COMPLEXITY AND DYNAMICS

sidestonepress

COMPLEXITY AND DYNAMICS

Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC–AD 1600)

MARIE **ØDEGAARD** AND INGRID **YSTGAARD** (EDS)

Published by Sidestone Press, Leiden
www.sidestone.com

Imprint: Sidestone Press Academics
This book has been peer-reviewed. For more information see www.sidestone.com

Lay-out & cover design: Sidestone Press
Photograph cover: Annette Græsli Øvrelid, Museum of Archaeology, University of Stavanger. Back cover: Magne Samdal, Museum of Cultural History, University of Oslo

ISBN 978-94-6427-042-6 (softcover)
ISBN 978-94-6427-043-3 (hardcover)
ISBN 978-94-6427-044-0 (PDF e-book)

Contents

“The 207 BC Dust Veil Event” and the advent of iron reaping tools in Scandinavia

Lars Erik Gjerpe

Abstract

Sickles and other reaping tools made of iron were taken into use as late as 200 BC in central Scandinavia, even though iron was known several hundred years earlier. This delay inspires two related questions: why did Scandinavians not take advantage of iron earlier; and why did they start around 200 BC? According to earlier research, this late utilization of iron was due to hostility to new technology. This paper suggests that the acceptance of new technology coincides with a year without a summer, caused by a volcanic eruption or other climatic disturbances in 207 BC. I argue that the bad year caused a scared population to open their minds to new technological solutions. The settlement at Dilling, where excavation results have proved so interesting, was located on the stone-free marine plains where the new iron tool was more effective than on the stony moraine, and the larger amount of fodder each person could harvest made it feasible and possibly desirable to keep cattle close to the settlement, thereby decreasing the use of forests and outfields for grazing. More cattle and possibly a new way to treat the dung made manuring better and the span between fallow periods longer, thereby making it possible or desirable to stay longer at a settlement and to build houses that lasted longer.

Keywords: Pre-Roman Iron Age, technology, climate, agriculture, luddites

Introduction

The acceptance of iron reaping tools in Scandinavia as late as c. 200 BC has been highlighted as an example of delayed introduction of a new technology, possibly a result of successful resistance (Sørensen 1989a; Penack 1993). Iron ornaments, buckles and repairs demonstrate the use of iron in central Scandinavia from c. 500 BC onwards at the latest, possibly as early as c. 800 BC (Levinsen 1983; Sørensen 1989b; Pedersen and Widgren 1998:264). Judged by the amount reaped per unit work invested, iron sickles are far superior to their counterparts in flint, stone or non-ferrous metals. Advanced steel technology is no requirement, for scythes may be made of soft iron (Stigum 1938), while iron extraction sites dated to c. 500–300 BC demonstrate both the presence of the necessary know-how and access to large quantities of the metal (Larsen 2013:60; Simonsen and Bukkemoen 2015).

In spite of this, Scandinavians did not make iron reaping tools before c. 200 BC (Penack 1993; Myhre 2002:110; Gustafson 2016), demonstrating that technology is a cultural phenomenon embedded in society (Dobres 2000). The acceptance of new technology is not merely a result of individual cost-benefit-analyses, it is as much about ideology and social

In *Complexity and dynamics. Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC–AD 1600)*, M. Ødegaard and I. Ystgaard (eds.), pp. 85-98. Sidestone Press, Leiden.

organization (Leeuw 1989; Layton 2000; Juma 2016). This delayed use of iron as a raw material for reaping tools leads to at least two related questions: why did Scandinavians not take advantage of iron earlier; and why did they start around 200 BC? During the ongoing study of the newly discovered settlement at Dilling, Østfold, in eastern Norway, we noticed evidence of intensified activity that could be dated to c. 200 BC, roughly at the time when iron sickles were taken into use. In my quest for an explanation for the two possibly concurrent and related incidents, I discovered a third contemporaneous happening, a dramatic change in temperature. Thinking with two sets of data, the Pre-Roman Iron Age settlements at Dilling and the climate and weather, both set in the general frame of the Pre-Roman Iron Age (500–1 BC) of eastern Norway, I will here explore the introduction of iron sickles. As demonstrated by Marie Louise Stig Sørensen (1989a), the highly conservative members of Early Pre-Roman society did not easily accept new influences, and my hypothesis is that they were scared straight[1] in c. 200 BC due to a climatic event.

Background

In the course of the last 15–20 years the concept of weather and climate causing change has once again gained acceptance (Moreland 2018; Gundersen 2019), notably through the Fimbulwinter theory or the "Dust Veil Event" of AD 536 (Gräslund 2007; Gräslund and Price 2012). Most scholars seem to agree that volcanic eruptions and subsequent dust veils caused years without summers, and with falling temperatures, resulting in crop failure and subsequent famine. The most dramatic events may have been in AD 536–541, but the average summer temperature in the period c. 536–650 was most likely the lowest in the preceding 2000 years, probably causing several bad years and low yield in the Northern Hemisphere. This period, labelled the Late Antique Little Ice Age by some, coincides with societal change reflected in material culture as well as written sources (Wiker 2001; Gräslund and Price 2012). This coincidence has caused archaeologists and historians alike to regard the temperature as a prime mover or agent causing change (e.g., Eisenberg *et al.* 2019), although some have pointed out the problems related to establishing whether cause-and-effect relationships can be deduced from coincidences in time, and the challenges of precisely relating dates of natural and cultural phenomena (Moreland 2018; Gundersen 2019). Others have pointed out that some of the changes are more likely to have been long-term changes originating in societal upheavals in the fifth century and that some even occurred prior to the event (Amundsen and Fredriksen 2014; Fredriksen *et al.* 2014; Ystgaard 2014; Gjerpe 2017; Røstad 2021).

Terms such as "catastrophe" and "disaster" are appropriate with regard to the aftermath of 536, and it seems beyond doubt that many died of starvation. Stories of catastrophes may become part of myths and legends (Cashman and Cronin 2008), as with the well-known myth of the Fimbulwinter (Gräslund 2007), and may also cause rituals to change (Axboe 1999). Catastrophes might also change the mentality and open for the introduction of new technology in an otherwise conservative society (Torrence 2016). For example, Birgit Arrhenius (2013) has demonstrated how rituals at Helgö moved indoors and burial grounds were re-located post-536. Daniel Löwenborg (2012) has revealed how a "kleptocracy" used the shock and chaos of these years to gain control over the valuable farmland in the Mälaren valley. Thus, the event not only caused demographic disaster, it also triggered cultural change.

I do not argue in favour of environmental determinism or mono-causality, for I acknowledge that an intricate socio-ecological system shapes societal response to environmental change or shock and that weather is a material condition embedded in social and cultural formation (Butzer and Endfield 2012; Pillatt 2012; Manning *et al.* 2017; Ljungqvist *et al.* 2018). To me, the lesson learned from the 536 debate is that "bad weather" could trigger mental and ideological change. The aim of this paper is to explore if similar natural events made iron reaping tools acceptable around 200 BC, while still acknowledging the underlying economic and political forces. Through Gräslund's work, the low temperature period 536–541 is now widely accepted as the historical background of the Fimbulwinter and I will investigate if this insight might be of relevance for the understanding of the earlier event. In fact, the myth was actually pinned down to the Pre-Roman Iron Age. Rutger Sernander (1910) suggested that the strictly limited archaeological evidence of the Pre-Roman Iron Age was due to a severe temperature fall causing population decline, and claimed this was the origin of the Fimbulwinter myth. His interpretation has gained little support from archaeologists (Wangen 2009:47; Dæhlen 2011; Gundersen 2019). Still, with the agency of weather and climate now acknowledged, it is worth exploring the basic idea again: did extreme weather cause a conservative mentality to change around 200 BC?

A framework for my discussion is resilience – the ability to survive and cope with a disaster (Cutter *et al.* 2008:600). The term is given a variety of meanings and is righty criticized for being vague, but is still a part of the discourse on disaster relief (Barrios 2016:29). It is a measure of how societies handle stress and crisis, and provides a way to understand why stable societies change, and the role of change (Redman 2005:72). Different societies may react in diverse ways to an accident. A society considering a flood the act of angry or vindictive gods reacts in another way than a society regarding it as the result of badly kept floodgates (Ebert 2018). The former society might placate the gods, while the latter might build better floodgates. Disasters are assessed according to how they influence human life, health, property, economic activity and other matters we care about, and are therefore social phenomena, as the example of the badly kept floodgates demonstrates (Shimoyama 2002:20; Dominey-Howes 2018:7). All kinds of societies are a mix of stabilizing forces in support of production and memory, while destabilizing forces are important for flexibility and innovation. Change might be a result of a sudden release of an accumulated stimulus, and flexible or resilient societies might handle the burst dam quite well. Not all seemingly dramatic climatic changes result in disasters. On the contrary, studies suggest that climatic change results in disaster only if political, social or economic circumstances allow it (Butzer 2012; Ljungqvist *et al.* 2018). A resilient society handles a potential disaster by changing and adapting to new conditions or by simply absorbing the shock (Birkmann *et al.* 2010). Disasters such as the Black Death and the 536 Dust Veil Event killed a lot of people, but also led to ideological change and mistrust of leaders (Herlihy and Cohn 1997; Arrhenius 2013). I will explore if a hitherto little acknowledged bad year in 207 BC may have been another catalyst for change by opening people's minds to new ideas and to the acceptance of new technology (Sørensen 1989a).

Temperature and precipitation in Pre-Roman Iron Age in eastern Norway

First, I will introduce the climate of the Pre-Roman Iron Age in eastern Norway. Due to local variations and to methodical and source critical considerations it is hard to be detailed. However, Rolf Sørensen *et al.* (2015) have adapted a summer temperature curve from Setesdal, southern Norway, to Ås, in the county of Akershus in eastern Norway, c. 30 kilometres from Dilling (fig. 1). In all likelihood, the climatic condition for cereal farming gradually worsened from c. 300 BC onwards, with colder and wetter summers, and with a severe temperature fall around 200 BC (Sørensen *et al.* 2015). As the conditions for cereal production in Scandinavia are marginal, even small changes for the worse could make a bad year (Stamnes 2016). The temperature fall around 200 BC is actually larger than the better explored fall around AD 536, widely acknowledged as disastrous. Similarly, a temperature curve from Gudbrandsdalen, in Oppland county, illustrates a dramatic temperature fall around 200 BC, showing lower summer temperatures in the two last centuries BC than in the 6th century AD (Nesje *et al.* 2016). Other studies suggest the temperature fall around 200 BC compares to the Late Antique Little Ice Age in other ways too. The Irish summer of 207 BC was so cold that the growth rings of oak trees evidence frost damage as severe as after 536 AD (Baillie 1992, 1995:fig. 5.2, 2007). German oak growth rings demonstrate a cold period from 208 to 204 BC, while Californian growth rings evidence frost damage in 206 BC (Baillie 2000:64–65).

The written evidence of the 207 BC cold period is of course even more scarce than that of AD 536. Still, they tell similar stories. Italian observations tell of a halo around the sun – when visible, the sun was red and there was abnormal daylight (Forsyth 1990). In northern China no stars could be seen in three months, and bad years resulted in starvation (Stothers 2002; Baillie 2007). This matches the descriptions of the AD 536 disaster and is consistent with the optical characteristics of volcanic eruptions (Robock 2000). I would therefore suggest that the bad year 207 BC was due to an eruption from an unknown volcano or possibly a comet impact (e.g., Baillie 2007; Manning *et al.* 2017). Richard Warner (1990:32), somewhat controversially, suggested that mythical notes in the Irish Annals on high cattle mortality actually refer to historical incidents in the years 209–199 BC (for critique, see Mallory 1993:18), and it has, moreover, been suggested that a volcanic eruption in 207 BC sparked rebellions in Egypt (Manning *et al.* 2017). All in all, evidence, albeit circumstantial, suggests that the year 207 BC was a bad year without a summer, probably caused by a volcano eruption (or comet impact, or possibly other climatic disturbances). Due to the similarities with the AD 536 event I will label the Pre-Roman Iron Age year without a summer the "207 BC Dust Veil Event". The temperature curves from Ås and Gudbrandsdalen aim to shed light on temperature over a long period, not to illustrate the incidents of 207 BC or AD 536 specifically. This may make the dating of the temperature fall appear more accurate than it is. Still, they illustrate that the Late Antique Little Ice Age is not the only Iron Age cold period. Just as in AD 536, a long period with lower summer temperatures is aggravated by one year "without a summer". Although the 207 BC event is less explored, the low summer temperature in 207 BC was probably brought about by an incident in some respects comparable to the event in AD 536 (Chambers 1993:252). In a period with a cold and wet climate, one summer when trees suffered frost damage, and when the harvest failed and the sun was less visible than ever before, must have been a shock – regardless of the cause – and must have given rise to hopelessness and desperation.

In addition to the temperature curve, a ^{14}C-dated pollen diagram from Ås allows us to single out known disasters such as the 536 Dust Veil Event and the Black Death, along with the less studied 207 BC event (Sørensen *et al.* 2015). All three were followed by enhanced levels of pollen from trees and bushes and a decrease in cereal and herbs related to agriculture – fields and pastures seem to be recovered by forests. Evidence from pollen diagrams and temperature curves thus indicates that the effects of the 207 BC event had much in common with the effects of the 536 event and the Black Death. Pollen studies from other parts of

Figure 1. The position of the main site at Dilling (216874) and location for the pollen diagram from Ås. Illustration: Linnea Syversætre Johannessen.

Scandinavia also indicate similar tendencies: decreased pollen from cultivated plants and increased pollen from trees, indicating reforestation from c. 200 BC onward (Berglund and Tesch 1991; Pedersen and Widgren 1998:30, 48–49, 178; Myhre 2002:19; Ekman 2004:128). The climatic preconditions for cereal-growth probably became less favourable from c. 300 BC to c. 1 BC, and hostile in 207 BC. Most likely the 207 BC event resulted in a single bad year, as opposed to the AD 536 event which caused two or several disastrous years and possibly decades with depressed temperatures (Baillie 2000:79; Toohey *et al.* 2016). Still, it is highly likely that the cold summer caused the harvest to fail and a shortage of leaf, grass and other fodder plants. The settlement at Dilling was established sometime in the third century BC, and flourished from c. 200 BC to AD 150– the period where paleoclimate research suggests agriculture declined (fig. 2). There has been little focus on the "207 BC Dust Veil Event" in Scandinavian archaeology, even if some have suggested that the cold period and the subsequent bad years influenced the settlement pattern in Denmark or caused Germanic migration eastwards (Konstantin-Hansen 2013 with references; Nielsen 2015). It is therefore underexplored if or to what extent the 207 BC event affected the settlement pattern in Scandinavia. As different kinds of society react differently to challenges, I will outline some fundamental characteristics of eastern Norway at the transition from Early to Late Pre-Roman Iron Age, before I go on to the Dilling site.

What kind of society met the "207 BC Dust Veil Event"?

Our perception of the Pre-Roman Iron Age has changed radically since the early 1900s when Sernander and other researchers found poor evidence for settlement and peopling. Methodological innovation, e.g., the ^{14}C method (dating of cremations with limited grave goods), top soil stripping (finds of houses and diverse evidence of settlement), and paleoclimate research have all provided a larger body of evidence from eastern Norway (Løken 1974; Rødsrud 2012; Sørensen *et al.* 2015; Skogstrand 2016; Gjerpe 2017; Solheim and Iversen 2019; Gundersen *et al.* 2020; Mjærum 2020). All in all, as a consequence of a new look at old evidence, the period is now considered dynamic (Bergsvik 2006; Dæhlen 2011). The Pre-Roman Iron Age is no longer divided in three (e.g., Becker 1961), but into Early (500–200 BC) and Late (200–1 BC), based on burials and artefacts (Pilø 1989; Nybruget and Martens 1997; Jensen 2005). Cremation with few or no grave goods and no (preserved) monuments is the predominant burial custom, even though some monuments and richer grave goods do occur (Johansen 1955; Nybruget 1978; Nybruget and Martens 1997; Rødsrud 2004; Wangen 2009; Gustafson 2016:32–45). The graves appear egalitarian when compared to the Late Bronze Age and Early Roman Period, even though some express prestige. Most graves are situated in or close to fields, but rarely on settlement sites themselves (Ragnesten 2007; Gjerpe and Østmo 2008; Meling 2017). The number of richly furnished graves increases around c. 200 BC, and graves with weapons are interpreted as evidence of the rise of an independent military organization (Martens 2008, 2011).

Mixed farming was well established as the main subsistence strategy in Scandinavia by the end of the Bronze Age (Pedersen and Widgren 1999; Myhre 2002; Jensen 2006), while the three-aisled building with separate rooms for humans and animals was the main farmhouse from c. 1500 BC until the Viking Age (AD 800–1050). Cattle, sheep, goats and horses were the customary farm animals, and wheat and barley the conventional cereals, supplemented by oat and rye, especially in southern Scandinavia. While Early and Middle Bronze Age society was hierarchical, and socially and economically stratified (Kristiansen 1998), Late Bronze Age and Early Pre-Roman Iron Age society was less stratified and more egalitarian, prompting Ulf Ragnesten (2007:3) to name it "the people's century". Understanding pre-disaster political strategies is the key to understanding post-disaster conflict (Peregrine 2019). According to archaeologists and historians alike, egalitarian societies are more resilient than polarized or hierarchical societies: "equality in the distribution of property and power was a vital component in pre-industrial societies' capacity to deal or recover from crisis" (Curtis 2014:270; see also Peregrine 2018). This being the case, an accident could cause Pre-Roman Iron Age society to innovate or change rather than collapse, probably reallocating resources and creating winners and losers in the process, sometimes benefiting the pre-disaster elite, and in other cases overturning them (Izdebski *et al.* 2018).

Dilling: settlement, sickles, and the "207 BC Dust Veil Event"

The material I use to explore the possible change of mentality and practice is from one of the largest excavated prehistoric settlements in eastern Norway, recently discovered at Dilling, Østfold (Ødegaard *et al.* 2017; Gjerpe 2019, *in prep.*; Ødegaard *et al.* this volume). There was sporadic activity here from the Bronze Age to the Viking Age, with continuous settlement from c. 300 BC to AD 200, flourishing from c. 200 BC to c. 150 AD (figs. 6.1, 6.2). Four to six farms within a distance of 800 metres were settled at the same time as a cremation burial site was used. As in the rest of central and southern Scandinavia, mixed farming was the main source of calories. Wheat and barley were the main crops at Dilling, and even though preservation conditions did not favour bones, it seems safe to suggest that cattle, sheep and goats, and possibly horses, were the main farm animals. The site lies on the

Burial nr.	Dated material	Dated material	Laboratory number	Date BP	Standard deviation	Calendar year 68%	Calendar year 95%
5201	Cremated bone	Cremated bone	Beta 470032	2030	30	88 BC–AD 20	156 BC–AD 53
	Charcoal	Charcoal Aspen/*Populus* or Willows/*Salix*	LuS 13114	2055	40	152–2 BC	178 BC–AD 47
5582	Cremated bone	Cremated bone	Beta 470031	2090	30	163–56 BC	195–42 BC
	Charcoal	Charcoal Birch/*Betula*	LuS 13123	1995	40	41BC–AD 52	106 BC–AD 85
9629	Charcoal	Hazel/*Corylus*	Ua 58229	2082	*30*	*159–52 BC*	*192–5 BC*
	Cremated bone	Cremated bone (Human)	LuS 13923	2050	40	111 BC–AD 2	174 BC–AD 49

Table 1. ^{14}C-dates from cremation graves with sickles at Dilling.

transition between the Ra, the largest terminal moraine in Scandinavia, and the marine silt and clay plain. From the settlement there was access to both the wetter clay plains and the dryer moraine. The settlement at Dilling has been thoroughly excavated and well dated. Due to trial trenching in a c. 100 metres wide and several kilometres long east-west development plan, the settlement has been defined in all directions except to the north and southeast. Trial trenching also revealed remains of activity in the landscape surrounding the settlement, such as cooking pits. Dilling is, then, well suited for a study of human interaction with topography, soil and climate. It also offers a suitable opportunity for studying early use of iron sickles, as three Pre-Roman Iron Age sickles were found there.

Lack of evidence for Scandinavian iron reaping tools prior to c. 200 BC is of course not evidence of absence – conservation of iron objects on settlement sites is poor and their presence in graves or depositions depends on custom. As of today, no reaping tools of any material are known from the Early Pre-Roman Iron Age of eastern Norway. However, other kind of tools were made of flint and stone, and I suggest the lack of reaping tools owns much to investigation. Pressure-flaked flint arrowheads from eastern Norway are dated as late as AD 200 (Mjærum 2012), and pressure-flaked tools were used in agricultural settings in western Norway through the whole Pre-Roman Iron Age (Bergsvik 2006). In southern Scandinavia the use of flint and stone tools continued throughout the Iron Age (Knarrström 2000, 2006). It is hard to link cutting stone or flint tools to Iron Age farms in eastern Norway, probably due to source critical problems – as archaeologists tend to interpret small finds of flint in Iron Age farm contexts as redistributed from Stone Age settlements. Some flints collected from Iron Age house grounds in western Norway have been interpreted as chippings, possibly from production of fire flint (Petersen 1933; Randers 1981). Flint blades have been found in Iron Age contexts such as graves, but are mostly interpreted as accidently redistributed or as antiquities used as memorabilia to create bonds to the past (Gjerpe 2008; Thäte and Hemdorff 2009; Reitan 2016). The scarce and little studied material makes it difficult to conclude whether people were still making reaping tools of flint or stone in the decades leading up to c. 200 BC, but circumstantial evidence suggests they might have been, and that the lack of iron tools is real and not due to poor preservation or depositing customs.

In eastern Norway, few iron sickles date to the Pre-Roman Iron Age. The cause of this may be a lack of precise typology, few graves dated by ^{14}C, and burial custom – however, it probably mirrors a scarcity of iron sickles. In this context, the three recently excavated cremations with sickles at Dilling are noteworthy. Two samples from each are dated (tab. 1). The results point to a Late Pre-Roman Iron Age date or possibly the first 50 years of the Roman Iron Age. The three sickles from Dilling can consequently be counted among the sickles – less than ten in all – from the Pre-Roman Iron Age of eastern Norway (Nybruget 1978; Gustafson 2016). All in all, evidence suggests reaping tools were made of other materials before c. 200 BC, and that it was around 200 BC that they were replaced by iron tools.

In general, there seems to be continuous settlement at Dilling from c. 300 BC, with a village-like structure in the period c. 200 BC–AD 150. The buildings are dated with one or more ^{14}C-dates of cereals or charcoal from postholes, fireplaces or other structures interpreted as a part of the building, and in some cases from (horizontal) stratigraphy (Gjerpe *in prep.*). As calibrated ^{14}C dates often cover many calendar years, dates from one house may cover several hundred years, even though a three-aisled building with dug down posts probably stood for less than 200 years or even as short a time as a few decades (see also Lindell this volume). This makes it hard to define how many buildings stood at Dilling in the third century BC. Eighteen buildings have dating that spans the third century, while all but three of them span well into the second century or later. From c. 200 BC to AD 150/200 the settlement flourished, with 86 of 98 dated buildings spanning parts of that period. Only four buildings are erected on the plain after AD 200, all within a small area. Most activity on the other areas ended around AD 150/200. The summed probability distribution of ^{14}C-dates also supports the assumption of

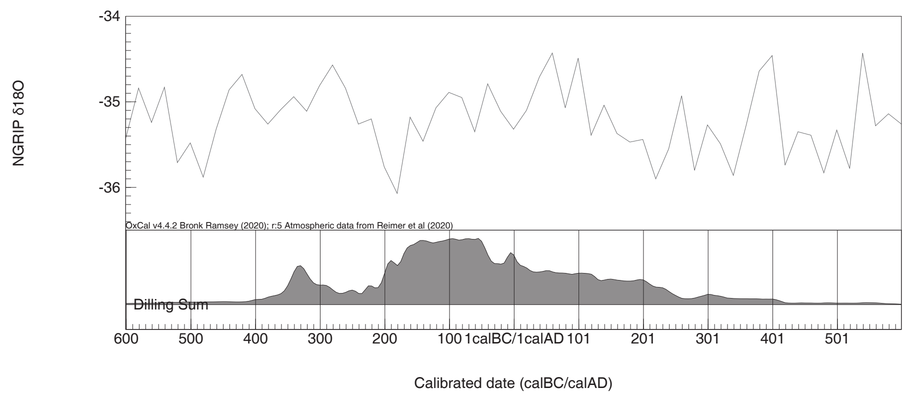

Figure 2. SUM of probability based on 499 ^{14}C dates from the Dilling settlement site (Gjerpe *in prep*.) and the NGRIP ice core δ18O record, a proxy for temperature on Greenland (Jouzel *et al*. 1997). Calibrated by OxCal v4.4.2 (Bronk Ramsey 2009), atmospheric data from Reimer *et al*. (2020). Note the steep rise of the SUM curve c. 200 BC. The "horn" c. 340 BC is probably a result of the gentle slope or plateau of the calibration curve, and does not reflect high activity. The ^{14}C dates are from Gjerpe *in prep*.

sporadic settlement on the Dilling plain before 300 BC, then continuous activity starting in the third century BC and flourishing from 200 BC to AD 150/200 (fig. 2). Thus, the activity at Dilling actually peaks at a time when temperature curves and pollen diagrams suggest low activity in eastern Norway.

This also coincides with another change. From c. 200 BC the use of isolated cooking pits in the outfields pauses at Dilling and decreases in the rest of eastern Norway and in parts of Sweden (Petersson 2006: fig. 107; Streiffert 2012:27; Persson and Reitan 2014: fig. 11.17, 14.7.10; Solheim 2017: fig. 5.2; Viken and Reitan 2019: tab. 1.7.3). Lone cooking pits in the outfields are interpreted as meeting places for herders to negotiate rights to pastures, but may also have offered heat for herders spending the night outdoors (Petersson 2006; Munkenberg 2015; Meling this volume). The end of this practice suggests either that pasture rights were no longer negotiable or that pastures were no longer used. Pollen diagrams favour the latter interpretation, and consolidated evidence suggests the outfield pastures were no longer important. Analysis of soil samples suggests that dung accumulated at the settlement site of Dilling indicates that cattle were held close to the site, not far away in the outfields (Macphail *et al*. *in prep*.). It therefore seems the new technology was roughly contemporaneous with economic and societal changes around 200 BC, and had a cause-and-effect relationship to them.

Luddites and cultural pessimism in Pre-Roman Iron Age

Resistance to technological innovation is to be found throughout time and in various places. The Luddites were an organization of textile workers who, in England early in the 19th century, destroyed textile machines, as they feared the time spent to learn their trade would go to waste (Jones 2006). Today the term refers to anyone who opposes technological development, often because they fear that new technology will make their skills and know-how irrelevant or redundant, and lead to them losing their manual jobs (Jones 2006). Cultural pessimists on the other hand fear that new technology somehow will "turn upon us", causing social upheaval and society to change for the worse for those benefiting from the current situation (Spengler 1988).

Lauriston Sharp's (1952) ethnographic study of the introduction of steel axes to, in his words, "stone age Australians" might substantiate cultural pessimists' fear of new technology. The Yir Yoront people centred their economic, cultural and social life around the stone axe, which was a totem, a symbol of masculinity and (older) men's dominance, as well as a good and functional tool to cut firewood or conduct other tasks, whether quotidian or rare. Only adult men could own stone axes, although women, youth and children used them in daily tasks, including collecting firewood. They had to ask an older man to borrow his axe, an act confirming his rightful dominance. Then "a snake" entered the paternalistic paradise – the steel axe. Christian missionaries started to give steel axes as gifts to Yir Yoront women, children and sometimes men, without being aware of the societal consequences. Men now had to ask women or children to borrow the more effective steel axes, an act which undermined the traditional pattern of male authority among the Yir Yoront people and gave the hitherto subordinate women and children more independence. The steel axe challenged gender roles and the social order more broadly, in the end causing the Yir Yoront culture to collapse, or at least radically change. As the new technology was not compatible with the institutional or ideological base, authority was redistributed in new ways (Iyigun and Rubin 2017).

The study demonstrates how resistance to new technology such as steel axes or iron sickles might be rational for those who might lose social or economic control or influence. In the Pre-Roman Iron Age hostility to more efficient sickles might have been rational for "the last Bronze Age Men" benefiting from male domination (cf. Kristiansen 1998, 2004). Luddism by proxy – the fear of what other people might do when they get too much spare time – the devil finds work for idle hands – is a form of cultural pessimism also known in the last centuries BC. Hellenistic society regarded slaves as both essential to production and as a potential threat (Green 2007:76). To keep slaves fully occupied with manual labour was a way to pacify them, inflicting a reluctance to accept labour-saving technology.

Further north, society in eastern Norway seems not to change much during the Early Pre-Roman Iron Age, and may fairly be described as conservative and reluctant to change. A long time passed from the introduction of iron to activation of its potential (Levinsen 1983). As Sørensen (1989a) has pointed out, the time lag was ideologically justified. The Iron Age economy was embedded in other values than that of maximizing production (Gjerpe 2017) and the Iron Age farmer was not a rational economic actor aiming for increased prosperity. New is not always better, and technological innovation is not always immediately socially important (Sørensen 1989a). It seems like iron was not regarded as an alluring metal in the Late Bronze Age and Early Pre-Roman Iron Age. Tradition and conservatism led to resistance to new materials and to a late acceptance of iron as a raw material for tools (Sørensen 1989a; Kristiansen 1998:156). This mentality changed around 200 BC.

People scared straight and cultural pessimists proved right

Against this background we can now return to our other main question: why were iron tools accepted around 200 BC? The previous paragraph discussed general issues relating to delayed acceptance of technical advances being caused by mental and ideological conservatism. Now we must check out the chronology of developments at the Dilling settlement in eastern Norway. The precision of the dating, as far as it goes, does seem to suggest a chronology that indicates that the acceptance of iron tools followed a bad year. I argue there is a causal link. However, I do not suggest that the 207 Dust Veil Event forced or caused the use of iron reaping tools. I argue that the bad year and the subsequent hunger, on top of the stress accumulated over decades of worsening conditions for cereal-growing, must have caused a resilient society to consider alternative ways of thinking and living.

The shock and awe following the 207 BC event reminded this conservative society that the world was changing, and removed a mental block, making way for the acceptance of new ideas and available technology. The direct consequence of the new technology in the form of iron sickles was higher output per work unit – a person could collect more fodder or cereals. While the Yir Yoront used the higher productivity of new technology to sleep more (Sharp 1952), the central Scandinavians used it to stay closer to home. Iron sickles made it possible to collect a larger amount of fodder; consequently, animals could be kept closer to the settlements. Pollen analysis implies reforestation, and the lack of cooking pits in the outfields from around 200 BC and for two centuries or so suggests there was no conflict related to grazing in the forest in this period.

The iron sickle must have been better suited to collecting plants on the stone-free marine clay plains free than on the stony moraine. At the same time as the animals were kept closer to the settlements, dung was treated in a new way, resembling "plaggen soil" (Macphail *et al. in prep*.). Increased quantity and possibly also quality of the manure made better manuring possible, resulting in higher yields and the possibility to cultivate the same field longer before leaving it fallow. The new manure management and need for dung made it desirable or necessary to keep the animals close to the settlement so that dung could be collected.

The direct and economic effect of the use of iron sickles was the opportunity to keep more cattle stabled, demanding increased access to winter fodder and larger buildings from c. 200 BC. In the Early Roman Period the combined dwelling and byre houses became smaller, but more outhouses may compensate (Ødegaard and Winther *in prep*.). A larger number of stabled cattle, possibly grazing close to the settlements and fields, gave better access to manure, resulting in higher yield. It is hard to separate the direct from the collateral effect of something decided more than 2000 years ago. Still, introduction of a new technology had unintended effects (Rogers 2003). Manuring and more extensive periods of cultivation without fallow made it possible or desirable to stay longer at the same place and in the same house. For that reason the houses were built more solidly or repaired (Bukkemoen 2015; Gjerpe 2017). When the activity in the outfields was reduced, it was not because of a general downturn, but because labour input was re-allocated to the settlement (Herschend 2009:20–25).

One of the collateral consequences might have been a change in gendered social and economic status. Geir Grønnesby (2019) has suggested that the division of labour was gender-based in the Pre-Roman Iron Age: greatly simplified, he suggests men raided and herded while women cultivated cereals. The new manuring regime and new tools must have raised the economic and social status of the users, as well as their productivity. If graves are dialogues with the gods (Kaliff 2007:84), then much of the conversation must have centred on harvesting, as sickles are one of the few types of tools in graves from the Late Pre-Roman Iron Age. Sickles might also be a symbol of food supply (Pedersen and Widgren 1998:357). At any rate, the importance of sickles is demonstrated by their being one of only a few categories of tools present in Late Pre-Roman Iron Age burials, and the lack of male graves with sickles might support Grønnesby's suggestion.

Conclusion

Inspired by the AD 536 Dust Veil Event discussion and historical and anthropological research, I have applied resilience theory to investigate the acceptance of the iron sickle around 200 BC. Tree-rings and sparse written sources indicate a volcanic eruption or other climatic disturbance in 207 BC causing one year without a summer, by me labelled the "207 BC Dust Veil Event". I have argued that the event scared the Pre-Roman Luddites of eastern Norway straight, and made a conservative but resilient society accept new technology in the form of the iron sickle. I have also demonstrated that the iron sickle, like other types of new technology, had both intended and collateral consequences. The iron sickle made it possible to harvest more cereals and fodder per work unit. The larger amount of fodder made it possible to keep more farm animals closer to the settlement, thereby increasing the amount of dung available for manuring. Better manuring made it possible to cultivate the fields longer without fallow periods, which again made it possible or desirable to stay longer at the same place, and therefore made it rational to build more solid houses. The larger amount reaped per work unit also increased surplus, allowing a more hierarchical society to develop. Sickles from the Pre-Roman Iron Age are mostly found in female graves, possibly reflecting the female involvement in cereal cultivation and fodder collecting, and the new technology may have altered the social and economic status of the users – probably for the better. Pollen diagrams indicate reforestation in eastern Norway as well as the rest of Scandinavia from c. 200 BC. As the settlement at Dilling was established around c. 300 BC and flourished from 200 BC to c. AD 150, I have argued that reallocation of resources from the outfields to the infields closer to settlement, rather than population decline, caused the reforestation.

Notes

1. The term «scared straight» refers to programs designed to scare young people into law-abiding citizens by exposing them to the consequences of the "wrong" choice (e.g., Thompson et al. 2009). I believe the term is a satisfactory description of how a disaster may scare people into ways that in retrospect may be considered the straight way.

Bibliography

Amundsen, M. and P. D. Fredriksen 2014 Når stedsbånd veves og løses opp. En sosial kronologi for bosetningen av Kalvebeitet i indre Sogn i yngre romertid og folkevandringstid. *Viking* LXXVII:79–104.

Arrhenius, B. 2013 Helgö in the shadow of the dust veil 536–37. *Journal of Archaeology and Ancient History* 5:1–15.

Axboe, M. 1999 The year 536 and the Scandinavian gold hoards. *Medieval Archaeology* XLIII:186–188.

Barrios, R. E. 2016 Resilience: A commentary from the vantage point of anthropology. *Annals of Anthropological Practice* 40:28–38.

Baillie, M. G. L. 1992 Dendrochronology and past environmental change. *Proceedings of the British Academy* 77:5–23.

Baillie, M. G. L. 1995 *A slice through time. Dendrochronology and precision dating*. B.T. Batsford, London.

Baillie, M. G. L. 2000 *Exodus to Arthur: catastrophic encounters with comets*. B.T. Batsford, London.

Baillie, M. G. L. 2007 Tree-rings indicate global environmental downturns that could have been caused by comet debris. In *Comet/Asteroid Impacts and Human Society. An Interdisciplinary Approach*, P. T. Bobrowsky and H. Rickman (eds.), pp. 105–122. Springer, Berlin.

Becker, C. J. 1961 *Førromersk jernalder i Syd- og Midt-Jylland*. Nationalmuseets skrifter. Større beretninger 6. Nationalmuseet, København.

Berglund, B. E. and S. Tesch 1991 The Roman Iron Age Landscape. *Ecological Bulletins 41*:78–81.

Bergsvik, K. A. 2006 Førromersk jernalder ved Skatestraumen – sosiale og økonomiske implikasjoner. *Viking* LXIX:107–130.

Birkmann, J., P. Buckle, J. Jaeger, M. Pelling, N. Setiadi, M. Garschagen, *et al*. 2010 Extreme events and disasters: a window of opportunity for change? Analysis of organizational, institutional and political changes, formal and informal responses after mega-disasters. *Natural Hazards* 55(3):637–655.

Bronk Ramsey, C. 2009 Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51:337–360.

Bukkemoen, G. B. 2015 Ett hus – mange livsløp. Boligens biografi i førromersk jernalder belyst gjennom et gårdsanlegg i Askim. *Viking* LXXVIII:95–118.

Butzer, K. W. 2012 Collapse, environment, and society. *Proceedings of the National Academy of Sciences* 109(10):3632–3639.

Butzer, K. W. and G. H. Endfield 2012 Critical perspectives on historical collapse. *Proceedings of the National Academy of Sciences* 109(10):3628–3631.

Cashman, K. V. and S. J. Cronin 2008 Welcoming a monster to the world: Myths, oral tradition, and modern societal response to volcanic disasters. *Journal of Volcanology and Geothermal Research* 176(3):407–418.

Chambers, F. M. 1993 *Climate change and human impact on the landscape: studies in palaeoecology and environmental archaeology*. Chapman & Hall, London.

Curtis, D. R. 2014 *Coping with Crisis: The Resilience and Vulnerability of Pre-Industrial Settlements.* Routledge, London.

Cutter, S. L., L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, *et al*. 2008. A place-based model for understanding community resilience to natural disasters. *Global Environmental Change* 18:598¬–606.

Dobres, M.-A. 2000 *Technology and social agency: outlining a practice framework for archaeology*. Blackwell, Oxford.

Dominey-Howes, D. 2018 Hazards and disasters in the Anthropocene: some critical reflections for the future. *Geoscience Letters* 5(1):7.

Dæhlen, T. M. 2011 *Myten om myten. En analyse av norsk forsking på førromersk jernalder.* Unpublished master thesis, IAKH, Det humanistiske fakultet, Universitetet i Oslo, Oslo.

Ebert, S. 2018 Starvation under Carolingian rule. The famine of 779 and the Annales Regni Francorum. In *Famines During the 'Little Ice Age' (1300–1800): Socionatural Entanglements in Premodern Societies,* D. Collet and M. Schuh (eds.), pp. 211–230. Springer, Heidelberg.

Eisenberg, M., D. J. Patterson, J. Kreiner, E. F. Arnold and T. P. Newfield 2019 Environmental history of the Late Antique West: a bibliographic essay. *In Environment and Society in the Long Late Antiquity,* A. Izdebski and M. Mulryan (eds.), pp. 32–50, Brill, Leiden, Boston.

Ekman, S. 2004 Bohuslänsk kulturmarkutveckling från stenålder till historisk tid. In *Projekt Gläborg-Rabbalshede. Bygden innanför fjordarna. 4. Metod- och materialanalys*, P. Claesson and B.-A. Munkenberg (eds.), pp. 113–144. Bohusläns museum, Uddevalla.

Forsyth, P. 1990 Call for Cybele. *The Ancient History Bulletin* (4):75–78.

Fredriksen, P. D., E. S. Kristoffersen and U. Zimmermann 2014 Innovation and Collapse: Bucket-Shaped Pottery and Metalwork in the Terminal Migration Period. *Norwegian Archaeological Review* (2):119–140.

Gjerpe, L. E. 2008 Kapittel 5. Gulli 5 og 15 – Bosetningsspor, dyrkingsspor, smie og graver fra bronsealder, jernalder og middelalder. In *Hus, boplass- og dyrkningsspor. E18-prosjektet Vestfold Bind 3*, L. E. Gjerpe (ed.), pp. 193–222. Varia vol. 73. Kulturhistorisk museum, Fornminneseksjonen, Oslo.

Gjerpe, L. E. 2017 *Effektive hus. Bosetning, jord og rettigheter på Østlandet i jernalder.* Unpublished PhD thesis. Institutt for arkeologi, konservering og historie, Det humanistiske fakultet, Universitetet i Oslo, Oslo.

Gjerpe, L. E. 2019 Var det en jernalderlandsby på Dilling? In *Arvegull*. *Rygge kirke*, B. Bandlien (ed.), pp. 30–39. Press, Rygge.

Gjerpe, L. E. (ed.) *in prep*. *Dilling – en landsby fra førromersk jernalder?* Cappelen Damm Akademisk, Oslo.

Gjerpe, L. E. and M. Østmo 2008 Kapittel 3. Ringdal 13 – Hus fra romertid-merovingertid og graver fra førromersk jernalder. In *Hus, boplass- og dyrkningsspor. E18-prosjektet Vestfold Bind 3*, L. E. Gjerpe, pp. 39–141. Varia 73. Kulturhistorisk museum, Fornminneseksjonen, Oslo.

Green, P. 2007 *The Hellenistic Age*. Random House, New York.

Gräslund, B. 2007 Fimbulvintern, Ragnarök och klimatkrisen år 536–537 e.Kr. *Saga & Sed* 2007:93–123.

Gräslund, B. and N. Price 2012 Twilight of the gods? The 'dust veil event' of AD 536 in critical perspective. *Antiquity* 86:428–444.

Grønnesby, G. 2019 *" . . . en pludselig og stærk omvæltning"? Eldre jernalder og overgangen til yngre jernalder i Trøndelag. Praksis og overregionale nettverk.* Unpublished PhD thesis. NTNU, vol. 276. NTNU, Trondheim.

Gundersen, I. M. 2019 The Fimbulwinter theory and the 6th century crisis in the light of Norwegian archaeology: Towards a human-environmental approach. *Primitive tider* 21:101–119.

Gundersen, I. M., C. L. Rødsrud and J. Post-Melby 2020 9. Kokegroper som massemateriale. Regional variasjon i en kulturhistorisk brytningstid. In *Ingen vei utenom: Arkeologiske undersøkelser i forbindelse med etablering av ny rv. 3/25 i Løten og Elverum kommuner, Innlandet*, C. L. Rødsrud and A. Mjærum (eds.), pp. 187–199. Cappelen Damm Akademisk/NOASP, Oslo.

Gustafson, L. 2016 *Møter på Veien – kultplass gjennom 1500 år. Et maktsenter på Ringerike i eldre jernalder.* Portal forlag, Kristiansand.

Herlihy, D. and S. K. Cohn 1997 *The Black Death and the transformation of the west.* Harvard University Press, Cambridge, Massachusetts.

Herschend, F. 2009 *The Early Iron Age in South Scandinavia: social order in settlement and landscape*. Occasional papers in archaeology, vol. 46. Societas Archaeologica Upsaliensis, Uppsala.

Iyigun, M. F. and J, Rubin 2017 The Ideological Roots of Institutional Change. *IZA DP No. 10703 Discussion Paper Series*. http://ftp.iza.org/dp10703.pdf, visited 3rd December 2019.

Izdebski, A., L. Mordechai, and S. White 2018 The Social Burden of Resilience: A Historical Perspective. *Human ecology: an interdisciplinary journal* 46:291–303.

Jensen, C. K. 2005 *Kontekstuel kronologi: en revision af det kronologiske grundlag for førromersk jernalder i Sydskandinavien*. Lag, Forlaget Kulturlaget, Århus.

Jensen, J. 2006 *Danmarks oldtid. Ældre jernalder 500 f. Kr.–400 e. Kr.* Gyldendal, Viborg.
Johansen, E. 1955 Ny datering av branngraver under flat mark. Gravskikken som kilde til sosial historie. *Universitetets Oldsaksamlings Årbok* 1951–1953:178–236.
Jones, S. E. 2006 *Against Technology: From the Luddites to Neo-Luddism*. Taylor & Francis, New York.
Jouzel, J., R. B. Alley, K. M. Cuffey, W. Dansgaard, P. Grootes, G. Hoffmann, *et al*. 1997 Validity of the temperature reconstruction from water isotopes in ice cores. *Journal of Geophysical Research: Oceans* 102(C12):26471–26487.
Juma, C. 2016*Innovation and its enemies: why people resist new technologies*. Oxford University Press, New York.
Kaliff, A. 2007 *Fire, water, heaven and earth. Ritual practice and cosmology in ancient Scandinavia: An Indo-European perspective.* Riksantikvarieämbetet, Lund.
Knarrström, B. 2000 *Flinta i sydvästra Skåne: en diakron studie av råmaterial, produktion och funktion med fokus på boplatsteknologi och metalltida flintutnyttjande.* Almqvist & Wiksell, Stockholm.
Knarrström, B. 2006 Flintor från järnålder. In *Järnålder vid Öresund. Band 2. Metod- och materialstudier*, A. Carlie (ed.), pp. 110–121. Riksantikvarieämbetet, Lund.
Konstantin-Hansen, N. H. 2013 Migration i førromersk jernalder. *KUML* 62:9–40.
Kristiansen, K. 1998 *Europe Before History. New Studies in Archaeology*. Cambridge University Press, Cambridge.
Kristiansen, K. 2004 Institutioner og materiel kultur. Tvillingherskerne som religiøst og politisk institution under bronzealderen. In *Ordning mot kaos – studier av nordisk förkristen kosmologi*, A. Andrén, K. Jennbert and C. Raudvere (eds.), pp. 99–122. Vägar till Midgård 4. Nordic Academic Press, Lund.
Larsen, J. H. 2013 Ovner med slaggrop i Sydøst-Norge – 400 BC–AD 800 – likheter og forskjeller. In *Ovnstypologi og ovnskronologi i den nordiske jernvinna*, B. Rundberget, J. H. Larsen and T. H. Borse Haraldsen (eds.), pp. 59–72. Portal forlag, Kristiansand.
Layton, R. 2000 *Anthropology and history in Franche-Comté: a critique of social theory*. Oxford University Press, Oxford.
Leeuw, S. E. van der 1989 15 Risk, perception, innovation. In *What's New? A closer look at the process of innovation*, S. E. van der Leeuw and R. Torrence (eds.), pp. 300–329. Unwin Hyman, London.
Ljungqvist, F. C., W. Tegel, P. J. Krusic, A. Seim, F. M. Gschwind, K. Haneca, *et al*. 2018 Linking European building activity with plague history. *Journal of Archaeological Science* 98:81–92.
Levinsen, K. 1983 Jernets introduktion i Danmark. *KUML* 31:153–168.
Løken, T. 1974 *Gravminner i Østfold og Vestfold et forsøk på en typologisk – kronologisk analyse og en religionshistorisk tolkning*. Unpublished magister thesis, Universitetet i Oslo, Oslo.
Löwenborg, D. 2012 An Iron Age Shock Doctrine: Did the AD 536–7 event trigger large-scale social changes in the Mälaren valley area? *Journal of Archaeology and Ancient History* 4:3–29.
Macphail, R., J. Linderholm and L. E. Gjerpe *in prep* Geoarchaeology and Morphology of a Mixed Farming Settlement. In *Dilling – en landsby fra førromersk jernalder?*,L.E. Gjerpe (ed.). Cappelen Damm Akademisk, Oslo.
Mallory, J. P. 1993 The Archaeology of the Irish Dreamtime. *Proceedings of the Harvard Celtic Colloquium* 13:1–24.
Manning, J. G., F. Ludlow, A. R. Stine, W. R. Boos, M. Sigl and J. R. Marlon 2017 Volcanic suppression of Nile summer flooding triggers revolt and constrains interstate conflict in ancient Egypt. *Nature Communications* 8(1):900. doi:10.1038/s41467-017-00957-y, visited 3rd of December 2019.
Martens, J. 2008 A princely burial at Bøli vestre, Østfold: the (re-)introduction of weapon burial rites in Iron Age Norway. In *Facets of archaeology. Essays in honour of Lotte Hedeager on her 60th birthday*, K. Chilidis, J. Lund and C. Prescott, pp. 309–322. OAS vol. 10. Unipub, Oslo.
Martens, J. 2011 Weapons, armaments and society. The Pre-Roman Iron Age on Zealand and in Scania. In *The Iron Age on Zealand. Status and perspectives*, L. Boye (ed.), pp. 147–173. Nordiske Fortidsminner, Series C, Volume 8. The Royal Society of Northern Antiquaries, Copenhagen.
Meling, T. 2017 Hellere i Rogaland og bruken av landskapet i førromersk jernalder. *Viking* LXXX:7–24.
Mjærum, A. 2012 The bifacial arrowheads in southeast Norway: A chronological study. *Acta Archaeologica* 83(1):105–143.
Mjærum, A. 2020 The emergence of mixed farming in eastern Norway. *Agricultural History Review* 68(1):1–21.
Moreland, J. 2018 AD 536 – back to nature? *Acta Archaeologica* 89(1):91–111.
Munkenberg, B.-A. 2015 Bara en härd! *In situ* 11:69–96.
Myhre, B. 2002 Landbruk, landskap og samfunn 4000 f. Kr.–800 e.Kr. In *Norges landbrukshistorie I. 4000 f.kr. – 1350 e.kr. Jorda blir levevei*, B. Myhre and I. Øye (eds.), pp. 11–213. Det Norske Samlaget, Oslo.
Nesje, A., I. M. Gundersen and R. J. S. Cannell 2016 9. Flommer og flomskred i Gudbrandsdalen i et værmessig og klimatisk perspektiv. In *Gård og utmark i Gudbrandsdalen. Arkeologiske undersøkelser i Fron 2011–2012*, I. M. Gundersen (ed.), pp. 80–93. Portal Forlag, Oslo.

Nielsen, S. K. 2015 Brud eller kontinuitet. Bebyggelsesstrukturer på overgangen mellom ældre og yngre førromersk jernalder i Nordjylland. KUML 64:99–125.

Nybruget, P. O. 1978 *Førromersk jernalder i Sørøst-Norge*. Unpublished magister thesis, Universitetet i Oslo, Oslo.

Nybruget, P. O. and J. Martens 1997 The Pre-Roman Iron Age in Norway. In *Chronological problems of the pre-roman iron age in Northern Europe. Symposium at the Institute of Prehistoric and Classical Archaeology University of Copenhagen, December 8 1992*, J. Martens (ed.), pp. 73–90. Arkæologiske Skrifter vol. 7. Danmarks Universitetsforlag, Copenhagen.

Ødegaard, M., T. Winther, L. E. Gjerpe and J. K. Hellan 2017 Gårder fra bronse- og jernalder – foreløpige resultater fra Dobbeltspor Dilling. *Primitive tider* 19:31–40.

Ødegaard, M. and T. Winther *in prep*. Bygninger med jordgravde stolper på Dilling – kronologisk klassifisering og romlig organisering. In *Dilling – en landsby fra førromersk jernalder*, L. E. Gjerpe (ed.). Cappelen Damm Akademisk, Oslo.

Pedersen, E. A. and M. Widgren 1998 Järnålder 500 f. Kr.–1000 e.Kr. In *Jordbrukets första femtusen år 4000 f. Kr.–1000 e.Kr.,* J. Myrdal (ed.), pp. 239–459. Det svenska jordbrukets historia. Stiftelsen Natur och Kultur, Borås.

Penack, J.-J. 1993 *Die eisernen eisenzeitlichen Erntegeräte im freien Germanien*. BAR International series, vol. 583. Hadrian Books, Oxford.

Peregrine, P. N. 2018 Social Resilience to Climate-Related Disasters in Ancient Societies: A Test of Two Hypotheses. *Weather, Climate, and Society* 10:145–61.

Peregrine, P. N. 2019 Reducing post-disaster conflict: a cross-cultural test of four hypotheses using archaeological data. *Environmental Hazards* 18:93–110.

Persson, P. and G. Reitan (eds.) 2014 *Vestfoldbaneprosjektet: arkeologiske undersøkelser i forbindelse med ny jernbane mellom Larvik og Porsgrunn. B. 2: Seinmesolittiske, neolittiske og yngre lokaliteter i Vestfold og Telemark.* Portal Forlag, Kristiansand.

Petersen, J. 1933 *Gamle gårdsanlegg i Rogaland fra forhistorisk tid og middelalder*. Serie B: Skrifter, vol. XXIII. Institutt for sammenlignende kulturforskning, Oslo.

Petersson, M. 2006 *Djurhållning och betesdrift, människor och landskap i västra Östergötland under yngre bronsålder och äldre järnålder.* Riksantikvarieämbetet Uppsala universitet, Uppsala.

Pillatt, T. 2012. From climate and society to weather and landscape. *Archaeological Dialogues* 19:29–42.

Pilø, L. 1989 *Den førromerske jernalder i Vestnorge: et kulturhistorisk tolkningsforsøk*. Unpublished magister thesis. Universitetet i Bergen, Bergen.

Ragnesten, U. 2007 *Individ och kollektiv i förromersk järnålder*. Gotarc, vol. B46. Institutionen för arkeologi och antikkens kultur, Göteborgs universitet.

Randers, K. 1981 *Høybøen – en ødegård på Sotra: en undersøkelse av bruksperioder og erverv basert på bosetningsspor fra eldre jernalder og middelalder.* Unpublished thesis, Universitetet i Bergen, Bergen.

Redman, C. L. 2005 Resilience Theory in Archaeology. *American Anthropologist* 107:70–77.

Reimer, P. J., W. E. N. Austin, E. Bard, A. Bayliss, P. G. Blackwell, C. B. Ramsey, et al. 2020 The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon* 62:725–757.

Reitan, G. 2016 Rapport arkeologisk utgravning kokegroper fra yngre bronsealder/førromersk jernalder, bygninger fra vikingtid/middelalder og hulveier Øvre Hoen, 78/1, Øvre Eiker, Buskerud. Unpublished excavation report, Kulturhistorisk museum, Universitetet i Oslo.

Robock, A. 2000 Volcanic eruptions and climate. *Reviews of Geophysics* 38:191–219.

Rogers, E. M. 2003 *Diffusion of innovations*. 5th ed. Free Press, New York.

Rødsrud, C. 2004 Gravfelt fra førromersk jernalder og overgangen til romertid. In *Mellom himmel og jord: foredrag fra et seminar om religionsarkeologi, Isegran, 31. januar–2. februar 2002*, L. Melheim, L. Hedeager and K. A. Oma (eds.), pp. 274–290. Archaeological Series, vol. 2, Oslo.

Rødsrud, C. L. 2012 *I liv og død: keramikkens sosiale kronologi i eldre jernalder.* Unpublished PhD thesis. Kulturhistorisk museum, Universitetet i Oslo, Oslo.

Røstad, I. M. 2021 *The Language of Jewellery. Dress-accessories and Negotiations of Identity in Scandinavia, c. AD 400–650/70*. Norske Oldfunn XXXII. Cappelen Damm Akademisk, Oslo.

Sernander, R. 1910 *Die Schwedischen Torfmoore als Zeugen Postglazialer Klimaschwankungen,* 11th International Geological Congress, Stockholm.

Sharp, L. 1952 Steel Axes for Stone-Age Australians. *Human Organization* 11(2):17–22.

Shimoyama, S. 2002 Basic characteristics of disasters. In *Natural Disasters and Cultural Change*, R. Torrence and J. Grattan (eds.), pp. 19–27. Routledge, New York.

Simonsen, M. F. and G. B. Bukkemoen 2015 Småhus og tidlig jernproduksjon i Sørum. In *Arkeologiske undersøkelser 2005–2006*, I. M. Berg-Hansen (ed.), pp. 121–135. Portal Forlag, Kristiansand.

Skogstrand, L. 2016 *Warriors and Other Men: Notions of Masculinity from the Late Bronze Age to the Early Iron Age in Scandinavia*. Archaeopress, Oxford.

Solheim, S. 2017 5. Naturvitenskapelige analyser. In *E18 Rugtvedt-Dørdal: arkeologiske undersøkelser av lokaliteter fra steinalder og jernalder i Bamble kommune, Telemark fylke*, S. Solheim (ed.), pp. 42–48. Portal, Kristiansand.

Solheim, S. and F. Iversen 2019 The mid-6th century crises and their impacts on human activity and settlements in southeastern Norway. In *Settlement change across Medieval Europe. Old paradigms and new vistas*, N. Brady and C. Theune, pp. 423–434. Ruralia vol. XII. Sidestone Press Academics Leiden.

Spengler, O. 1988 *Mennesket og teknikken: bidrag til en livsfilosofi*. Dreyer, Oslo.

Stamnes, A. A. 2016 Effect of Temperature Change on Iron Age Cereal Production and Settlement Patterns In Mid-Norway. In *The agrarian life of the North 2000 BC–AD 1000. Studies in Rural Settlement and Farming in Norway*, F. Iversen and H. Petersson (eds.), pp. 27–40. Portal Forlag, Kristiansand.

Stigum, H. 1938 Gården. In *Norsk kulturhistorie bind 1 Fra hulen til gården*, A. Bugge and S. Steen (eds.), pp. 259–330. Capellen Damm, Oslo.

Stothers, R. B. 2002 Cloudy and clear stratospheres before A.D. 1000 inferred from written sources. *Journal of geophysical research* 107(D23):AAC17/11–AAC17/10.

Streiffert, J. 2012 I fokus: Daterade kokgropar från Halland. *In situ* 10:21–34.

Sørensen, M. L. S. 1989a Ignoring innovation – denying change. The role of iron and the impact of external influences on the transformation of Scandinavian societies 800–400 B.C. In *What's New? A closer look at the process of innovation*, S. E. van der Leeuw and R. Torrence (eds.), pp. 182–120. Unwin Hyman, London.

Sørensen, M. L. S. 1989b Period VI reconsidered: Continuity and change at the transition from Bronze to Iron Age in Scandinavia. In *The Bronze Age – Iron Age Transition in Europe. Aspects of continuity and change in European societies c. 1200 to 500 B.C*M, L. S. Sørensen and R. Thomas (eds.), pp. 457–492. International series 483, British Archaeological Reports, Oxford.

Sørensen, R., H. I. Høeg and A. Pedersen 2015 Holocen vegetasjonshistorie og utviklingen av en myr i søndre Akershus. *Blyttia* 73(3):175–191.

Thäte, E. S. and O. H. Hemdorff 2009 Økser, amuletter og overtro: en steinalderøks i jernaldergrav på Avaldsnes, Karmøy. In *Tverrfaglige perspektiver*, M. Nitter and E. S. Pedersen (eds.), pp. 43–52. AmS-varia vol. 49. Arkeologisk museum, Stavanger.

Thompson, L. E., J. R. Barnett and J. R. Pearce. 2009 Scared straight? Fear-appeal anti-smoking campaigns, risk, self-efficacy and addiction. *Health, risk & society* 11:181–196.

Toohey, M., K. Krüger, M. Sigl, F. Stordal and H. Svensen 2016. Climatic and societal impacts of a volcanic double event at the dawn of the Middle Ages. *Climatic Change* 136:401–12.

Torrence, R. 2016 Social resilience and long-term adaptation to volcanic disasters: The archaeology of continuity and innovation in the Willaumez Peninsula, Papua New Guinea. *Quaternary International* 394:6–16.

Viken, S. and G. Reitan 2019 Naturvitenskap og ekspertanalyser. In *Kystens steinalder i Aust-Agder: arkeologiske undersøkelser i forbindelse med ny E18 Tvedestrand-Arendal*, G. Reitan and L. Sundström (eds.), pp. 47–56. Cappelen Damm Akademisk, Oslo.

Wangen, V. 2009 *Gravfeltet på Gunnarstorp i Sarpsborg, Østfold*. Norske Oldfunn XXVII. Kulturhistorisk museum, Universitetet i Oslo, Oslo.

Warner, R. 1990 The 'Prehistoric' Irish Annals: Fable or History? *Archaeology Ireland* 4(1):30–33.

Wiker, G. 2001 Om konstruksjon av en ny type menneskelig identitet i jernalderen. *Primitive tider* 4:51–72.

Ystgaard, I. 2014 *Krigens praksis: Organisert voldsbruk og materiell kultur i Midt-Norge ca. 100–900 e.Kr*. Unpublished PhD thesis. NTNU, Trondheim.