Landslides vs Archaeology

Case Studies of Site Loss and Emergency Fieldwork in Västra Götaland County, Sweden

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Landslides are one of the few types of natural hazards that have affected Sweden regularly in the recent past. We can expect that this geological phenomenon will only increase in frequency in the near future given the ongoing processes of anthropogenic climate change, and this likelihood motivates some historical retrospection. This paper explores how landslides have impacted archaeological sites in Västra Götaland, the country's most landslide-prone region, from the mid-twentieth century onwards, and how, in turn, archaeologists have had to respond to these disasters. The 1957 Göta, 1973 Fröland, 1977 Tuve and 2006 Småröd landslides are highlighted in particular, as is the landslide-impacted site Hjälpesten. Connections are made to other different but related archaeologies of hazard and disaster, providing insights into the impact that climate change has had and will have on the discipline. While the paper showcases a set of local case studies, it is further argued that its findings have relevance for other areas as well, calling for the attention of the cultural heritage sector.

Keywords: disasters, hazards, geoarchaeology, rescue archaeology, emergency management, climate change

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Introduction

In one way or another, the Covid-19 pandemic has forced us all to reflect upon the material realities of contemporary disasters, both globally and on a local level. These can take many different forms: visible and invisible, fast and slow, geological and political. The vital nature of effective emergency management has seldom been as apparent in modern times as now, at the time of writing, necessitating further research from all angles and disciplines to develop and strengthen the mechanisms safeguarding our communities and what we hold important.

As far back as Rousseau (1756) writing in the wake of the Lisbon earthquake (Chmutina & von Meding 2019:284), scholars have discussed and challenged the causes of disasters. Over the last several decades, a growing academic movement has argued for the revision of common understandings and definitions of hazards and disasters. This is encapsulated by the recent #NoNaturalDisasters campaign (Blanchard 2018). It contends that while hazards – avalanches, earthquakes, blizzards and so on – can be wholly natural phenomena, disasters cannot be natural, as they arise solely from the impact of hazards on human communities. In other words, there is no such thing as a 'natural disaster'. It is further argued that by employing the language of 'natural disasters', the responsibility for failures in infrastructure development, urban planning, socioeconomic inequalities, resource overexploitation and other societal factors in the creation of disasters is shifted away from the authorities at hand towards more esoteric and elusive causes (Chmutina & von Meding 2019:284). This is especially pertinent at present, as anthropogenic climate change has led to a global increase in the frequency and severity of hazards, and will continue to do so.

The frequency of disasters varies greatly across the world. Sweden has in the recent past been spared most types of large-scale natural hazards that cause deadly disasters abroad, such as larger earthquakes, tsunamis and volcanic eruptions, with rare exceptions (e.g. Riede 2014:348; Mäntyniemi et al. 2021). There is, however, one type of geological event that does affect Sweden on a regular basis: landslides. These phenomena require further consideration. In this paper, I have opted not to describe any landslide event as a 'natural' disaster, both because of the discourse at hand and because none of the major disasters discussed is entirely without anthropogenic root causes. In virtually every case discussed it is possible to point towards industrial exploitation, improperly built infrastructure or housing, or factors like deforestation and artificially induced changes in local hydrology. The modern Swedish landslide could be described as a *geocultural* phenomenon: the 'cultural' is inseparable from the 'geological' (Reynard & Giusti 2018; Scarlett & Riede 2019).

Several noteworthy landslides have occurred in Scandinavia over the last few years, among them the 13 November 2019 Lökeberg landslide in western Sweden's Kungälv municipality (Odén & Pedersen 2019); the 3 June 2020 Kråkneset landslide in northern Norway's Alta municipality (Larsen & Quist 2020); and the 30 December 2020 Ask landslide in eastern Norway's Gjerdrum district. While all three caused the mass destruction of local infrastructure and personal residences, thus constituting disasters, the latter proved especially tragic, with ten people killed and over a thousand people evacuated from their homes (Eriksson 2021). These events drew attention to the subject and demonstrated the dangers posed by landslides, being one of just a few serious natural hazards to regularly occur on the Scandinavian peninsula. At the same time, both Sweden and the rest of the world are increasingly affected by the ongoing processes of global climate change, which will continue to proceed and escalate throughout the twenty-first century. It is generally accepted by the international scientific community that these complex processes alter hydrological cycles and temperature scales, and will therefore have a direct impact on slope stability conditions, leading to a higher frequency of landslide events (e.g. Hultén et al. 2007; Rianna et al. 2014; Bergdahl & Odén 2015; Gariano & Guzzetti 2016).

Reports by the Swedish National Heritage Board in the past decade have highlighted the threat posed by landslides induced by climate change to cultural heritage and archaeological sites (Riksantikvarieämbetet 2014:4, 2016:15, 2019a:21), as have other studies commissioned by, for example, the Nordic Council of Ministers (Kaslegard 2011:22) and the Stockholm County Administrative Board (Länsstyrelsen Stockholm 2019:13). If we accept the legal stipulations of the Historic Environment Act that 'the protection and conservation of our cultural heritage is a matter of national concern' and that 'responsibility for cultural heritage is shared by all' (Riksantikvarieämbetet 2019b), or even just the fundamental idea that cultural heritage has some importance for the long-term survival and well-being of local communities, then this topic merits further investigation.

It is easy to hypothesize about the future possible consequences of landslides on the cultural heritage sector, but there is a difference between an evident present and a possible future. Are the risks theoretical or can actual examples be found? Have past landslides already had an impact on archaeology? These are the questions which lead this paper. Adding a historical dimension (Riede 2014:336) to the current understanding of landslides and their relationship to archaeology is appropriate. Maxims regarding the necessity to learn from the past to improve the future are often repeated within archaeology, with varying degrees of applicability to the subject matter. With this in mind, this paper examines several documented landslides, further tying these into both the practices of the contemporary cultural heritage sector and the difficulties which confront archaeologists in many different fields of research due to the ongoing processes of anthropogenic climate change.

The many hazards of Västra Götaland

The choice was made to limit the scope of the study to Västra Götaland, a large region (25,247km^2) in the country's western part. This delineation was motivated by the high regional frequency of landslide events in this area, resulting from its sensitive clay soils (Sundborg & Norrman 1963; Hågeryd et al. 2007:4; Källerfeldt et al. 2012:34), especially in the Göta river valley (Rudberg 1997:466; Hultén et al. 2007:150). There are, as a result of this frequency, many hundreds of known landslide scars in western Sweden which have been identified by geologists, dating from the Early Holocene post-glacial land uplift (Smith et al. 2014, 2017) to modern times. Furthermore, virtually all of Sweden's most devastating landslide events from the twentieth century and later have occurred in the county, with the sole major exception of the 1918 Getå railway disaster in Östergötland (Wegmann 1998). Extensive geotechnical investigations and risk assessments have been carried out in Västra Götaland because of this, making it a hotspot for landslide research compared to other regions.

Many of these landslides have changed the landscape substantially, doubtlessly modifying or fully destroying the earlier archaeological record within it in the process. As with many past hazards and disasters, data resolution is an issue (Riede 2014:338). Stratigraphies have shifted, finds have been displaced, spatial contexts have been turned and twisted, palimpsests have formed. This poses a problem for all research into ancient disasters. The scope of this paper was therefore further limited to only a select number of such sites, namely those deriving from the large-scale landslide events which have occurred from the mid-twentieth century onwards. This is a choice made with the region's early and extensive archaeological surveying projects in mind, from pioneer archaeologists like Emil Eckhoff in 1879 to the end of the so-called Gothenburg Survey in 1929 (Sarauw 1923; Winberg 1978:97–98), avoiding the nearly complete data loss ensured by earlier events. If lost archaeological sites had existed, there would at least be a chance to identify them.

Among these most substantial landslides of the modern era, some – such as the 1946 Sköttorp, 1950 Surte, 1953 Guntorp, 1993 Agnesberg and 1996 Ballabo landslides – could not be shown as part of this review to have had an archaeological impact, although some occurred with substantial known sites in their near vicinity. It is by no means impossible for this to have been

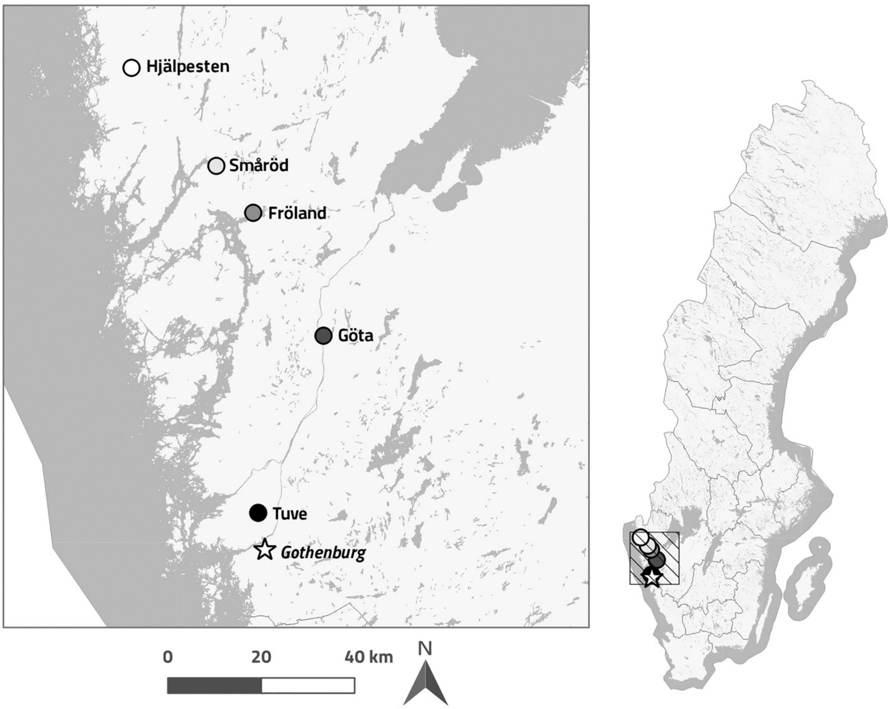

Figure 1. Map of the five key sites mentioned in the text, all located in Västra Götaland County to the north of the regional capital Gothenburg. Map: Paula Molander.

the case, however, since absence of evidence is famously not evidence of absence. On the opposite end of the spectrum, three of the largest landslides of the twentieth century in Västra Götaland– the 1957 Göta, 1973 Fröland and 1977 Tuve events (figure 1) – can indisputably be determined to have destroyed prehistoric sites, a fact that has not previously been highlighted in either archaeological or geological scholarship. Furthermore, landslides forced emergency fieldwork to take place at two sites: Småröd in 2007 and Hjälpesten in 2018. These are scenarios which likely will occur again, given the increased frequency of landslides in the future. Although the study of past disasters by archaeologists is by no means a new field (see for example Torrence & Grattan 2002; Riede 2014; Brown 2017), this particular type of study appears to be a first in Sweden to date.

THE 1957 GÖTA LANDSLIDE

Göta is a locality in Fuxerna parish, Lilla Edet municipality, on the eastern shore of the Göta River. It grew from the manor of Hanström, which dates to at least the mid-fourteenth century (Hollman n.d.:1), and did not receive its modern name until 1906, when a railway station was built there (Forsæus 1978). The new name was derived from the factory Sulfit AB Göta, which was established the year before (Anonymous 1905:2). The sulphite paper mill joined an older brickyard somewhat to the south within the manorial estate, adding to an industrial milieu that permanently changed the formerly aristocratic and agrarian landscape. The paper mill later closed, but several corporate offices, logistic centres and warehouses remain on the former manufacturing site. Both the Gothenburg–Trollhättan railway and the major E45 road pass through Göta.

With its location on a prominent river bend in a fertile valley, the Göta area might be expected to have seen much prehistoric activity. Few intact traces remain of this, limited largely to two pairs of stone-setting graves located north and east of the former manor, Fuxerna 37:1–2 and 41:1–2 respectively (Fornsök). The records of the Gothenburg Survey show that several other now-lost find sites and prehistoric cairns once existed around Göta, and it is apparent that the heavy industrial activity has likely destroyed or damaged the majority of the area's archaeological material. Less clear until now was the impact of one of Sweden's most devastating landslides.

The Göta landslide occurred on 7 June 1957. During this event, 2km of shoreline slid into the Göta River, a stretch of land measuring about 32ha. A significant part of the sulphite paper mill came down as well (figure 2). The subsequent surge wave likewise destroyed the brickworks on the other side of the river and caused flood damage downstream. Three people were killed in this event, many were injured and the economic damage was significant (Jakobson 1952; Caldenius & Lundström 1955).

During this study, it has been concluded that the landslide also destroyed one Stone Age site, Fuxerna 47:1 (Fornsök). This site was first recorded in 1919 during the Gothenburg Survey. The discovery was aided by the presence of an open gravel pit, on a plateau by the foot of the hill Trinnås (Lantmäteriet 1857), sloping down towards an open field by the river shore. The finds included many burned and unburned flint blades and blade fragments, scattered worked flint (likewise both burned and unburned), as well as about a dozen ceramic sherds, among which was one rim piece with pit-style decoration. A flint axe and chisel had previously been found but could not be located at the time of the survey. Two circular features, which were interpreted as the possible foundations of hut-like structures, are also mentioned in the survey notes as being visible in the gravel pit (Gothenburg Survey).

These finds and the site's location with regard to the process of shoreline displacement (Kartgeneratorn) are consistent with a Neolithic dating. As found during later surveys, nothing remains today of the site Fuxerna 47:1 (Fornsök). Although the gravel pit would have damaged part of the site, the 1957 Göta landslide and subsequent post-disaster landscape remodelling undoubtedly destroyed any remaining structures and scattered

Figure 2. Aerial photograph of part of the 1957 Göta landslide. The site Fuxerna 47:1 is located just out of view along the scarp to the left. Photograph: Unknown, Edetgruppen.

all finds, as it would have done for any other undiscovered sites along the hazard zone. It is possible that the industrial activities at Göta would also have eventually encroached upon the site if it had been left untouched, but it is likewise possible that it would have been left intact or even excavated as part of the development process.

Several finds were further made in 1919 during the Gothenburg Survey immediately south of the later disaster zone, within the limits of the old Hanström brickyard. Based on the geography and find material, which included pottery and a quernstone, the site was dated to the Iron Age and registered at the time as Fuxerna 40 (Gothenburg Survey), which has not survived into the modern archaeological databases such as the National Heritage Board's Fornsök. This lost site shows the potential for prehistoric finds that once existed within the disaster zone as well, being in a similar topographical position as the lower parts of the hazard area, on the shoreside fields below the Stone Age site.

Another find which is not registered in the current databases is a nearly intact bronze sword found in 1918. The well-recorded find was made by labourer Karl Norr while digging in a clay pit just north of the brickyard, 40m from the river shore, below 2m of alluvial sand and clay (Gothenburg Survey). It shows Bronze Age activity around Göta, adding to the aforementioned Stone and Iron Age sites. Had other similarly deposited items been embedded in the shoreline affected by the Göta landslide they most certainly would have not only initially lost their stratigraphic context but also then been destroyed by post-disaster erosion and dredging. This is something to keep in mind all along the Göta River, where landslides have likely destroyed other depositional contexts.

THE 1973 FRÖLAND LANDSLIDE

Fröland is an industrial zone dominated by a stone quarry and located in the parish of Herrestad, Uddevalla municipality, on the northern shore of Byfjorden. The area contains the lands of two historical hamlets, Rävsdal and Fröland proper. While the earliest attestation of Fröland and Rävsdal only go back to 1436 and 1661 respectively (Palm 1978), the place name 'Fröland' would appear to indicate Iron Age origins, whether or not it is indeed sacral in nature as some would suggest (Palm 1978; Brink 1990:476; Vikstrand 2013). Although mainly known for its quarry, the area is also notable for the vast landslide that occurred there in 1973. The event has become known as the Fröland landslide (Bjurström 1982) even though it took place on the former lands of Rävsdal. Based on the nineteenth-century source material it would likely be even more historically appropriate to refer to the site using the now-lost place name 'Basteviken' (Anonymous 1881a:2). 'Fröland' is the name used here to follow established tradition.

Test blasting in an older, smaller quarry at Fröland was carried out on 5 June 1973 in preparation for more substantial development. The shock waves triggered clay liquefaction and through it a substantial landslide, bringing 150,000m^2 of soil down into Byfjorden. The physical and financial damage to the facilities and equipment was extensive, although fortunately no one was injured. The landslide was photographed as it happened by the foreman Erik Hafstad, becoming one of the first landslides to be documented as it took place. The after-effects were long-lasting. As late as 1982 partial liquefaction and minor collapses were still occasionally taking place along the landslide scarp (Bjurström 1982).

As in Göta, many now-destroyed sites previously existed within the Fröland area, and there have also been other finds made within Rävsdal which have not entered the modern registries. Rävsdal farmer J.H. Bengtsson donated several objects to the nascent Uddevalla Museum, such as an 'ancient whetstone' (Anonymous 1862:4), three flint arrowheads and a wheellock musket (Anonymous 1873:4). The most significant surviving prehistoric sites of the area are the substantial Iron Age hillfort atop Ormskredsberget, Herrestad 164:1, and the large stone cairn Herrestad 35:1 located a short distance to its south-east (Fornsök). It has been argued that the hillfort was reused in the seventeenth century as a temporary fortification during the Dano-Swedish Wars, due to an assortment of historical finds made there. The aforementioned musket found nearby and the military-related

Figure 3. The Neolithic arrowhead from Herrestad 186:1, one of the few surviving traces of the lost site which was destroyed by the 1973 Fröland landslide. Photograph: Göteborgs stadsmuseum.

place names of some natural features add to this interpretation (Anonymous 1881b:2). This would mirror the reuse of other prehistoric fjord forts, such as Korsborg in Gullmarn during the Scanian War of 1675 (Holmberg 1867:180), adding a historical archaeology dimension to the area.

The two sites on the hilltops overlook the desolate landscape of the Fröland quarry immediately to their east. It is here the destroyed sites were located. At least six separate sites and one find-spot, all dating to the Stone Age, are recorded in the area. One site in particular, Herrestad 186:1 (Fornsök), is noteworthy because it was not destroyed by the quarrying but instead by the 1973 landslide, a fact which has not been observed previously. The extent of the lost site has also been poorly understood in the past, but appears clearer after archival studies.

The database of the Swedish National Heritage Board (Fornsök) marks the location with a seemingly exact and single point in the landscape. However, the maps of the Gothenburg Survey show that Herrestad 186:1 was previously designated as being a much larger, less well-defined area, further east of the currently marked location (Lundin 2003). The written descriptions given by archaeologist Emil Eckhoff in the late nineteenth century, and during the Gothenburg Survey a few decades later, also point towards a far more substantial size than that indicated by the modern-day categorization as an individual 'find-spot'. Eckhoff described having located a 'production site' in this field, with notable finds including a substantial quantity of flint blades, a triangular flint arrowhead and a polished greenstone axe (Eckhoff 1888:41–42). The Gothenburg Survey further located a tanged flint arrowhead (figure 3), still kept in the collections of the Museum of Gothenburg, which can be typologically ascribed to the Middle Neolithic (pers. comm. Lindström 2021). Apart from a few isolated surviving finds and scant archival data, the seemingly rich site is now lost to the archaeological record.

Much like Fuxerna 47:1, which was destroyed by the Göta landslide two decades earlier, it stands to reason that the subsequent gradual industrial development at Fröland may have eventually prompted archaeological investigation of this destroyed site, as was the case with the nearby Herrestad

284:1–2 the year before the landslide (Fornsök; Gothenburg Survey). Data loss resulting from the quarrying was not an inevitable outcome, but the landslide certainly ensured it.

THE 1977 TUVE LANDSLIDE

While the Fröland landslide has been largely forgotten by most people other than specialist geologists, the Tuve landslide has not left the public mind. It can be difficult to talk about the modern Gothenburg city district of Tuve, located on the island of Hisingen in Tuve parish and Gothenburg municipality, without touching on the subject of the tragic disaster. The Tuve landslide struck on 30 November 1977 in the middle of a densely populated residential area (figure 4). The primary causes were improper construction on unstable slopes, artificially altered groundwater levels and heavy rainfall acting as a trigger. The event moved 27ha of clay soils down east into the Kvillebäcken valley, destroying houses by the dozens as it went, making 436 people homeless, injuring 62 and killing nine. This makes it one of the deadliest disasters in modern Swedish history (Larsson & Jansson 1983; Hartlén 1984). The scope of this tragedy has also led to the Tuve landslide being by far the most well-documented and studied Swedish landslides in history, prompting research in subjects ranging from hydrology (Blomquist & Gustafson 1981) to emergency medicine (Brandsjö 1978) and sociology (Syrén 1981). The disaster's archaeological aspects, however, have not been considered until now.

The Tuve landslide occurred in a rich ancient landscape. It took place on the southern slopes of the hill Snareberget, atop which the medieval Tuve Church is placed alongside a series of prehistoric sites, most prominently the very large Iron Age grave field Tuve 17:1. Several other Iron Age grave fields, as well as an assortment of other tombs, also exist in the vicinity of Snareberget (Fornsök). Three separate sites had also been excavated before the disaster within the immediate vicinity of the landslide crown. Furthest away, 40m from the disaster zone's edge, is the Bronze Age site Tuve 147:1, which was in fact excavated only two months before the disaster, between August and September 1977 (Sjöberg 1978; Fornsök).

Closer still are the two stone setting graves Tuve 18:1–2 and the Stone Age site Tuve 117:1, all of which were excavated in 1968. These are located only metres away from the edge of the landslide and, in the case of the Stone Age site, likely well into the disaster zone as well. Although Tuve 117:1 is today registered as a single find-spot (Fornsök), it was at the time estimated to be 8 000m^2. It consisted of a cultural layer in which was found a substantial number of Neolithic finds, including ceramic sherds, burned bone, stone axes, arrowheads and flints at all stages of production (Lundborg 1968).

Figure 4. Aerial photograph of part of the 1977 Tuve landslide. The lost Tuve sites were located between the houses to the left and the displaced road. Photograph: Åke Hillefors, Göteborgs naturhistoriska museum.

Although much of this site would have been destroyed by construction in the 1970s, this was not the case with three further documented Stone Age find-spots, designated as Tuve 95:1, 118:1 and 119:1, the latter two of which were near the wider aforementioned site. All three of these were within the disaster zone and would have been displaced a long distance eastwards during the mass movement of the landslide. While Tuve 95:1 was a poorly described general find-spot of worked flints, the two 'find-spots' Tuve 118:1 and 119:1 are specified to have been areas measuring at least 75x20m and 75x40m respectively, within which worked flints had been found. They were even estimated to possibly have formed one cohesive site, which is not reflected in the modern mapping recorded in Fornsök. Given the proximity to Tuve 117:1 it is, in fact, possible that these sites make up one larger unit, perhaps sharing the Neolithic dating. Like the similar sites at Göta and Fröland, they have now been lost due to the landslide and subsequent post-disaster recovery efforts.

Emergency fieldwork at Småröd and Hjälpesten

The most significant landslide so far in twenty-first-century Sweden has been the Småröd landslide. It took place on 20 December 2006 at Småröd in Foss parish, Munkedal municipality. The disaster brought down a strip of land several hundred metres long and wide, destroying sections of the newly constructed route of the E6 road, the older E6 route, the Bohus Line railway running between Gothenburg and Strömstad and the 'Chateau Småröd' railway museum. Some people were swept down in their cars, fortunately suffering only minor injuries. Transport through the province was greatly hindered by this, impacting both individual lives and commerce until the E6 and the railway could be rebuilt. The railway museum closed permanently. The societal costs of the landslide have been valued to over half a billion Swedish kronor (Myndigheten för samhällsskydd och beredskap 2009).

A large part of this large cost came from the reconstruction process, which was a high priority due to the importance of the disrupted transport routes. The E6 could be reopened already by 14 February 2007 and the Bohus Line ten days later on 24 February. Unlike the 1977 Tuve landslide, where archaeology failed to become part of the reconstruction process, emergency fieldwork did take place at Småröd in the immediate aftermath of the disaster. Archaeologists from the Museum of Bohuslän were deployed at breakneck speed and came under immense scheduling pressure. Even the subsequent report title makes clear the nature of the excavation: 'An Urgent Assignment' (Hernek 2007; author's translation).

This fieldwork did not take place to excavate sites damaged by the landslide itself, but rather to investigate those that faced possible damage during the infrastructure reconstruction. An area measuring ca 900x90 m was investigated by the archaeologists, part of which included the Stone Age site Foss 237:1 located immediately east of the railway (Fornsök). The fieldwork took place over 72 labour hours spread out between 9 and 15 January 2007, investigating 75,000m^2 (Hernek 2007:24). A series of trenches were dug using a small excavator, although some inaccessible areas had to be investigated through spade-dug test pits (Hernek 2007:10). A total of 33 flints were found, including Neolithic arrowhead fragments, as well the remains of two later but undated charcoal production pits and one World War II-era foxhole (Hernek 2007:14–18). The month was, by the standards of the time, unusually mild and rainy, meaning that the ground was unfrozen, which otherwise would have been a major hindrance (Hernek 2007:8). The archaeologists would also have had to contend with the short hours of sunlight per day in addition to the weather conditions, it being a Swedish winter.

The 2006 Småröd landslide remains the most significant Swedish landslide of the twenty-first century, although numerous others have occurred as well. It is also the first landslide that has forced emergency archaeological fieldwork to take place in its wake. However, it is not just large-scale landslides that can have an impact on cultural heritage. The threat of landslide

Figure 5. Archaeologists at work during rescue excavations at Hjälpesten, investigating a site partially damaged by a landslide and at risk from more. Photograph: Annika Östlund, Kulturlandskapet.

activity has motivated at least one other fieldwork project within Västra Götaland County, namely at Hjälpesten in Kville parish, Tanum municipality.

Kville 1502, connected to the site Kville 998:1, is a Neolithic and Bronze Age wetland site centred around a valley creek. Well-preserved organic finds eroding from the creek banks have come to light there since 1987 (Kindgren 1989), such as wood and antler artefacts in addition to unburned and burned bone, substantial ceramic sherds, flint and other stone tools. This amount of preserved organic material is comparatively rare for Bahusian prehistoric sites. At the core of the site is a burnt mound with associated artefacts and structures that indicate Bronze Age metalworking, while other finds indicate a seasonal meeting place involving livestock. Notably, the clay-rich creek valley of Hjälpesten is like so many other western Swedish areas prone to landslides, and evidence for this hazard posing an immediate risk prompted an emergency rescue excavation of the site (Östlund 2018; Toreld 2021).

The excavation took place over two weeks in June 2018 (figure 5), during a sweltering summer drought, and was carried out by the commercial archaeology company Kulturlandskapet with emergency funding and permission from the Västra Götaland County Administration (Toreld 2021). Motivated by the significant risk of further erosion and the need to secure artefacts and other data in time, they found that the site at some point during the past decade had been affected by a landslide. This event had caused the burnt mound structure to slide down into the creek ravine, shifting its position by several metres and exposing both fire-cracked rocks and artefacts to water erosion. Future landslides could destroy the stratigraphy further. The project also indicated that more burnt mounds exist further upstream and are likewise facing erosion, showing that Kville 1502 and 998:1 are part of a larger site (Östlund 2018:2; Toreld 2021).

Data loss and future threats

Had the rescue excavation at Hjälpesten not taken place with public funding and permission, it appears plausible that substantial data loss would occur with the next landslide and ongoing erosion. Had the emergency fieldwork at Småröd not taken place, data loss could also have occurred due to the post-landslide reconstruction work. It stands to reason that similar work as was undertaken at Småröd in 2007 and Hjälpesten in 2018 will become necessary elsewhere in Västra Götaland as climate change continues and landslides become more frequent. However rarely employed, there exists a need to develop a set of cohesive guidelines to manage the role of archaeology within emergency management as well as the role of emergencies within archaeology. This is currently dealt with on a largely *ad hoc* basis, seemingly with – as in the 2018 Hjälpesten case – the shared personal engagement of both archaeologists and administrators as the main driving factor rather than any formal framework, quite unlike the highly regulated Swedish system of contract archaeology (Smits 2020), for example.

With these two excavations in mind, some conclusions can be drawn when looking back to the three landslides of the twentieth century discussed above. While the Stone Age sites Fuxerna 47:1 and Herrestad 186:1 would both have been fully lost once the disaster struck, sliding out into the river and fjord waters to be scattered by currents and dredging, the Tuve sites would have been displaced eastwards and their stratigraphies shifted by the 1977 landslide. Artefacts and other data could feasibly have been recovered if archaeology had been incorporated into the emergency response and the subsequent long-term restoration of the Tuve landscape. The study of a similarly displaced site may appear peculiar, but is in essence no different from that of any other archaeological material affected by later geocultural processes. After all, some would argue that 'all archaeological deposits are palimpsests of one form or another' (Davies et al. 2016:451). It is in theory even possible for a landslide to reveal new sites which otherwise would not have been found.

Substantial geotechnical risk assessment has taken place in Västra Götaland, especially along the Göta River, regarding the threat posed by landslides, especially to residential areas (e.g. Alén et al. 2000; Göta älvutredningen 2012). Little, if any, attention has been given to archaeology within those studies. The Stockholm Count Administration, based in an area that has proportionally far fewer and smaller landslides than Västra Götaland, published a report in 2019 on the threats posed by climate change towards the region's archaeological and historical sites. Using simple GIS methods of combining slope elevation geodata, soil survey data and the National Heritage Board's archaeological registries, the study found that no fewer than 1921 known sites within the Stockholm region were at potential risk from future landslide damage (Länsstyrelsen Stockholm 2019:13).

Although these are preliminary results and the subject requires further study, the numbers are striking. One avenue of future research is to carry out a similar study to that conducted in the Stockholm region on the West Coast as well, the results of which could be amplified by the significant geotechnical data already collected along the most exposed river valleys. In addition to new guidelines, a heightened state of awareness and preparedness appears necessary. Although I am somewhat critical of the term 'resilience' and how it is used within archaeology (see Brewer & Riede 2018; Resta et al. 2019; Rashidian 2021), it does appear apparent that the cultural heritage sector needs to strengthen its resilience towards sudden and destructive events such as these.

Archaeologies of hazard and disaster

Although landslides are the central topic of this paper, they are not the only climate change-amplified events that put Swedish archaeological sites at risk, and which will demand the attention of Swedish archaeologists increasingly often in the future (not to mention the public expenditures to be incurred). An early experience with this can be seen in the many severe storms that hit Sweden in the early twenty-first century, notably the cyclones 'Gudrun' and 'Per' in 2005 and 2007 respectively, which together killed fourteen people and led to record damage costs. Much archaeological fieldwork took place as a result of those storms across an extended period of time (e.g. Ohlin 2006; Reuterdahl 2007; Svarvar & Backman 2009; Ameziane et al. 2010). Extreme weather events are likely to increase in frequency over the coming century, and storm damage to archaeological sites will follow with them, not only in the form of windfalls but also deriving from flash floods eroding riverine and coastal sites.

Recent outbreaks of forest fires also affect woodland sites, such as the 2014 Västmanland fire and the dozens of large fires that occurred during the 2018 summer drought. Although the biological and economic costs of the fires have won the most attention, they naturally also impact the many archaeological sites located within Swedish woodlands. To date, a handful of studies have been produced on the subject. One such study is a recent student paper on eight Swedish woodlands that burned in the period 1992–2018. Finding that fires and subsequent processes (response, mitigation, reforestation) damaged the archaeological record both in the short- and long-term, while also providing opportunities to survey new sites, Ivarsson (2020:28) highlighted that, at present, there are no guidelines for archaeologists to follow when surveying and writing reports on this topic. Of course, forest fires, like landslides, can also reveal previously undocumented sites, such as was the case following the large 1999 Tyresta fire (Pettersson & Wikell 2006).

Not all results of climate change are as visibly and immediately destructive as cyclones, forest fires and landslides. 'Slow disasters' (Irwin 2013:xv) also abound, occurring across a wider timespan. Amplified conditions for mould, rot and vermin infestation threaten buildings and collections of cultural heritage importance, drought dries out waterlogged deposits, coastal sites are faced with gradual processes of sea-level rise and erosion and so on. Although many reports and plans have been published regarding the damaging impacts of climate change on Swedish cultural heritage (e.g. Västra Götalandsregionen 2014; Riksantikvarieämbetet 2014, 2016, 2019a; Brandt 2018), the majority focus on non-archaeological aspects, such as the maintenance of historical buildings and public art conservation.

One such type of slow disaster is the damage done to sites through acidification and oxidation. Much has been written on this, for example in connection with the preservation of metal artefacts and rock art (e.g. Nord & Lagerlöf 2002; Nord et al. 2007), but one recent case study concerning the Mesolithic site Ageröd is especially troubling, since it found that organic finds have suffered an accelerated process of degradation, and often complete destruction, in the last 75 years (Boethius et al. 2020a; Boethius et al. 2020b). These conditions are likely to worsen given global changes in temperature and precipitation and the increased frequency of extreme weather events. As stated by the authors, 'we do not have the luxury of waiting for a more convenient time' (Boethius et al. 2020b:29).

Another type of slow disaster is the glacial melt caused by warmer climatic conditions. Rapid loss of permafrost, ice patches and glaciers across the world have highlighted that not only does this process result in the thawing-out of many finds, but also to their destruction alongside the ice and frost that once kept them intact. In neighbouring Norway, the *Secrets* *of the Ice* project has gained much attention for the rich ancient organic finds made while surveying the melting edges of glacial areas (e.g. Pilø et al. 2020). Although small-scale, a series of similar pilot surveys carried out by Stockholm University have shown the potential for glacial rescue archaeology within Sweden as well, and have located, for example, Migration period-era reindeer bone (Fjellström et al. 2019:255) and part of a late medieval ski (Fjellström 2020:6). All of these forms of hazards and disasters, from the northern glaciers to the southern river valleys, share many commonalities in their relationship to archaeology, including an immediate need for comprehensive oversight, management and funding, all efforts currently being largely dependent on individual initiative.

Concluding remarks

It is now abundantly clear that no single part of this planet will be able to avoid the short- and long-term consequences of climate change. The 'landslide archaeology' (Sw. *skredarkeologi*, perhaps) brought forward in this paper is inherently entwined with, for example, the 'glacial archaeology' (Sw. *glaciärarkeologi*) of Fjellström et al. (2019:253), the 'woodland archaeology' (Sw. *skogsmarksarkeologi*) of Ivarsson (2020:29) and all other works related to the archaeology of hazards and disasters in Sweden. These emerging subdisciplines are all in need of further development and cooperation.

Life in the Anthropocene (Solli 2018), or perhaps rather the Pyrocene (Pyne 2018; Alexandra 2020:77) or the Age of Destruction (González-Ruibal 2018), requires dramatic alterations to all aspects of human life. This includes archaeology, which – if we desire for it to remain, or perhaps become, relevant – cannot remain in stasis while the rest of the world changes. Effective guidelines and structures relating to emergency management are currently lacking. The Swedish cultural heritage sector would do well to address this, and to develop a cohesive and systematic approach to the many different impacts of global anthropogenic climate change.

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