratification. Rather, a landscape is more complex with regards to diachronic, synchronic and agency processes (Opitz, Nuninger and Fruchart, 2012; Criado-Boado, 2017; García-Contreras, 2019, pp. 220-221), symbolical/phenomenological aspects (Tilley, 1994; Bruck, 2005; Van Dyke, 2014; Criado-Boado, 2017), and active human engagement (Martín Civantos, 2007a, 2018; Martín Civantos y Bonet García, 2015; Martín Civantos y Delgado Anés, 2016; Moshenska *et al*. 2017). Such conditions force us to expand our gaze from the micro and regional scale to the land/seascape-scale, integrating data that so often is left aside from these studies (as noted by Opitz, Nuninger and Fruchart, 2012, p. 397). In broadening our lens, we assume greater difficulties -complexity- but we gain a wider picture of the co-evolutionary history.

The study of landscapes or *scapes*, therefore, requires a holistic approach, and at the same time allow us to research in deep-time or *long durée* time-scales (Malpica Cuello, 2009; Fleming, 2012; Fairclough, 2012; Byock and Zori, 2013; Byock, 2014; Feinman, 2015; Crumley, 2017; Crumley *et al*. 2017). Moreover, as we have seen, studying a landscape has profound social consequences beyond the mere rhetoric of engagement (Fernández Fernández, Alonso González and Navajas Corral, 2015; Moshenska and Fernández Fernández, 2017; Martín Civantos, 2018), just as Human Ecodynamics practitioners try in their studies (see section 2.2.2; McGovern, 2014).

This makes the study of landscapes the crux between more traditional landscape studies and Human Ecodynamics. This is implemented in one way through Historical Ecology (Crumley, 2017). Equally, the study of HE can be carried out through an explicit landscape-scale research framework.

#### 2.1.4.1 Implications for Icelandic Landscape Archaeology and NABO's reports

In the first chapter, I wrote that the Icelandic farmhouse, epistemologically speaking, is the "centre of the word". That is to say that Icelandic fieldwork is influenced by the position of a specific farmhouse or farmstead. This is arguably in line with the main feature of the Viking settlement in Iceland: "predominately made up of single farms with an area of infield around the dwelling, sometimes with outlying fields used for hay production, and often with areas for grazing." (Aldred, 2014, p. 68). We can go into more specific details with this definition by using different terms: farm (*bær*), farmhouse (*skáli* or *langhús*), animal sheds

or huts (some attached to the farmhouse), barns, hayfields (*tún*) around the farm, and walls (*stakkgarður*, *túngarður*) (Attwood *et al.*, 2001, pp. 733-734).

All these focus on a micro-scale. This scale is an issue if we are to understand HE. We need to expand the scale: socioeconomic history and power dynamics in Iceland were determined by a diverse set of resources: woods, meadows, communal pastures (*almenning*), fishing-sea, lake and riverine resources, fjords (*firdir*), etc. at the landscape scale.

This forces us to reconsider our practice. As it is shown by the numerous quantities of archaeological reports already mentioned, plus the ones which I will use in Chapter 3, the methodology followed heretofore is far from considering all the landscape. Normally, NABO approaches fieldwork as a mesh of midden-deposit excavation, followed by isolated studies of some features.

This is the standard approach in Icelandic archaeology, influenced by farm-mounds (tell-like structures formed by an abandoned farm). The use of large-scale trenches is uncommon; instead it is common to excavate in section-like trenches (Vésteinsson, 2004a, 2010). Even in the cases where other landscape features are researched (e.g. earthworks, herding structures, etc.), these are isolated from the rest of the contextual information of a broader landscape-scale (Aldred, Einarsson, Hreiðarsdóttir and Lárusdóttir, 2005 and 2007; Aldred and Koch Madsen, 2008; Koch Madsen, 2008). While useful, this vision is partial and not truthful to the complexity of the ancient Icelandic landscape (Aldred and Einarsson, 2011; Aldred, 2013), nor to the Icelandic social community that goes beyond the isolated farmstead (Vésteinsson, 2006; *cf.* Bolender, 2006).

Moreover, we need to change this approach if we reconsider NABO's main concern broadly (the understanding of North Atlantic Human Ecodynamics with the final aim of applying that knowledge to benefit today's society). The main issue here is the "antinomy" or opposition between Human Ecodynamics and the tight scope of NABO's field practice. For example, when we study a midden, we choose a micro, partial understanding of a farm's ecodynamics. We may see how a part of the landscape evolved in a dialectical dynamic between humans dumping materials into the soil, and the biotic and geological determinants of that soil. But we are blind to other social dynamics which could have an important aspect on how land was managed.

Addressing a broad question is not possible if we try to do it by thinking through micro-scale frameworks (the zooarchaeological, entomological, etc. record). We have disconnected stories, a situation that makes difficult the comprehension and creation of grand, complex

narratives concerning the historical development of "coupled systems". This vision, hence, misfits HE broader scope. At its best, we only have a partial, inconsistent story of the historical ecodynamics. In ontological terms, the problems attached to this are clear. In epistemic terms, the situation is not much better: a partial understanding of the material past leads us to partial reconstructions of the human past.

On these bases, I argue that it is necessary to change our fieldwork approach. Reconnecting all these different features into a broader scale is fundamental not only because is better for the understanding of HE, but also because is aligned with Icelandic landscapes and society's reality.

## 2.2. Representing and expanding knowledge in Archaeology

The fundamental problem posed by DataARC is how to represent, and even expand or enhance, knowledge using computational applications. This issue is by far not new and has a long-standing scholarly tradition. As has been shown in the first chapter, since the 1950s, different researchers have been attempting this (e.g. Jean-Claude Gardin [Moscati, 2015]). Representing knowledge in Archaeology is, therefore, quite a thing (Van Dyke and Bernbeck, 2015).

With 'representing knowledge', I refer to the process of describing linguistically/symbolically certain data for laying out an argument. This conception is similar to the threefold layers developed by Opitz (2018, p. 571) for Gabii's Archaeological Report mentioned in the first chapter. However, here I am following Gardin's thinking (Gardin, 1980, pp. 6-10), in that the aim is to reflect on the processes of how to interpret, describe, and link data.

Achieving good representational standards in our discipline is fundamental. Without a method which can represent the complexity of archaeological facts/processes (as demanded by Molino, 1992, p. 23), we may fail in communicating archaeological and historical knowledge. Moreover, we may not fully understand the interrelationship between different facts, failing thus in expanding knowledge. These consequences make fundamental the study of how we epistemologically represent our truth. Therefore, the interconnection of different datasets in a comprehensive and reasonable manner is essential.

It is necessary, then, to study data language naturality-artificiality (how natural is the language used for representing data [Dallas, 2016, p. 310]), its symbolical representation,

and its semantic relations for representing knowledge. In theoretical terms, the aims of reflecting on these topics belongs to semiotics (Gardin and Peebles, 1992, p. 2). For our case, this semiotic analysis is applied to the creation of the computational ontology, from its basic form as a seminatural language to its more formal and symbolic form expressed on the final ontology (Fig. 3). This connects with Gardin's work on computational linguistics (Dallas, 2016). Consequently, this section, and the following one, becomes a metalanguage studying an object-language which represents realities intertwined by way of ontological and semantic interrelationship, generality, and importance.

This study of data language is embedded in more ontological questions. These must be addressed first to understand how everything in a given situation under specific conditions is related. This is fundamental if we are to understand how our ontology works. Actor-Network-Theory provides a useful basis for this exploration. Developed by Bruno Latour (2005) among others nearly 40 years ago, it was firstly applied to the study of technology but later to a wider spectrum of themes (Latour, 2007, p. 10). In my view, this theory attempts to assemble structuralism, post-structuralism, agency, and post-humanism in a wider understanding of the ontological realm(s).

The theory can be summarized as the breakdown of the "social" concept in its traditional, hermetic, and homogenous definition: "it is not clear whether there exist relations that are specific enough to be called 'social' and that can be grouped together in making up a special domain that can function as 'a society'. The social seems to be diluted everywhere and yet nowhere in particular" (Latour, 2007, p. 2). That is to say that "there is nothing specific to social order […] no 'social context' [or] 'force' [that there is no] society" (*ibid*. pp. 4-5). It is a fluid concept, as social or society is not a "thing among other things" but a "type of connection" between different things in ever-shifting conditions of reality or *state of affairs* (*ibid*., pp. 5-6). To put this on the ground, think of a concrete landscape; you will soon realise that it is neither social nor natural *per se* but a product of different entities that act in concrete and diverse space-times. ANT serves for understanding that everything is in a continual, contingent movement of networks. In this dynamic, society is not a thing anymore; instead, is a thing's property.

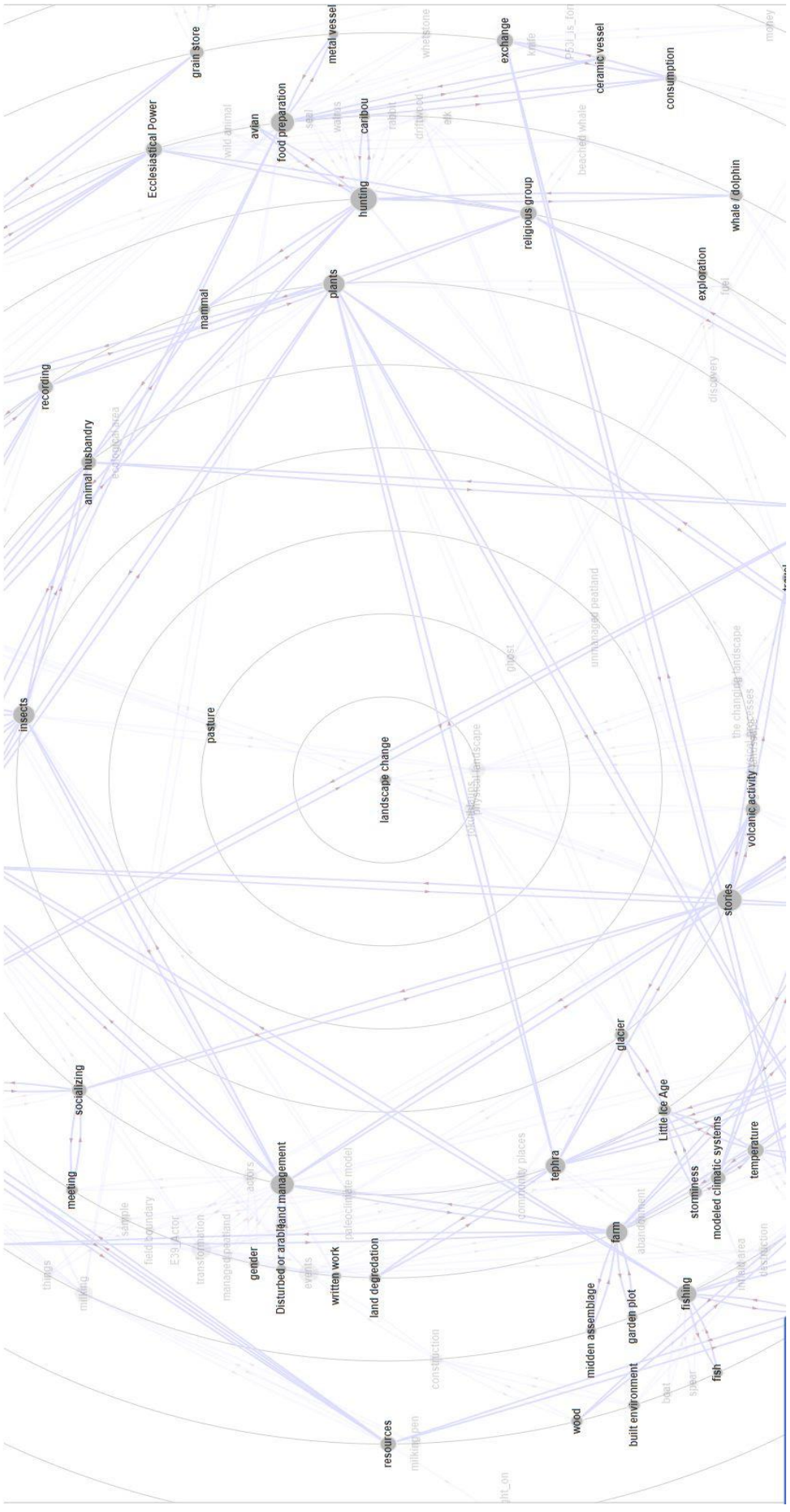



Figure 3. DataARC's ontology using a combinator. It is displayed here as the concept; around which others are more or less related depending on its ontological proximity.

Our own approach to entangled anthropological, historical, and archaeological issues have true meaning only after considering this complex, ever-shifting, interrelationship between and among different entities. Some scholars may be sceptical of this approach, but it has been applied effectively elsewhere (Prendergast, 2015; McKim Malville, 2015; Silva, 2015; Crabtree, Vaughn and Crabtree, 2017) -providing useful parallels to DataARC's approach.

The core theoretical implication of DataARC's ontology is reconstruing the complex interrelationships existent between and among entities depending on concrete variables and different contexts. In the third chapter, I will explain more technically (but not devoid of theory) how we create these entities/domains and their interrelationships. For now, it is important to understand that our approach is based on hierarchy and proximity. The last two concepts are, of course, attributed by our understanding as researchers on how some proxies have more *ontological status* than others. The interaction or proximity between and among those domains is *artificially* given by a semi-logical language that entails deep ontological implications: our vision as archaeologists/historians, geologists, ecologists, etc. on how different entities interact in a given moment and situation. Therefore, the different datasets that DataARC is using, are ordered based on intricate and complex interactions. Ordering different datasets in such an in-depth manner might be the only possibility for understanding and communicating Human Ecodynamics and their consequences depending on different *states of affairs*; *viz*. climate change and anthropological impact, etc.

The concept introduced by ANT of dissolving the social as a thing is grasped by DataARC's ontology: datasets under the umbrella of a domain are not "social" or "natural" *per se*. Instead, these domains might be social or not -as a property- depending on how they are interconnected between other domains under specific conditions (*state of affairs*). In a concrete way, what lies behind these processes is a language, half logical half natural, that relates different concepts. It is seminatural as it is written in a natural but concrete manner, and semilogical because it relates different terms in a formal-logic way. These connections are semantic in form but ontological in their interrelationships. The language is written using well-structured text in a rather simple procedure: a column for a concept, another for its "ontological" relation, and another column for the concept to which the former is related. The procedure is thus semantic, whilst the relation is ontological.

In practice, this creates hierarchies of interrelations, where some concepts are closer or not depending on how they are ordered. In reality, this is the same as Gardin's metalanguage for describing mental operations: a lexicon of terms for indexing, a semantic organisation, and

a grammar indicating their syntactic relations (Moscati, 2016). Nonetheless, our approach is more sophisticated because it introduces ontological relationships.

We can express this in a graphical view, for example a graph made of nodes (dots) and edges (lines) (Fig. 4). In the image, we can observe how some dots have more connections between them that others do. The dots might represent our concepts, the strings our semantic relations, whereas the seemingly abstract interconnection between and among them is their ontic interrelations. Those dots with more *edges* will have more ontological relations and can be ranked as higher in our hierarchy. This is a computational ontology, at least in our case. Indeed, this is a quite good representation of what ANT lays out: the semantic relations might be social/non-humans/natural or not, the dots are the entities (now free from a property *per se*), the filters inserted in the cyberinfrastructure a concrete s*tate of affairs*, and the overall *product* an ontology.

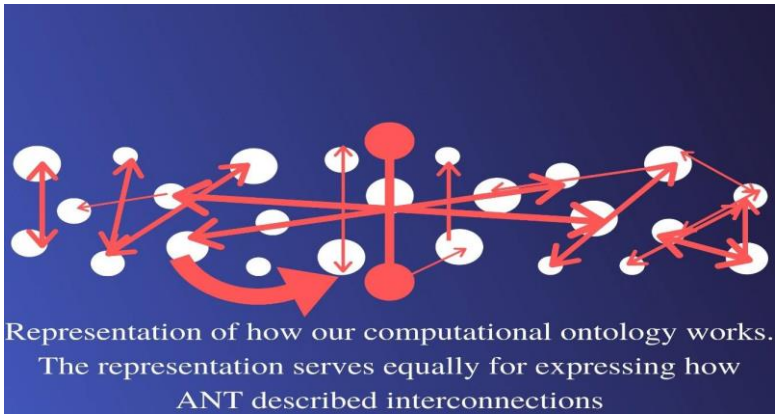


Fig. 4

It is important to stress that the project is not just trying to give a new version of the cataloguing process *per se*. It is not a data-dump-sorting-searching-retrieving project. On the contrary, it is a new strategy for documenting and interconnecting data in a much more complex way than done before. The challenge here lies in interconnecting complex conceptual phenomena useful for complex, nuanced historical interpretations. Behind that process, there is a descriptive language which organises and interconnects different domains. Again, this is related to Gardin's theory and method (Moscati, 2016).

This is in contrast to the common method for representing the interrelationship between signs/items (see section 2.2.1 for an explanation): the grouping of those items -say, an artefact, a sample, etc.- in units of a higher order -list of artefacts, samples, etc. (Gardin, 1992, p. 88). This is a common trend in our discipline, necessary for its methodological utility rather than for its ontological capability. The method appears quite similar to the semiological one -and maybe, precisely because of its complete reliance on structuralism, has its own weaknesses. It seems to me that the most fundamental weakness of such a process is that it does not explain alone the whole picture. At its maximum, it can explain the creation of different categorical domains in archaeology.

Therefore, there might be two categories for representing knowledge in Archaeology. One can arguably be described as a categorical grouping of signs/items -a data compilation. The other, however, can be seen as a thorough insight into the past by creating domains of signs that had interactions between them or not depending on different contexts. It goes without saying that the latter is more accurate for having an intrinsic and profound relation to the ontological approaches proposed by ANT.

### 2.2.1 Computational ontology and *Combinators*

So far, we know that DataARC's computational ontology is based on a modelling language. A modelling language is:

> an artificially constructed language that is much simpler than a natural language. But, like a natural language, a modelling language has a lexicon, a syntax and some semantics. The lexicon is the set of "words" or basic language units that we can use. The syntax is the set of rules that we must obey when putting lexicon elements together in order to compose meaningful "sentences". And the semantics is the collection of relationships between these "words" and the things in the world they refer to. (González-Pérez, 2018, p. 12).

As noted in section 1.4, the entire modelling language has followed the CIDOC CRM standard -with some of its extensions. In this language, some semantics and ontic properties of the words in use are what DataARC has designated as *Combinators*.

DataARC's ontology tries to communicate in a complex and symbolical manner the utter interrelationship existent among different ontological domains. This creative process can be classified somehow as a semiotic exercise (for a comprehensive finality, see Molino, 1992, pp. 15-17). DataARC's computational ontology is, then, a symbolic tool which represents and communicates fundamental properties between and among different concepts. This is done by linking complex, different datasets without losing the context and meaning portray by each fragment of data.

Potentially, the most difficult step is the synchronisation of different data characters: the project includes descriptive and quantitative datasets with different space-time scopes (Angel, Brin, David Cothren *et al.* 2018). It is at this moment where three filters are used:

temporal, spatial and conceptual. In practice, this means that each data must yield three main indicators (time, space, and concept [linked to by a *combinator*]). This procedure allows us to link different datasets in base on this threefold division (*ibid*). Of those three, the latter is the most important one.

What semioticians tend to name signs (see *supra*), here can arguably be called *Combinators*: symbols produced and reproduced by different actors that make references to the world (Molino, 1992, p. 17). These combinators play with the notion of *series* (Molino, 1992, p. 21) where a concept englobes different related data. This is to assume that an object, a wall, or any other data isolated, is not meaningful; only when they are integrated under the banner of a *combinator* they function as a fact or process (Molino, 1992, p. 21). This, of course, is more complicated in practice: the *combinator* must contain a minimum level of detail, as well as a maximum (Opitz, Strawhacker, Buckland *et al* 2018). This process is of extreme importance, as it will mark how different domains might have relationship depending on the grade of hierarchical and semantic interrelationship. The standard process is to reduce different data to a meaningful concept. These concepts will always have different links with others, depending on the given ontological relationship we agree to concede to each one.

This might represent a good transition from epistemological deadlocks to ontological grounds that can enhance our (Archaeo-Historical) knowledge. In the next chapters, I will explain the method that I follow for linking archaeological data with the rest of DataARC's datasets in our ontology and the procedures followed for creating new *Combinators* without losing overarching interpretations. However, before, it is useful to consider some caveats regarding interpretation.

## 2.3 Subjectivity in Archaeological reports: understanding implicit theoretical frameworks and their limitations

There is a broad consensus within the archaeological community in assuming the influence of biases. In our research, we tend to focus on and prioritise some aspects over others. Indeed, our own ideological positions determine the questions that we ask, the methods used for answering them, the conclusions reached, and the construction of our narratives about the past (Gardin, 1980; Hodder, 1987, 1997; Tilley, 1993; Hodder, Shanks, Alexandri *et al*. 1997; Shanks, 2012; Buccellati, 2017). Therefore, the representation and expansion of knowledge depend on subjectivity.

Subjectivity and interpretation are active before undertaking excavations (Hodder, 1997; Buccellatti, 2017; *cf.* Barker 1982; Tilley, 1993): choosing where to excavate, the stratigraphic recording model, etc. is determined by the purpose pursue in our research. Therefore, interpretation and subjectivity play their role not only when assigning meanings to an object, symbol, place, etc. but also before -preparation- and during -field-action- the act of excavating or surveying.

For the case of NABO's community, it is necessary to ponder how their position affects their use of different methodologies and data. We can examine their reports to understand how implicit theoretical frameworks influence their methods, and ultimately configure the articulation of different datasets. We might say that such an exercise will permit us:

> to make explicit the mental operations that allow us to make sense of categories of particular archaeological materials […] the mechanism and the foundations of the arguments linking the empirical base to the speculative superstructure of each hypothesis, conclusion, theory, model, etc. (Gardin and Peebles, 1992, p. 4).

This procedure serves for tracing

> the logical and semantic operations which account for the transition from the initial material data (the *explanandum*) to the final conceptual propositions (the *explanans*) (Gardin, 1980, p. 102).

Ethically speaking, this reasoning is arguably important for us all. First, because it might be the only possible way of being "objective" (Buccellati, 2017, p. 53). Second, because in so doing we might achieve more clarity with ourselves and with the readers.

In reality, I have already done a small test in that respect. In section 2.1.4.1, I have acknowledged a misfit between their implicit theoretical framework, their fieldwork, and the aims they sought to accomplish through. NABO's reports are partial because they do not allow for bridging their data with their narratives. They have made a leap in understanding human-nature interrelationship in a more complex manner, but it has not been in hand with a change of attitude towards the recovery and articulation of different datasets.

For resolving this issue using Grey Literature/Data, we need new ways of articulating micro-scale datasets to meet macro-scale questions. To bridge this gap, we can look to inter- or transdisciplinary approaches. A constant dialogue between different scholars can create a more complete picture while diminishing individual subjectivities. This might articulate

different datasets without prioritising one over another. Indeed, this framework allows for prioritising the general question of Human Ecodynamics.

Finally, it is a challenge to integrate Grey Data into an ontology designed for addressing macro-scale issues. We cannot forget that such an endeavour might be influenced by the theoretical frameworks, expertise limitations, and fieldwork approaches that led to the write-up of the reports I am working with. In the third chapter (3.3), I will explain how I could detect these implicit frameworks. But in the next few lines, I will address this issue by reflecting on the role of computational ontologies for dealing with the integration of fieldwork data, as well as for constructing knowledge.

## 2.4 In the making: computational ontologies and the creation of knowledge

It is arguably sensible to consider the role of ontologies in the process of knowledge production. The question of knowledge creation based on digital technologies is important not only because it is a new way of doing so, but especially because it carries interesting challenges. These challenges are normally not openly confronted (although see Huggett, 2015a; 2020; Nuninger, Opitz, Verhagen *et al.* 2020; Nuninger, Verhagen, Libourel *et al.* 2020), resulting a landscape where computational ontologies are sometimes used with no consideration at all. Interoperability is one of the most flagrant problems posed by this method, especially if for integrating field data. As Nuninger, Opitz, Verhagen *et al.* (2020) discuss, even the same kind of data sometimes do not allow for interlinkages due to semantic and methodological biases (Foxhall, Rebay-Salisbury, Brysbaert, *et al.* 2015 also stumbled with this issue). The panorama is reinforced by a loose use of meta and paradata (Huggett, 2020). While the latter issue might find its solution on a more consistent use of standardised formats, it is more complicate to elucidating a solution for the former problem. To address this, it is important to first understand what is the role for computational ontologies in the way we create knowledge.

Throughout this thesis, it is constantly discussed the role of computational ontologies in the process of knowledge creation. At the end of this text it will be substantiated my own position: if well developed, they have a great potential for this matter. So much so that they contribute greatly to the integration of a "morass of digital information to produce coherent, compelling, data-embedded archaeological narratives" -which is an "imperative" task (Nuninger, Verhagen, Libourel *et al.* 2020). This imperative meets another one, namely to

enhancing the study of complex systems (Kohler, 2012, p. 114). Indeed, as I discuss at length in chapter 4, and as previously pinpointed by Huggett (2017), computational ontologies might be understood as a digital apparatus. This is, a digital artefact capable of enhancing the way we create and represent knowledge. By semantically linking data, and guided by an ontological reasoning (i.e. human-natural systems interrelationship), computational ontologies rearrange multiple datasets in an interoperational manner. They are an advancement for understanding complex systems because they break down these systems, looking at the interactiveness of different entities embedded in human-natural systems (see Kohler, 2012). As a result, this approach helps in remodelling the way we create and represent knowledge, further contributing in current top-priority debates of socioeconomic and environmental nature.

Computational ontologies, moreover, are an apparatus of great aid for another fundamental task: better understanding the *explanans* and *explanandum* (following Gardin, 1980's jargon). Does this help in integrating field data? Yes, but how? The answer lies in the way they work. As remarked above, computational ontologies mobilise a wide range of literature and data, from records and reports to synthesis and analysis, presenting opportunities for thoroughly reinterpreting these sources. Not least, they pose new possibilities for better mapping/interlinking these data. It is in this process that current-state knowledge can be somehow "deconstructed": by re-reasoning, rearranging, and breaking down implicit theoretical knowledge (Nuninger, Verhagen, Libourel *et al.* 2020). This is but one great way of achieving Gardin's ideal of understanding the theoretical frameworks which constrain, frame, and explain researchers' mind -as well as their results.

Summing up, computational ontologies change the way we produce and represent knowledge. Equally, the help in solving some of the most important issues of integrating field data in new research for obtaining different, enhanced, results. But this might be not always the case; for example, if researchers do not interrogate the data they are working with or the minds (theoretical backgrounds) behind the datasets. The challenges of integrating disparate datasets from fieldwork, therefore, can only be overcome by a careful interrogation of them. This first step of the workflow does not, however, end at this point but after reintegrating in a meaningful fashion the data through the mapping process.

For the last section of this chapter, however, I would like to explore a pressing question for me. I am quite concern with our ethical and political role as researchers. As such, I consider that we must wonder about our research's implications. Equally, I argue that we should

consider if taking the time and effort to develop frameworks as the one here developed has a social impact. If so, towards whom? If not, how can we do our research socially?

### 2.5 All this effort for what? Archaeology, HE and Social Ecology (SE)

In a lecture series at the University of Glasgow, Professor Gavin Lucas[4] gave four consecutive talks. In the final one, he expressed his thinking regarding the importance of history in our present: "the sense of the past is fundamental for the sense of the future" (Lucas, *The Archaeology of time*, Darlymple lecture series, University of Glasgow, Thursday 21st February, 2019). In other words, the way in which we engage with the past -and perceive it- partly determines our possible futures. Unfortunately, Lucas notes an important caveat as he sets out two main manners of envisioning and engaging with the past in the present:

1. The past is disconnected from the present. This is to say that society neither knows nor cares about the past. As such, the past is seen as a distant *entity* with no worth in our today.

2. The past is objectivised in the present. No doubt, some sectors of our society do care, study, and contextualise the past. But in so doing, we might fall into the trap of the "capitalist-modernist logic" of *heritage* (González-Ruibal, Alonso González and Criado-Boado, 2018, p. 513). In this vein, the past is perceived as a passive object -conceptualised as a type of heritage reduced to its usefulness, applicability, and productivity.

Additionally, I argue, the past is used in the present in romanticised and de-contextualised manners (e.g. political discourses, search of existential meaning, etc.). This distorts the past because some facts are cherry-picked without contrasting them or omitting other visions of the past. This generates dynamics where suitable assumptions are taken for granted to fit dubious narratives -generally embedded in existential symbolism, flat political syllogism, fear, and hatred to alterity.

In this guise, the past is "alienated in the present" and, therefore, cannot give meaning to the future (Lucas, *The Archaeology of time*, 2019). This forces us to give a solution once understood the hard situation we are in and our ethical responsibility. It is firstly necessary to refute romanticised visions. We should contextualise the past: engage against dubious narratives by discrediting false facts and the rhetoric underpinning these discourses (Nilsson

[4] Professor of Archaeology at the University of Iceland.

Stutz, 2018, p. 53). But how do we do this? I believe that one way is by using contextualised data -i.e. our reports. The problem, however, is their incomprehensibility because they split facts from interpretations. This might ultimately distort the past. Changing our approaches to the act of writing is thus sensible.

But think exclusively about data. They are the backbone of everything we publish. In this sense, I argue that an enhanced management of multiple datasets will allow us to better contextualise our research, and consequently, the past. As a by-product, this would allow for discrediting dubious and distorted narratives which jeopardise the past. Computational ontologies might solve some of these problems by better integrating, connecting, and presenting multiple datasets.

On similar lines, some topics might open the possibility of using the past in the present for better. This is the case of environmental issues with a clear impact on society (Riede, Andersen and Price, 2016; Milek, 2018; Nilson Stutz, 2018; González-Ruibal, Alonso González and Criado-Boado, 2018). But for achieving a societal impact in this regard we should transcend some intrinsic power relationships within the "academy" (e.g. researchers vs the public, epistemological barriers, etc.). For so doing, I argue that our research should be framed within broader theories. One of this is Social Ecology. As defined by its developer, Murray Bookchin, this philosophical theory considers that:

> "nearly all of our present ecological problems originate in deep-seated social problems. […] these ecological problems cannot be understood, let alone solved, without a careful understanding of our existing society and the irrationalities that dominate it". (Bookchin, 2006, p. 19)

Bookchin asserts that today's "most serious ecological dislocations" are epidermic symptoms of "economic, ethnic, cultural, [or] gender conflicts" (*ibid.*). Consequently, it is naively wrong "to separate ecological problems from social problems– or even to play down their relationship" (Bookchin, 2006, p. 20). The core idea is the existence of a dialectical relationship: that of humans relating to nature, and that of humans relating to humans. For Social Ecology, the way humans as social beings stablish relationships between them determines the way humankind relates with nature. As a result, the only way "to addressing the ecological crisis" is by overcoming "the hierarchical mentality and class relationships" so that the "idea of dominating the natural world" can be surmounted (*ibid.*). SE is used in this thesis as a framework through which archaeo-historical studies can be enacted for analysing and understanding ecological problems (e.g. Guttmann-Bond, 2010; Lane, 2015;

Shaw, 2016; Riede, Andersen and Price, 2016; Bauer, 2018), whilst offering possible solutions to them.

Archaeology and SE complement themselves. One of archaeology's potential lies in the capability of providing deep-time data for understanding the material and socioeconomic conditions which led multiple cultures to different engagements with nature (similar to what Bauer, 2018, p. 166 and Bauer and Ellis, 2018 propose for Posthuman Political Ecology; see also González-Ruibal, 2018). Social Ecology gives a new philosophical framework for interpreting such data -affording new interpretations of dominance between humans and non-humans. By combining both approaches and understanding these dialectical relationships, we might be in a better place for offering solutions to our current crisis.

Narrowing down to the topic of this thesis, Open Archaeology (Milek, 2018) can be enriched by (re)introducing practices drawn from SE. Principles from direct democracy or indigenous worldviews (Bookchin, 1999, 2015, 2017 [1986], p. 61, Biehl, 2015, pp. 61-71) can reinforce multivocality and community engagement - hence resolving some issues pointed by Hardt and Negri (2017, p. 14) related to power dynamics. Practicing Open Data also creates new ways of engaging with the public through our research (Pulsifer, Huntington, Pecl, 2014). Computational ontologies can be of aid to this end inasmuch as they can be enhanced by following SE's ethical approach.

I will not enter here into more details and instead will finish by quoting Rathbone (2017): anarchist theories introduce quite interesting views and practices for implementing Archaeology's potential. In this case, SE tights up abstract philosophical themes and our digital endeavours with current socioecological problems.

## 2.6 Brief summary

I will provide a brief overview of the main ideas presented in this chapter so that I can conclude it. I have proposed the use of an ontological framework for archaeological reports that allows the integration of concrete information about the past within Social Ecology's framework. Further, I propose the use of ANT's theory for organising and representing complex narratives that needs the integration of multiple datasets from a wide array of disciplines, as happens with Human Ecodynamics.

## Chapter 3: Methodological Framework. Data, formats, Ontology…Digital Archaeology!

This chapter provides an explanation of the method I developed for my MPhil Project, informed by a dialogue with my first supervisor and peers. The method starts from the data contained in the archaeological reports and, through several steps, arrives at the articulation and integration of the data into the project's ontology. I have followed different steps to accomplish this:

- First, a contextual-analytical examination of the data;
- Afterwards, some key concepts were selected from that data;
- Later on, an inner classification of those concepts was deployed. This was done depending on the main information contained by the terms;
- Finally, I reshaped the formats wherein the concepts are. This was done for purposes of data cleansing and ontological adjustment.

This brief description of the method is further explained below. However, it is of importance the understanding of this schematic/outline version for its simplicity.

On the other hand, the final section of the chapter presents some results concerning those concepts which are the most used here. This procedure aims to detect the implicit theoretical frameworks adopted by the archaeologist who collected the report's data. That quantitative analysis is backed up by another qualitative approach, relying on a hermeneutic analysis.

In its core, the theme and the method used here belong to the (sub-)field of Digital Archaeology (see Huggett, 2013 for other concepts applicable to this subfield). While some authors express concern that we can too easily forget how theoretically embedded our methods are (Huggett, 2012a, 2015 a and b, Huvila and Huggett, 2018), this thesis focuses explicitly on theoretical digital archaeology.

As can be observed in this chapter, the method is not a straight reproduction of the "data-information-knowledge-wisdom" model or pyramid (González-Pérez, 2018) -which sometimes entails problems of different magnitude (Huggett, 2015a). Indeed, sometimes our method is arguably more similar to the model which proposes almost the inverse path; that is: from knowledge to data (Huggett, 2015a; 2020). However, I do not find either path completely useful in theoretical terms. We tend to see this pyramid as a strong theoretical

conceptualisation: either is data, or the information constructed from the data, or the knowledge based on that information, or vice versa. Therefore, we tend to approach this problem as if it were a straight line which can be ascended or descended in one way or another.

Critically examined, however, the nature of that pyramid is much more fluid. I will expand this point briefly using some examples. If we think of an archaeological report, we will likely examine it as a text formed by data, the information given by the data, and the knowledge acquired after the interpretation of both. However, in another archaeological report or in a publication, the knowledge of the previous report may be used simply as a small piece of data (e.g. a citation or quotation) within a network of data. Hence, knowledge may be seen just as data in some contexts. To be more concrete, each archaeological report can be disentangled as if it were a small ontology: compounded of data and intrinsic interrelationships between and among them, creating some sort of knowledge. Interestingly, as the consequence of the process of knowledge becoming other reports' data, a small ontology can be reduced to data which nurture the foundations of another ontology. The sum of reports, thus, is nothing but an ever-increasing body of small ontologies. This conceptualisation informs us of some difficulties in the creation of our big ontology. The importance of understanding this is huge, as I will show later.

## 3.1 From text to data: a method for selecting appropriate archaeological data

The first step in this research was to disentangle the important data embedded in the archaeological reports, a search for needles in haystacks. In practice, this means to go through the different texts in search of important concepts that can be used or treated as data. Such a process is seemingly simpler and "easy". However, it actually involves a critical reasoning of the different texts in search of terms and archaeological data capable of backing up Human Ecodynamics knowledge. This complex and critical process will be further explained throughout this chapter.

Nonetheless, before that, it is appropriate to make an ethical remark regarding this arduous process and the nature of archaeological data publication. As previously stated, my method aims to convey Human Ecodynamics by selecting data and knowledge from Archaeological reports. In addition, I seek to interlink this and other datasets from the different sources integrated into the general ontology. In section 1.1, I have reflected about how these aims

emerged from the incapability of understanding grand historical narratives just by using traditional reports. In effect, the absence of clear data publication and communication distance ourselves from rooting Human Ecodynamics knowledge. Realistically speaking, only a very interested reader would go through a critical process as the one here presented without desisting in understanding complex historical and biocultural inquiries. Therefore, a flaw in data, either in their content or in their manifestation and communication, is equally dangerous and unethical.

The method followed here may be seen as somewhat contra-intuitive in comparison to the ever-more standardised approaches in Digital Humanities -or Archaeology, if you may like it more. In effect, I have not used data/text-mining, although many methods point out to its use for an easy, rapid and extensive analysis-and-retrieval of key data and trends contained in a given format -say, a text, a list of numbers, etc. (Hearst, 1999; 2003). Rather, the approach followed might arguably be classified as *tradition-laden*.

Our non-data mining standard might contrast against some projects which have been developing procedures for extracting words and sentences out of texts by following NLP - Natural Language Processing (e.g. Byrne and Klein 2009; May, Binding and Tudhorpe, 2010; Tudhope, Binding, Jeffrey et al. 2011). NLP is arguably a useful procedure -especially given that these cases aimed at creating sets of linked data by using RDF triples. For us, however, it would not have been as useful or consistent as expected. Considering how NLP works, our starting conditions and setting are different from Byrne and Klein's example: the archaeological reports used in our study do not follow a pattern for structuring sentences with similar meaning or for designating actions related to human ecodynamics. Indeed, it is easy to find a wide range of words for naming the same action or feature within a single report.

The problem is magnified by the fact that this dataset has to be connected with others which might use different words for the same concept –a not-so-rare combination (Pálsson and Opitz, 2019). Undeniably, some projects that used NLP techniques faced analogous problems (e.g. Tudhope, Binding, Jeffrey *et al*. 2011) and yet arrived to similar conceptual categories as the ones we are seeking. But these cases are not directly comparable. The STAR or STELLAR Projects, for example, sought out to digitise in a formal way (RDF triples) what was already expressed in some archaeological reports. Their aim, therefore, was to replicate that very same narrative but adding a digital framework capable of offering interoperability. NLP's affordances are better developed to this aim. Our case, on the contrary, tries to re-write, enhance, reports' narrative so that it can better express knowledge.

It seems obvious in this guise that our case presented some noteworthy difficulties. They were pondered to assess the usefulness/cost-effectiveness of NLP techniques over human reading. In so doing, it appeared that the most sensible option was by hand -i.e. extracting data from grey sources to a simple spreadsheet after human-reading.

Our method, furthermore, might be surprising considering the topic and concern of this research. However, the reasons are obvious if it is taken into account the epistemological limitations of data-mining and alike methodologies (Hearst, 2003; Huggett, 2015a and b; González-Pérez, Martín-Rodilla and Epure, 2018), along with our abovementioned project-specific conditions. Indeed, as Huggett (2015a) claims, this kind of approaches entail a great contradiction in Digital Research:

> Increasing access to increasing amounts of data has to be set against greater distance from that data and a growing disconnect between the data and knowledge about that data […] Data are therefore accessed in largely de-contextualised state, and the increasing development of automated processing techniques associated with `big data´ exacerbates this situation still further

Furthermore, the situation is even more difficult in Archaeology and similar disciplines where many decisions and procedures are not closed-defined and non-deterministic. This methodological "openness" means that changes are taken "on the fly", modifying the methods in use (González-Pérez, Martín-Rodilla and Epure, 2018). Consequently, this also makes impossible a unification of terms, content, and data expression. This is our case: knowledge and its expressions vary from report to report, preventing us from the use of machine-learning techniques in our pursuit.

As better explained below, moreover, we did not start with pre-assumptions about what to find for our interest. This means that it is not quite sensible to apply pipelines such as the one developed by Byrne and Klein (2009), although they are effective for other instances. Said another way, data mining is a useful procedure if one knows beforehand what to find and if the text follows a similar structure all along. As this was not the case, the by-hand golden standard (Byrne and Klein, 2009) was used over any type of machine learning/text mining procedure. Precision over recall, hence, guided our own pipeline.

In sum, these new techniques create a work-ambient of "less intimate relationship with the object of record" -in this case, archaeological reports- which creates a "lack of context" (Huggett, 2015b), and a lack of "awareness about the theories, purposes and processes which

lie behind those data (Huggett, 2015a). All the more in text-mining methods, where different filters limit, exclude or include data following a given criterion. Consequently, the "misunderstanding, misconception, misapplication, and misinterpretation" of data remain as commonplace (Huggett, 2015a). Considering these issues, it might be said that I have come across the problem of applying data and text-mining approaches to complex texts. In this case, to avoid these filtering and lack of context issues, I have scrutinised all the texts "manually". That means to read through all the different archaeological reports in a systematic way: page by page, paragraph by paragraph. Arguably, I consider that a critical and close reading of large texts may address the "uncontextualised data-mining" issue. Therefore, although surprising for representing "a step back" into more "traditional" approaches, this perusal manifests itself as consistent and satisfactory for our purpose.

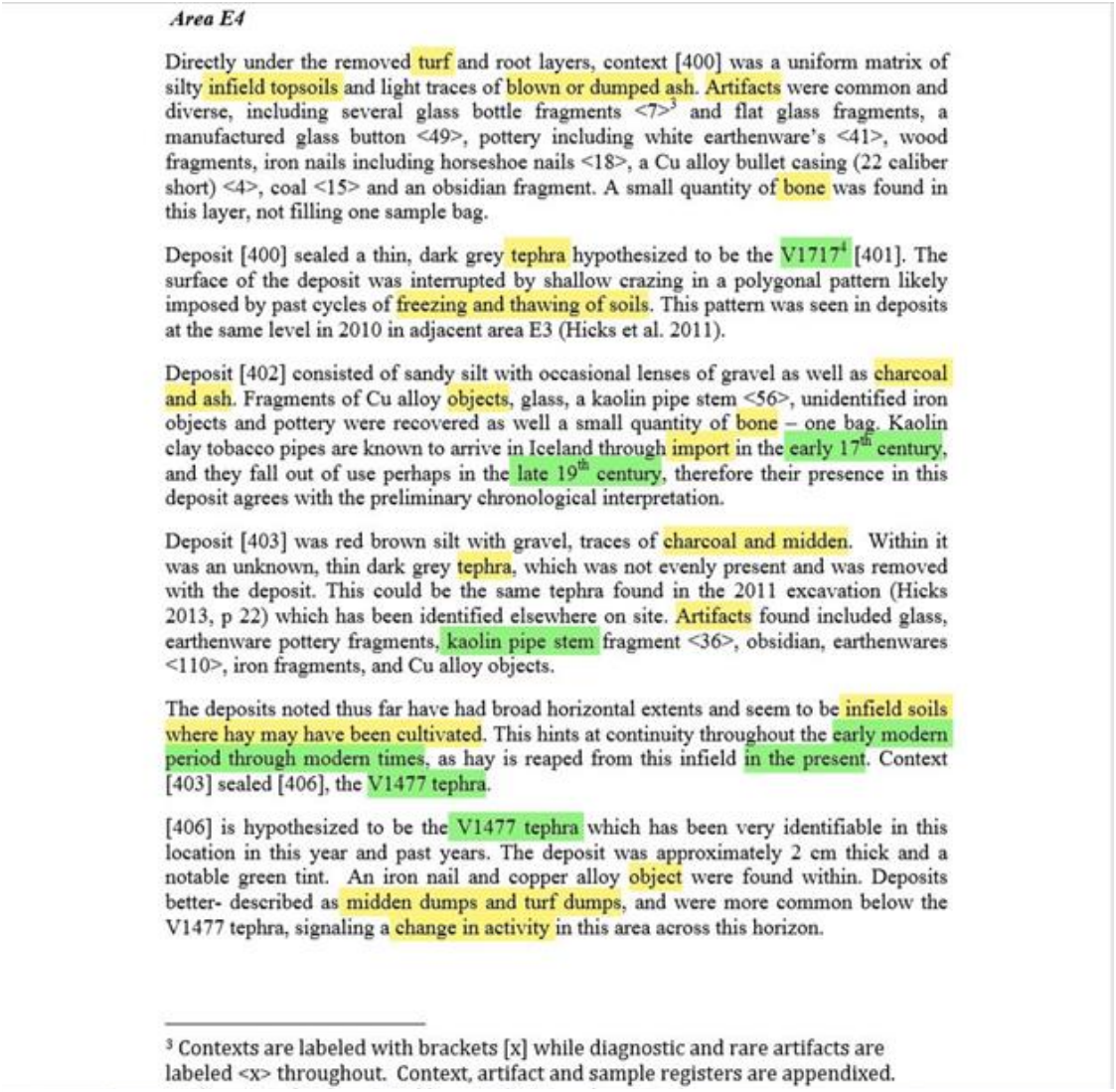
Of importance here was the mental approach followed: for us, there is no *a priori* or *posteriori*, no *ad hoc* or *post hoc* data/information in the text. At the beginning of the process, everything was equally valuable. Importantly enough, in our classification we did not distinguish or discriminated between "raw and derived data" (Royal Society, 2012, p. 12) for their utter contradictory meaning and simplistic view of what constitutes data (Huggett, 2015a, pp. 15-17). On the other hand, our data-creation approach forced us to disentangle the pyramid of "data-information-knowledge-wisdom" (González-Pérez, 2018): as previously said, everything is of equal importance, because under some conditions it may all be seen as data. In fact, had it been otherwise, it would have replicated theoretical problems related to the nature of data and information; as if they were less creative that knowledge (Huggett, 2015a, p. 16). By breaking down the text manually, I assumed as equally important and of creative potential the data, their description and interpretation. Furthermore, this is the practical consequence of assuming that the pyramid is made of fluid components.

In light of this, what matters is the whole narrative, which englobes not only knowledge itself but also the building blocks of it (data and information). In some manner, it can be said that our data were, indeed, the whole narrative.

For disentangling the narrative, a sensible approach was used: a reading of each paragraph and the selection of concepts contained by them. The "one [paragraph] by one" was preferable at the beginning of the process, as I did not know how the information was expressed or how it was to be organised. However, the correlation between paragraphs and concepts opened the possibility of joining a broader series of paragraphs, and even pages, to specific concepts.

In practice, this means that I had a bulk of read paragraphs, of which I selected key information (as pointed before, knowledge or information can also be data) -a concept- based on the interrelationship between the concept and its context. The only restriction for the creation of concepts was threefold (Figs. 5, 6 and 7):

1. It might give spatial information;
2. It might give chronological information;
3. It might give information related to Human Ecodynamics (e.g. human modification of the landscape, an object, entomological information, etc.).



***Area E4***

Directly under the removed turf and root layers, context [400] was a uniform matrix of silty infield topsoils and light traces of blown or dumped ash. Artifacts were common and diverse, including several glass bottle fragments <7>[3] and flat glass fragments, a manufactured glass button <49>, pottery including white earthenware's <41>, wood fragments, iron nails including horseshoe nails <18>, a Cu alloy bullet casing (22 caliber short) <4>, coal <15> and an obsidian fragment. A small quantity of bone was found in this layer, not filling one sample bag.

Deposit [400] sealed a thin, dark grey tephra hypothesized to be the V1717[4] [401]. The surface of the deposit was interrupted by shallow crazing in a polygonal pattern likely imposed by past cycles of freezing and thawing of soils. This pattern was seen in deposits at the same level in 2010 in adjacent area E3 (Hicks et al. 2011).

Deposit [402] consisted of sandy silt with occasional lenses of gravel as well as charcoal and ash. Fragments of Cu alloy objects, glass, a kaolin pipe stem <56>, unidentified iron objects and pottery were recovered as well a small quantity of bone – one bag. Kaolin clay tobacco pipes are known to arrive in Iceland through import in the early 17th century, and they fall out of use perhaps in the late 19th century, therefore their presence in this deposit agrees with the preliminary chronological interpretation.

Deposit [403] was red brown silt with gravel, traces of charcoal and midden. Within it was an unknown, thin dark grey tephra, which was not evenly present and was removed with the deposit. This could be the same tephra found in the 2011 excavation (Hicks 2013, p 22) which has been identified elsewhere on site. Artifacts found included glass, earthenware pottery fragments, kaolin pipe stem fragment <36>, obsidian, earthenwares <110>, iron fragments, and Cu alloy objects.

The deposits noted thus far have had broad horizontal extents and seem to be infield soils where hay may have been cultivated. This hints at continuity throughout the early modern period through modern times, as hay is reaped from this infield in the present. Context [403] sealed [406], the V1477 tephra.

[406] is hypothesized to be the V1477 tephra which has been very identifiable in this location in this year and past years. The deposit was approximately 2 cm thick and a notable green tint. An iron nail and copper alloy object were found within. Deposits better- described as midden dumps and turf dumps, and were more common below the V1477 tephra, signaling a change in activity in this area across this horizon.

[3] Contexts are labeled with brackets [x] while diagnostic and rare artifacts are labeled <x> throughout. Context, artifact and sample registers are appendixed.

Fig. 5. An archaeological report page in which different data are selected.

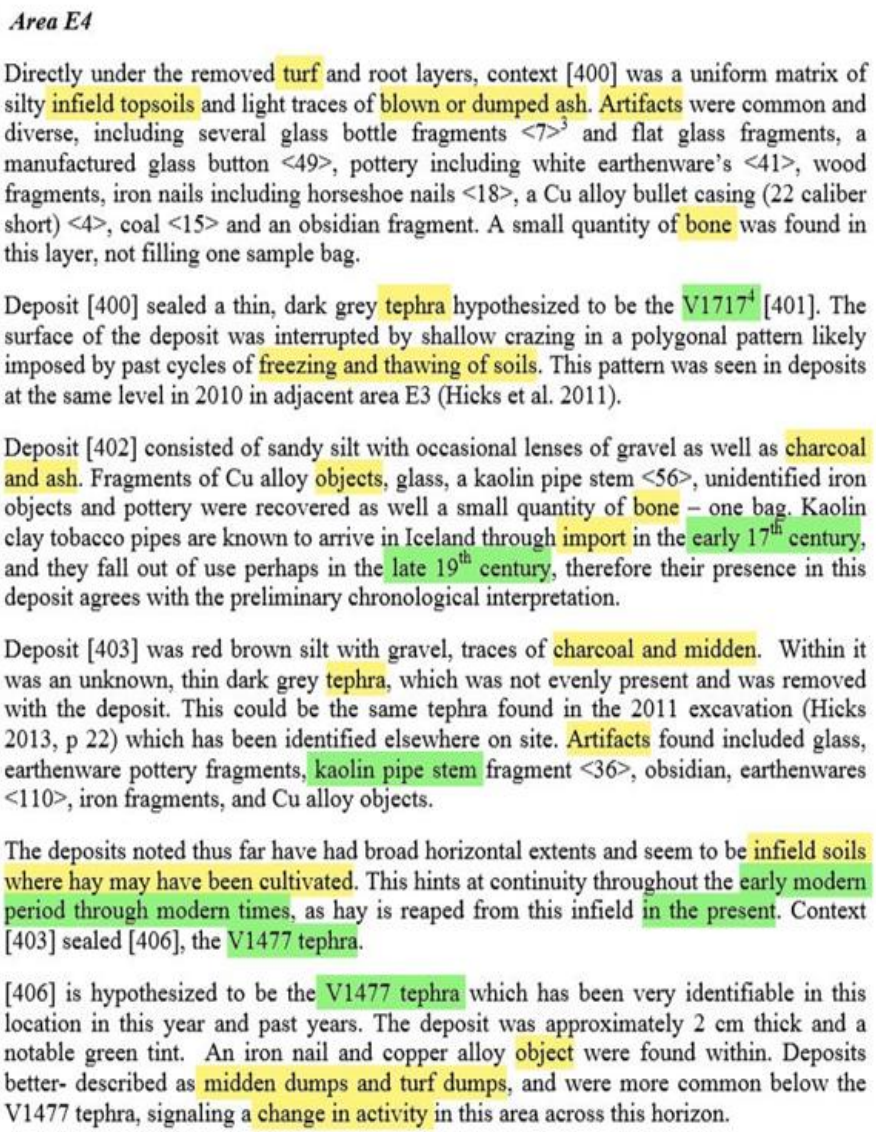
In other excavation areas on this farm mound, the grey V1410 tephra [418] has similarly been found just a few centimeters below the V1477 tephra with moderately anthropogentic or fairly empty deposits in between the two chronologically close tephras. These deposits are of interest as they can potentially provide evidence of Iceland's experience of the black plague eposides in 1402-3 and the late 15th c.

Below the V1477 tephra and subsequent context [411], a linear arrangement of stones was partially exposed, oriented in

Figure 3 Finding the contours of the uneven ground surface below the 1477 tephra.

a north/south direction, on the western and uphill side of the excavation unit. These formed part of an unknown ruin, of which the outline and central depression are barely visible contours in the modern day homefield grasses. Below the V1410 tephra, more collapsed structural stone was uncovered and left *in situ*. Midden remains increased in density; ash, bone and artifacts were more common and a series of deposits of mixed turf and midden dumps were interdigitated with gravel deposits associated with wall collapse [434]. After the loose gravel was removed, a 1 meter protective baulk (unexcavated area) was delinieated along the entire western side of the trench to protect the structural remains and preserve them for future excavations.

Fig. 6. An archaeological report page in which different data are selected.



*Area E4*

Directly under the removed turf and root layers, context [400] was a uniform matrix of silty infield topsoils and light traces of blown or dumped ash. Artifacts were common and diverse, including several glass bottle fragments <7>[3] and flat glass fragments, a manufactured glass button <49>, pottery including white earthenware's <41>, wood fragments, iron nails including horseshoe nails <18>, a Cu alloy bullet casing (22 caliber short) <4>, coal <15> and an obsidian fragment. A small quantity of bone was found in this layer, not filling one sample bag.

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[406] is hypothesized to be the V1477 tephra which has been very identifiable in this location in this year and past years. The deposit was approximately 2 cm thick and a notable green tint. An iron nail and copper alloy object were found within. Deposits better- described as midden dumps and turf dumps, and were more common below the V1477 tephra, signaling a change in activity in this area across this horizon.

Fig. 7. An archaeological report page in which different data are selected.

Each concept was later classified into a raw, simple table. The table unifies the key concepts and images (whether tables or photos) selected from one paragraph or bulk of paragraphs if those had some connection(s) between them (e.g. same stratigraphic unit, same trench, same materials, etc.), as can be seen in the following table below (see the Appendix for the whole table):

| Report reference | Concepts |
|---|---|
| P. 3, Section 1 | Settlement, Viking Age, Landnám, ecology, economy, Middle Ages, farm, long-term, soil, midden, tephra, modern period |
| P. 3, Section 1, Fig. 1. | Landscape, Viking Age, farm |
| P. 4, Section 1, First par. | Bones, artefacts,environment, Middle Ages, midden, turf, hearth, tephra, structures, modern period, long-term, economy |
| P. 4, Section 1, Second par. | Bones, modern period, long-term, economy, midden, sustainable management, farming, community sociopolitical relationships |
| P. 8, Section 1, Fig. 2 | Midden, farm |
| P. 8, Section 3, firts par + P. 9, Section 3, First par. | Modern, farm, midden, Middle Ages, tephra, bones, artefacts, structure, infield, dump, turf, abandonment, sagas |
| P. 9, Section 3, Second par. | Midden, soil, modern period, posthole, Saga |
| P. 9, Section 3, Table 1 | Coordinates |
| P. 10, Section 3.1, First and second par. | Turf, midden, infield, dump, artefacts, smithy, bone, tephra, environment, |
| P. 10, Section 3.1, Third and fourth par. | Midden, charcoal, artefacts, smithy, bone, modern period, 17th-19th c., tephra, |
| P. 10, Section 3.1, Fifth par. | Infield, hay, modern period, tephra |
| P. 10, Section 3.1, Sixth par. | Tephra, smithy, midden, dump, management change |
| P. 11, Section 3.1, First and second par. + Fig. 3 | Midden, tephra, Middle Ages, smithy, stones, bones, farm, mound, black plague, 15th c., |

Table 1. It shows a small selection of the first data classification from archaeological reports.

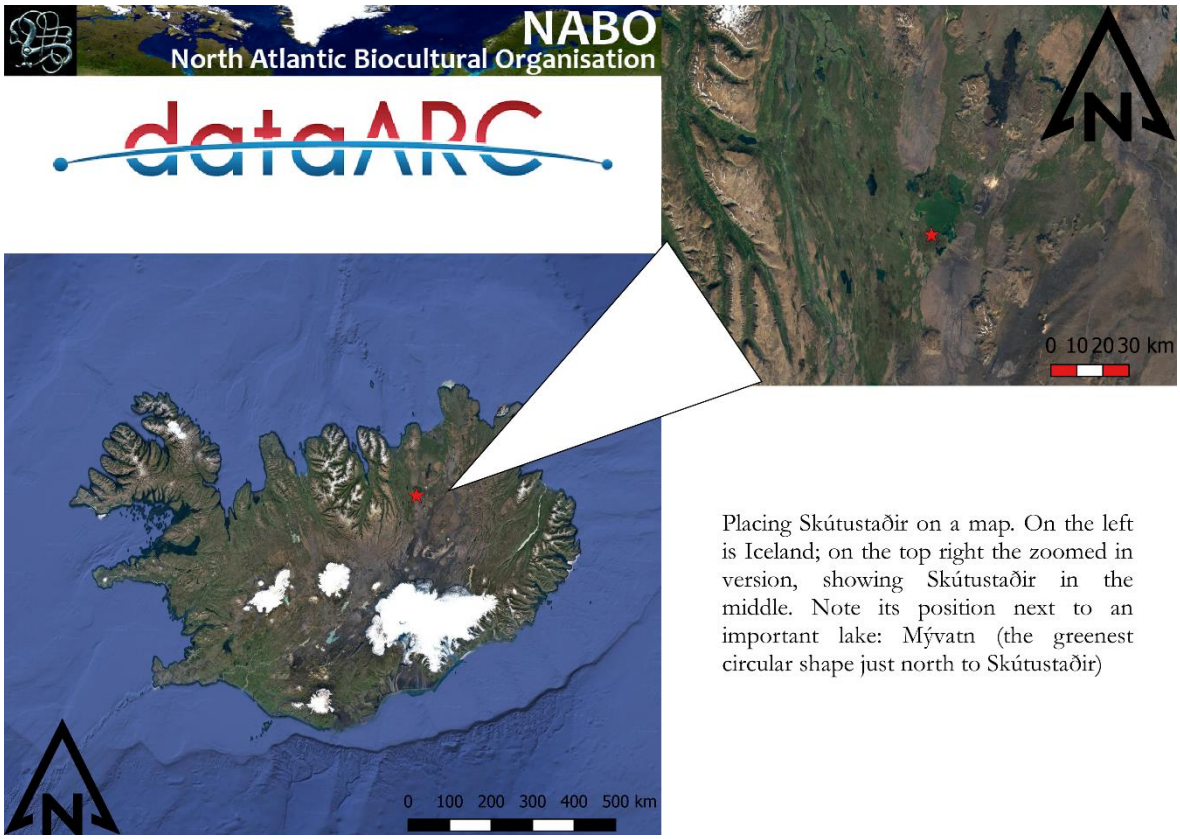
With this, I achieved the atomisation of different data, information, and interpretation irrespectively of their differences within the pyramid. Another manner of expressing this is that everything behaves as data here. I will further explain this below but suffice is to say

now that what matters at this point is not how we can frame a concept (may it be data, information or knowledge). On the contrary, what matters is how well the concept plays with complex meanings related to Human Ecodynamics. Whilst at this point is not yet clear how information and interpretation are not lost; it is arguably easy at least to understand that I achieved a disentanglement of the hierarchical relations imposed by our conceptualisation of how knowledge was built in the archaeological reports. What I prioritised is the ontological properties of the different bits which compound the narrative -here treated as data.

The method so far may be summed by saying that it was mainly me -with the aid of some of DataARC's members- who decide what was of importance for creating data depending on the interpretation given to a key concept in relation to its contextualisation within a paragraph or block of paragraphs. Here, of course, raise issues of authority: who is to take the lead in selecting data and taking decisions? Might it be the excavator? Or may an external reader deploy a better approach? My answer to this question is not definite, and it is bounded to change depending on different vicissitudes (e.g. single-context sheets excavations or not, the impact of new artefacts in how features are recorded, etc.). However, it might be expected some compromise between the excavator and a neutral reader. With this, the approach can be benefited from the expertise of those who excavated an area or feature, and from a neutral vision focused on other questions related to the ontological creation.

I am afraid this method might not be the most suitable in a world of Big Data and fast pace (Caraher, 2015, 2019). But it is the price to pay if we are to solve the contextual-absence problems posed by machine learning methods, among others. In addition, it is a traditional procedure which might solve problems related to the creation of ontologies based on distanced and diverse data (Huggett, 2012a, 2015a).

Before going forward in our methodology, it is important to clear out a fundamental aspect of the approach here designed. For this exercise, I had only worked with the reports from one archaeological site (Skútustaðir, in Mývatnssveit, North-East of Iceland [Fig. 8]). In total, there are 8 archaeological reports from this site (Edwald and McGovern, 2008; Edwald Ágústa, *et al.* 2009; Edwald and McGovern, 2010; Hicks, 2010; King and Fobes n.d.; Hicks and Pálsdóttir 2011; Hicks *et al.* 2013; Hicks *et al.* n.d.).




Placing Skútustaðir on a map. On the left is Iceland; on the top right the zoomed in version, showing Skútustaðir in the middle. Note its position next to an important lake: Mývatn (the greenest circular shape just north to Skútustaðir)

Fig. 8

This constriction is due to the available amount of time. Nonetheless, this method may be used in the future, reason why I deem necessary to explain how to proceed in the hypothetical following cases. In our ontology, the choice of one report over another should be guided by the correlation between spaces; i.e. regionality over entropy. In reality, however, this approach might vary depending on the ontological purpose and on the historical characteristic of a landscape.

In practice, this is applicable to what I have done in exploring all the reports generated by successive archaeological campaigns over a specific archaeological site. However, regionality over entropy also means to choose those sites depending on how closely one is from another: after Skútustaðir, the logical step is, therefore, to replicate the method here developed in its nearest archaeological sites. The process should be followed from one site to another, creating a network of sites. The theoretical framework which justifies this is bounded to what I have explained before in relation to Landscape Archaeology and Human Ecodynamics (section 2.1): a landscape and their human ecodynamics might be better understood by a focus on extensive areas.

I argue in favour of an ontological approach based on understanding landscapes when ontologies are created for resolving issues of Human Ecodynamics or alike. Nonetheless, simpler ontologies may just do not care about this point. In the former case, the historical

constitutions of landscapes might be considered. In these cases, extensiveness or regionality must be defined based on how different biocultures *behaved* in a given landscape. For the Icelandic case, I argue, a landscape is constituted of single farms (reason for choosing a site by site, depending on closeness), which have networks between them -a *hreppur* (the reason why I advocated for creating an extensive approach but starting from a regional point of view).

### 3.2 To select and transform creating a coherent "narrative" using data

As I see it, our general ontology differs from many others since its inception. Unlike many ontologies, DataARC's one proposed the creation of concepts and combinators not based on specific pre-given terms by the databases in use (Gruel, Tricoche and Charnotet, 2015; Gruber and Smith, 2015; Caltabiano, Puglisi, Celesti and Salamone, 2015; Gerth, Beck, Schmidle and Cuy, 2018; Gruber, 2018). Rather, ours try to create those terms and combinators seeking out Human Ecodynamics concepts to which can be tagged concepts from different fields and datasets (Pálsson and Opitz, 2019). To put it simply: terms from different fields, say, zooarchaeology, geoarchaeology, etc. might carry some fundamental, ontic, property under which they all can be summed up. That property is in our concept; subsequently, the ontic and semantic interrelationships among/between different concepts made of the combinators.

Therefore, the purpose our ontology was created for -enhancing the understanding of Human Ecodynamics- lead us to firstly develop concepts that can englobe complex processes of human-nature interrelationship. Later on, a reasoning of the different datasets led to choose linguistic concepts of similar meaning to those terms first created, linking data in that way. Consequently, a great abstraction is needed. Nonetheless, if applicable, we have the flexibility of adding new concepts and organise them in a suit-hierarchical level. Hence, our approach is quite different from many previous ontologies; it is almost an inverse pathway (by way of comparison, see González-Pérez and Martín-Rodilla, 2015, where another method equally valuable for integrating multidatasets into a general ontology is developed). Additionally, the ontology represents a path forwards in exploiting the whole potential of what ontologies are capable of (Huggett, 2012a, p. 542).

Another difference between our ontology and many others is its final aims. Over the course of ontological applicability to Archaeology and related fields, many projects have developed ontologies with the intention of "querying, sharing and reusing" data (as declared by Caltabiano, Puglisi, Celesti and Salamone, 2015. See by way of comparison *ibid*., Gruel, Tricoche and Charnotet, 2015, and Gruber, 2018). In the best of the cases, those ontologies

have also sought a coherent time-space deployment and interoperability (Huggett, 2012a). With these objectives in mind, many ontologies have successfully achieved the retrieval of some cultural and historical patterns as a by-product (e.g. Caltabiano *et al.* 2015). However, albeit being a useful exercise for speeding up the linkage between data and patterns of some sort of importance for some cases, it is not much better than a traditional database. That is not to say that such ontologies can be directly equated to a database -the former is in a *superior stage* for linking data. Nonetheless, the underlying fundamental and ontic properties existent among data and datasets are normally forgotten (*cf.* Tolle and Wigg-Wolf, 2015 for an interesting development in representing uncertainty). In other words, standard ontologies are absent from profound and critical reasoning. At their best, they are normally useful tools for modelling some sorts of linkages; yet bare of new in-depth knowledge. On the contrary, ours tries to identify and represent the implicit interrelationships of datasets considering their ontic properties.

Clearly, the above changes the whole process and the overall approach. What matters is not to encompass datasets in *soft* relational manners (e.g. a coin from X period minted under Y ruler in Z place, store in A museum, with links to C, D, F…etc. coins). What DataARC cares about is on how to better disentangle (by creating categories and hierarchies) fundamental ontological (in the philosophical sense) properties that occur in Human Ecodynamics processes. In other words, it is not a data-dump project; it is not an exercise in futility.

Another related challenge was to create concepts applicable to different datasets -whose essences vary. In the making of them, some compromise might happen: an effort must be made in the creation of classes and hierarchies. At the same time, an effort is made in selecting data from the datasets which are encompassed in concepts, classes, and hierarchies.

One of the keys for understanding the DataARC Project, its ontology, and this thesis, is in this compromise. In the latter case, this is done with the archaeological reports. If follows, hence, the question of how it is possible to select and transform an entire written narrative -which is treated as data- without losing complex information or knowledge. Or, in other words, how it is possible to create a coherent "narrative" using archaeological data in an ontology. I will answer to this by unpicking and explaining three different processes followed for this project, namely:

a) How a seemingly simple process as changing formats in which the data is contained indeed served for enhancing the quality of the data, at the same time that aided in expressing complexity.

b) How the creation of a hierarchical ontology aided in reassessing the ontic meaning of the data.

c) How the *combinators* are the ultimate process for linking data by way of semantic and ontological interrelationship between datasets.

### 3.2.1 CSV to GeoJSON towards DataARC

It is important to understand the ever-changing form our dataset have had, and the consequences of such changes.

Remember the first step: I had a simple table. Now the data is transformed into a more complex, sophisticated classification. For that, the table was changed to a CSV format. With such a change, it was not only done a mere format change; on the contrary, it was done a reorganisation and classification of our data. In other words, when the format was changed, the data went through a *cleansing* process. The data was therefore divided and classified following a straightforward criterion. Below is presented the classification of the data, where each bullet is representative of one CVS column:

- Coordinate X of the site
- Coordinate Y of the site
- Historical Period(s). In this case, we have followed a standard chronological division in Icelandic research: Viking Age, Medieval Period, and Modern Period. The reason of this was twofold: NABO have been working with these chronologies during many years; and DataARC's chronological framework follows this standard.
- Start Period
- End Period
- Concepts (for tagging with *combinators*)
- Bibliographical reference of each archaeological report -some of which did not have a clear citation before this step.
- Link to the Webpage from where the Archaeological Reports can be accessed
- The text from the Archaeological report itself.

The latter one, however, is not always a text: images and charts are also included in this project. In this case, the approach is slightly different: instead of adding the image or chart,

it is first copied and upload into an open web-storage page: in this case, Zenodo (https://zenodo.org/deposit/3545584), in a Zip folder which contains 8 different folders (one per report). For the sake of standardisation, each image in the folder is named after the same numeration in the bibliographical reference (e.g. 2008, p. 3, Fig. 2). The link from the image's location is written later in the CSV, and the CSV is also uploaded to Zenodo (*ibid*).

Once the CSV is done for each report, it is upload into an online converter (http://convertcsv.com/csv-to-geojson.htm). This transforms it into a GeoJSON file to make it usable within the DataARC tool. Finally, the GeoJSON file is upload into DataARC's tool, where our dataset is intertwined with the rest of datasets used by the project. In the following lines, I will explain how my dataset is interconnected with others. On the other hand, the Excel, CSV, and the GeoJSON files may be found in the Appendix of this thesis.

In the process of moving the data from the first format to the spreadsheet format, a scrutiny of the computational ontology created revealed itself as fundamental for avoiding important overlappings. Many of the *Combinators* (see sections 1.4, 2.2.1 and *infra*) already in used/created were fine for expressing complex concepts. Nonetheless, other concepts were created in order to expand and enhance our ontological model. Henceforward, I provide an explanation of the criterion followed, as well as the method for creating hierarchies and connecting new and old *Combinators*.

I will use some examples only for explaining the criterion for creating new concepts. An insight into some of the new concepts (Cathedral, artefacts, smithy, crafting, Landnám, social hierarchy, structures, outfields, etc.) yields the idea of heterogeneity in hierarchical terms. In effect, with this work, I identified some gaps in the ontology which were fixed. However, the criterion was not always straightforward: some concepts were simply not added due to the risk of overlapping and inconsistency. In other cases, some concepts were cast aside for being too deep in a hierarchical level. To use one example of the concepts introduced, I can pick "Social Hierarchy". The concept it is high in the hierarchical order, but it is not isolated at all: it can be linked to "Humans" or "Ecclesiastical Power" from the top-up, or to "Bones", "Sheep", etc. from the bottom-down ladder of the hierarchy. The reason for the latter case is that "Social Hierarchy" can be equated to "feasting" too, which would be linked to "bones", etc. At the same time, this new concept avoids the introduction of a deeper concept. In this case, it fits quite well in the inner mechanism of our ontology.

I will illustrate why some concepts were cast aside by explaining the problem faced in the parts of the reports where there are references to written sources. In those cases, it was

decided not to introduce new concepts. Instead that data were tagged with concepts already created. In this example, the nature of the data could be tagged to “Stories” and “Actors” - as they can be considered stories deployed by human actors. Another ubiquitous example is the case of “coring”, a concept never introduced. Instead, the technique was tagged to the concept of “tephra”: both make reference, among other things, to soil and geological information, and “tephra” encompass these properties. Below I argue how the introduction of concepts like this one here explained serves for creating narratives, instead of losing complex meanings.

On the other hand, it is important to consider which framework was followed in segregating or joining paragraphs in the spreadsheet. I analysed the content of various paragraph, and even entire sections, on those cases where I deemed as possible to join them. If it was decided to respect divisions for a concrete reason (e.g. they contain different chronological information), then they were not merged into one line of our spreadsheet. They were merged into one of our CSV lines if the context and content of different paragraphs represented some unity.

The criterion followed for ascribing paragraphs to some historical period was quite clear: they were merged under one spreadsheet line if one or more paragraphs with similar content and context could be ascribed to a specific period or set of periods. The same procedure is applicable to lists of artefacts, pictures or charts.

There were some exceptions to the rule. Many exceptions were due to previous data constrains (in what Huggett, 2012a inform us as a risky danger): some pre-given data was impossible to unpack more concretely due to the way it was originally treated. Most of these exceptions are related to chronology; paragraphs containing data from multiple periods (more than two different chronological divisions) were directly named as “Multiperiod”. Unfortunately, the issue is more common than desirable, affecting the final product.

As such, this seemingly mechanical step was, indeed, fundamental. It allowed us to transform and expand the ontology with new concepts; equally, it was possible to cast aside previous concepts generated during the first step. Thus, there is no automated processing here either: it implies key reasoning with the aim of configuring the ontology’s extensiveness. This process marks the connections between the archaeological reports and the Computational Ontology.

### 3.2.2 Criteria for creating hierarchies

The creation of classes and subclasses or hierarchies is an important aspect in computational ontologies. The irony of this standard procedure is, however, that there is not a straightforward criterion for it -beyond some general guidelines (Tudhope, Binding, Jeffrey *et al*. 2011; Bruseker, Daskalaki, Doer and Stead, 2018). This lack of standardisation, indeed, has arisen strong criticism for generating problems such as losing the real meaning behind the data or hiding different sorts of knowledge (Huggett, 2012a, 2015b).

To my knowledge, the kind of flexibility offered by ontologies in these matters is dangerous, but also has value: depending on the purpose and field, each ontology may choose to have more or fewer classes and subclasses, facilitating a better knowledge-representation. Further, for our case, and also for many other cases in Archaeo-Historical and Cultural Studies, I would warn against too much standardisation. Too much focus on standardisation could lead us into losing the sight of our real concern: the understanding of the people of the past.

Of equal importance in this line of argumentation is the consideration of the "overlapping issue". The issue of overlapping hierarchies is a common thread in the literature and in CRM Ontologies, although it is rarely explicitly addressed: in the consulted literature, from the most technical to the more "archaeologically-laden", the issue of how many levels are necessary and how to avoid an overlap between them is mentioned here and there, but it is never addressed or resolved in a concrete manner (Doerr and Crofts, 1999; Doerr, 2003, p. 89; Huggett, 2015a and b). For example, the class hierarchy itself, thanks to its pyramidal structure, suggests a natural 'top down' presentation. However, this point has the inevitable drawback of starting with some extremely high-level abstractions which may be difficult to grasp, and which have no obvious practical application. The problem, therefore, remains open.

For our case study, we might find useful to consider some questions. Following Bruseker *et al*., 2018, it is interesting to follow the fourfold "standardisation" of the Arena, Purpose, Intension and Potential (see 4 pages below from here), whilst bearing in mind the question of "how well does the model represents reality?" (Huggett, 2012a, p. 548). Beyond these, it is also useful to consider some aspects from the perspective of user experience design: thinking who the potential users are, what expectations might they have, which are the drawbacks of using too many hierarchical layers or vice versa, etc. It must be emphasised that this procedure is not straightforward; it must be guided by the final aims of the ontology: in this case, creating a coherent narrative of the Human Ecodynamics of the North Atlantic.

Regarding the benefits and drawbacks of using shallow or deep hierarchies in ontologies, it is worth considering a point in between both. Neither the latter nor the former ensures success if complex narratives are to be achieved. A shallow hierarchy may be better used when ontologies seek the communication of simpler knowledge (e.g. recalling coin ontologies as those already mentioned, many ensure understanding with shallowness: Authority, Place, Image, etc.). In contrast, deeper hierarchies may better ensure the creation of complex narratives -for example, in biological sciences where classifications of realms, species, subspecies, and their interlinkages are deployed. For the case which concerns us here, our narrative is more complex if compared to the first example, whilst its complexity in transmitting linkages and properties between/among more abstract concepts forces the withdrawal of a deep ontology. Below, I develop the concrete steps taken in hierarchical ontology creation, moving from the simplest to the most complex one.

Boiling the example down to our case, DataARC's ontology does not have a formal, pre-fixed number of hierarchical levels; the numbers change depending on the chosen concepts. For example:

a) Under the concept of 'farm', we might have 3 main layers of hierarchy. This can be seen below, using 2 concepts (improved land and land management) as "parents" of another layer or subclass:

| Level of Hierarchy | Concept |
|---|---|
| 1. | Farm |
| 2. | Improved land, land management, midden assemblage, infield area, garden plot, family, agricultural building, humans |
| 3. | Church farm, Insects, woodland management, field boundary, managed peatland, transformation, disturbed or arable, weather |

Table 2. It shows the selected spanning of our hierarchy. It follows the hierarchical development from "Concept Mother", a second phase in which I chose two other concepts for further development, and a third level showing how the previous two concepts evolved into deeper concepts. Therefore, yellow at level 2 is the partner of yellow at level 3; the same happens with the greenish concepts.

b) Equally, following the same example, from the previous set of concepts (I chose the first one [Church farm]), it reveals four or more subclasses in some cases:

| Level of hierarchy | Concept |
|---|---|
| 4. | Shieling shed, cemetery, ecclesiastical power, grain store, driftwood |
| 5. | Sheep bone and shearing, grave |

Table 3. It shows the continuation of the previous table. Red and grey at level 4 are partners at level 5

There are some cases in which there might be even one more layers. However, for reasons of clarity, I will not go into too much detail. I will express the above in the simplest manner (Fig. 9). Here I follow a representational standard in many ontologies (in this case, using as the main example "improved land").

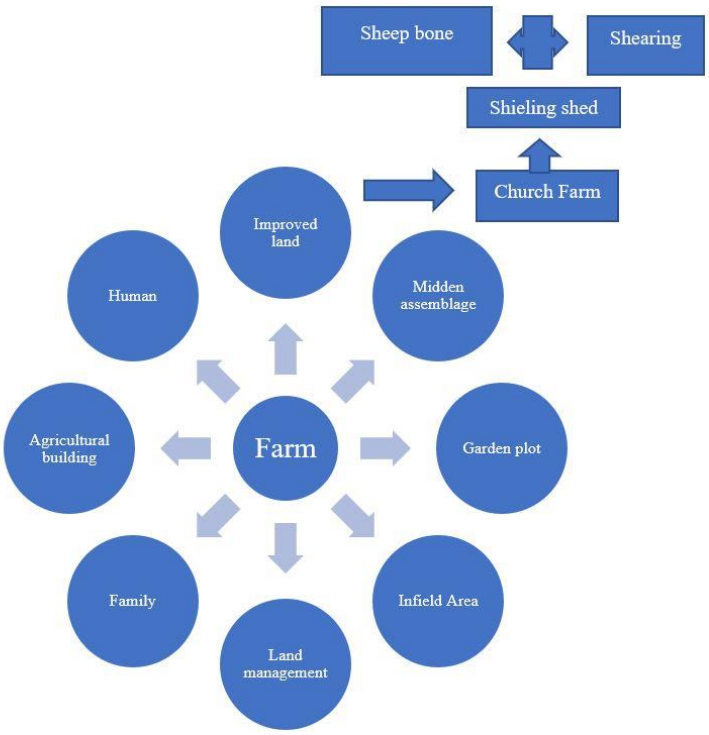



Fig. 9. It shows a simple representation of how our ontological hierarchy works by following the disentanglement of one concept.

From this exercise, we can conclude that a certain lack of standardisation might be beneficial depending on its use and capability for representing reality. This flexibility is important because ontologies sought to represent reality, and a certain fluidity allows them to better represent some properties of the so-called reality. Moreover, a certain sort of flexibility might prevent us from ignoring everything else which does not belong to a certain kind of abstraction (a common problem pointed out by Huggett, 2012a). On the other hand, such an approach allows better interoperability (Tolle and Wigg-Wolf, 2015, p. 178). Therefore, multiplicity and nuances may be the price to pay for the sake of representing complex realities and ontological reuse. It can be said, in sum, that it was considered as necessary for

representing Human Ecodynamics' complexity to cast aside too much top-down or top-up hierarchical organisation, as well as allowing some nuances.

Some points must be considered regarding the issue of user-experience design. To start off with, we seek scientific communication and outreach. If the former can be more restricted in terms of the demographic spectrum (scientific community), the latter breaks down academic barriers and its restrictions. However, communication is not an easy task even within the scientific community. As archaeologists, historians, or anthropologists (*insert yourself* within the *category* you like the most), we normally take for granted concepts and understandings which are everything but obvious for colleagues with other backgrounds: ecologists, biologists, philologists, etc. might understand the category "landscape" in a different sense than we do. Moreover, there is no consensus even between archaeologists of what it is englobed within the concept of "landscape". This is to say that there is too much implicit knowledge behind our assumptions –and this motivates the development of the *Combinators* (see 3 pages below for further explanation).

However, in seeking out solutions for this problem, we can find the virtuosity in overlapping: similar concepts which might be encompassed for some of us as the same thing, can be disentangled into smaller abstraction. So, for "Landscape", our ontology retrieves: "Landscape change", "the changing landscape", "physical landscape", "imaginary landscape", "managed landscape area", and "unmanaged landscape area". All are interconnected between them, but function as separated levels of abstraction; in this manner, we avoid the highest and much complex level of abstraction of "Landscape". Each of those concepts, beyond being interconnected, have their own subclasses. These subclasses might be related to land management (which derives into concepts that may affect it or being its proxies: insects, weather, field boundary; or associated with it: farm, family, transformation), or to other related concepts.

The core thing here is to understand and recognise that in the process of linking concepts with greater or lesser abstraction between and among them, multivocality and multiplicity exists -in an *intra* and *extra* sense. *Intra* to recognise and respect different scholarly expertise and approaches. *Extra* as a much-needed ethical position in transdisciplinary studies (Nilsson Stutz, 2018; Lukas, Engels and Mazzukato, 2018; Milek, 2018), encouraging and seeking outreach to a broader public. We realise, therefore, that it is beneficial to include multiple levels of abstraction with similar concepts, along with a flexible hierarchical scale, when this diversity of potential users is considered.

The questions of reality, its representations and interpretations, connect us with Huggett's inquiry of "how well does the model represents reality?" (Huggett, 2012a, p. 548). In the first instance, a high level of abstraction is needed in some cases for encompassing concepts such as "Landscape", "Humans", etc. Nonetheless, this does not necessarily mean to include them in such a high level of abstraction. Rather, we have seen that some concepts are disentangled into many other similar concepts, which are also abstract but more specific to Human Ecodynamics. This, I argue, is in line with reality. Indeed, this is also in line with human cognition: multivocality is respected by using similar concepts but with some utter different connotations. For example, two paragraphs above discussing the concept of "landscape", I avoided a total overlapping by using similar, although different, terms. This procedure respects reality (multiple aspects of a landscape) while at the same time respect how diverse users might think of the concept "landscape".

I have previously discussed the possibility of considering everything as data. Equally, I have shown how it is possible to consider every single archaeological report as a small ontology. Now, it would be interesting here to formulate the question of how this aspect of reality affects our ontology. The answer is clear: as stated above, some problems emerged due to inconsistencies from the reports (chronology, etc.), and it is not possible to resolve these problems at this stage. However, considering everything as data, instead of respecting the traditional hierarchy, was useful. To my knowledge, it is impossible to apply hard ontologies (in the sense of representing ontic realities and the unpacking of such realities into hierarchical concepts) to the knowledge pyramid. It is simply impossible, as both collide into hierarchy: the knowledge pyramid is hierarchical, and so are ontologies' hierarchies. This means that it is impossible to adjust the ontological format to a hard model of pyramidal knowledge. It is hardly impossible to insert data separated from information or knowledge when it does not behave as such once introduced in the ontology. As we have seen, data may behave as knowledge, or vice versa. Hence, if everything is of equal value, if everything is data which contains some sort of knowledge in its core, then the data can be linked into concepts aiming to represent the ontological reality of Human Ecodynamics. In other words, the knowledge pyramid is sacrificed in the name of a more nuanced vision which represents realities within an object-oriented vision.

In a more theoretical sense, recalling some thoughts from Chapter 2, our ontology follows an ontic reasoning: linking different concepts and aspects of reality without prejudgments of whether X concept is social or "from the natural realm" *per se*. This quite abstract aspect of reality and the main ideas brought by ANT are respected by:

1. the different concepts obtained after sacrificing a pyramidal categorisation of data vs knowledge
2. their interlinkages depending on the filters used
3. the users' interpretations.

The next section, which discusses the *Combinators*, should reveal more concretely the effectiveness of our approach. However, I think that it is possible to conclude that our model respects and reflects well the reality that it tries to portray.

Finally, some thoughts should be given to Bruseker *et al*. (2018) fourfold "standardisation".

- Arena is defined as "the scope of the ontology [which must aid in] reasoning a particular type of certain, perhaps broad, but always limited domain […] The interest is not in providing a total model of the world, but an adequate model". Following this, the arena of the general ontology is well-defined: representing Human Ecodynamics in the North Atlantic through the combination of multiple datasets from different disciplines. For the case of this thesis, the arena is the representation of Human Ecodynamics through archaeological reports, with special attention to a wider understanding of landscapes.

- Purpose is the understanding of "the restrictions that the purpose imposes on the classes declared within it. All classes should be considered as playing a functional role […] classes in a good ontology do not play a simple taxonomic role. Rather, they are the anchor points for talking about the world in certain ways; making particular statements about relations between things". In effect, the flexibility between some classes and subclasses, with more shallow or deep divisions, allows for a better representation of the reality we try to present. This part is better understood once the *Combinators* are taken into account. However, suffice it now to say that our classes do not cluster reality inasmuch as they respect multivocality; rather, some overlapped concepts might give better insights into the variable nature of the things that they are supposed to portray. Equally, following ANT, they give a concrete relation between things depending on context, and not in a deterministic way.

- Intension "gives the qualities which determine if an instance can be subsumed under a certain class." It basically means to understand under which circumstances one subclass is well merged into its wider class. A class and its subclasses must not be created depending on its extension but on its intension (Bruseker *et al.* 2018), and they give four criterions "identity, substance, unity and clear existence conditions"

(*ibid*, pp. 28-29). In other words, this step determines whether one subclass belongs to a class. For our case, I believe that the descriptions made above on how to discriminates or join concepts is well defined: in all the possible cases, I followed time-space, material, and meaning within Human Ecodynamics' topical domains.

- ❖ Potential is what determines "where a class belongs in the ontological hierarchy". This might be the most difficult one: in our case, there are some tensions between classes (possible overlapping). However, such overlapping concepts must be treated as separate entities because they split very abstract concepts into smaller, manageable parts; albeit all of which may belong to the same hierarchical class depending on the circumstances and users' interpretation. This tension might cause a flaw in the overall result. However, there are significant difficulties in overcoming such a problem when dealing with ontic concepts which are not identically conceived of in all human minds. I argue that nuances and flaws are necessary if we are to achieve multivocality and variability.

  Indeed, as Nuninger, Verhagen, Libourel *et al.* 2020 demonstrates, it might be desirable or helpful some grade of "overlapping" in matters of terms and ontological hierarchy. Such an approach allows for better use of terms which might refer to the same concept. As a result, an ontology might be more consistent by presenting an assemblage of terms which refer to the same or slightly different, but pretty close-connected, concept(s). This is in line with some semiotic and philosophical theories which highlight the role of intersubjectivity in the creation of knowledge (see the reference in *ibid*, p. 7 for the former, or Sbriglia and Žižek, 2020 for the latter). If this is so, computational ontologies thus make the case for combining two apparently contradictory ontological theories: ANT and intersubjectivity.

It is now necessary to discuss the development and use of *Combinators* within DataARC's ontology. This will complete the picture of our ontology's character within the broader context of computational ontologies.

### 3.2.3 Not losing the meaning: how to express complexity with *Combinators* and their concepts

The biggest challenge for this thesis and DataARC is how to express complexity. This is possible thanks to the *Combinators*. As I will explain in this section, they allow us to map terms to the ontological complexity they refer to. Before explaining this, I will make a small

digression to mention Recogito (https://recogito.pelagios.org/). Recogito is an Open Source Software which permits to tag basic concepts (places, people or events) from texts or images to maps (https://recogito.pelagios.org/help/tutorial). This system is interesting and useful for archaeological reports. It would allow us to map simpler but very common and ubiquitous concepts to maps whilst openly sharing the data. Nonetheless, it is not used very often for this task. In any case, for us it is not quite useful as we have more diverse and complex concepts. It was necessary, therefore, to develop another approach for expressing complexity. The *combinators* system was designed to this end.

In section 2.2.1, I explained the theoretical basis and implications of the *Combinators*. They have been developed by Rachel Opitz based on a modelling language (González-Pérez, 2018, p. 12), and are the axis, key, and core of how we connect data to DataARC's ontology. I have already said that these *combinators* are *symbols* produced and reproduced by different actors that make references to the world. They give real meaning to the datasets by connecting fragmentary pieces of data with the abstract meaning or idea they try to express. I should recall that our ontology sought to address a representation of higher abstract order than many others do, at the same time that combines datasets which vary in nature (descriptive or quantitative) and time space-time's scopes (Angel, Brin, David Cothren *et al.* 2018). Therefore, the data linkage process is not as obvious as in other ontologies.

First, the ontology forces the *combinator* to contain a minimum level of detail, as well as a maximum (Opitz, Strawhacker, Buckland *et al.*, 2018), but the amount of detail will vary depending on the dataset. The issue is greater if we consider that all the relevant data must be contained within the concepts to which they refer. This implies that some data which refer to very specific ideas or items (a fishing hook), and which would be too deep in our hierarchy (forcing the creation of too many new concepts), cannot be included as such. In these cases, what we have done is to tag that item to a higher concept in the hierarchy (fish/fishing) and whose *combinator* allows us for expressing the idea to what this item makes reference to (the act of fishing and consuming fish). Therefore, compromise is the solution in the abstract exercise of linking data to a concept. Another example can be found in the all-too-often-and-ubiquitous process of "soil dump". This event is treated as data which expresses a certain human approach to nature (the manner of treating an environment for a concrete purpose - normally, soil enrichment). However, moving along a hierarchical scale, going down from a higher concept related to environment to the event of dumping, would be a complex exercise. Instead, it has always been equated to some higher concepts such as "managed landscape", "the changing landscape" and so forth.

All that implicit reasoning and conceptualisation is contained in the *Combinators*. Subsequently, they allow us to create interlinked ontic abstractions which are strictly embedded in the different Human Ecodynamic processes. Additionally, those concepts are interlinked between or among them following a semantic procedure similar to RDF Triples, mapping DataArc concepts to CIDOC CRM and CRMsci standards (Pálsson, Opitz, Strawhacker *et al*., 2017).

A total data interlinkage is thus achieved, first by way of ontological links, and later by way of semantic interrelationships. Moreover, it represents quite well the fluidity and uncertainty express by ANT inasmuch as it does not force a pre-given definition to the interaction amongst data. Lastly, considering ontological integrity, *Combinators* reinforce its consistency, especially if we follow Bruseker *et al.* 2018 points of Purpose, Intention and Potential: as a whole, they are flexible representations of the world, merging, joining or dissolving between or among them depending on an ever-shifting *state of affairs*.

### 3.2.4 A comprehensive summary of the ontology so far

It is moment to reflect and summarise the process so far from a new perspective. This will give an insight into what our ontology really is. Heretofore I have explained the mechanism for creating our ontology, using my case study as an example. The process should be clear enough at this point. But the real manifestation -i.e. the shape and graphical representation of the ontology- remains vague and abstract. The same happens with its structure. It is thus necessary to change the gaze now and explain the representational shape of our ontology. This section complements section 2.2; I suggest to look backwards to it, if needed.

Simply put, the ontology seems to be a graph (Fig. 3 and 4). The graph is formed by different edges and nodes. The edges represent the different concepts we have created, while the nodes are the semantic and ontological properties which connect the concepts. Each edge moreover has a geo-chronological "topological" demarcation. In this graph, not all edges are connected; their linkages (and degree thereof) depend upon their interrelationships -a knowledge conveyed by the nodes. As simple as it seems, this representation is based on graph theory (see Brughmans, 2013 for understanding its applicability and usefulness in archaeology). Using this theory's jargon, in what concerns the degree of interlinkages, our ontology is a directed graph. Our ontology's representation can also be described as a network because it represents "the structures of relations among different entities" within a given set of domains (Brughmans and Peeples, 2020).

So, how is the data from a concrete dataset aggregate into the ontology? When are the combinators use and how they really work? How is, later, that data link to the data from other NABO's datasets? I will use a diagram for clarifying the process (Fig. 10).

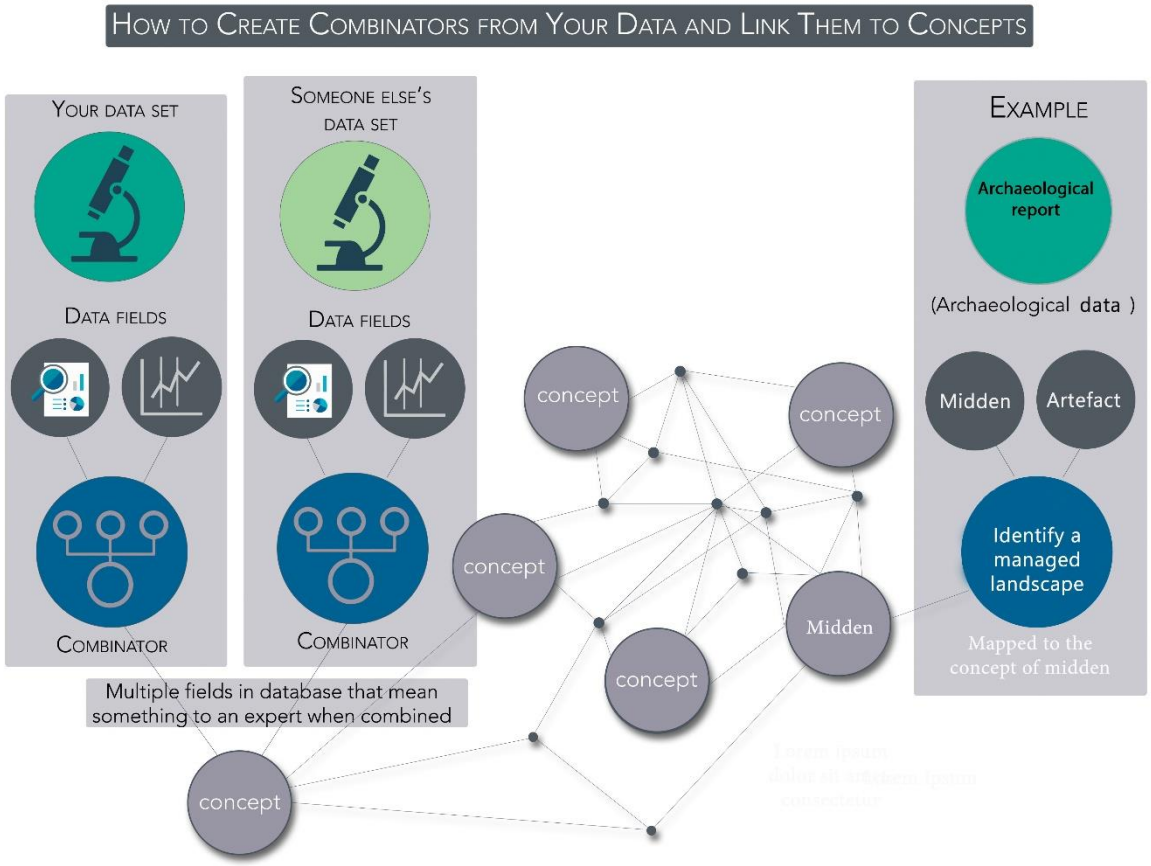



Fig. 10. Schema of the procedure followed for mapping data to the computational ontology. Modified after Pálsson and Opitz, 2019. The same procedure is followed for different sources -depending on which, different terms, more accurate for, say, written sources might be used.

Once the specific source -in this case, an archaeological report- has been perused, its content is extracted and transformed into a dataset. This dataset must contain information of critical importance such as geo-chronological adscription or specific denominators, concepts, which summarise and convey bits of ontological knowledge. The geographical and chronological data will serve as the spatial-temporal references inherent to every and all archaeological data. But more important is the conceptual data. Each concept contains some sort of archaeological information/knowledge related to complex human-natural systems. This would naturally put an end to the first step in our "chaîne opératoire".

The next step is to build in the computational ontology with these concepts. This is done by first listing the new concepts within the ones already created. All these concepts have a semantic meaning, and consequently they can be interlinked. Here, and from my point of view, semantics has a twofold sense (Fig. 11). On the one hand, these concepts are words, which are at the same time charged of meaning -a reference to a "real" thing. Understanding

this interrelationship is linguistic semantics; which is arguably part of the semiotic analysis. On the other hand, our isolated words charged of meaning can be related to other words, creating expressions in a logical way -a discourse. Mathematical semantics analyses this process: the efficient and logical structuration of words/symbols, leading to the creation of a discourse, which in turn refers to a referent or "real" thing. This conceptual division is, nonetheless, press-fitted. Actually, analytical philosophy and the philosophy of language encompass both procedures. But for our case, it is important to bear the distinction in mind: we need to firstly understand the meaning of our words in order to articulate and interlink them in a logical fashion.

But words are words. Alone, unarticulated, they cannot create a discourse. How do we create it -i.e. interlink words? By making use of the CIDOC CRM language. This language provides a set of relations between entities (our words):

Object A *has X relation with*[5] Object B.

Where the objects are the data we have previously created.

To put this into a real example, let us think about a midden: in the archaeological record we might find several ecofacts and artefacts dumped in a concrete area; our implicit knowledge as archaeologists will lead us to think that this is a dynamic wherein humans dump the soil with "trash" in order that it can interact with different microbes, insects, and physical properties, with the final aim of enriching the soil so that it can yield more agricultural production. In our computational ontology, by using the CIDOC CRM language, this will be expressed as it follows:

Managed landscape area→ E24 Physical Man-Made Thing→Midden

Midden→ E25 Man-Made Feature →artefacts

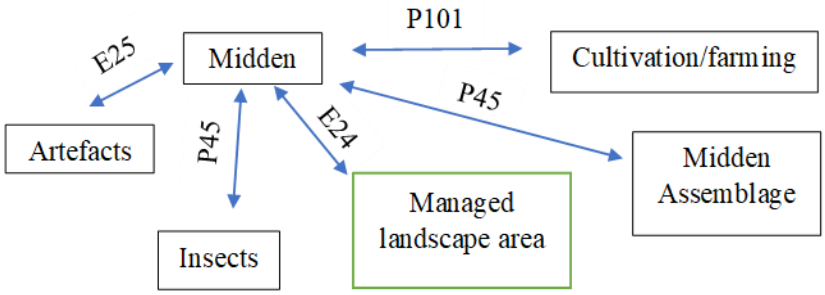
Midden→P101 had as general use (was use of)→cultivation/farming

Midden→P45 consists of→Insects

Midden→P45 consists of→midden assemblage

[5] Italic denotes the language provided by the CIDOC CRM framework.

Or graphically as:




This is but one example of the many that occurs in our computational ontology. As it can be observed, this procedure is efficient for connecting different bits of data. It also shows that one concept can and should not be single-mapped, especially in an inter/transdisciplinary ontology. On the contrary, parallel mappings are beneficial in that they allow for further interlinking datasets while reinforcing a more complex, nuanced, narrative of biocultures (Pálsson and Opitz, 2019). Our results, moreover, arguably underpin the recent favourable assumption about the suitability of the CIDOC CRM language for network ontologies (Pálsson, 2020).

The issue of combinators is yet to be discussed. The discussion hitherto has explained how to extract data and create a dataset from a grey source; how to map it into our ontology; and how different bits of information can be interlinked. In this process, however, we have forgotten the more profound ontological meaning of the data we are mapping. As it has been said before, the combinators entangle these meanings within the computational ontology. Doing this last step is key to obtain a well-refined product.

All too often, researchers tend to forget that computational ontologies can and should model (complex) reality. This process of reality-modelling has a clear ontological (in the philosophical sense) meaning. What is more, the semantic ordering is also embedded in the ontological abstractions (Fig. 11). How? I have previously said that linguistic semantics try to study the interrelationship between a word and its meaning. This meaning refers to a "real" entity -its referent. Philosophical ontology, for its part, is concern solely with the profound interrelationship between the entity and its real meaning. Ontology hence tries to define what really is an entity, starting from the question of the being. The study of the being unfolds the broader question of what reality is, which are its constituents, and what kind of relationship happens among them. Undoubtedly, ontology can be studied from different perspectives or areas of reality. As such, it is an ontological task the understanding of Human Ecodynamics

- human-natural systems either from the scope of systemic ecology and from past human cognition.

Our computational ontology helps in this by presenting a framework capable of condensing profound interrelationships among entities and/or beings. Said another way, our framework describes a selected number of domains of the ontological reality. This means that it models a concrete spectrum of reality, according to some and diverse ontological insights. These insights reflect our understanding, as researchers, of how operates the concrete reality of human ecodynamics. Combinators is what describes this ontological reality. For example, following the example used above, a proper combinator would be "Modified farming landscape". This is one example that, indeed, can also be mapped to our computational ontology as a high hierarchical concept.

This combinator entangles some data from our grey source with its overarching contextual and ontological meaning. This means that we are modelling complex reality, and even rethinking the terms of complexity by making more explicit the different connections and interactions happening in these dynamics. In effect, we are producing a model capable of representing how beings and things are and behave within some specific ontological domains. This connects and helps expanding philosophical inquiries about reality and beings because it orders some domains by making explicit connections of different actors. In this sense, the DataARC Project, with its eminent inter and transdisciplinary approach, is also a philosophical endeavour.

Ironically, and probably unintentionally, the project clashes with two philosophical school of thought. This is a natural consequence of modelling reality with a network, but human-made, computational ontology. And it is a positive outcome, to some extent. It is clear that our approach matched perfectly with many of the views proposed by ANT. Much less clear, but present anyway, is the connection with "(inter)subjective ontology" (as per described by Sbriglia and Žižek, 2020). The former presents reality as a network of actants -i.e. objects with no specific place for humans interacting in an infinite set of possible combinations. The latter described reality as dependent on the "unconscious self" -i.e. the sublation of the external force of reality with the internal force of the unconscious. Are both visions colliding in our computational model? Yes! The explanation is simple: let us think about our combinator (Modified farming landscape); on the one hand it described a network reality between different beings (humans and non-humans); on the other, however, it entangles two dimensions of the unconscious. The first dimension is that of the people who have created the combinator, as they are making use of implicit knowledge and self-understanding for

developing it. The second dimension is that of inferring in the "why did they do what they did?"; they modified the landscape for farming (intersubjectivity) in spite -unconscious- of the many dynamics happening at that specific time-space (actants in the web).

If we concede some truth to this hypothetical vision, them our ontology demonstrates a principle of interoperation between two ontological theories. If this is so, the DataARC Project contributes to philosophical ontology by further entangling up two theories hitherto mostly separated.

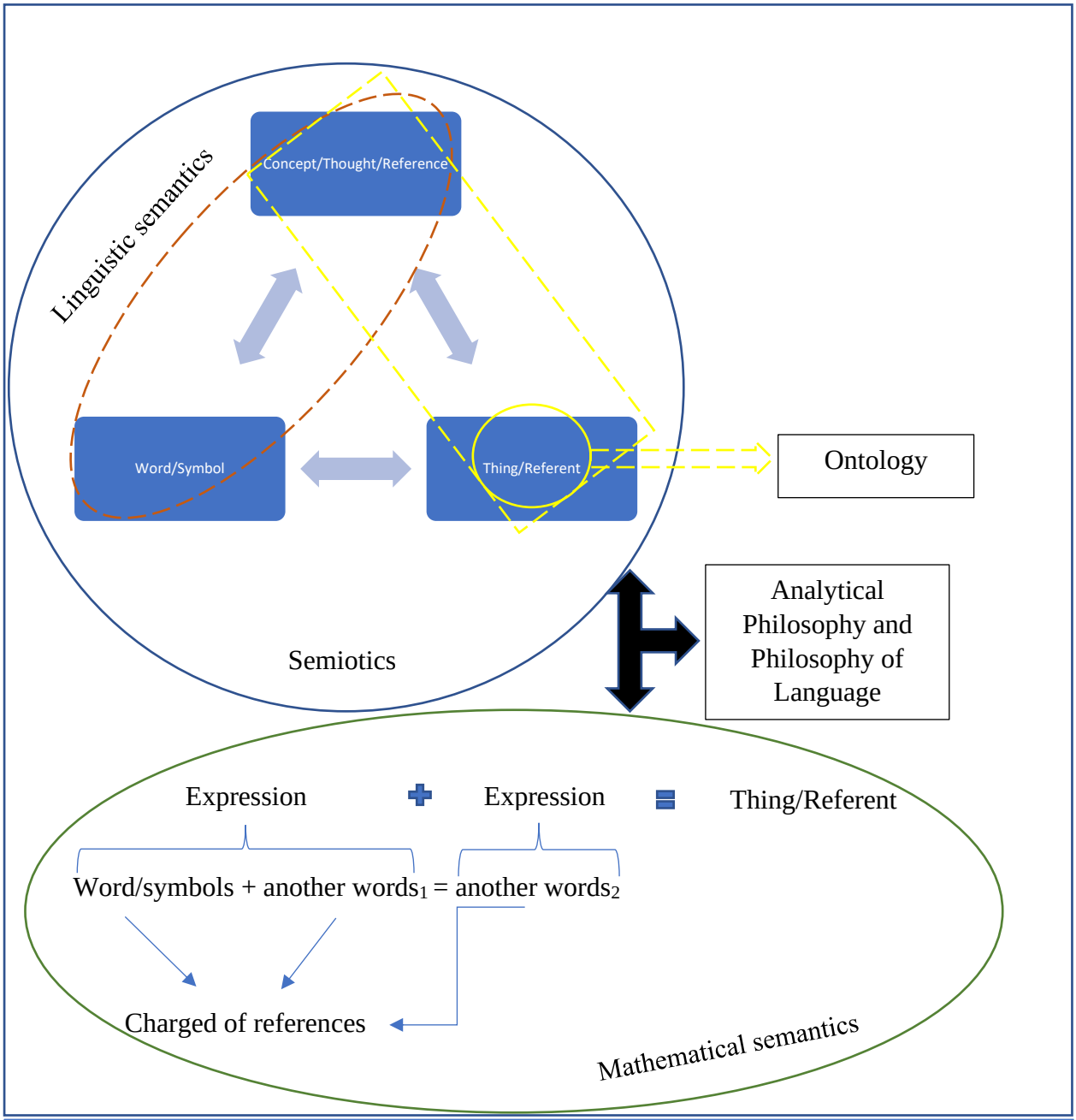



Fig. 11. Schematic vision of the different theories as mentioned in the text and their relationships. This vision may differ from others but it is useful for our present context.

Overall, I consider this ontological and computational exercise robust, capable of dealing well with uncertainty, cognitive and ontic flexibility, semantic interoperability, and complexity. I have demonstrated how this approach creates a strong narrative which can go either from complex conceptualisation of the reality behind Human Ecodynamics, or more importantly, from small bits of data and information to grand narratives. The implication for Archaeo-Historical Studies is as much as one can think of: from redefining grand narratives of human impact and adaption, to the daily life of the Vikings and their way of living-in, among many others. It is a reconfiguration of how we back up our knowledge, now making explicit those mental operations and theoretical frameworks which are implicit in our research.

### 3.3 Hermeneutics and data; detecting implicit theoretical frameworks

As Huggett (2012a) pointed out, studies and researchers who make use of Grey Literature and Legacy Data are frequently influenced and limited by previous implicit theoretical frameworks and by inherited flaws in the data. Hence, working with Legacy Data is done at the risk of unintentionally replicating those frameworks and flaws, shaping our knowledge of the past (Huggett, 2012a, p. 543). Such a problem challenges the idea and practicality of reusing data (Huggett, 2018). Therefore, at least as an ethical stance, it is interesting to question how different "standards" or theoretical frameworks might have influenced and biased this project.

As stated above, my approach is twofold: quantitative and hermeneutic. Eventually, this section aims to show how both things are embedded in the process of knowledge production. In many fields, hermeneutics are widely recognised as useful – mainly because interpretation is always in play (Zimmermann, 2015). It might be useful to clarify what I mean with hermeneutics before going into more detail.

The short answer is to say that with hermeneutics I mean "interpretation" -in so far as it refers to the understanding of texts, signs, situations, etc. (Zimmerman, 2015, p 1). In effect, hermeneutics does not only refer to the mere application of some rules to seek sense out of texts; it stands for the interpretative process of grasping the meaning of something -which goes beyond rules application (*ibid*; Johnsen and Olsen, 1992 reached a similar view after considering late hermeneutics' rejection of equating hermeneutics as a simple method). For our purpose here, I have excluded the philosophical definition of hermeneutics as "understanding the circumstances that allow for the event of understanding" (*ibid*) I am,

however, not negating that our present affects (shapes) the way we grasp the past -it does (Johnsen and Olsen, 1992).

Hermeneutics makes us aware of our limitations because we do create knowledge out of our own mental approaches. Furthermore, each person is always influenced by others (*ibid*, pp. 9-10). Zimmermann also refers to hermeneutics as the foundation of deep knowledge, because it integrates facts into a meaningful whole. The notion of hermeneutics, thus, collides with the meaning-making process in the Age of Information:

> Our modern culture tends to think that the real knowledge consists in quantification, that is, in the scientific numerical description of things in the world (Zimmermann, 2015, p. 8).

As I will show in the following lines, hermeneutics are necessary if we are to grasp real knowledge. Indeed, the previous sections of this chapter should have shown how our ontology breaks with the idea of accumulating data for the sake of it in order to understand grand narratives. Rather, the ontology integrates multiple datasets only after reflecting on the meaning beyond them. Hence, hermeneutics connects us with DataARC inasmuch as both propose interpreting and understanding facts as the first step for creating knowledge.

Interpreting Archaeological reports is not always easy due to their nature: dry, technical, and dull. However, some interpretations can be made based on their content. In so far as this can be done, some sort of insight might arise; although that level of interpretation is less profound. For our case, however, it is more useful to bring in other texts connected to the archaeological reports, namely: NABO community's documents wherein they explain their main research goals. Using these kinds of texts hugely facilitates our research, because they express explicitly some of their overarching aims.

Understanding the standpoint of NABO's community it is not too difficult once it is understood that the cooperative works towards very concrete and clear goals (e.g. NABO Report, 2007). As section 1.3 shows, this cooperative has a very clear position regarding its main research points (McGovern, 2014, p. 214):

a. Human impact on island ecosystems and the long-term result of intentional and unanticipated results of settlements.

b. Climate change impacts on humans, domestic plants and animals, key wild resources, and culturally modified landscapes and seascapes.

c. Local and regional-scale interactions of human economies, markets, and proto-world system interaction webs.

Without forgetting the importance of giving space to multivocality: Local Traditional Knowledge and outreach are also fundamental. Indeed, LTK is sought to be integrated into the rest of the projects (McGovern, 2014) -posing new challenges on how to integrate it in the digital world (e.g. ontologies). As for outreach, NABO has been implementing courses with the main focus on rural children, aiming the education and participation of local people on different ecological and heritage activities for the sake of their empowerment. Beyond empowerment, they sought to create long-stable partnerships and local stewardship (McGovern, 2011 and 2014, Maher and Harrison, 2014). This insight into their main areas of research offers a common vision. Although being an extensive organisation, with members from different fields of expertise, their goals are quite defined and bounded to some key questions. Therefore, it might be agreed that the different members of this cooperative works towards the same goals. As such, it is a collective mind with a clear standing point.

Beside this, the cooperative may well be regarded as one that has set the research agenda for the North Atlantic towards new questions in accordance with the challenges of the 21st century:

> Viking Age North Atlantic settlers and their medieval descendants have become actors and case studies in a new set of controversies about the complex dynamic of human intention, variability in the natural world, and often unexpected intersection between short term events in the grand processes of the *long durée* (McGovern, 2011, p. 291).

An agenda which has brilliantly been shaping and changing our understanding of the North Atlantic during the Viking, Late Medieval, and Modern periods:

> Research since 2000 has transformed our scientific understanding of the processes […of] long term human ecodynamics […in light of this…] Diamond's account now appears not so much wrong as overly simple (McGovern, 2011, p. 292).

Now, with new studies and an ecological crisis prone to pose new dangerous challenges, NABO and similar initiatives (IHOPE, HfE), sought to renew and reinvigorate the North Atlantic research by fully integrating environmental humanities and social sciences within the studies of global environmental-change (Hartman, Ogilvie, Ingimundarson, *et al.* 2018). In other words, they seek to integrate Human Ecodynamics into the broader field of

environmental studies. The reason for that, simple as it may be seen, has been ignored by the scientific community for many decades, but it is of especial importance:

> Threats both from nature and human interactions with the environment have been experienced throughout history. A long term perspective enables us to explore how the impacts of realized threats may have played out over the years and decades following notable, system-affecting events. By more thoroughly exploring the relationships between the nature (and scale) of threats and their consequences for human societies, we may achieve a better understanding of how human communities can become vulnerable or resistant, or how people at various scales within these societies may cope with threats or be overwhelmed by them. (Hartman, Ogilvie, Ingimundarson, *et al*. 2018, p. 124).

This is to say that the understanding of coupling human-nature systems might lead us to better understand the dynamics driven by the agency of both. Moreover, they advocate that knowing how people in the past coped with climatic crisis, and seeking sustainability and resilience in the past, will inform us and enhance our responses to natural threats. One of the assets of this agenda is the integration of a long-term historical perspective, instead of insisting on a research centred on more recent events. Another important point here is the stress on a synthetic view between different fields -making the research agenda to evolve from the perspectives held 15/20 years ago, towards:

> One viable model of research organization and execution that can serve to close gaps in knowledge, make accessible new or otherwise unused data and generate new understanding concerning responses to threats of the New Human Condition through a combination of empirical and deductive methods. (Hartman, Ogilvie, Ingimundarson, *et al*. 2018, p. 135).

The integrated approach proposed means the use of multiple specialised fields of knowledge within a transdisciplinary framework (Hartman, Ogilvie, Ingimundarson, *et al.* 2018). Transdisciplinary means the integration of new and old data, methodologies, and tools drawn from social and natural sciences, and humanities. Additionally, as remarked by the quote above, the perspective also prioritises Open Data. The latter aspect urges us to consider how to enhance data processing-presentation. On the other hand, this agenda forces us to consider the implications of their previous data-treatment for achieving its aims -as it is done below.

We cannot ignore the fact that NABO has shaped this agenda in as much as the agenda has shaped the approaches and aims of NABO. As one of its main founders says, NABO, along with other projects and researches, have sought to "combine disciplinary strengths, new analytical approaches, enhanced digital resources, and new data from archive, field site, and laboratory in order to make the past record of human interaction with landscape, seascape, resources, weather, time and fate more useful to modern peoples attempting to cope with rapid social, economic, and environmental change." (McGovern, 2011, p. 291). Therefore, NABO's main aim is to use new and old data through multiple cutting-edge approaches to understand past Human Ecodynamics and use this knowledge in our current context of ecological crisis. Fundamental to this, as well as for avoiding oversimplifications, is the creation of good-quality data, interpretation and integration within multiple datasets (McGovern, 2011; Maher and Harrison, 2014; Hartman, Ogilvie, Ingimundarson, *et al.* 2018). As highlighted in section 1.4, that was the main reason behind the creation of DataARC. To contextualize this development, I reflect on how well they had been approaching these aims before the project's inception.

To this end, I draw upon some statistics from the concepts used to include the archaeological dataset within the general ontology. This procedure might give us an idea of what were the main questions in the mind of the archaeologists who dug the archaeological site. It also sheds light into the way these archaeologists approached fieldwork practices, and how they built up knowledge. As part of the thought experiment, I include some new concepts which I created to expand the general ontology. This might indicate us if there is some contrast between my approach and the archaeologists' procedure.

The first image (Fig. 12) shows a pie chart with a selection of 42 concepts which I make use of for integrating the dataset. It combines terms which were in use before my project (e.g. midden, horse, cattle, sheep) and others created by me (e.g. *Landnám*, structures, ash). In the Appendix you can find a table with the data used for creating the statistics. Overall, this selection includes more terms that were already created than *ex novo*. The latter is done as a representation of the reality: my project makes use primarily of concepts that were already in the ontology.

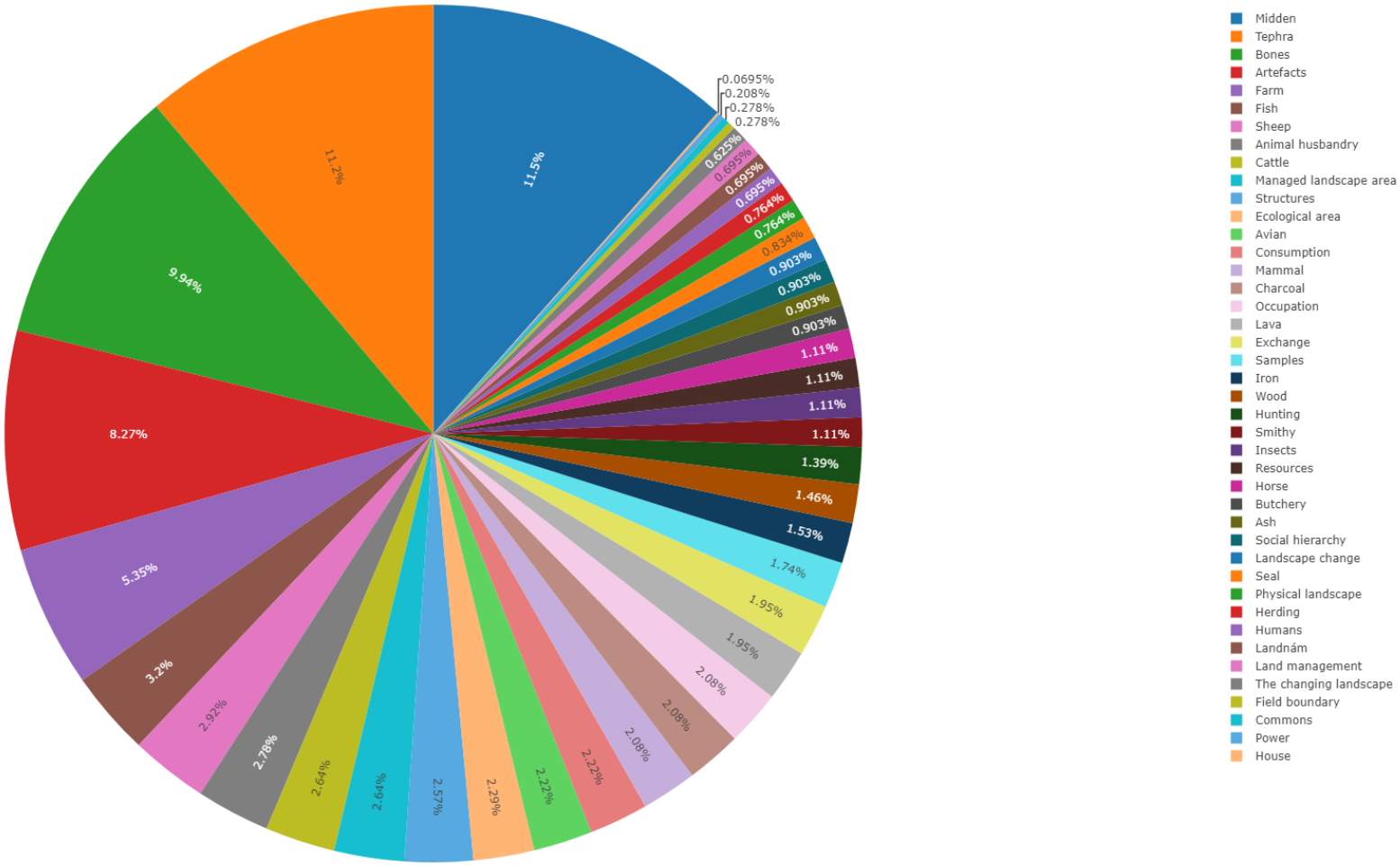



Figure 12. Pie chart showing the appearance frequency of a selection of 42 terms. This selection has been taken from the concepts I used for creating my own dataset. Note the contrast in the percentage of appearances between different concepts. The column with the terms is ordered from highest to lowest percentage. Created using RStudio.

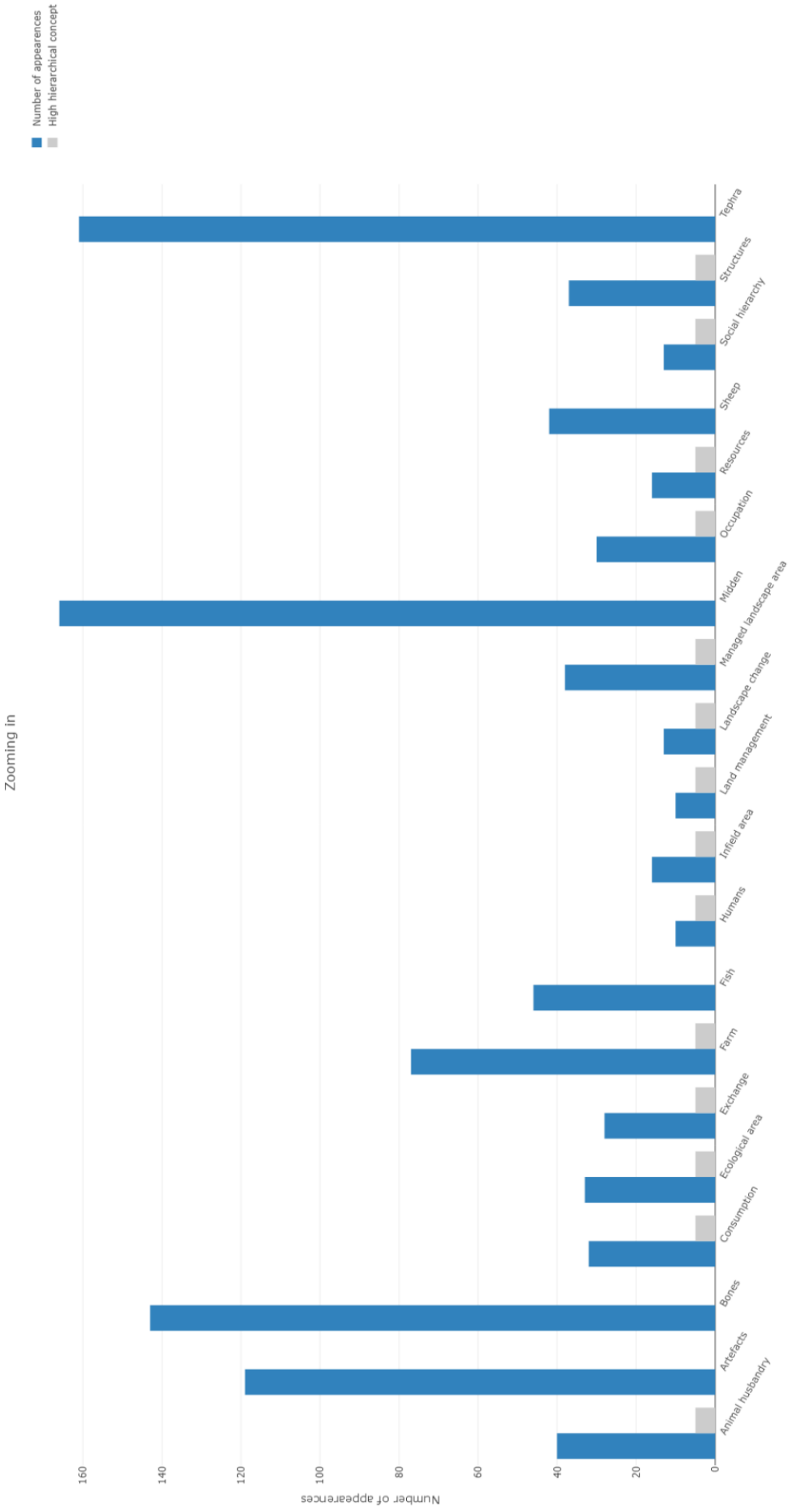



Figure 13. Zooming in the previous selection. The blue column represents the number of appearances of these concepts. The second, grey, column appears in those terms which are of a high hierarchical order. Created using RStudio.

Going into the nuts and bolts of the image, the first impression is a huge contrast between

some few terms that repeat themselves many times and a great percentage of the 42 concepts that rarely appear. Just considering the 4 most repeated concepts (midden, tephra, bones, and artefacts), they cover more than 40% (40.91%) of the chart. This is surprising if we consider that all of them refers to low hierarchical levels within the ontology. In contrast, high concepts such as farm, social hierarchy, humans or consumption do not frequently appear. No doubt, this is a good representation of the archaeological report's schemata where artefactual, zooarchaeological, and geoarchaeological data appears more often. Arguably, this reflects fieldwork practices beyond that: low level concepts are closets to the data they retrieve from excavations. And here is the problem: so often, excavators do not make the leap of mapping to high level concepts from the primary data they have. Consequently, they favour the creation of some specific narratives -more focused on small details-, which *a priori* makes difficult the conclusion of grand narratives. Before arriving to further conclusions, it is possible to zoom in using the second image (Fig. 13).

Fig. 13 shows a selection of conceptus included in figure 12. Here I stress a contrast between old and new concepts: while the old ones appear frequently, representing concepts working at the low hierarchical levels in the ontology, the new ones function in the opposite direction. This is to say that most of the newly created concepts belong to higher hierarchical levels. This does not mean that new concepts do not refer to low level concepts: as already mentioned, "Artefacts", and even some concepts that are below it in the hierarchy (iron, for example), were introduced by me. In our ontology, this is important because the introduction of high-level concepts aids us in mapping data to the complex narratives they refer to. On the other hand, the introduction of new low-level concepts is fundamental in connecting the reports to the general ontology.

Three key points emerge from this discussion. First, this exercise appears useful for better expressing the ideas and data contained in the archaeological reports: small bits of information, mainly related to the recovery of zooarchaeological, geoarchaeological, and artefactual data.

Second, this is an ethnographic account of how fieldwork is done: excavation of middens, micro-landscape analysis, and recovery of small fragments of knowledge govern the archaeological investigations. Their results are expressed in the reports, albeit in a dull, disorganised manner which makes difficult the backing up of grand narratives. Moreover, this gives us some insights into the implicit theoretical frameworks of the archaeologists: the special focus on some themes (zoo-/geoarchaeology), plus artefacts recovery, demonstrates their special focus on the economic daily-life of the Vikings and their descendants who lived

in a specific place, and how they affected and were affected by some environmental factors. However, it leaves aside questions related to social hierarchy, power construction, life beyond the nearest farm-field, and other ecological factors -all of which are fundamental for fully understanding Human Ecodynamics.

Finally, the ethnographic reflection is useful for showing how my project is deeply embedded in previous theoretical and methodological frameworks. No doubt, this limited the scope of how I integrated this dataset within the others used in DataARC's ontology. However, at the same time, this exercise shows how the introduction of new concepts, some of them contrary in hierarchical nature to the majority of concepts used by these reports, enhances the variability and visibility of different aspects contained in them. This was not a deliberate action after considering which things prioritise the archaeological data -it was just my intuition. However, for future work, it might be useful to deploy an ethnographic analysis before attempting to create the final version of the concepts to be used.

What can we conclude from this review? The agenda is set. Its outcomes (visible in Hartman, Ogilvie, Ingimundarson, *et al.* 2018, for example) might have the potential of transforming the way we research in various ways. The developers of this framework explicitly signals its potentiality for recalibrating "the prevailing scientific assessment model, including a widening of the community of participating scholars and scientists [something that should lead us to] a new understanding of the kinds of knowledge that must be inventoried in any assessment of the earth system" (Hartman, Ogilvie, Ingimundarson, *et al.* 2018, p. 135). Moreover, the outcomes may shed light into the pressing problems faced by human-nature-kind within the Earth system. However, this exciting assessment might achieve nothing if some issues are forgotten. Without considering how we have been researching, that is, to identify good practice and what must change for the better, it is impossible to enhance our work. In other words, an irreflexive forward-looking movement will make it impossible to meet expectations.

In this case, I have demonstrated how certain theoretical frameworks bias our approach, sometimes zooming in too much into some topics, forgetting others. This situation becomes more tortuous with the way archaeological reports are written; that is, without considering their real importance and complexity. Changing this towards better standards or connecting in new ways old data, as DataARC proposes, might influence and help the new agenda to achieve and deploy all its potential. Otherwise, we might all fail in the same way we have been doing up until now. In addition, this change is an ethical issue which can influence the way outreach is done.

### 3.4 Connecting datasets

So far, I have accomplished the connection of the archaeological reports' data to the DataARC's ontology. Now it is important to give some thought to how to better connect this dataset with others used in the ontology. Although some projects -such as ARIADNE- try to connect multiple datasets, there is no standard procedure here either. For me, I argue, this is not a great problem because our ontology is vastly different in comparison to others. The relationships between datasets are normally defined following linear reasoning: this coin is similar in context, time, and image to X other; therefore, there must be a linkage between both.

On the contrary, our ontology does not follow this simpler reasoning. What matters is not the data's superficial information but their content. This it is not a trivial issue. I argue that linking datasets using concepts which will cross-map them is important not only for interoperability. Further, this procedure connects different domains of reality regarding HE. In my opinion, the most reasonable standard for doing so is by using the same concept used in different datasets, so that it can refer to the same or a similar reality. With this, we achieve cross-mappings (interoperability) and, more important, the connection of similar ontic dynamics occurring in HE.

I do not consider essential the use of diverse hierarchical concepts for connecting my data with each of the others, but it has been tried where possible in an attempt of achieving variability. On the other hand, I deemed necessary to use few of the concepts in this process for the sake of easiness and interoperability (there is a table with the concepts used at the end of the chapter). To my knowledge, my dataset can be linked to three other datasets: *Jarðabókin*, Tephrabase, and the numerical data from the same archaeological reports (which have also been treated separately).

- ***Jarðabókin***

*Jarðabókin* is a project led by Gísli Pálsson (Pálsson, 2017, 2018) whose final product is a cybertool (http://www.jardabok.com/). This resource models and represents all the information contained in *Jarðabók*, a Modern period complete census -probably the most important for Iceland. The nature of the document, an administrative record that covers habitational, demographic, and socioeconomic information, guides how my dataset should be connected to this one. However, it is quite difficult to find a concept capable of directly

connecting all the information carried by this document. For this reason, I created a new concept which is the homonymous of the written source, “Jarðabók”. The reason for this, beyond the importance of this document for the entire North Atlantic region, is because it directly connects both datasets in the ontology. Albeit being a low-level concept, it communicates/represents information regarding geographical properties (e.g. the position or effective occupation/abandonment of farms, shieling huts, etc.) Further, in our mapping using CIDOC is an important term for carrying information regarding written sources, settlement stories or demographic change.

Besides “Jarðabók”, several other concepts are used:

- Humans, because they are the main actor behind the document.
- Farm, because it is the main habitational unit considered.
- Infield area, because it is the main productive place.
- Ecological area. Although not of real importance in the written document, it might be important if combined with archaeological data.
- Church farm, given its role in the census.
- Ecclesiastical power and Government, because they are the main agents here.
- Occupation, because the census gives an overall good insight into the settlement story.
- Built environment, because it is a concept that can encompass many other concepts related to settlements and habitation.
- Social hierarchy and power, because the document is an account of both things.
- Managed landscape area and woodland management as terms which express human mentality towards the environment.

- **Tephrabase**

This web resource (https://www.tephrabase.org/) is a database created by Anthony Newton (University of Edinburgh) which mainly contains information related to tephra layers research. Tephra layers refer to those soil layers formed after volcanic activity (eruptions), when the fallen ash is sedimented. Although its main information for Archaeology is of a chronological nature, it also yields information regarding environmental changes and events.

The latter aspect is the chosen one here for interconnecting both datasets. Concretely, I have chosen 6 terms:

1) Tephra, because it is the main concept and appears in both datasets
2) Ash, because it is an important ecological concept for understanding HE (volcanic activity)
3) Ecological area, because volcanic events have an impact on the environment.
4) Built environment, because volcanic activity might influence (and therefore link information regarding) events of occupation or abandonment.
5) Land degradation, because blasts have a negative impact on the landscape. Additionally, a decay in land intensification might be a proxy if associated with farm abandonment due to a volcanic event.
6) Paleoclimatic model, because some traumatic volcanic events influence the climate.

- **Numeric data from the archaeological reports**

These data are the charts and tables from the archaeological reports. DataARC has treated these data from two different perspectives: mine, which integrates them within the rest of the data from the reports; and another approach which disentangles the data from the rest. Both approaches are valid and complementary because they offer two visions: one integrated with their interpretations and the other respecting the information yielded by this data isolated from interpretation.

In my case, I used the ontological value the data possess: low hierarchical connections of multiple aspects, from ecological to economic. The reasons for using these concepts are because they are the most repeated terms to which the data make references, or because they connect activities with small materials recovered during excavations. Further, they are important proxies that appears in both datasets. The concepts are:

- ❖ Artefacts.
- ❖ Crafting.
- ❖ Iron.
- ❖ Bones.

- Samples.
- Sheep.
- Cattle.
- Mammals.
- Avian.
- Insects.
- Fish.
- Midden.

As can be seen, these data carry multiple information types; but it is not knowledge on its own. Hence, it only achieves meaning after interpreting the meaning behind them.

| **Concepts used for interlinking datasets** | | |
|---|---|---|
| Jarðabókin | Tephradatabase | Numerical data from the arch. Reports |
| Jarðabók | Tephra | Artefacts |
| Humans | Ash | Crafting |
| Farm | Ecological area | Iron |
| Infield area | Built environment | Bones |
| Ecological area | Land degradation | Samples |
| Curch Farm | Paleoclimatic model | Sheep |
| Ecclesiastical power | | Cattle |
| Occupation | | Mammals |
| Built environment | | Avian |
| Social hierarchy | | Insects |
| Power | | Fish |
| Managed landscape area | | Midden |
| Woodland management | | |
| Government | | |
| Exchange | | |

Chart 1. Concepts used in the process of linking multiple datasets in DataARC's ontology

| Concept | E24 | E30 | E74 | P101 | E39 | E25 | E53 | E94 | P45 | P89 | P122 | P101 | P172 | P75 | E12 | E11 | P104 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jarðabók | X | X | X | X | | | | | | | | | | | | | |
| Humans | | | X | | X | | | | | | | | | | | | |
| Farm | X | X | X | | X | X | X | X | | | | | | | | | |
| Infield area | X | X | X | | X | X | X | X | | X | X | X | | | X | X | |
| Ecological area | | | | | | | X | X | X | | | | X | | | | |
| Church farm | X | X | X | | X | X | X | X | | | | | | | | | |
| Ecclesiastical power | | X | X | | X | | | | | | | | | | | | |
| Occupation | X | X | | | X | | X | X | | | | | | X | | | |
| Built environment | | | X | | X | X | X | X | X | | | | | | | | |
| Social hierarchy | | X | X | | | | | | | | | | | | | | |
| Power | | X | X | | X | | | | | | | | | X | | | |
| Managed Landscape Area | X | | | | X | X | X | X | X | | | X | | | X | X | |
| Woodland management | | X | | | X | | | | | | | X | | X | X | | X |
| Government | | X | X | | X | | X | | | | | X | | | | | |
| Exchange | | X | | | X | | | | X | | | | | | X | | |
| Tephra | | | | | | | | | X | | | | | | | | |
| Ash | | | | | | | | | X | | | | | | | | |
| Land degradation | X | | X | | X | X | X | X | | | | | | | | | X |
| Paleoclimatic model | | | | | X | | X | | X | | | | | | | | X |
| Artefacts | X | | X | | | X | | | X | | | | | | X | | |
| Crafting | X | | X | | | X | | | X | | | | | | X | | |
| Iron | X | | X | | | X | | | X | | | | | | X | | |
| Bones | X | | X | | | X | | | X | | | | | | X | | |
| Samples | | | | | X | | X | | X | | | X | | | | | |
| Sheep | | X | | | | | | | | | | X | | | X | | |
| Cattle | | X | | | | | | | | | | X | | | X | | |
| Mammals | | X | | | | | | | | | | X | | | X | | |
| Avian | | X | | | | | | | | | | X | | | X | | |
| Insects | | | | | | | | | | | | | | | | | |
| Fish | | X | | | | | | | | | | X | | | X | | |
| Midden | X | | | X | X | X | X | X | X | | | | | | X | | |

Chart 2. It shows the concepts of Chart 1 and some linkages from the CIDOC CRM framework that might be used for mapping and interlinking these bits of data. As can be observed, many can be linked multiple times to different concepts by making use of diverse links. In order of appearance: E24 Physical Man-Made Thing; E30 Right; E74 Group; P101 had as general use (was use of); E39 Actor; E25 Man-Made Feature; E53 Place; E94 Space Primitive; P45 consists of (is incorporated in); P89 falls within (contains); P122 borders with; P101 had as general use (was use of); P172 contains; P75 possesses (is possessed by); E12 Production; E11 Modification; P104 is subject to (applies to). “E” denotes “entity” whilst “P” equates to “property” (of).

# Chapter 4: Reflecting on the results

This chapter reflects on the process and outcomes of this project. Has this methodology replicated some of the previous issues of Digital Archaeology? Has our theory-driven approach changed this project's outcomes? Have we helped in the creation or articulation of new meaningful knowledge?

## 4.1 Data-dumping or new meanings?

It is now my aim to reflect on the value and lessons learned emerging from this project. I begin by addressing the biggest and most important issue concerning computational ontologies. Throughout this thesis (Chapter I and 3), I have shown many of the critiques and problematics posed by Grey Literature, Legacy Data, Open Data, and many existent ontologies. In Chapter 2, I have also explained how data issues affect society and outreach activities. In sum, these problems can be encompassed under the banner of unconnected data, fragmented knowledge, and absence of meaningful narratives. For the case of computational ontologies, some of these problems are "resolved" by connecting data. This procedure, however, has generated criticism for not offering meaningful narratives; what it is more, they seem to disembody meaning and narrative by prioritising specific data (Huggett, 2012a, 2015a and b). Expressed in other words: albeit ontologies are an evolution of traditional databases, they normally do not overcome being data-dumping cyber-tools in a world of Big Data.

The methodology explained in the previous chapter tried to expound how to overcome that issue. To my knowledge, one of the fundamental errors in many ontologies is the way they are conceived and developed: only to link data in a *soft* relational manner (see Chapter 3 for understanding *soft*). On the contrary, our ontology was developed for aiding in understanding Human Ecodynamics by linking low-level data with high-level concepts. As I have highlighted in 2.1.2, HE is a rather abstract and high concept-*paradigm* which entails broad implications and actors. This forces us to first reflect upon the implications of ANT and on abstract theoretical-ontological interrelationships between or among beings, things, etc. This supposes the consideration of how different human/non-human actors have subtle connections in a broad scope, on a set place, during a long-time scale. Only afterwards, the computational ontology can be designed.

Another aspect which differentiates our ontology in contrast to others is the way our concepts were created. Recalling other approaches, these ontologies are normally designed in accordance with the data and datasets the projects have. In so doing, the potential of this

digital tool is undermined at the expense of following datasets' rationale. For example, many ontologies (Gruel, Tricoche and Charnotet, 2015; Gruber and Smith, 2015; Caltabiano, Puglisi, Celesti and Salamone, 2015; Gerth, Beck, Schmidle and Cuy, 2018; Gruber, 2018) are designed in accordance to what it is apprehended at first glance: materials, figure, value, place, time, etc. At their best, some can add a logic of uncertainty (Tolle and Wigg-Wolf, 2015) but they are relegated once again to shallow and short-sight reasonings. DataARC's ontology, in contrast, proposes the inverse path (Pálsson and Opitz, 2019): theoretical-ontological concepts related to Human Ecodynamics are first thought following a criterion of "level adjustment" (shallowness versus deepness). Therefore, the data and datasets in use are modelled to fit the concepts -contrary to the other way. As a consequence, the ontology prioritises abstract reasoning, exploiting computational ontologies' deep-learning capability.

Both things, prioritising high abstraction-representations and adapting datasets to designed concepts, change radically our ontology from many others previously developed. Problems with previous ontologies were, amongst others, limitations to knowledge representation and data shadowing by another kind of data. Yet, this project has shown how high knowledge modelling can be deployed without risking data representativeness.

Moreover, previous problems posed a greater issue; namely, a lack of narrative which prevents from backing up broad understandings of historical, anthropological, ecological, etc. inference. The reason behind this lies at previous visions regarding the service a computational ontology was designed for. In effect, should the representation be adjusted to express *soft* and shallow relationality, the tool is unable of narratively expressing a complex message. On the contrary, however, ontologies can deploy complex narratives. It is useful to take an example from DataARC's ontology. Following the reasoning of "if querying in the ontology X concept, I might get Y related concept":

- Farm→land management→field boundary
- Farm→improved land→managed landscape area[6]
- Farm→family→land management
- Managed landscape area→resources→butchery
- Managed landscape area→animal→food

[6] Red denotes a link which is not already in the ontology but that will be added thanks to this thesis' work. In this case, the relation would be the act of dumping a landscape for improving the soil capability -which is a process for improving the land.

Another further developed examples can be found in the previous chapter. In all the cases, there is a complex narrative told by the ontology. The basic message is how humans and non-humans have interrelationships; both "agents" modify and are modified through their agency. That is not surprising at all, though. What it is new here is how this is express by linking data, instead of creating a broad statement about HE without showing in a clear and simpler way the data. In the first case (*supra cit.*), for example, we might understand how a farm's household (human) can modify the biotic entities (non-humans) of a landscape through the creation of a field boundary (made of non-human components but designed and created by humans). In the last case, one might understand how humans decided to modify the landscape using animals' agency; animals which later will be consumed by humans using their own agency too. These interlinkages are better communicated by retrieving, in this case, the fragments of a specific archaeological report which explain such complex processes.

What do these examples mean? A brief answer would be that our ontology is more than a mere database evolution, allowing us to back up, if not to create, broad narratives of ecological, archaeo-historical and anthropological nature. Our ontology is not simply designed for storing, sorting and retrieving data. Importantly, this is not to say that gathering data was not one of our aims; but I claim that we are not dumping our data "out of the blue". Falling into the data-dumping trap would have been an exercise in futility if we were to understand Human Ecodynamics or akin complex dynamics. In reality, we can create complex narratives that address HE in an easy, relational, manner. Therefore, our ontology creates new meanings from loose archaeological reports. To that extent, ontologies can be deemed as a cognitive artefact or apparatus (Huggett, 2017). DataARC's ontology, therefore, allows us for creating new narratives concerning a fundamental ontological condition, namely: humans and non-humans have agency; they interact with each other in an ever-shifting *state of affairs*, in dynamics that can be encompass in what we call Human Ecodynamics.

## 4.2 Challenging the perspective

The possibility of creating an ontology that enhances our understanding of HE was possible only after examining some of the problems posed by our practices and outcomes. For the case of the archaeological reports, it was important to admit that the problem was not minutiae. Indeed, many NABO and DataARC members are aware of some of the issues entailed by the writing practice so far -and to some extent this justifies DataARC. As I have

shown in Chapter I, pinpointing how misleading our reports are and how they fail in expressing the details contained by them is not new. The creative turn (see, for example, Hodder, 1989; Boivin, 1997; Bealley and Reilly, 2017), although compelling, interesting and necessary, is not enough. The problem is not just reports' dullness or overspecialisation (albeit both things are criticised here). A transformation of how we approach to the act of presenting knowledge is necessary. Moreover, my project points out that the problem is far beyond the creativity of writing: it lies in data and how we think about it.

My main concern is, therefore, of much profound signification: it regards how the bits of data-information-knowledge are articulated within these reports. In other words, my main concern draws attention to how archaeologists articulate what they have to write -say, data or knowledge. Archaeologists are normally so embedded in the process-making of archaeological reports that an absence of critical reasoning of their praxis is commonplace. Consequently, reports are misleading, fragmenting data/information/knowledge here and there without a concrete criterion. This was the case of the reports used in this project, as is the case of many others. Moreover, this issue makes these documents to lose their purpose: communicating and preserving the vanishing archaeological record. It might be argued that the data transformed in information which is later used for creating knowledge -a small ontology in itself- is within the report's pages. However, I argue that this is not the case: the message to be said (archaeological knowledge) relies upon how the message is coded into some sort of linguistic rules which expresses it (how well the report is written). Therefore, a dubious communication of knowledge/data risks its effective preservation and communication.

This discussion connects us with a broader area of concern in the archaeological discourse: why do we write archaeological reports? Just to preserve what we have found in the archaeological reports while using specific techniques? Is this process done and thought just with the sole purpose of communicating our findings to academic fellows and peers? Of course not. I align myself with the agenda of "engagement", against the idea of the academic isolated from the world in its ivory tower (McGovern, 2011; Brophy *et al.* 2012; Martín Civantos y Bonet García, 2015; Moshenska *et al*. 2017; Brophy, 2018; Criado-Boado, 2018; Milek, 2018; González-Ruibal, Alonso González and Criado-Boado, 2018). Our job is social (Malpica Cuello, 2003, p. 33) -and so must be its outcomes (Martín Civantos, 2007a, 2018; Martín Civantos y Delgado Anés, 2016; Moshenska, 2017). We, as *actants*, have an ethical responsibility towards society. This connects quite good with Public Archaeology, and as far as it concerns the wired world, with Public Digital Archaeology (Bonacchi and

Moshenska, 2015). Narrowing down now the topic to the issue of writing archaeology, two main conclusions are self-evident:

- The realisation that we must do our job and its outcomes -in this case, archaeological reports- with society in mind. This is to recognise that what we do have an effect on society that must be accepted along ethical lines.
- If the above is to be achieved, we must think about how to better articulate archaeological reports.

I sought to expand the last point by taking a couple of further considerations. Hodder (1989) argued that data is not "self-evident", and he asked for explicating the context in which the data were recorded. In our 3.0 world, that equates to provide meta- and paradata (Huggett, 2012c). However, as I said in 1.2.3, this does not resolve the problem of expliciting interlinkages between data. Hodder (1997) goes on by arguing in favour of reflexivity, interpretation, and multivocality instead of dry, closed, and depersonalised reports (Hodder, 1997, p. 699). And he poses some rhetorical questions:

> Where does one draw the line between those within and without the 'team'? Is there a need to draw a line? Is not the better solution to make the line as permeable as possible while being responsible to the protection of certain rights? Is it not better to accept openly that even in the construction of archaeological data, interpretation is required? (Hodder, 1997, p. 700).

Although Hodder's text strictly referred to excavation methodology, I argue that its propositions are equally valuable and applicable to archaeological reports. That would mean to write (and recognise) different interpretations, from within and outside the "team" -should those interpretations be valid for that purpose. Equally, it means the joining of sections and text from closely related interpretations, joining field and lab interpretations. Moreover, a self-reflexive and critical view of archaeological reports must lead to the breakdown of sections which divide data from interpretation. The latter, however, can be resolved by following some new digital archaeological reports standards (see Clarke, 2016; Sullivan and Snyder, 2017; Luzón and Alonso, 2017 [dianaarcaizante.com]; and specially Opitz, 2018a). This step is not too far from where we are now. Indeed, new technologies and their introduction in the excavation process, aid us in heading towards new digital formats and media (Shipman, 2005; Opitz and Johnson, 2015; Breggren, Dell'Unto, Forte *et al.* 2015; Romero Pellitero and Martín Civantos, 2017; Romero Pellitero, Delgado Anés and Martín

Civantos, 2018). The introduction of new (digital) techniques might resolve some of the essential and underlying issues in our practice.

I do believe, however, that the problem regards not only the technological sphere. The introduction of new techniques for the sake of it means nothing. Not understanding why we do what we do may indeed have the contrary impact to the desired one. A technological deluge does not resolve our problems; it is counterproductive. For this reason, Opitz (2018b) suggests to first think the reasons for introducing technologies by resolving the following inquiries:

- Who are our audiences?
- What are the differences between how write and present information and narratives for a scholarly audience, the web public and museum visitors?

Responding to these questions is useful, and influenced the way my project was carried out. Although the questions might seem quite shallow, they are not: yes, many would agree that the audience is not just your academic neighbour; but the general public is not a static image. On the contrary, different places, countries and cultural costumes can modify the way we approach our audiences. And so does the way we chose to represent knowledge. It is not the same to publish our outcomes as a computational ontology than as a report. The same is true for traditional archaeological reports versus digital reports. In our ontology, for example, the potential users can be:

A) Scholars working in the North Atlantic;

B) Ecologists whose main region of expertise is, for example, the Sahel;

C) A student starting her/his BA degree;

D) Or an average person from outside the academy wishing to know if Vikings raided their environment as they did with Christian monasteries.

That influenced how user-friendly the ontology should be. Equally, the ontology must be designed for allowing multivocality and multiple interpretations -which, to some extent, justifies a fluid hierarchy. No doubt, an ontology might be more difficult to understand than a good archaeological report. However, this is not the case for some of NABO's reports. In contrast, however, an ontology facilitates the way different datasets are interlinked between them. Therefore, an ontology might answer the need of making explicit how different data

have interrelationships with other data. In any case, it forces us to rethink how we approach the act of writing reports.

All the above can be summarised as a critical reflection on how we record, interpret, and express data in archaeological reports. This project, indeed, demonstrates how different data/knowledge is entangled and interlinked in multiple ways. This multiplicity of visions and interlinks are nonetheless diminished by the way archaeological reports are written. The issue is burgeoning due to an increasing amount of grey and new literature which follow old standards. It is also pressing our ethical responsibility towards our peers and the rest of the public. This thesis, therefore, makes the case for changing our mindset and practice as reports writers. In other words, the project, along with others, challenges the way we express our outcomes. If we are to resolve our professional and ethical problems, then we are forced to think not only at the trowel's edge (Hodder, 1997; Shipman, 2005; Breggren, Dell'Unto, Forte *et al.* 2015) but also at the user's edge (Opitz and Johnson, 2015). This might be the only way forward to change our problematic *ethos* as *actants*.

## 4.3 Enhancing archaeo-historical knowledge framed into Human Ecodynamics

I have mentioned above (4.1) that ontologies can be described as digital-cognitive apparatuses. This is true as long as they are human-made digital objects employed for complementing us in cognitive tasks -and which are able to represent, store, retrieve and manipulate information (Huggett, 2017). Is this even true for our case? The answer is self-evident: yes, our ontology complements, if not expand, our cognition in understanding what is at stake in a multiplicity of cases which involves Human Ecodynamics.

The ontology complements us in the way it processes the datasets. I am not referring only to high-speed time processing -which, of course, is important and true. Rather, here it is important to understand that the ontology complements our cognition in how it articulates different datasets. The latter is fruit of a human group with different expertise, working altogether through a common goal: the development of a computational ontology capable of representing Human Ecodynamics (Pálsson and Opitz, 2019). Therefore, an ontology, our ontology, might be seen as a collective mind.

At this point, it is interesting to questioning if it is better to use the word "complement" or "extend". I cannot but agree with Huggett (2017) in choosing the latter. It is true that ontologies are human-made, not self-aware of -indeed, dispossessed from- any sort of

independent cognition. Yet, as a collective mind, they expand our isolated human mind by using the multiple knowledge contained in them. For example, the DataARC's ontology is capable of interlinking my archaeological dataset with Tephrabase's dataset in a different manner than the reader of an archaeological report is able to. Not only because our tool connects multiple data in a matter of seconds -whereas a reader must take time reading, thinking, and searching in Tephrabase. But also, because the interlinkages generated by the ontology are quite unique inasmuch as they are fruit of a collective mind which has taken time and great knowledge in creating that interrelationship. A person, alone, might not do the same after years of work and communication with different experts.

Another example might be that of the landscape. Archaeologists/historians, etc. are aware of the fact that a landscape is the result of an interrelationship between humans/non-humans. However, most of the time, due to specialisation, funding or other constraints, we tend to focus just on one side of the story (in humans). The same is true for ecologists and alike whose focus is greater on other non-human agents. Although sometimes we are reluctant to accept our limitations, we have to give the devil his due and assume that an isolated human mind, specialised and skilful in some topics, might not interlink multiple data as accurately as an ontology does. Going back to the landscape, this means that landscape archaeologists are normally unable to accurately understand the whole implications and phenomena to be included in their studies. By contrast, an ontology makes clear the underlying interconnections at play in different landscapes. This, for example, can be seen in the different examples described in chapter 3 (e.g. 3.2.4): the same concept -a midden- can be mapped to other data through multiple combinators (Pálsson and Opitz, 2019, p. 145). This reflects the interrelationship between different disciplinary domains (*ibid*.). But, most importantly, the example mirrors the interrelationship between different entities; a midden is made of humans and non-human features.

The latter argument pinpoints that a computational ontology clarifies the agency of different human/non-human agents whilst some archaeologists/historians/anthropologists, or ecologists are somehow unaware of this (Bauer, 2018). Therefore, although ontologies do not think by themselves, they expand human cognition by better expressing entanglements in complex systems.

This is not to negate the existence of good interdisciplinary studies that yield a complex vision of a landscape (e.g. McGovern, Vésteinsson, Friðriksson *et al.* 2007). Nonetheless, however successful these outcomes might be, they appear only after many years of research (and successful funding applications!). What is more, sometimes the data behind these kinds

of studies are not as evident as in an ontology. As such, an ontology is more than a decent solution for addressing complex themes/studies using Grey Literature and Legacy Data, as well as for aiding in understanding complex dynamics.

The above allow me to conclude this section by claiming the potential use of well-developed ontologies. They can enhance the study of complex dynamics which encompass a multiplicity of agents and experts. They can break down some of the limitations hitherto faced in our research. On the one hand, they expand or clarify archaeohistorical knowledge. On the other, they can link data and knowledge outside the archaeohistorical realm in a most efficient way than before. As I have shown in Chapter 2, for studying Human Ecodynamics efficiently, we must consider a multiplicity of phenomena hardly to grasp in our traditional, restricted, scholarship procedures. Therefore, an ontology designed for addressing HE can deploy all its potentiality by interlinking datasets of multiple nature, enhancing our understanding. From the perspective of historians/archaeologists, etc. this equates to enhance their archaeo-historical knowledge framed within a broader perspective of Human Ecodynamics.

This more theoretical inquiry connects us with the next point, namely: theory is always in play, no matter how "practical" our method is. This is, I argue, true for Digital Archaeology.

## 4.4 Digital Archaeology; not only praxis but also theory

Much criticism to Digital Archaeology comes from outside its sphere, albeit there is strong criticism from some of its practitioners. The main complaint generated from the latter is the absence of strong theoretical reasoning behind the digital praxis (Hugget, 2012a and c; 2015a, b, c; 2017; Beale and Reilly, 2017; Bonacchi and Kryzanska, 2019). As Beale and Reilly say (2017), "that is not to say that innovative theoretical work has not taken place in archaeological computing". Indeed, I would argue that the problem is not a lack of theory but that this reasoning has been only done by a small group of digital archaeologists (beyond those cited above, see Gardin, 1980; Opitz and Johnson, 2015; Opitz, 2018a; Crema, 2018). This problem increases if focused on computational ontologies (maybe Tolle and Wigg-Wulf, 2015; González-Pérez and Martín-Rodilla, 2015; Bruseker, Daskalaki, Doerr and Stead, 2018 are some of the few examples whose work incorporates critical reasonings).

This is not trivial. The issue has consequences at the level of research-impact -as I refer in the line below. But, moreover, it is an important point inasmuch as technology may have a social role: they are entangled within power relations. Consequently, they influence how

archaeological knowledge is created, represented, manipulated, modelled, and understood (Huggett, 2012c, p. 204). Hence, technology and its deployment entail ethical responsibilities. In this case, the responsibility may well be seen as the act of thinking about the social impact of using digital tools.

On the other hand, the mindset which leaves to others the responsibility to thoroughly ponder the different implications of our digital practices is counterproductive. Such a dynamic is evidently problematic as it can replicate previous problems, generating doubts, fears, criticism, etc. Moreover, we might face issues concerning the outcomes and uses of our digital practices: if new technologies do not aid for better resolving our research's questions, and indeed generate more problems, are they really worth using? Visions which disentangle theory from praxis cannot be farther from my standpoint. We should aim for uniting "mind with hand", theory with practice -as is the case during field seasons.

In Digital Archaeology, the above equates to "thinking beyond the tool" (Huggett, 2015b). That is:

> - to discuss the underlying theoretical concepts behind our methodological tools;
> - to examine the extent to which constraints of these tools alter our perceptions and interpretations about the past;
> - to investigate future directions from a theoretical perspective
>
> (Huggett, 2012c, p. 204)

Huggett goes on by specifying the questioning of "the wider implications of the application, the constraints it may have imposed, the way the research questions may have been shaped by the tool, how the tool may have structured the research" (*ibid*). Additionally, he proposes a method based on McLuhan's four laws for understanding artefacts' impact on humans (1977), expanded by a sort of Hegelian reasoning. The method works by answering the following points (Huggett, 2012c, pp. 211-212):

1. Things enhanced by the tool;
2. Obsoleted tools after the introduction of the new one;
3. New tool's retrievals;
4. New tool's reverse sides;

5. Old issues retrieved by the new tool;
6. Things diminished by the tool;
7. New enhancement of old problems;
8. The downsides introduced by obsolescence.

It might be an iterative process, as some almost overlap others. This is not to say that following this method or another similar is not of great value for understanding some of the most important theoretical implications of our wired archaeological practice. For example, my work in sections 3.1-3.2 addresses many of these questions.

Nonetheless, I must reiterate some of the fundamental ideas which arise after doing an ethnographic, self-reflexive, inquiry of our practice (Huggett, 2012a; Huvila and Huggett, 2018). It is worth saying that an account of similar characteristics might be quite useful for resolving some of the problems faced here with archaeological reports. While in Chapter 3 these ideas are extensively developed, now I seek clarification and synthesis. To start with, I have shown how my project is limited by previous theoretical frameworks. As Huggett (2012a, p. 540) puts it, this is due to the "situated nature of data [which] arises from their creation by specific people, under specific conditions, for specific purposes". Even though I have inexorably followed previous standards, these are counteracted with the introduction of new concepts and *combinators*. The latter aspect creates a better equilibrium between what the archaeologists who dug wrote on the reports and the narrative we seek to create. This can be observed in some examples from the previous chapter: if they focused too much on small aspects of human ecodynamics, I created a middle-range step capable of elucidating more explicitly broader aspects of these dynamics; and vice-versa if applicable.

I have purposely shown the importance of thinking beyond the tool in not using data/text-mining procedures for extracting information from the archaeological reports. In effect, I detected an error in proceeding using digital techniques in the context of my project. Although some projects have used Natural Language Processing tools with ease -generating interesting results- (e.g. Byrne and Klein 2009; May, Binding and Tudhorpe, 2010; Tudhope, Binding, Jeffrey *et al*. 2011), these software are not error-free. There is an epistemological gap in our way of perusing big amounts of data, taking for granted that a machine can do our job without risking contextuality. As shown in Chapter 3, this is not the case. Hence, theoretical reasonings before using specific techniques might prevent us from replicating important issues in Digital Archaeology and Humanities. Theory, therefore, can challenge some emerging procedures from our world of Big Data. Something similar happens when

we contest the “natureness” or “trueness” of the data-information-knowledge pyramid (as I have done; see also Huggett, 2015a).

A clear-cut case of how ontologies modify our visions of the past (Huggett, 2015b) is how they represent multiple facets of that past. In our ontology, for example, we have at hand the possibility of envisioning in an abstract manner the entanglement between humans and non-humans. No doubt, neither our modern nor past societies could see these interrelationships so easily and rapidly. We might take the risk of devirtualising some aspects if we forget that we are using an ontology designed for representing complex dynamics which are contingent and not straightforward at first sight.

Equally, ontologies impact on our practice (Huggett, 2012c, p. 206). At the same time that reinvigorates or enhances our knowledge of the past, it modifies our approach. It helps in reorienting how we conceive past cultures, their relationship with the non-human spheres, and the impact of these spheres into past humans. Moreover, this change can lead us to the questioning of new methods to better understand these dynamics (e.g. the use of different viewsheds or ROIs in GIS, the choose of different variables for modelling, etc.). The risk here is to take for granted new approaches and visions that are too mechanistic (for example, linear thinking similar to the ontological one but without the critical reasoning that created our interlinkages).

It is clear that our ontology does not limit itself in being a copy of some previous versions. Huggett (2012a) expressed that ontologies are capable of much more of what they are traditionally used for. In fact, our ontology pushes the limit forwards: it does not only link datasets in *soft* relational ways but add some sort of logic (introduced by the collective mind). In giving it the status of a Digital Apparatus, we assume their real purpose as a generator of reasonings and hypothesis of ecodynamic character.

Importantly, I believe that I have expressed here how embedded in theory digital practices are. This project and thesis, for example, are impossible to understand without the theory that underpins them. Without theory, my dataset, which is not conventional, would not be considered as such. I will explain this further: when we think about datasets, especially in Digital Archaeology, we tend to think in quantities and numbers (spatial, archaeometric, statistical data, etc.). Mine, however, is quite the opposite: full of words, with almost no numeric values. It is not possible to understand such a dataset without understanding how an ontology designed for representing complex dynamics works. In effect, these words are used for tagging concepts and creating *Combinators*. To some extent, my words deploy a similar

function to what numeric data do by articulating the calculations which generate spatial information.

The same is true for Chapter 3. Normally, chapters or journals' sections dedicated to methodology explain the use of specific tools for obtaining data which aims to resolve some sort of research questions. Chapter 3, by contrast, is rather different. Indeed, it can be described as the maximum expression of what I have mentioned above as entangling theory and praxis. Throughout the chapter, I described the method used, albeit always embedded in theory -be it ANT, computational ontologies theory, etc. Moreover, Chapter 3 would be hard to understand without going through the previous one -where some foundational theories are explained.

Let us not fool ourselves. Many methods carry their own theories, but they are not normally explicitly addressed. This situation generates some of the problems pointed out here; all of which can be summed up by saying "technological fetishisation" and "weak logic". I claim, therefore, that Digital Archaeology can only be well understood and carried out if explicitly embedded in theory and in an introspective self-criticism.

It is important to reflect on a fundamental topic: all the narrative involving Chapters 2 and 3 is mainly characterised by ANT. Paradoxically, I might have made clear how embedded Latour, other thinkers of ANT, and logicism are in some archaeological theories. This is clear in three main aspects:

1) Jean Claude Gardin is strongly influenced by logicism, and to some extent, he can be described as a logicist concerned with how the logicist approach affects Archaeology. In addition, some of his thoughts connect with Latour's thinking (e.g. the way technologies affect the archaeological procedure).

2) Ian Hodder is highly influenced by ANT. This can be observed in his seminal book *Entangled: an archaeology of the relationships between humans and things* (2012), as well as in a more recent book *Studies in Human-thing entanglement* (2016). This is also true in the way he understands agency between objects and humans, influencing his field methodology.

3) The interconnection of the above two points and the development of our ontology. The tool is designed for representing entanglements at the Ecodynamics level. This is better understood once after elucidating the complex ties bounding Hodder, Gardin and Latour's work.

All the above pinpoint to the fact that Digital Archaeology is far from just being praxis. There is so much more underlying theory than many have recognised (*cf.* with the authors mentioned 5 pages above; many of their ideas were used here for laying out my own arguments). This thesis contributes to challenging the non-critical-theoretical Digital Archaeology deluge. Indeed, I have questioned the traditional use of many computational ontologies -which limits its usage to a mere evolution of databases. Moreover, DataARC radically changes the perspective of how to think about this digital tool (maybe similar to the third wave proposed by Huggett, 2015b, p. 88). For the project, ontologies are not just a path to discover, disseminate, reuse, enhance, and recombine data as Jeffrey (2012, pp. 557-558) proposed for many digital technologies. On the contrary, ontologies help on that but are also capable of reinvigorating critical theoretical questionings about our praxis (including a contested vision against that which presents data structures as empty vessels), our assumptions of the past, and generally about our ontological visions. In other words, computational ontologies, if well used, aid on thinking epistemological and ontologically. This can help in reconfiguring conceptualisations of both.

Ontologies, and Digital Archaeology more generally, also aid in improving our social impact. Once again, this is possible if framed within critical social theory. I will show this by reflecting on my own project and its wider social implications.

## 4.5 Framing the results: applicability to today's issues for possible futures

If our outcomes must be social, in what position are we now for offering solutions to society? What is the role of the historian or archaeologist in this context?

### - Public engagement

As I have been claiming, our ontology is hoped to be used by multiple users. This is fundamental for the case of archaeological reports. As it has been shown, some of the main problems of NABO's reports are their dullness, length, and disorganised laying out of data and interpretation. This is a problem for archaeologists, researchers in general, and the public. I will, however, focus here more on the general public. Ethically, we cannot assume that a reader will go through hundreds of pages to connect all the bits of information, for later connecting them with datasets of another nature. The consequence of this impossibility is that the reader will have a partial vision of what we are doing and of the knowledge that

we generate. Even worst, there might be a scenario where people directly do not care about the past due to its nuances and complexities. Both situations are problems highlighted in section 2.4. Equally, we are by no means holders and guardians of the past; ethically, we are not entitled to hoard the data generated.

Yet, the problem persists, either for "laziness" in engaging with ethical issues or for institutionalised laws. In any case, the root is ethical: an absence of understanding the urge and fundamentality of sharing good standardised data, meta- and paradata.

The problem, therefore, is not the access regime of data but the data in itself. Following Huggett (2015a), we might agree that NABO's literature and data are in Open Access. However, this is not Open Data. Their data is not open. Beyond the ethical problem posed by this issue, it also might generate a reluctant approach to the narratives generated by NABO's research: where is the data? Why can't I reuse it? Where is the real correlation between data and narrative? The latter, indeed, is a pressing issue considering NABO advocacy in aiding on understanding human impact on climate change. Clearer connections between narrative and data might help in breaking polarised "echo-chambers" and "false certainty" against climate change (Farrell, 2015).

DataARC tries to break down the barriers of Open Data. To some extent, the datasets in use are standardised and are interoperable inasmuch as they all are prepared for working within the ontology. This is achieved by closely following most of LOUD's and FAIR's standards. Moreover, the data is now directly related to the propositions (*Combinators*) expressed. This is fundamental if we are to seek socio-ecological information out of the past which can be used in diminishing the anthropic impact on the Earth systems. As pointed out before, this is equally valuable for expressing and communicating to the public our research. Yet, it is not entirely open data because not all the data can be reused (e.g. drawings from the reports in GIS). But in general, our work is a very positive step forward towards new ways of communicating and engaging with the public.

Additionally, our ontology respects multivocality. This might be positive and useful in how potential users can understand the knowledge expressed by the cyber-tool. Functions such as "why", which explains the reason for obtaining specific results from the ontology, provide a level of confidence for how the data was processed. This, along with a user-friendly designed, have the potentiality of engaging the public with what we do and what we have to offer to society. Therefore, with these kinds of digital tools we may have in our hands the

possibility of finishing the crisis which affects society today regarding a disengagement with the past (Section 2.4).

### - Social Ecology, LTK and Archaeology: Utopia?

In section 2.4, I have argued in favour of framing Archaeology within theoretical positions with a clear social implication. Now, I aim to lay out a frame for future work.

Many archaeologists seek a transdisciplinary study by hearing what local and traditional communities have to say (McGovern, 2014). SE pushes this further by proposing a much more radical agenda. I argue in favour of including the voice of those communities silenced by capitalist dynamics into more synergetic and transversal dynamics. Learning and promoting LTK is fundamental for empowering communities and for preserving alternative practices which face their oblivion in our society (McGovern, 2011; Pulsifer, Gearheard, Huntington *et al*., 2012; Pulsifer, Huntington, Pecl, 2014; Einarsson, 2015; Ruiz Ruiz and Martín Civantos, 2017). SE can reinforce this by including these practices into a wider anarchist perspective. Precisely, this perspective, which emphasises socioeconomic approaches, may resolve some issues pinpointed by González-Ruibal (2018) which limit archaeology's potential to study the Anthropocene or HE in general: concretely, some epistemological paradoxes and their ontological foundations.

Further, another challenge here is to develop standards capable of recording and expressing LTK in interoperable manners. This would also serve for respecting indigenous worldviews. Difficult as it might be, we must fight for ethical and positive actions that can be applied in our present for changing to the best our future. Utopic or not, we must go forwards into ethical practices.

# Chapter 5: Conclusions

## 5.1 My thesis in the context of the DataARC Project

DataARC started years before my thesis. As such, the originality of *Combinators* and design of the ontology belongs to the team that started the project. The way the ontology was designed influenced my view of how to study Human Ecodynamics. Equally, most of the terms and their combinations were developed prior to my work, and so are many of the datasets used in the ontology.

On the other hand, I designed and created the archaeological reports-based dataset -although this concerns only one archaeological site. This means that, in the future, the archaeological report- based dataset can and should be expanded and enriched. But with my project I hope to have exemplified some of the problems entailed by our practice (knowledge shadowing, distorted formats), and the implications that these issues have for the creation of knowledge and complex narratives.

Moreover, I developed an extended explanation of the theoretical frame underpinning how the ontology works in conjunction with complex theories of realities. In so doing, I have illustrated some of the theoretical implications computational ontologies have. This might help to overcome "naïve" approaches to computational ontologies.

## 5.2 Is this research meaningful?

The main contribution of this thesis is to unite and embed a "mechanistic" process with(in) constant theoretical reasoning. The creation of my dataset and the subsequent project's ontology expansion are constantly embedded into theory. Narrowing down to theory, two main schools of thought are present here, namely: from Philosophy of Science, Latour's ANT; from Metaphysics, Ontology. Nonetheless, both are utterly interconnected insofar as ANT study beings and entities' agency -which is a fundamental ontic property. I will return to this point later. Suffice to say now is that this project connects Digital Archaeology with the ontological turn undertake in the rest of Archaeology's specialities (Caraher, 2016). Note, however, that "ontological turn" here does not mean ethnographic questioning but metaphysical inquiry (*cf.* Alberti, 2016). Notwithstanding, in assessing how the ontology was developed followings specific steps during the reports' addition, it can also be thought to be an ethnographic account.

A purely Digital Archaeology project can only be well developed if integrated into theory. Many Digital Archaeology projects are, but in an implicit, subconscious, way. And here is where the problem lies. Many projects fail in understanding and developing their methods' downsides and implications because they do not tackle theory explicitly in their procedures. That reason, for example, explains why many ontologies have received critiques from outside and inside the community of digital archaeologists.

By contrast, my project aims not to replicate these common issues. From its onset, the method was designed by a constant dialogue with theory. Indeed, this is the workflow followed for the development of DataARC's ontology. During Chapters 3 and 4, I have demonstrated that the ontological implications and "categorisations" entail in the North Atlantic Human Ecodynamics were firstly thought. Afterwards, this "ontological unpacking", was delimited by computational ontologies' constraints (hierarchies of categories and subcategories with properties). Thereupon, different datasets were perused and adjusted to connect with the ontology. The latter step was the trail I followed with NABO's Archaeological reports. However, it was not the last step. As I have shown in Chapter 3, some concepts can be added to our ontology when needed, expanding it. This expansion is not trivial and must be based on strong and in-depth assumptions on how our ontology works in conjunction with the theory behind it. This was the other main contribution to knowledge of this thesis: making explicit the ontology's theoretical underpinnings. This is to say that the criterion for adding new concepts is to allow the ontology for englobing all the data from the different datasets without losing the final purpose of representing complex processes. In other words, for expanding the ontology it is necessary to respect some equilibrium between shallow and deep unpacking, as well as between ontological concepts and data:

- Think, for example, of the process of dumping the soil for, probably, enriching its properties in order to intensify cultivation. Unpacking this in our ontology's hierarchy would mean to oddly add too many layers (e.g. managed landscape area→farm→land management→disturbed or arable→dumping). This unpacking is, indeed, unnecessary once understood it can easily be expressed with two concepts: managed landscape area and land management. Moreover, both concepts do not change or hide the meaning of dumping soils.

- Now, think of expressing the possible location of a smithy area inside a farm. In this case, it would be difficult to express that without unpacking it (e.g. Farm→production→crafting→smithy). This is a real example made by me in the

ontology. However, note that not all the crafting activities were unpacked with such detail; this case, however, was necessary due to its iterativeness in the reports.

Therefore, the ontology is informed in two ways: first by the theory underpinning it; secondly by the necessity of different datasets. In any case, it is not the dataset "who" leads the ontology. In contrast, the theory builds the ontology and it is only later slightly modified by some data (see Fig. 12 to contrast this procedure with other's one). Now the ontology represents complex HE processes instead of being an evolution of traditional databases.

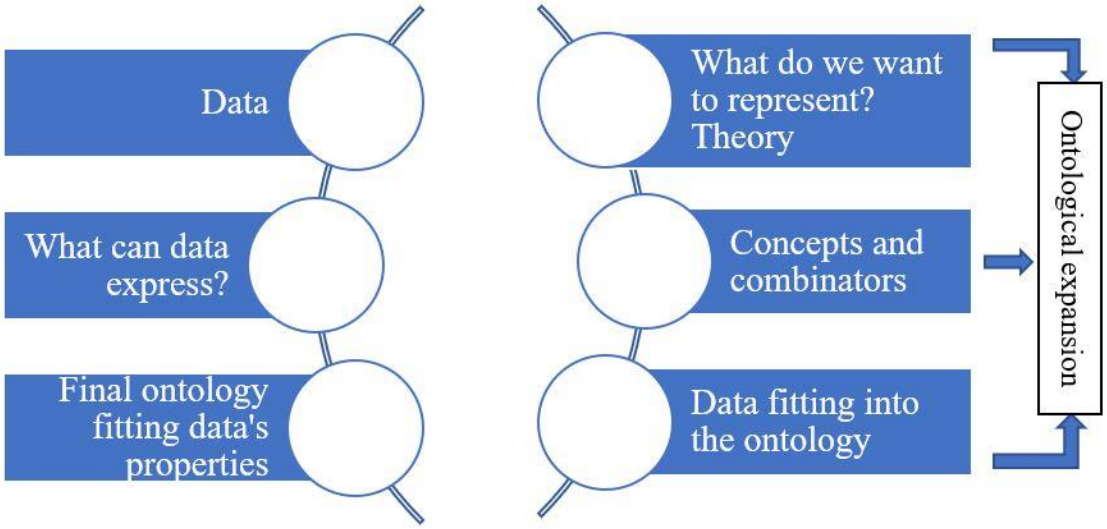



Fig. 14. Schematic workflow contrasting the mindset between other ontologies (left) and ours (right). The onological expansion that I carried out had to go backwards and forwards through the different steps.

This project represents a statement against any sort of de-theorised Digital Archaeology. The ontology represents a step forward inasmuch as it expresses complex narratives. For example, my contribution expanding the ontology make use of archaeological datasets in a quite different manner from previous projects (Fig. 12). Moreover, this research informs, or might inform, other inquiries both in epistemological and ontological terms through the theory here developed. I will expand the latter in the following sections.

### 5.3 Research's implications for Digital Archaeology: the Digital Era is here

Our studies are already embedded in different digital practices; it has been for more than half a century since Gardin's pioneering work. Effectively speaking, our disciplines -say, Humanities, Studies of the past, Archaeology, etc.- have entered the Digital Era (Huggett, 2012b). Yet, as we have seen, this "new epoch" has come without generalised theoretical reasonings. Some scholars presumably approach to the digital world as if technologies carry a halo of utter objectivity. They reify the digital world. In so doing, they take for granted a variety of digital tools without inquiring in their implications. Unsurprisingly, this uncritical

use generates strong criticism and epistemological problems. This is indeed a consequence of ontological misunderstanding. Some of Object-Oriented-Ontology's (OOO) extremest postulates (Harman, 2018) claim the inexistence of the Real (as understood by Sbriglia and Žižek, 2020) -i.e. there is no transcendental difference between humans and non-humans; therefore, we are all objects (*actants*, if following Latourian terms) in networks. Of course, Harman's theory is the consequence of stretching ANT to its extreme. I am personally not sure that ANT stands for negating subjectivity in this sense. The Real, anyway, seems to endure even after considering OOO (Sbriglia and Žižek, 2020). This, applied to our concern here, means that our subjectivity affects the very foundation of how we approach and use (cyber)tools. Our epistemological and theoretical frameworks define the ways of using digital tools -they are not objective whatsoever.

Therefore, our epistemological *habitus* puts at stake its very deployment. Phrased another way, the strengths of computation/digital tools are downgraded by a lack of theoretical reasoning. The issue is of first concern once understood the digital paradigm in which disciplines are. Should this *habitus* prevail, we might face an important consequence which, to my knowledge, can be twofold: either we keep going on with this dynamic until the point of generating meaningless studies; and/or we will end up after a period of digital scepticism with a backward, conservative, epistemological movement. These scenarios are by no means mutually exclusive; indeed, it is possible that the latter will follow the former. Therefore, we should change this dynamic to avoid negative outcomes.

I am personally reluctant to embrace an uncritical Digital Era. This is a pragmatic stance. What my thesis seeks to express here is that we must be aware of the fact that the Digital Era is already here, but it might not be the kind of era we would really like to be in. In explicitly handling theory all over this piece of work, I hope to have demonstrated the virtuosity of a digital project founded in critical reasoning from its onset. For example:

a) I have left aside some techniques and tools for the problems they pose for the kind of results I wanted.

b) DataARC and I have demonstrated how to enhance computational ontologies by diverting the general workflow. Using theory first is key for representing complex dynamics and changing how an ontology can behave.

c) As exposed by Huvila and Huggett (2018), ethnographic reasoning allows for better understanding weaknesses and strengths of the research which is being carried out.

Moreover, and fundamental, this theoretical inquiry equips researchers with some ideas for enhancing their work.

Hence, theoretical considerations are always important, in one way or another.

It is also important here to dispel the subtly and common consideration which associated Digital with unlogic technical action. Nothing is further from reality. Theory may well be constantly adrift (Pétursdóttir and Olsen, 2018), but it is always involved and embedded in praxis. Here lies one of the main contributions of this project: acknowledging the presentness of the Digital Era and adding a message of wariness against un-theory.

## 5.4 Studies of past biocultures (Human Ecodynamics)

Though not surprising at this point, both the project and my thesis have implications related to the study of past biocultures, under the banner of Human Ecodynamics. The ontology strengths new conceptions of "biocultures" and "human ecodynamics" inasmuch as shows an utter interrelationship between the traditional dualistic division of human/non-humans. This is not to say that HE or DataARC's ontology offers a vision of complete division between both. On the contrary, they offer a partial, fluid, and likely accurate vision of coupled-systems (Amundsen, 2014). This is quite clear in many of the concepts used in our ontology, as one of them can be mapped and linked to others by various connectors/combinators. Some of these connectors describe human properties, whereas others do so for non-human properties (Pálsson and Opitz, 2019, p. 145). It might be said that we have effectively accomplish deploying quite complex interrelationships happening on a single "actor" in our network.

Albeit centred in the North Atlantic, the ontology offers a general schematic representation of what these interrelationships might be in general. Needless to say, the ontology is more accurate for the North Atlantic basin. The emphasis is placed on the Viking and Medieval Periods, partly because they are the most study periods. Nonetheless, NABO's vision has helped in developing a *long-durée* record, allowing for a better understanding of Human Ecodynamics. The ontology is therefore a useful guide for all those disciplines whose main concern is the study of humans' past following renew standards brought by HE -possibly, one of the most promising paths for future research.

Moving to another aspect, it is important to reflect upon our praxis. As seen in the previous chapter, archaeological reports need to change, at least in the manner data and interpretation are treated, and subsequently presented. Moreover, concerning HE, new ways of doing

fieldwork must be followed. New standards in conjunction with the coupled-system above mentioned must arise if we are to enhance our archaeological understanding of different biocultures. To put an example, new methods which, for example, aims to study how socioeconomic hierarchies were constructed by an utter interplay between humans and non-humans are hitherto impossible. Traditional approaches to the act of writing archaeological reports, thus, must change.

What are, therefore, the implications of this project if only related to HE? First, it offers a general framework for understanding how biocultures evolved in an interrelated dynamic. Second, it is the first study offering this schema for the North Atlantic. The latter is equally applicable to the Viking Age and Medieval Period, where traditional research tends to focus on more specific, narrow, studies. Third, it represents a step forward in some archaeological practices (e.g. fieldwork, act of writing, landscape-scale, etc.). At last, I can see another important implication. DataARC, as this thesis has shown, fosters a common ground for different fields and disciplines which have undergone through a Digital turn. For the case of Archaeology, my work shows some possibilities (data linkages) for the creation of a framework beyond interdisciplinarity, in an effort of achieving trans-, if not post-, disciplinarity. And in so doing, it opens a space of much-needed inclusivity (Huggett, 2012b).

## 5.5 Philosophical implications

My thesis has a threefold theoretical implication: 1. For Linguistics and Logicism; 2. For Political Ecology and Ontology; and 3. For Ontology informed by ANT and OOO.

In Chapter 2, I use semiotics to explain some characteristic of computational ontologies. Note here how interesting is to find resemblances between ANT and semiotics. Precisely, both things have a common ground in assessing agency in different spheres of "reality" (one in language games, the other in ontic connectivity). Returning to semiotics, it would be interesting to study how our ontology's multivocality allows for better understandings of what is in play between those who send a message (us, archaeologists, ecologists, etc. in DataARC), the message (any aspect of Human Ecodynamics represented first as schematisations and later as statements), and the receivers (users, who will interpret/search depending on their interpretations and world ordination). *Combinators* may be here the most useful tool to inform semioticians.

In what concerns to Linguistics, I see a strong correlation between Wittgenstein and this project. Wherein he seeks to understand language and meaning for understanding how the world is cognitively apprehended (be the answer "devoid of meaning" [*Tractatus*] or "meaning according to language-games" [Philosophical investigations]), DataARC proposes an ordination of some "world" according to specific usages of concepts and their properties (a language-game). DataARC orders the world of Human Ecodynamics according to some linguistic rules (*Combinators* and terms). Of interest here would be to question how accurate this ordination is in a more transcendental and abstract manner. Culturally situated, the inquiry may be redirected to "how true these ontological statements are in different cultures and in different languages-games". Different answers might give diverse insights of how meaning is contingent depending on context; and whether reality is contextual or inapprehensible.

There are some implications for Political Ecology, if considered as a transcendental and ontic way of seeing the world. The main one is that it allows for better understanding of entities' ordination. The ontology might give insights into how human/non-humans interrelate between or among them, and what ontic "status" that agency confers them. Bauer (2018) correctly assessed the fundamental role Archaeology has in expanding Post-human theory: it offers an insight into how radical visions of monism or dualism are both wrong, risking positive answers to current climate threads. Section 2.4 also serves to Political Ecology insofar as it gives a frame -that is, Social Ecology's theory- to expand its reasonings and its effective, transformative actions (similar to *sensu* González-Ruibal, 2018).

Finally, there are some implications related to Ontology and its relation to ANT and Object-Oriented-Ontology (OOO). The most noteworthy implication is that our ontology works in a similar manner to what ANT add to our ontic understanding. It is what Caraher (2016), reflecting on Lucas's work (2013), referred to with finding "new ways of understanding the dense relational network that includes a diverse range of human and nonhuman objects". This is what our ontology does for representing Human Ecodynamics. The question here is the equilibrium between this model and ontological theories. I argue that our computational ontology does not only respect theory but expand it by adding new dimensions and relational networks. Hence, the project has implications for the ontological theory.

In a call for caution, I argue that seeing reality compounded of relational networks of objects is an incomplete picture. ANT is arguably a theory capable of explaining how ontic reality works in connecting and disconnecting entities and beings. Yet, claiming Object-Oriented-Ontology as the definitive theory of reality is not completely accurate. As a theory of the

whole, is too mechanistic -and simplistic to some instance. Albeit applicable to studies such as HE, it does not explain other realities' aspects which are always in play. In trying to be the definitive explanation, OOO fails in understanding other fields of reality. As a consequence, Žižekean transcendental (inter)subjectivity -i.e. the Real, the subjects' unconscious (http://zizekstudies.org/index.php/IJZS/issue/view/60; Žižek, 2013; Sbriglia and Žižek, 2020; García and Aguilar, n.d.), and even new-realists theories (such as Ferraris' or Gabriel's proposals), are rejected by OOO (Harman, 2018, p. 161, 256). No doubt, such rejection leads to a partial and poorer, rather than total, ontic explanation.

### 5.6 And then?

I have already shown the theoretical embeddedness of Digital Archaeology -even when some people do not explicitly handle theory in this specialisation. The theoretical implications of this thesis might be surprising for the latter group. But I believe that my project, precisely because it constantly engages with theory, might be important for the group of researchers who has developed and established a strong theoretical basis for Digital Archaeology. In my case, I have contributed to this theoretical body by theorising inter- or transdisciplinary Digital Archaeology. This is a by-product of one of the most important contributions of this work: to theorise DataARC's approach in this context of blurred disciplinary barriers towards the study of more complex issues.

Perhaps the most important outcome of the thesis is that I have laid out the arguments for claiming that Digital Archaeology (in this case, ontologies), and paradigms such as HE, have clear connections with our societal issues. In order to fulfil our ethical duties towards society, I have argued, we need to join forces with theoretical schools such as SE. In that sense, digital technologies have an important role in regard to data treatment.

Finally, another contribution from my thesis is the argument that archaeological theory can inform Philosophy (as in Chapters 2, 3, and 5). In particular, I have attempted to demonstrate how Digital Archaeology can inform other disciplines' theories, opening up new epistemological and ontological venues for Digital Archaeology and Humanities.

## Annexes (USB Pendrive)

In the USB Pendrive you will find all the information regarding the data use, first a simple two columns format, and later as the final dataset. The dataset is presented in its Excel format, as well as in its CSV file. The images and charts from the archaeological report are also to be found here. The corresponding metadata is also to be found here. It provides an explanation for the CSV, as well as for the images/charts uploaded to Zenodo. The metadata was done following ADS guidelines for projects and files levels (https://guides.archaeologydataservice.ac.uk/g2gp/Gis_3-3; https://guides.archaeologydataservice.ac.uk/g2gp/Gis_3-2)

On the other hand, you will find the Excel table used for generating chapter's 3 graphics (Spreadsheet 1 for the pie chart; Spreadsheet 2 for the Plot graphic).

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