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Animal domestication in the high Arctic: Hunting and holding reindeer on the I͡Amal peninsula, northwest Siberia

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ABSTRACT

The history of animal domestication in the Arctic is often represented as marginal or a weak copy of more complex pastoral situations in southern climes. This article re-assesses the classic archaeological site of I͡Arte 6 on the I͡Amal Peninsula of Northwest Siberia for markers of early *Rangifer* and dog taming and the emergence of transport reindeer husbandry at the start of the Iron Age. We critically examine published and unpublished Russian language material on this first millenium site, and evaluate the interpretations against three ethnoarchaeological models: herd-following, decoy-mediated hunting, and transport reindeer husbandry. Using new ethnographic, geoarchaeological, botanical, and palynological evidence, as well as a revised site chronology, we demonstrate that I͡Arte 6 was likely the home of several different types of adaptation over a much longer period of time than had previously been assumed. This leads us to question the standard models of reindeer pastoralism, and to argue for a renewed attention to the ways in which *Rangifer* are held and enticed into a long-term relationship with people, the possibility that canine domestication may have also been a key factor, and how these relationships leave imprints in the environmental record.

1. Introduction

The practice of animal domestication has traditionally been linked to the development of cultural complexity, the accumulation of surplus, and the "transformation" of societies (Zeder, 2015; Childe, 1928). The classic models come to us from the Levant and the Near East (Vigne, 2011; Clutton-Brock, 1999; Harris, 1996; Allentuck, 2015), and are associated with how the "whip, spur, harness and hobble" (Ingold, 1994) help humans take control over the reproductive cycle and physical forms of their wards. Within this framework, the domestication of reindeer by Eurasian Arctic peoples has been portrayed rather poorly, with reindeer being characterized as being "deficiently" domesticated (Cf. Laufer, 1917: 94, 120), or at best in "an early stage" of domestication (Larson and Fuller, 2014: 118). Siberian hunter-herders have been left out in the cold, as it were, since their pastoralist skills also place them outside of the debates on hunting and gathering adaptations (Leacock and Lee, 1982: frontispiece; Schweitzer, 2000; Murdock, 1969: 16). In an attempt to bridge these divides, some scholars have turned back to circumpolar ontologies – arguing that "bringing home [wild] animals" (Tanner, 1979) can often be done with rituals of respect, reciprocity and mutual communication (Losey et al., 2011; Anderson et al., 2017b; Argent, 2010; Hill, 2013). These models erase the dualistic distinction between wild and tame, and with it, raise questions about exactly what type of data can be used as evidence for the history of domestication (Honeychurch and Makarewicz, 2016). If a bridle does not necessarily dominate, and a tether does not necessary control, what are the material features of Arctic human/animal assemblages? In this article, we present a range of ethnohistorical and geoarchaeological techniques that shed light on human/animal proximity and indirectly upon human/animal mutuality and interdependence. Some of these techniques have been used for the first time in a permafrost environment and were developed specifically for this study. Through a detailed re-analysis of an evocative multi-layered archaeological site in northwestern Siberia – thought by some to be a

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hearth of Arctic domestication as early as the first century BC – we present an account of encountering and holding *Rangifer*, which captures a variety of strategies of human/animal co-presence suggesting an extremely long-term and durable model of Arctic domestication.[1]

The I͡Amal peninsula is an iconic landscape for the study of indigenous livelihoods. Stretching northwards from the mouth of the Ob' river, this long, sandy, windswept peninsula is today the homeland to Nenets hunters, fishers, and herders, who manage some of the largest stocks of domesticated reindeer anywhere in the circumpolar Arctic (Klokov, 2011a). The peninsula is also the focus for hydrocarbon development, and the development of Arctic shipping, threatening the livelihood of reindeer herders – although the herders have proven to be remarkably resilient to these changes (Forbes and Kofinas, 2014). Recent extreme weather events have led to repeated and extensive icing-over of autumn, winter and spring pastures, and the mass starvation of reindeer herds (Forbes et al., 2016; Golovnev, 2017), prompting very recent proposals for strict conservation measures and controls on reindeer numbers (Staalesen, 2018). Therefore, a long-term understanding of human-animal relations within a history of climate change becomes all the more crucial to placing the future of this region within a broader context.

Our contribution applies new methods to re-interpret one extremely rich archaeological site suggesting that the I͡Amal peninsula, and in particular the I͡Uribeĭ river valley, was an important site of early *Rangifer* domestication (Fig. 1). Our work focusses on what had been classified as the 11th/12th century "fortress-settlement" I͡Arte 6 (Plekhanov, 2016). I͡Arte 6 is one of a chain of archaeological sites on the south bank of the I͡Uribeĭ river, on a semi-circular terrace which encloses a chain of lakes (Fig. 1). Unlike the other archaeological sites in the valley, I͡Arte 6 is covered by a lush grassy meadow, easily distinguished from the prevailing dwarf-shrub heath tundra vegetation (Fig. 4). It has also yielded one of the largest collections worldwide of *Rangifer* faunal remains and artefacts linked to *Rangifer* hunting and domestication. A key aspect of the assemblage is the presence of over 22,000 bones and bone fragments that belong to either/both domesticated and wild *Rangifer* (Nomokonova et al., 2018). Up until recently, leather and wood remains were preserved in the permafrost. The site features specialized carved bone pieces interpreted by many as harness-pieces for sled-pulling domesticated *Rangifer* (Aleksashenko, 2004) (Fig. 2). Further, it features a unique set of scrapers made from the scapula of *Rangifer*, which might have been used to clean and soften strips of skins and to produce the ropes and tethers needed to hold domesticated *Rangifer* (Aleksashenko, 1999; Plekhanov, 2014: 55) (Fig. 3). Finally, there are fewer but significant faunal remains of dogs, Arctic fox, fish, and birds which may form part of the socioeconomic equation (Nomokonova et al., 2018: Table 3).

The present article reinterprets material remains uncovered at this landmark site using an interdisciplinary dataset, including palaeolandscape reconstructions, new radiocarbon dates, and a variety of soil characteristics mapped in the immediately vicinity of the site, all considered within the context of Northern ethnographies and *Rangifer* ethology. In particular, we argue that by paying close attention to the physical affordances of the topography, *Rangifer* behaviour, the chemical composition of the soil, and the structure of present and past plant communities, we can better understand the development of relations between humans and domestic and/or wild *Rangifer* at I͡Arte 6 and in northern Eurasia more widely. Moreover, the novel, interdisciplinary methodology detailed here can be applied worldwide to better understand the evolution of human-animal relations.

[1] Russian language terms, proper names, and place names in this paper are transliterated with the full Library of Congress system including ligatures. In order to hold open the idea that reindeer in the region may have been wild or tame at different times, we employ the genus name *Rangifer*.

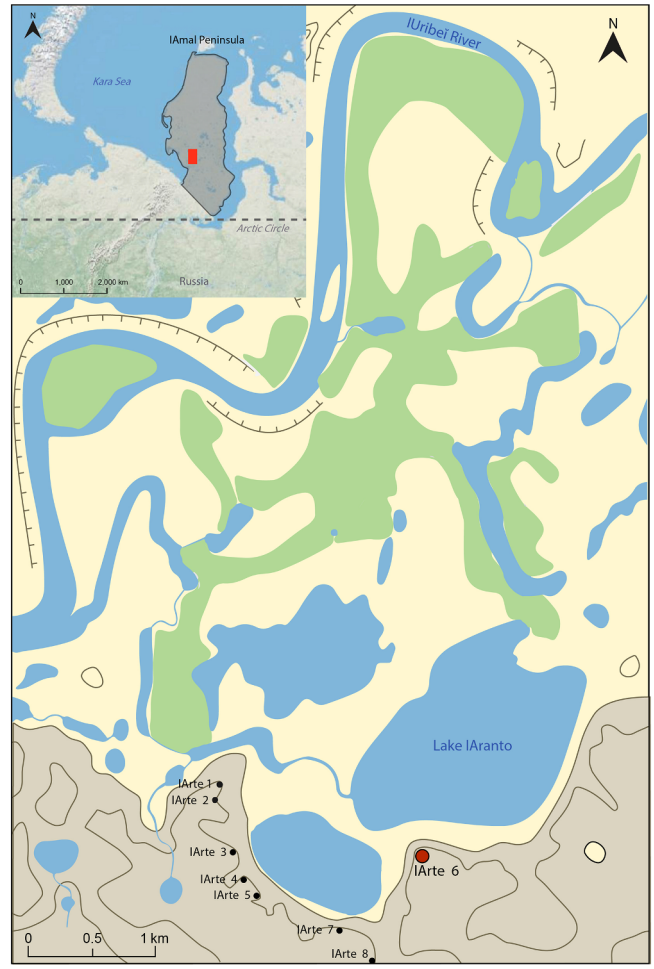

Fig. 1. Topographical map showing the I͡Uribeĭ River, Lake I͡Aranto, and the semi-circular sandy terrace around which the eight I͡Arte sites are spread. The red circle indicates the site of I͡Arte 6. Attention is drawn to the semi-circular headland on which IArte 6 is situated. The inset shows the location of the I͡Amal peninsula within Western Siberia. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2. The I͡Amal peninsula as a hearth of animal domestication

Archaeological research on the I͡Amal peninsula began early in the Soviet period with the pioneering excavations of V.N. Chernet͡sov in 1929 at Tiuteĭ-Sale – a high Arctic site on the maritime coast of the Kara Sea approximately 200 km north of the mouth of the I͡Uribeĭ River (Chernet͡sov, 1935; Chernet͡sov, 2014 [1930]). In the late 1950s, Chernet͡sov reworked his early notes on the "dune-dwellings" at Tiuteĭ-Sale into an influential cultural-historical model, which he named the Zelenegorsk archaeological culture. In Chernet͡sov's classic conception, the ceramic complex excavated in 1946 at Zelenai͡a Gorka, a site at the mouth of the Ob' River, provided a key for interpreting a range of early Iron Age sites that crossed Eurasia from the High Arctic to the Altaĭ Mountains near the Chinese border (Chernet͡sov, 1953: 67). This ancient culture expressed its complexity, much like the Soviet Union of that time, through the development of weapons, armour, and fortified settlements (*gorodishche*), a regional division of labour, and a standardized "semantic" culture that could be identified by the patterns stamped into its ceramics (Chernet͡sov, 1953: 68–9). Chernet͡sov popularized the idea that the northern Zelenogort͡sy represented part of a single culture whose unity could only be made possible by the development of animal pastoralism (Chernet͡sov, 1953: 70–1).

The form and type of animal domestication employed by the Zelenogort͡sy at their northern boundary was addressed specifically by

Fig. 2. A collage of harnessing pieces taken from two archaeological digs. From left to right, a smooth-sided reindeer head gear piece from I͡Arte 6 (Plekhanov 2014); a barbed reindeer head gear piece, and a bone swivel, both from Ust'-Poluĭ. The barbed head gear piece is the oldest known artefact of its type associated with the first century BC (Gusev et al., 2016: 205–6).

Fig. 3. A collage of representative artefacts from I͡Arte 6 all from Plekhanov (2014). From left to right, a scapula scraper showing the punctured and worn interior with two holes interpreted as stays; a miniature "toy" boat; a fragment of a miniature sled runner; a miniature axe/adze.

Fig. 4. The I͡Arte promontory photographed from the east towards Lake I͡Aranto featuring the anomalous lush grass and the willows growing along the ravines.

Vanda Moshinskai͡a in a chapter in the same seminal volume (Moshinskai͡a, 1953). Working primarily with artefact collections from Ust'-Poluĭ (now within the City of Salekhard), Moshinskai͡a noted the presence of scattered remains of reindeer "head gear" (*uzdechki*) – a type of angular, over-the-eye bridle – mixed in dog remains, and a unique collection of what she understood to be swivels used to tether

dogs to sleds (Moshinskaia͡, 1953: 84–6) (Fig. 2). By employing a then-common Soviet cultural-historical axiom, she argued that if any evidence of dog transport were present, then harnessed transport reindeer should be absent. She therefore interpreted the reindeer head-gear as evidence that tamed reindeer had been held as decoys in order to attract migratory wild *Rangifer* closer, to make it easier to hunt them. Making reference to Cherenet͡sov's earlier excavations at Tiuteĭ-Sale, Moshinskaia͡ concluded that the adaptation of the residents of Ust'-Poluĭ, and by extension that of the I͡Amal North, was similar to those of Canadian Caribou Eskimos – a culture of dog-breeders who fished, hunted migratory *Rangifer*, and were thought by her to also hunt sea-mammals (Moshinskaia͡, 1953: 102).

Archaeological research along the length of the I͡Uribeĭ River itself only began at the end of the Soviet period, stimulated by field surveys commissioned to find a suitable place to bridge the river to build a railway. An interdisciplinary expedition led by Andreĭ Golovnëv surveyed the region from 1991 to 1993 (Golovnëv, 1998). Their initial research uncovered a range of settlements along the I͡Uribeĭ River, and in particular, a set of six settlements surrounding the system of floodplain lakes known as I͡Arte (I͡Aratato). By the end of their work in 1995, they had identified over 28 sites within the space of 11 km in what they dubbed the I͡Arte Archaeological Microregion, ranging in age from the Mesolithic to the late Medieval Period (Plekhanov, 2016: 11; Sokolov, 2002).

Of these archaeological sites, the one labelled I͡Arte 6 stood out from the rest. The research team saw it as a "fortress-settlement", characterised by visible earthworks interpreted as seven semi-sunken hut foundations organized in two rows and separated from the rest of the headland by a "defensive" ditch. The layout of the site – on a high, windswept escarpment, defended by a ditch, with pit-dwellings organized in linear rows – they felt bore strong similarities to several known Zelenogorsk sites in the southern forested zone (Pletnev 1994: 418 Fig. 39; Chernet͡sov, 1957: 232). The territory enclosing the parallel linear-aligned depressions of I͡Arte 6 has since been intensively excavated by Russian archaeologists (Fig. 5). From 1990 to 1991 Sokolov excavated the majority of the area (approx. 234 m^2) (Sokolov, 1992). This was followed by two expeditions led by Fedorova, partly supported by a joint venture between an American and Russian oil company in 1995 and 1996 (Fitzhugh, 1994; Fedorova, 2016, 1998). The Fedorova excavations focussed on the final set of depressions near the edge of the escarpment, and also featured a trench dug near the "defensive ditch" (Fig. 5). Although the artefacts and extensive faunal collections of the Sokolov and Fedorova excavations found their way into museum collections, and spurred further comparative research, the excavation reports themselves were never completed, which left unresolved questions about how the site developed, and whether it might represent a succession of sites rather than a single site. In 2013 and 2015, Andreĭ Plekhanov of the Scientific Research Centre of the Arctic led a new set of excavations at the site. These significant additions (72 m^2) concentrated on the region of the "defensive ditch" and were situated against the edges of the previous excavations in an attempt to complete a picture of the site (Fig. 5). Plekhanov published a catalogue of all known artefacts from I͡Arte 6 (Plekhanov, 2014). One of his significant findings was that the ditch, which initially may have been dug as a boundary, was later widened to help drain the site, and was finally infilled with bones and other waste.

What Natal'ia͡ Fedorova (2016: 47) describes as the "Epoch of Big Projects" brought new interpretations to this microregion. The oil-financed recovery work was originally intended to map out "sacred sites" to protect them from development (Fedorova, 2016: 48). Sven Haakanson, who is the author of the only ethnoarchaeological study of semi-sedentary Nenets hunters and fishers along the I͡Uribeĭ River (Haakanson, 2000), observed impressive piles of reindeer antler during his visits to the 1996 excavations, which reminded him of the above-ground offerings that Nenetses make today at sacred sites (pers. comm). This is an interesting memory, since these substantial collections of antler were never catalogued or kept, and are therefore absent from zooarchaeological reports. Bill Fitzhugh brought to the site his interests in finding what he described as the "holy grail": a cradle for a circumpolar culture of marine sea mammal hunters (Fitzhugh, 1997). This international team attempted to define a self-sustaining indigenous northern ecological adaptation on I͡Amal (Brusnit͡syna, 2000). Having also re-excavated Tiuteĭ-Sale (Fedorova, 1998), they promoted a vision of a complex and diversified regional economy where sea mammals were hunted at one site (Tiuteĭ-Sale), wild reindeer hunted and processed at a second site (I͡Arte 6), and rituals performed at a third site (Ust'- Poluĭ). In Fedorova's (2016: 47) words they sparked "a new paradigm which understands the legacy of the native peoples of the North as one of the important [contributors] to a general Russian cultural legacy".

One important aspect of their paradigm has been a shift to understanding contemporary tundra Nenets reindeer pastoralism – with its relatively large herds of reindeer, caravans of sleds, and mobile dwellings – as an adaptation that extends into the deep past. In a series of articles, the Salekhard-based archaeologists led by Natal'ia͡ Fedorova (2006, 2000) and Gusev et al. (2016) confronted earlier interpretations of the development of dog transport, reindeer decoys, and maritime adaptations. What she describes as "unification of culture" across Western Siberia between 1000 BCE and CE 1000, defined by ceramic ornamentation, bronze artefacts, and military equipment, can only be explained by a "transport revolution" associated with the development of large-scale use of reindeer in harness (Fedorova, 2000). Several key artefacts support her argument. The most important are a set of wooden stays, and/or fragments of runners and stanchions, that she associates with reindeer sledges recovered from Ust'-Polui (Fedorova, 2006) and Tiuteĭ-Sale (Fedorova, 2000: 64). The unique punctured scapula-scrapers are associated with the cleaning of hides and the production of narrow leather strips for the weaving of lassos and tethers to harness reindeer (Gusev et al., 2016). Moreover, the extensive collections of finely crafted miniature models of boats, sleds, and bows and arrows found at Tiuteĭ-Sale and I͡Arte 6 are interpreted as evidence that children once played with toys at these sites, and that women were therefore present as well (Fedorova, 2006) (Fig. 3). The Fedorova team also put forward a significant re-assessment of the artefact assemblages analysed by earlier scholars. The carved bone swivels found at Ust'-Polui, once thought by Moshkinskaia͡ to be unambiguous parts of dog sleds, are now interpreted as an early component of the long tether that sends signals to a lead reindeer in a set of harnessed animals (Gusev et al., 2016: 233–4). It should be noted that no swivels have been uncovered at I͡Arte 6. The angular but smooth, L-shaped head-gear, the oldest examples of which have been found at I͡Arte 6, are now considered to be the bridles that bind a subsidiary sled-transport reindeer to the lead reindeer (Gusev et al., 2016: 236). To drive this point home, photographs of contemporary Nenets reindeer gear are used to illustrate how the ancient gear might have been used (Fig. 6). Finally, Fedorova has proposed interesting interpretations of various carvings and drawings, suggesting that domestic *Rangifer* may have been strangled and sacrificed at these sites in a manner similar to the way that contemporary Nenetses carry out reindeer sacrifices (Fedorova, 2000: 57). Their vision inverted the previous axiom, arguing, in essence, that any evidence of *Rangifer* tethering implies that dogs were not used for transport. Gathering all of these observations together, along with citations from the historical literature, Fedorova put forward a model that tundra sites like Tiuteĭ-Sale and I͡Arte 6 were created by groups of multi-generation families who travelled northwards to harvest sea mammals and wild reindeer, in caravans of wooden sleds with herds of 200 or more domesticated reindeer (Fedorova, 2006). Placing a heavy weight on a carved bone harness piece found with a strata at Ust'-Poluĭ associated with the date 50 BC (Fedorova, 2000: 66) (Fig. 2 – middle), she situates I͡Amal as one of the great ancient hearths of reindeer domestication.

Fig. 5. Topographical map showing the ÎÃrte promontory with the excavated area, estimated locations of the eight pit-house depressions, the defensive ditch, and the soil survey grids. The pits from which radiocarbon dates were models are indicated.

Fig. 6. Photograph of a contemporary tundra Nenets male lead reindeer showing carved bone head gear and a metallic swivel attached to the lead tether (Photo: A Gusev).

In summary, three generations of scholars contributed to the identification and documentation of a range of sites across ÎÃmal – each of which features overwhelming evidence of *Rangifer* slaughtering, skin-working, and tantalizing evidence of animal tethering and perhaps of animal traction. Each generation of scholars also relies heavily on "unifying similarities" (*sovokupnost'*) that bind sites together so that artefacts in one place "speak" to artefacts in another place. Over time, a consensus has developed that the southern half of this high Arctic peninsula – bounded by the ÎÙribeĭ River – supported a unique Arctic adaptation, heavily reliant on transport reindeer pastoralism, and involving the regional interchange of personnel, artefacts, and a sometimes-militarised culture. There has also been a simplification in the models used to explain relationships with domestic animals. If initially it was assumed that the early residents of the ÎÙribeĭ River valley used a range of domestic animals (dogs, reindeer), now the literature promotes a single model: that *Rangifer* were kept in large numbers for transport at all times in a manner similar, if not identical, to that of the large-scale Nenets herds of today. This article queries this long debate on the nature or natures of reindeer and dog domestication. Taking our focus away from the head-gear, swivels, and scrapers, we introduce new ethological and geoarchaeological interpretations to show how ecofacts rooted in the landscape might imply a variety of human-animal adaptations. In the following sections, we review the physical evidence for these adaptations and consider their relationships to the spatial and ecological features of the site.

3. The spatial and ecological implications of hunting and holding *Rangifer* at I͡Arte 6

A number of ethnoarchaeological assumptions have been used in the past to interpret the remains found at archaeological sites across I͡Amal. Here, we draw out the spatial and ecological signatures that might be expected to arise from the implicit ethnographic analogies among Caribou Inuit, Evenkis, Nganasans, and Nenetses. We apply new data to weigh the appropriateness of each model to understanding the human-*Rangifer* relationship at I͡Arte 6.

These theories are:

1. Herd-Following: That the site was a prime location for encountering, spearing, and processing migratory wild *Rangifer* by a highly nomadic society that did not use *Rangifer* for transportation. Directly compared to the historic example of Canadian Caribou Inuit, this society of hunters, which travelled on foot, may have combined a strategy of *Rangifer* herd-following with a yearly round that also included the hunting of sea mammals.
2. Decoy-Mediated Hunting: I͡Arte 6 may have been an important place for attracting small groups of wild *Rangifer* with specially trained domestic *Rangifer* decoy-reindeer and trained dogs. This hunting and herding society, directly compared with the Taĭmyr Nganasans, would have held up to a dozen domestic reindeer trained to act as decoys, but is also likely to have pulled sleds or carried cargo.
3. A Specialized Skin-Working Site: I͡Arte 6 may have been a specialised site for encountering migratory wild *Rangifer* – perhaps in large numbers – in order to process their skins and make the gear necessary to support a large-scale, inter-regional economy dependent on reindeer for transport. These ancestors to contemporary tundra Nenetses are thought to have harnessed *Rangifer* in a similar way as Nenetses do at present, and therefore would have to have held around 200 head of reindeer to service the site at I͡Arte 6.

Each of the three models of human-reindeer relations implies different impacts on the landscape surrounding the site. In this section, we outline the anticipated spatial and ecological impacts of each scenario by examining the **topography and vegetation** necessary to attract and/or keep *Rangifer* at the site, the **density** of animals gathered at the site, the expected **proximity** of people to animals, and finally the **seasonality** of the adaptation.

3.1. Herd following

Both Valeriĭ Chernet͡sov and Vanda Moshinskai͡a make direct comparisons with the so-called "Caribou-Eater Eskimos" of the Eastern Canadian Arctic, who were made known to them through the work of Kai Birket-Smith (1929). The Caribou Inuit, as they are known today, are said to have abandoned a lifestyle of hunting sea mammals on Hudson's Bay and, under the influence of the fur trade, turned to hunting the Kaminuriak caribou herd within its tundra range. The archaeologist Bryan Gordon (1996: 11–12) associates their occupation of the tundra adjacent to Hudson's Bay with the end of a two thousand year tradition of "herd following" (Gordon, 2003, 2005, 1996) – which involves an intimate knowledge of the landscape and allows hunters on foot to encounter animals at regular lake and river crossings. According to Gordon, the success of the strategy depends on hunters following the herd 400–600 km across their entire range including both forested and tundra portions. He associates this ancient adaption with that of what he calls the Taltheilei archaeological tradition, which preceded the adaptations of both modern Chipewyan and Caribou Inuit.

The landscape of the Thelon River has much in common with that of I͡Amal, being composed of windswept, sandy ridges alternating with large rivers and lakes. Gordon's KjNb-7 site in particular presents striking similarities to I͡Arte 6 (Gordon, 2003: 18 fig. 4). Built on the top of a steep bank overlooking the Thelon River, this many-layered site, rich in bones and lithics, was assumed to have been used repeatedly as an outlook and consumption site for 8000 years (Gordon per.comm). The dynamics of *Rangifer* migration in the two regions are also roughly similar with animals (and people) moving from the Barrenlands in the summer to the forested interior in the winter. Although Burch and Blehr (1991) cast doubt on the ability of any human family to keep up with a migratory herd of caribou, Gordon argues that knowledge of the regularities of the migration and the micro-topography of the region allowed Taltheilei to anticipate herds at defined places and times. In other words, his hunters do not plod behind migrating caribou, but use their imaginations to anticipate and intersect their movements.

It has been argued that in order for herd-following to be successful, it must be geoarchaeologically invisible. The ethic of "keeping the site clean" is widely reported among Northern Canadian indigenous peoples today who continue to hunt migratory wild caribou [Kazan River (Stewart et al., 2004: 198); Thelon River (Gordon per.comm); Tłı̨cho (Legat, 1999: 79–80)]. Communities who rely upon the repeated regular return of animals to specific sites, year after year, go through great lengths to avoid contaminating them with guts, blood and the smells of butchering. Specifically, the bank where animals first enter a lake or a river is kept free of refuse and may be subject to taboos on human activity (GNWT, 2018: 51).

This "zero-impact" strategy of encounter was nevertheless intimate, because people needed to come into close proximity with the animals. This can be inferred from the tools used. Given that we know that they successfully hunted caribou with spears and arrows, they must have had techniques to get close to the animals. Traditionally, the technique of subterfuge is employed to do this. On this basis, the landscape would have to contain crevices, or tufts of brush, where the hunters could conceal themselves before jumping out to slaughter the animals. Equally important was the fact that the animals had to be encouraged to approach the hunters. This could be achieved by constructing guiding fences made of brush or stones, or simply by keeping the shoreline clean and silent.

The combined spatial signature of close proximity, and a zero-impact encounter is "unbalanced" - to use the term suggested by Stewart et al (2004: 198). While the places of encounter are invisible, the butchering and consumptions sites produce heaps of bones, lithics, and other artefacts. They note that dispersal of the "high impact" butchering sites are predominately confined to one shore of a river – the one where the animals emerge. Most of the deposits have been found at the top of wind-blown escarpments. It is thought that the early hunters preferred to work on the quartered, butchered carcasses high-up in a windswept, insect-free environment, and to make further use of the wind to help dry the meat. In this scenario, the presence of a butchering and processing site at the top of an escarpment would be a marker of a summertime hunting strategy. Herd following in the Canadian tundra was primarily a mid-summer to late autumn activity. The animals were harvested for meat, but the meat was not cached. It is assumed, therefore, that the meat was consumed immediately or dried.

There are many documented cases across Eurasia of close proximity encounters with migratory *Rangifer* at water-crossings. Rather than describing the intimate knowledge of the animals, and of the land, Eurasian accounts tend to focus on the ability to slaughter large numbers of animals quickly and efficiently. Vladimir D'i͡achenko has undertaken an exhaustive review of the literature on water-facilitated *Rangifer* hunting (D'i͡achenko, 2005, 2007). The vast majority of harvests at river-crossings in Eurasia were organized during the autumn. In the case of Taĭmyr, wintery autumn conditions allowed hunters to pile-up hundreds of carcasses for up to two days without them spoiling, allowing time to work the meat (D'i͡achenko, 2005: 145). There are rare mentions of water-mediated hunts during the spring migration. Popov (1948: 32) briefly records that Nganasans organized one spring hunt on the Pi͡asina River. Vladimir D'i͡achenko (per. comm.) speculates that springtime, river-facilitated hunts in Siberia should be rare since northern rivers are often still frozen when migratory wild herds cross

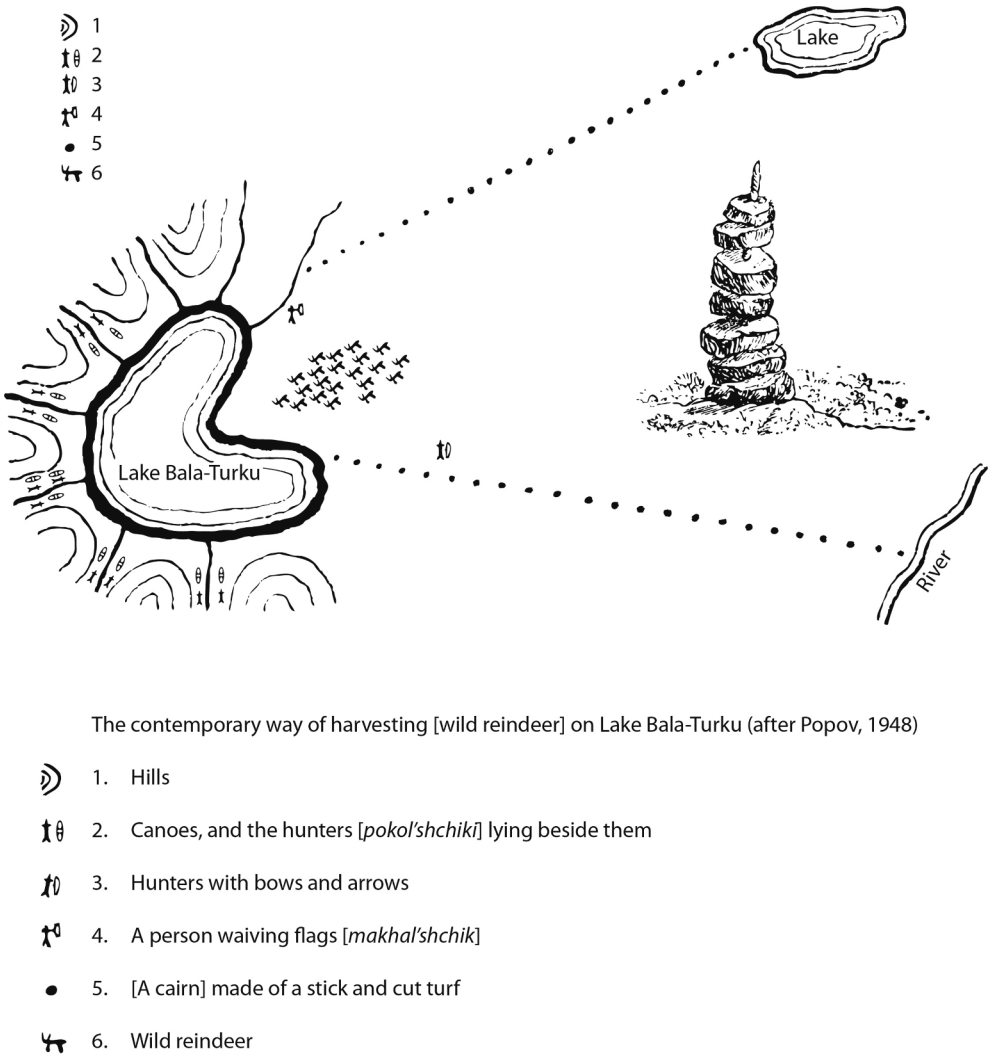

Fig. 7. The landscape affordances at Lake Bala-Turku, Taĭmyr facilitating a water facilitated hunt. The diagram shows a guiding corral of stones placed between a river and a lake. The group of wild reindeer is chased into the lake. Hunters are concealed by willows in the ravines surrounding the headland (Popov, 1948 Fig. 6).

them. It is interesting for our case that there are rare but documented cases of using lakes to assemble and position *Rangifer* for slaughter. The I͡Arte sites are all adjacent to a chain of lakes in the floodplain of the I͡Uribeĭ river. D'i͡achenko (2005) records the following strategies among Dolgans and Northern I͡Akuts: the use of a trained dog to drive a single animal into a lake; the use of fences to guide a small group of animals into a lake; and the use of children to scare animals into a lake. It is striking that all cases of lake-mediated summer *Rangifer* hunting involve dispatching a very small groups of animals – sometimes only one or two – and require the use of a small boat or canoe to approach the animals. Thus the use of lakes *versus* rivers for hunting implies profoundly different scales of activity.

Andreĭ Popov (1948) described and illustrated one example of hunting at Lake Bala-Turku, Taĭmyr, which seems particularly appropriate to I͡Arte 6 (Fig. 7). In his account, Nganasans guided small groups of reindeer into a lake using lines of stone cairns. Hunters who had concealed themselves in the ravines and the brush at the base of a prominent headland, then used canoes to approach and spear one or two animals as they crossed the lake. The hunters would be dispatched by a watchman who monitored the hunt from a tent near the top of the escarpment. Both the topographic position of the tent and the low shrubs growing along the edge of the escarpment helped to conceal it from the reindeer. In this scenario, the topography, the precise placement of the hunters' camp, and the habitual crossing points of the reindeer created the necessary conditions for herd-following. The description of the site matches almost one-to-one the topography of I͡Arte 6.

3.2. Decoy-mediated hunting

Enticing wild *Rangifer* to approach humans using trained domestic decoy reindeer is much discussed in the literature, but there are few documented examples of this technique. The fieldwork of Vladimir D'i͡achenko with Eastern Taĭmyr Dolgans is likely the only ethnoarchaeological study of this practice (D'i͡achenko, 2005, 2007; Chesnokov et al., 1996).

The literature on decoy-hunting tends to focus on the gear used to control and to send instructions to decoy reindeer. In most accounts, the decoy is tethered by a concealed hunter holding an extremely long and unusually thin braided lead. All accounts point out that the tether is attached to a set of special angular bone pieces, which have sharp teeth on the inside that cut into the skin of the reindeer. We are only aware of four documented examples of such gear. Bogoraz-Tan (1901: tbl 15:5) and Middendorf (1869: 495) provide line drawings of the barbed head gear for Chukchi and Samoeds [Nenetses]. D'i͡achenko (2005: 153) provides an excellent photograph of a similar barbed and angular headpiece attached to a thin tether. Popov (1948: appendix table 3) documents an unusual example of a tether attached to a barbed angular

piece which is considerably larger, and which Nganasans placed around the neck of the animal instead of over the head of the animal. The decoy is trained to respond to commands sent through the thin tether to sit or stand, and in short to behave like a grazing wild reindeer. The sharp barbs on the gear accentuate the effect of the hunter's tugs and jerks, which might otherwise be dampened by the length of the tether. As mentioned above, the presence of barbs on many of the archaeological artefacts from I͡Amal (Fig. 2) was classically interpreted as one line of evidence that decoy reindeer were used at Ust'-Poluĭ, and by extension, at all the sites in the Northern Ob' region.

During the Taĭmyr fieldwork of DGA with Khantaĭka Evenkis, if an opportunity arose to attract a small group of wild reindeer, herders would simply transform their existing harness reindeer into decoys. To do this, the hunters would uncouple the existing smooth-sided L-shaped transport headgear – similar to those uncovered at I͡Arte 6 – from over the head of the animals, to let it drop around the neck of the animal. A lasso was quickly used to extend the length of the lead tether. The most important element in this hunting scenario is knowledge of a good place, a good opportunity, and the ability to refashion materials at hand to make a functional arrangement. Whether the equipment was barbed or not was unimportant. An additional element was the way in which human behaviour was projected or concealed to invite wild *Rangifer* in – such as the use of mimesis in Rane Willerslev's (2007) classic account of I͡Ukagir moose hunting. Some of the ethnohistorical accounts comment on the importance of choosing a reindeer that has the same pelage and stature of a wild reindeer (D'i͡achenko, 2005). Successful decoy hunting therefore requires the ability to bridge the division between wild and tame, and human and reindeer, but not necessarily a need to carve specialized gear.

Decoy-hunting would work with many of the same principles of proximity and density as for herd-following. A successful decoy would entice a small group of wild reindeer to come close enough that they could be ensnared, or dispatched with an arrow. The encounter with groups of wild *Rangifer* would probably occur some distance from the dwellings (and the other herd animals). In addition, the place of encounter should be kept clean to be able to attract other animals in the future. Paired to this slight or "zero-impact" strategy of curating the place of encounter, would be a strategy of concentrating the butchering and consumption at a different site. The only difference between this strategy and a strategy of encountering animals as they cross water, is that the scale of decoy hunting is an order of magnitude less than that possible at a river crossing, and, therefore, there should be fewer bone remains at the consumption site. The most diagnostic spatial signature of decoy-hunting would derive from keeping the decoy reindeer itself close to hand: a weak environmental signature of grazing, trampling and organic enrichment at the place where the tamed deer were held, tethered, or enclosed.

Gusev et al. (2016), in presenting their pastoralist model *contra* Moshinskai͡a, believe that there would be little to distinguish decoy hunting from small- or medium-scale transport reindeer husbandry. They note that the decoy itself would have to be a highly trained animal, which would be able to function as a harnessed reindeer as well as a decoy. Unlike the ethnographic analogies provided by Popov and D'i͡achenko, they argue that the signatures of decoy-hunting would be similar to, but on a smaller scale than those of larger scale transport reindeer husbandry. The key piece of evidence that could settle this debate would be if the geoarchaeological signals of standing reindeer implied a small herd of 5–10 animals, or a larger herd of 200 head.

There is no unambiguous seasonal signature for decoy hunting. The ethnoarchaeological examples of Chesnokov et al. (1996) are all examples of spring hunting. Wild male reindeer could also be attracted to a tethered domestic female in the autumn rutting season, although in this season the meat would not be edible. On the other hand, the thick skin of a rutting bull might be useful for making strong ropes. Theoretically, *Rangifer* could be attracted by decoys in any season.

3.3. A specialized leather processing site

The most recent interpretation of the I͡Arte 6 site by Gusev et al. (2016) is that the thick bone deposits are the work of hunters who engaged in intensive harvesting of migratory wild *Rangifer*, and later worked the skins to create the leather needed for small- to medium-scale transport reindeer husbandry. To service a herd of transport reindeer, which are regularly tethered and harnessed, a large volume of cured and braided leather strips are needed. These strips are used to weave lassos, to make tethers, and to string together headgear. Rather than build corrals, tundra reindeer herders take advantage of the fact that in a flat featureless environment a single strand of worked leather looks to a reindeer like a barrier. Therefore, long leather ropes might also have been used to string together barriers to confine groups of reindeer for short periods of time – for a few hours or at the most a day.

The suggestion that I͡Arte 6 may have been a specialized leather-working site is linked to the prevalence of a unique scapula scraper (Fig. 3). Scrapers for making clothing, or to prepare skins to make tent coverings are generally semi-circular or flat. While these are also found in large numbers, I͡Arte 6 features one of the largest concentrations of a punctured scapula-scraper – where a relatively narrow opening was probably used to produce narrow strips (Aleksashenko, 1999). Over 200 such items were uncovered at I͡Arte 6 (Plekhanov, 2014, 49). This item is peculiar to the Northern Ob' district and to our knowledge is not found at any other archaeological sites other than I͡Arte 6, Tiuteĭ -Sale, and Bukhta Nakhoda (and at the latter two, in small numbers).

The spatial parameters of specialised skin processing are similar to those of reindeer following, except at a much larger scale. The source of raw material for skin production is assumed to be migratory wild *Rangifer*, which were perhaps slaughtered during the autumn migration as they mounted the I͡Arte headland. Presumably the place at which the wild *Rangifer* accessed the headland was kept clean, as in dozens of similar sites across the circumpolar North. The record of human/animal co-presence would therefore be unequally distributed – and the huge accumulations of bone at I͡Arte 6 are an excellent example of an unbalanced distribution.

This multi-generational group using reindeer for transport would have nevertheless left a strong spatial ecological signature. Building on the analogies of a contemporary nomadic Nenets family, it is estimated that a multi-generational group of five families of men, women and children would need a minimum of 200 head of reindeer (Podkorytov, 1995). The domestic herd likely would also be a complex mixture of castrated and trained transport males, breeding males, breeding females and calves. Perhaps some of the transport males could also double as decoys.

In comparison to the other models, this would be the *Rangifer-MAX* model – both in terms of the scale of the slaughter of the wild *Rangifer*, and also the environmental impact of the domestic herd. Unlike herd-following or decoy hunting, a specialized group of leather-processing hunters would aim to maximize their production. The processing site, which is assumed to be I͡Arte 6, would be steeped in the products of their work. Given the presence of a small-to-medium size herd, there might be multiple sites of encounter, with harnessed *Rangifer* used to transfer the quartered carcasses to a single centralized processing site. Similarly, a domestic *Rangifer* population would leave a strong ecological signature. The transport herd would be kept on a nearby, wind-swept headland to reduce their exposure to flies, perhaps tethered or enclosed with the use of ropes. If it were not enclosed, the domestic herd would probably be allowed to forage for a limited time before being marshalled back to the campsite – enticed perhaps with fish[2]. An

[2] *Rangifer* are omnivores and can crave food other than plants and lichen. Many contemporary Siberian fieldworkers record in their unpublished field notes the use of fresh fish, or salted fish, to attract domestic reindeer to the camp (Anderson; Arzyutov; Oishi; Stammler; Volzhanina). There are few

enclosed herd, or a periodically assembled herd, would be expected to leave strong geochemical and botanical impacts on the surrounding soils and vegetation.

In terms of the landscape setting, the hunting of the wild animals would have to be some distance away from the residential camp so that the animals would not be frightened by the sounds and smells of the processing. Further, there would have to be a conveniently located, open headland nearby where the herders could glance up to keep an eye on their domestic herd. Presumably having their domestic herd swept away by a migrating herd of wild *Rangifer* would be a death sentence for families entirely dependent on reindeer transport.

The seasonality of the leather production is also likely to be a distinguishing feature of this activity. Contemporary reindeer herders, be they sedentary Nenetses, Nganasans, or Evenkis, only use spring skins for making leather tethers. Summer skins are impossible to use since they are perforated with botfly holes. The spring furs are soaked in water to help loosen the moulting fur, the skins are scraped to remove fat, and then sharp cutting-edges are used to created long tethers by cutting the skins in a spiral pattern. In a variant, as mentioned above, coarse early autumn skins could also be used to weave strong ropes.

Production on this scale would require a large number of fires – and therefore a supply of firewood – to warm the dwellings, and to allow people to cook and render the bones. The supply of firewood is a contemporary concern for tundra Nenets migrating on the Ĩ͡Amal Peninsula. Nenetses use domestic reindeer to carry firewood or driftwood inland since the contemporary willow cover does not provide a reliable supply of wood for a large group of people. To some extent, this background fact has a heavy influence on models that insist that settled or semi-sedentary life on the Ĩ͡Amal Peninsula is unimaginable without domestic reindeer. Imagining a different adaptation of small-scale husbandry, or foot-bound herd following, therefore also implies imagining a different climate and different plant cover. As we shall see, the question of what that shrub cover might have been like 1000 years ago is a key factor in interpreting past livelihoods.

Ĩ͡Arte 6 is clearly a pivotal site for the understanding of how human and animal relations have evolved in a dynamic Arctic environment. Each of the competing hypotheses about how to interpret the archaeological remains at the site is based on a different reading of the available evidence for how people, animals and environment were entangled. Up until now, the dominant hypotheses of the use of this site, and indirectly of the character of Arctic domestication, have been based on the interpretation of significant and evocative artefacts. We now focus our discussion on a new set of geoarchaeological, botanical, and palynological data, which can be used to answer questions about the affordances, the density of animals, the proximity of people to animals, and the spatial signatures of human/animal interaction.

4. Interrogating the models: The palaeoecology of Ĩ͡Arte 6

We conducted fresh fieldwork at Ĩ͡Arte 6 from 2013 to 2015 in order to collect new ethnographic and palaeoecological data that could be used to assess the 'landscape logic' of the site (Anderson et al., 2014; Zedeño et al., 2014). Our methods extend the existing accounts of the site, which, on the whole, hung their interpretations on the perceived function of ceramic and bone artefacts, to an appreciation of the biophysical characteristics and context of the site. This research, outlined below, has produced new information on the chronology, seasonality, climatic context, intensity of occupation, and the proximity of people to relatively stationary *Rangifer* herds – and or groups of dogs – at and around the site, leading in turn to a revision of theories on the origin and resilience of large-scale reindeer husbandry.

4.1. Field methods

Our key field method is based around a systematic geoarchaeological survey of the flat semi-circular plateau behind the Ĩ͡Arte 6 "fortress" settlement. The goal of this survey was to search for buried palaeosols, and to take samples for a number of established and experimental laboratory methods, which could provide information about the presence, absence and concentration of animals at the site. A magnetic susceptibility surface survey using a Bartington MS2D field sensor was conducted using a 0.5 m^2 grid over a 900 m^2 area on the southeast side of the escarpment. To map the soils, 0.3 m^2 soil test-pits were excavated on a 10 m^2 grid over a 3200 m^2 area to the southeast of the main excavation site (Fig. 5). The soil sequence in each pit was photographed and we described the depths, thicknesses, anthropogenic inclusions, soil colours (Munsell Color, 1975), textures and soil structures (FAO, 1996) for each horizon. Between two and four brown (organic) soils were identified in each test-pit, often separated by layers of lighter-coloured windblown fine sand and silt. A small bulk sample (c. 200 ml) was taken from each organic soil horizon, and any charcoal or bone fragments observed in these soils were collected for possible radiocarbon dating.

The bulk soil samples were dried, pulverised, and passed through a 2 mm sieve in a field 'lab tent'. Charcoal and bone fragments were picked out of the > 2 mm fraction to provide material for radiocarbon dating, and any remaining roots and pebbles were discarded. The < 2 mm fraction was used for soil pH tests and electrical conductivity (EC) analysis to test for areas of elevated nutrients. The results of EC analysis were plotted in QGIS (QGIS Development Team, 2016) and a zone of enhanced EC (nutrient) values close to the archaeological site was selected for more detailed soil test-pitting and sampling on a 5 m^2 grid (Fig. 5). A number of off-site soil test-pits were also excavated to provide comparative soil profiles and samples. All of the dried and sieved bulk soil samples were taken to the University of Aberdeen for low frequency magnetic susceptibility, phosphate, and faecal lipid biomarker analysis (see Supp Mat S1).

In addition to the soil survey, we took additional samples from the 2013 excavation at Ĩ͡Arte 6. Bone samples for radiocarbon dating were selected from among identifiable faunal remains collected in the uppermost and lowermost stratigraphic phases. In addition, bulk samples were taken from hearths and pit fills containing charcoal, and bucket floatation was carried out on site in order to extract the charred plant component for palaeobotanical analysis and radiocarbon dating.

In order to gain more information on regional climate across centennial time scales, as well as human and animal use of the site, three peat and lake cores were taken for palynological analysis (Supp Mat S2). For various reasons, only one of these cores – that taken from "Lake Three" – yielded data that could be linked to the archaeological site. "Lake Three" is located 7 km southwest of Ĩ͡Arte 6, at N 068°53'01.6"/E 069°48'05.6" (Supp Mat S2e).

Two further contiguous 50 cm soil monoliths were sampled from the eastern profile of the 2013 excavation area at Ĩ͡Arte 6 (Fig. 8). This work was intended to build on and expand the published pollen diagram of Nata Panova (2008) from the south wall of the 1996 excavation (Supp Mat S2c). We reconstructed the stratigraphy of the edge of the excavation, from where Panova took her monolith from the unpublished fieldnotes of Natal'ĩa͡ Fedorova (Supp Mat S2d).

One of the most enduring and visible features of the Ĩ͡Arte 6 site is its thick grass cover. A survey of the vegetation covering the excavated and unexcavated parts of the site was conducted in 1996. From five to fifteen 1x1 m point-frame quadrats following the ITEX method (Walker, 1996) were used to characterize each disturbed and undisturbed vegetation type in the field depending upon the heterogeneity of the cover. For bryophytes and lichens, species composition and frequency (presence-absence) were determined and an estimate of abundance made for each taxon in the manner of Braun-Blanquet (1932). Ten random measurements were made on the height of the upper vascular

(*footnote continued*)
published references to this practice (Zen'ko-Nemchinova, 2006: 95; Oĭshi and Porshunova, 2018; Arzĩ͡utov, 2017: 335).

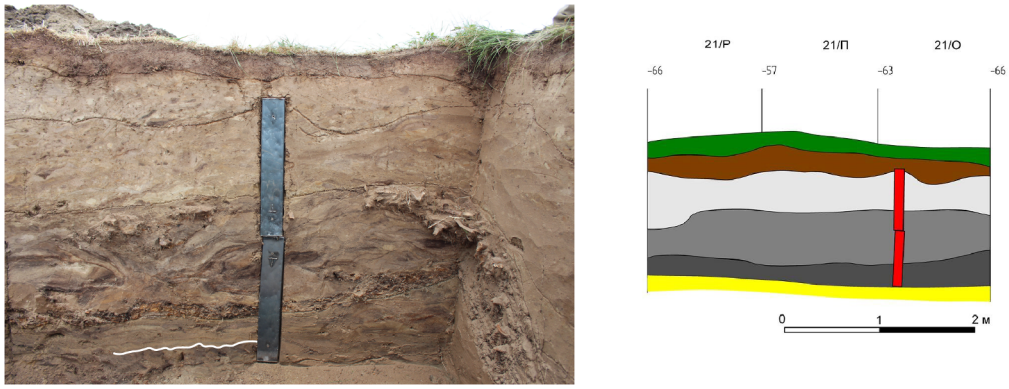

Fig. 8. The profile on the edge of the 2013 excavation from which the 100 cm monolith was collected. The diagram at the right shows the published stratification. The white line in the photograph on the left shows the approximate location of layer Ia as distinguished by palynological statistics.

canopy within each quadrat. Ordination analyses (ter Braak, 1998) was used to distinguish between the various vegetation types, which corresponded to a gradient from heavy anthropogenic disturbance to undisturbed, as discussed in Forbes and Sumina (1999).

4.2. Laboratory methods

A short summary of the methodologies employed is provided here. For a full description of analytical procedures and data tables, see Supp Mat S1 and S2.

The core from Lake Three was subsampled and the pollen analysed on contiguous 5 mm intervals (Supp Mat S2a). The two 50 cm monoliths from the I͡Arte 6 excavation area were subsampled in 10 mm intervals, but since the on-site sediments did not form by incremental deposition, pollen preparations were made at 4 cm intervals (Supp Mat S2b). The raw pollen data were modelled using CONISS cluster analysis (Grimm, 1987).

Radiocarbon assays on charcoal recovered in the soil survey, the bone samples from the 2013 excavation, and the core from Lake Three were conducted at the Uppsala and Poznan Radiocarbon Laboratories, and calibrated using OxCal 4.3.2 (Ramsey, 2009, 2016; Reimer et al., 2013). It did not prove possible to identify macrofossils to date the soils taken from monolith tins. The C14 dates from the 2013 excavation were published in Nomokonova et al. (2018). The new sets of dates from the 2015 excavation are in Supp Mat 3b.

Humified organic matter (i.e the alkali-soluble fraction or humic acid fraction) from the lowermost layers of the monolith core taken from the eastern edge of the 2013 excavation were extracted with KOH at the Environmental Archaeology lab at Umeå University. They were dated by Beta Analytic and calibrated as above.

The samples taken during the soil survey were analysed for volume-specific low-frequency magnetic susceptibility (κ) using a Bartington MS2B dual frequency sensor (Bartington Instruments Ltd., nd; Dearing, 1994). Phosphate analysis was conducted using the wet oxidation method by sulphuric acid and hydrogen peroxide, and by colorimetry, following the procedures of Grimshaw (1987). Faecal lipid analysis was conducted by sonication extraction with organic solvents, purification on a silica column, and gas chromatography mass-spectrometry in selected monitoring mode, with quantification achieved by external calibration using authentic standards. The full method is described in Harrault et al. (2019). Eleven key organic compounds were subsequently quantified (Supp Mat S5a), integrated into a PCA-hierarchical cluster model with 41 mammalian reference samples using R (R Development Core Team, 2017), and attributed to species (Supp Mat S5b). Spatial distributions of anthropogenic inclusions, magnetic susceptibility and phosphate values, and faecal lipid biomarkers where mapped and analysed using ArcGIS 10.5.1 (ESRI, 2017). Due to the discontinuous character of the buried soil horizons (explained in Supp Mat S4), the results of soil analyses are presented using graduated symbols, rather than interpolated surfaces.

4.3. Ethnohistorical methods

As part of the wider HUMANOR consortium which led this project, ethnographic and linguistic fieldwork was conducted by Zoya Ravna (2018) and Roza Laptander (2015) with Nenets families in the I͡Uribeĭ region in 2013 and 2015. Our own extensive review of the published and unpublished Russian language literature was also built into this study. As much of the original archaeological work on I͡Arte was not published, we also conducted interviews with those archaeologists who worked on the 1996 excavations. Much of the insight into wild and domestic *Rangifer* ethology is built upon the fieldwork of DGA in several regions of Siberia, including Taĭmyr and Zabaĭkal'e (Anderson, 2000; Anderson et al., 2017a). We also conducted cursory interviews with fisher Nenets families camped around the I͡Arte site in 2015.

5. Results

5.1. The landscape logic of I͡Arte 6

At the heart of most accounts of the I͡Arte 6 occupation are strong assumptions about how the landscape presents opportunities for encountering and keeping reindeer. The high, sandy south bank of the I͡Uribeĭ river today remains an important staging area for Nenetses holding large herds of reindeer. In the late spring, families gather with their herds on the south bank, often adjacent to the I͡Arte site, to wait for good ice-free conditions to cross the I͡Uribeĭ river. This well-drained terrace is often dry and completely cleared of snow by the middle of June. These sandy embankments provide a reliable place for the long-term summer storage of winter effects, which are wrapped under canvas and left on sleds awaiting the return of the families in the autumn (Ravna per.comm). Contemporary nomadic Nenetses marshal their herds by constructing temporary structures made from sleds connected together with a rope. The I͡Arte promontory – unlike many other promontories on the south bank –is itself backed by a semi-circular headland cut in on two sides by steep ravines, creating a natural shape which at one time may have once been useful for monitoring a small herd of domestic *Rangifer* (Fig. 1). The fact that the promontory is windswept would make it a viable place to protect reindeer from insect harassment during the summer. Behind the I͡Arte site, and behind the headland, is a hill which rises three to four meters above the surrounding the landscape. Although this at first may not seem particularly high, in this flat tundra landscape it seems to tower above the land. This feature may have helped early hunter-herders to find the site. This landmark hilltop has recently regained importance by being the only spot around from which contemporary herders can get a mobile telephone signal.

One of the most significant features of the I͡Arte 6 site, which has attracted the attention of both Nenetses and scientists, is the rich meadow-like plant cover that characterizes the promontory (Fig. 4). This lush vegetation is extremely rare in this tundra environment. The well-drained surfaces of I͡Amal are generally characterized by relatively poor, sandy soils supporting dwarf-shrub heath (Walker et al., 2018). The lower, saturated terrain is dominated by mires with clayey soils and standing willow thickets (Pajunen et al., 2010). The anomalous meadow-like vegetation covers the remains of the habitation site, and extends downwards over the edges of the sharp gullies on either side of the settlement. It does not extend into the flat plateau where the soil survey was conducted. The dense sward averages 50 cm in height and is dominated by the grasses *Poa pratensis* and *Calamagrostis langsdorffii*, with lesser amounts of the ruderal herb *Artemisia borealis*. These graminoid- and herb-dominated meadows have long been associated with localized anthropogenic and zoogenic disturbance regimes across the circumpolar Arctic (Forbes et al., 2001; Forbes, 1996; Fredskild and Holt, 1993). It has been assumed that the waste deposits of human activity, and the faecal input of animals, fertilized the ground, encouraging the growth of grasses, sedges and herbs. Recent research on anthropogenic reindeer milking grounds in Sweden, however, suggests that Arctic graminoid patches often transition to a stable ecological state of their own and may persist for hundreds of years without continuous inputs and grazing by reindeer (Egelkraut et al., 2018).

It should be pointed out that there are some small-scale herder-fishers who live along the I͡Uribeĭ year-round and do not travel. At the time of our fieldwork, there was a herder-fisher encampment directly opposite I͡Arte on the north bank of the river. That family included the I͡Arte escarpment as part of their local landscape, taking care of abandoned sleds and equipment cached on the side of the escarpment for future use.

Contemporary Nenets herders do not camp or keep reindeer on the I͡Arte escarpment itself. The site is associated with being a "strange promontory" (*strannoe mys*). As Golovnëv (1998: 102) notes, contemporary Nenetses believe the site to be a place where aggrieved underground land-spirits struck down and killed a migrating group of reindeer with lightning. This event was enough to make the peninsula a place to be avoided. The Nenets' initial opinion of the bone deposits at I͡Arte, which Golovnëv (1998: 102) relates with some irony, was that it was a residence of reindeer poachers since the broken and processed bones had been buried and hidden at the residential site. This contrasts with the standard Nenets practice of discarding bones over the edge of an embankment – in public view. Another significant comment was that the very large antlers originally excavated at the site had to be those of wild migratory *Rangifer*, since they differed so dramatically from those of domestic reindeer (Golovnëv, 1998: 111).

To our knowledge there are only two historical references to Nenetses hunting with decoy reindeer – and these are from the neighbouring Arkhangel'sk region (Islavin, 1847: 96–7; Kuroptev, 1927). The particular technique cited is also a uniquely low-yield strategy – the use of a special snare designed to entangle the antlers of a single wild reindeer, which spars with the decoy without the hunter necessarily being present. According to our conversations, contemporary I͡Amal Nenetses deny ever using the practice.

Roza Laptander (2015) collected a set of legends about I͡Arte 6 in 2016, twenty years after Golovnëv. Laptander (pers. comm) confirms that the site – now called the Sikhiritia͡ Sale – "peninsula of the [underground people] Sikhiritia͡" – remains "strange". She emphasises that it is not "sacred". In her account the artefacts are interpreted as the remains of a residential camp of the three [human] Ve"le reindeer-herding brothers whose entire settlement was destroyed by a bolt of lightning. The disaster is said to be have been a punishment by the underworld spirit Nga to whom the brothers had refused their sister's hand in marriage. The story of the three Ve"le brothers implies that I͡Arte was once a place where it was once reasonable to keep a small herd of domestic reindeer. Intriguingly, these mythic events are said to have occurred during a transitional period when contemporary Nenetses interacted with and potentially intermarried with the co-existing underground Sikhiritia͡ people. Further, the bone-rich deposits at I͡Arte 6 are associated with a sudden, disastrous, and atypical calamity, which put an end to the use of the site. The calamity was associated with the above-ground Nenetses refusing to honour established rules of reciprocity. It might therefore be possible to interpret this widely known legend as relating to the breaking of established norms – perhaps pursing an unsustainable intensification in the *Rangifer*-hunting, leading to punishment, retribution, and an abrupt end to the use of the site.

5.2. The chronology of I͡Arte 6

The chronology of the I͡Arte 6 site is crucial to contextualize the site and to situate it within a range of possible human-*Rangifer* accommodations. The original dating for I͡Arte 6 was estimated on the basis of ceramic typologies, which placed its occupation roughly contemporary with that of Zelenaia͡ Gorka in the medieval period. It was subsequently dated by dendrochronology on a set of 46 "willow pegs" and "fragments of [wooden] trunks" (Shiia͡tov and Khantemirov, 2000: 113). Twenty-three of these dates came from wood excavated by Sokolov's team in 1991, abandoned on the surface of the site, and then sampled many years later by Fedorova's team in 1996. Their stratigraphic context was therefore unknown. A further 14 dendrochronological dates were on wood fragments and pegs excavated by Fedorova's team in a different part of the site, whose stratigraphic provenance was also not documented. The entire library of dendrochronological dates suggests parts of the site were used during a very constrained period of time, from CE 1066–1100. Shiia͡tov and Khantemirov (2000) used this fact to argue for a very short single occupation of the site. However, it cannot be discounted that the pegs all came from the same stratigraphic horizon late in the site's chronology, and that older phases of the site were not represented in the sample. The preservation of bark and sapwood made it possible to estimate the harvest season for each sample. Shiia͡tov and Khantemirov (2000: 113) concluded that 19 of the samples were harvested between September and May, with most cut between June and July. This suggests a mid-summer occupation, although it is possible that this period extended into the late autumn.

In order to improve the understanding of site chronology, our team obtained 32 radiocarbon dates on wood, charcoal, bones, and bone artefacts from the uppermost and lowermost horizons of the 2013 and 2015 excavations. Twenty-five dates taken from a single stratigraphic sequence within the "defensive ditch" were modelled by Nomokonova et al. (2018). Their age model suggests that the ditch fill sequence began in 1016 CE* and ended in 1122 CE* (94.5% confidence). These dates overlap with the dendrochronological work of Shiia͡tov and Khantemirov, and open the possibility that the ditch began to fill earlier in the eleventh century. Unfortunately, there are no dates from artefacts or bones unambiguously linked to the perhaps deeper horizons in the 1991 and 1996 excavations. Nomokonova et al. (2018) also obtained dates from bone artefacts taken from pit-houses 3 and 4, which match the dates from the ditch contents. This suggests that the people living at the far northern edge of the site participated in filling the trench with bones.

We extracted new dates from two previously undocumented soil horizons at the bottom of the monolith tin taken from the 2013 excavation. These two layers yielded calibrated dates of 45 BC*–AD 85*, and 222 CE*–385 CE* – albeit in inverted order. These new dates suggest that the site is made up of multiple occupations, and that the very earliest occupations may indeed have been concurrent with other well-known sites in the I͡Amal region. In this study we will work with the later date from Horizon 1a, and treat the earliest date as a tantalizing outlier.

To date the buried soil horizons on the plateau southeast of the main excavation area, and to understand their relationship to the main site, 18 samples of *Salix* sp. and *Betula* sp. roundwood charcoal were dated,

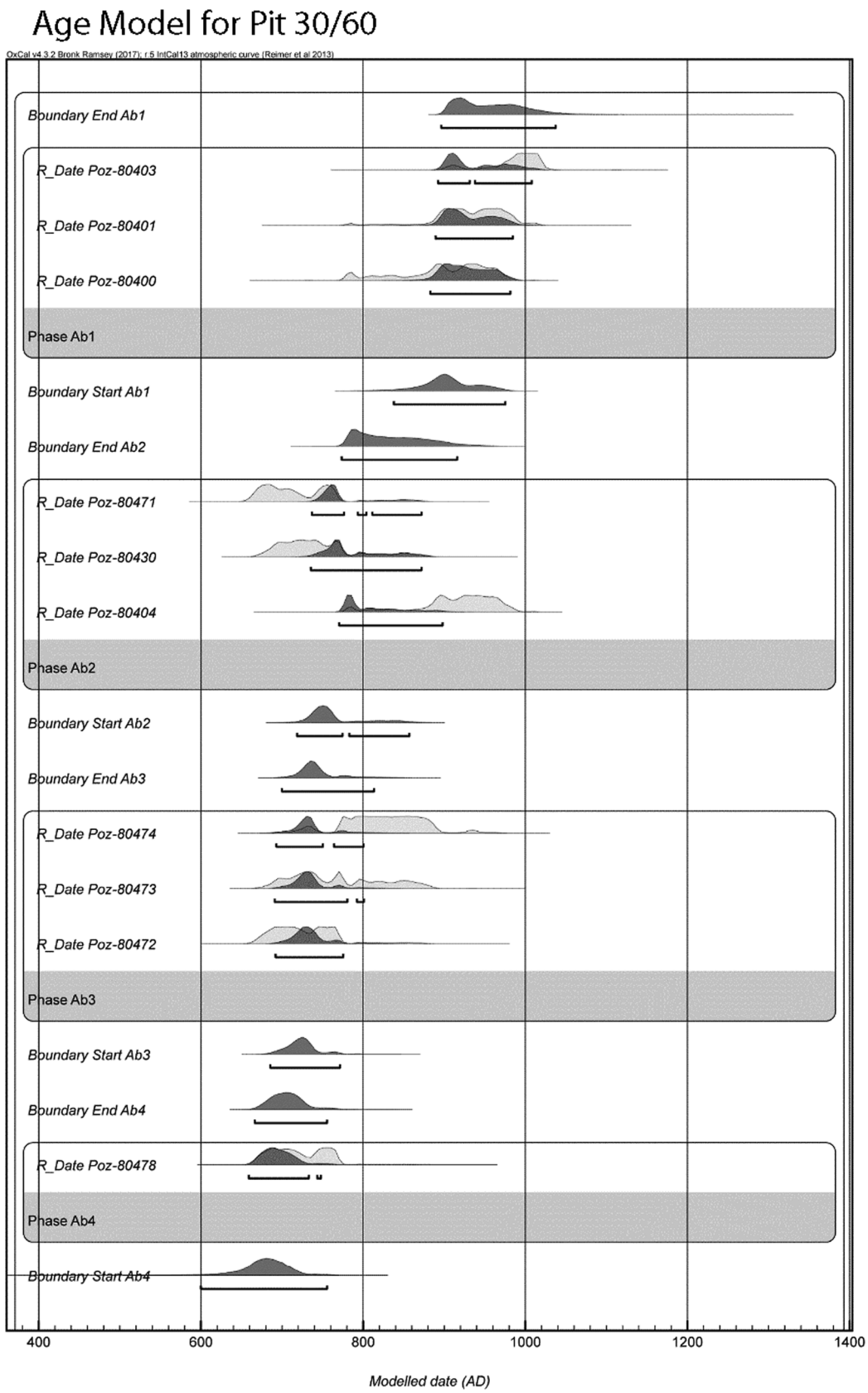

Fig. 9. OxCal 4.3.2 boundary/phase model for both soil test-pit 30/60 and 20/75, showing the original (light grey) and modelled (dark grey) calibrated radiocarbon dates from each of the buried soils (A_{b1}-A_{b4}).

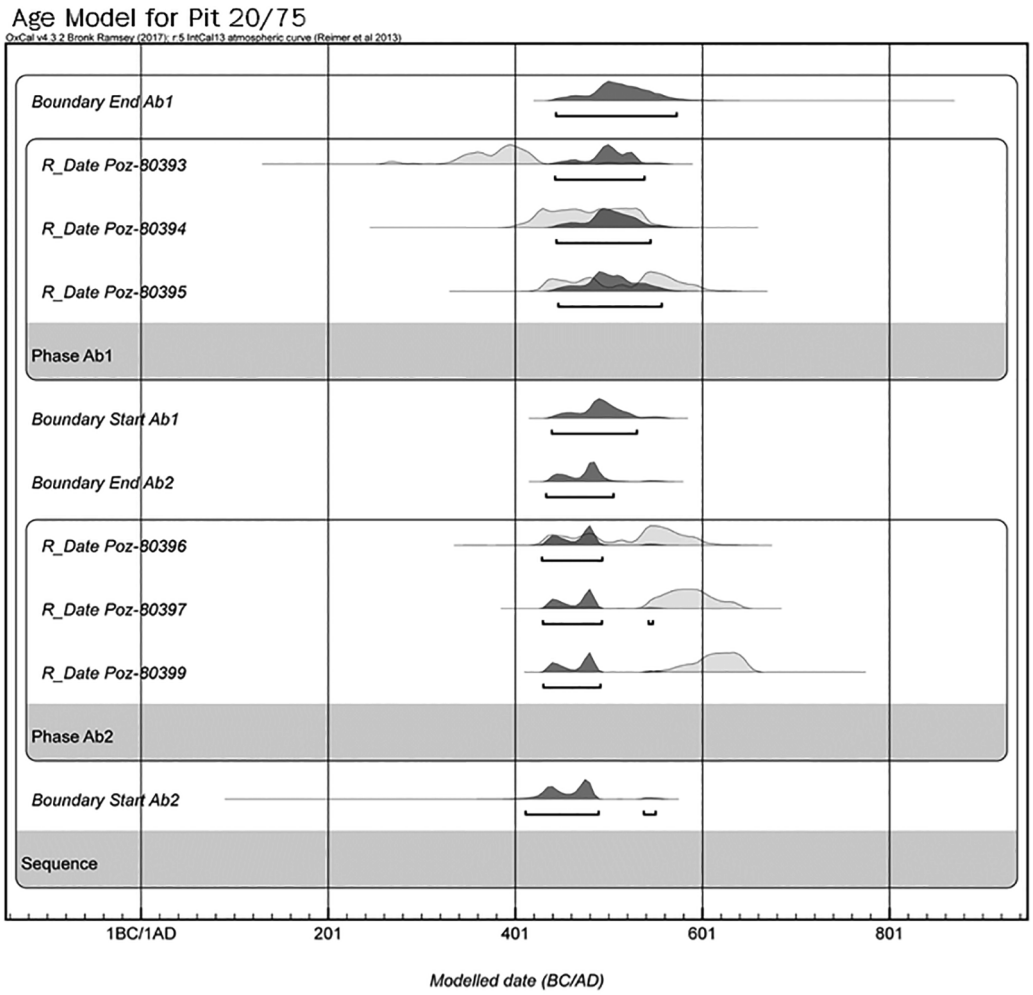

Fig. 9. (*continued*)

three from each buried soil horizon in test-pits 30/60 and 20/75 (Fig. 5). These test-pits were selected because identifiable charcoal was available for each soil horizon, enabling us to construct a boundary/phase age model. This model is described in Supp Mat S3a. Fig. 9 presents the full calibrated phase model for the layers in both of the pits. The apparent inversion of the dates in test-pit 20/75, and the poor fit of two out of the three dates in the second buried soil in test-pit 30/60, suggests that some of the charcoal sampled had been disturbed and re-deposited in later soils. The implications of the patchy and discontinuous nature of the soil horizons, and how the age model was adjusted to take this into account, are discussed in Supp Mat S3a and S4a.

According to the phase model, the wood used to fuel a fire on the oldest soil surface in test-pit 20/75 dates to AD 412 CE*–551 CE*, and that used to fuel a camp fire on the earliest soil preserved in test-pit 30/60 formed in 600 CE*–755 CE* (95% confidence). The latest soil surface preserved in test-pit 30/60 dates to 896 CE*–1037 CE* (95% confidence), which slightly precedes and overlaps with the phase of ditch-filling with *Rangifer* bones. Without any dates from the southern portion of the site excavated by Sokolov in 1991, it is impossible to know if perhaps these soil surfaces overlap with older occupations.

Our unexpected findings, therefore, were that I͡Arte 6 itself may be composed of multiple occupations, and that the plateau where I͡Arte 6 is situated was used as a camping place periodically as early as the 5th or early 6th century CE. There might also have been other campsites on this plateau at around the same time that the main site was occupied, a view supported by the artefactual and magnetic susceptibility evidence described below.

5.3. Palaeoclimate

The best available proxies for reconstructing the palaeoclimate of the I͡Amal peninsula before, during and after the occupation of I͡Arte 6 come from dendroclimatology and palynology. The resolution of these two techniques differs dramatically, due to the nature of the proxies, with broader trends perceptible in vegetation changes, and a more precisely dated, fluctuating picture visible in the tree ring data.

The Lake Three pollen core was analyzed for regional vegetation (Supp Material Fig S2e). The rate of sediment accumulation was very slow, and the 25 cm core covered almost 8000 years of vegetation history. These results indicate that the vegetation in central I͡Amal may have remained more or less the same through most of the Holocene. The only significant change in the vegetation occurred around AD 800, when there was a change to a drier and warmer climate, signaled by a decrease in *Cyperaceae, Poaceae* and *Sphagnum*, and an increase in *Alnus*, and *Pinus*. The timing of this change occurred after the earliest use of the I͡Arte 6 plateau as a campsite, overlaps with one of the horizons identified in the monolith tin (discussed below), and preceded the 'ditch-filling' phase of the I͡Arte 6 site.

The palynological analysis of the two monolith-tin cores taken from the profile on the edge of the 2013 I͡Arte 6 excavation area provide an insight into the climate during the various occupation phases of the site, as well as to how people and animals used the site (Fig. 10). We linked our results to the published palynological study by Panova (2008) of a different profile within the 1996 excavation (Supp Mat S2c). The profile on the edge of the 2013 excavation was originally divided into four horizons based on soil colour. However, the photographs of the profile

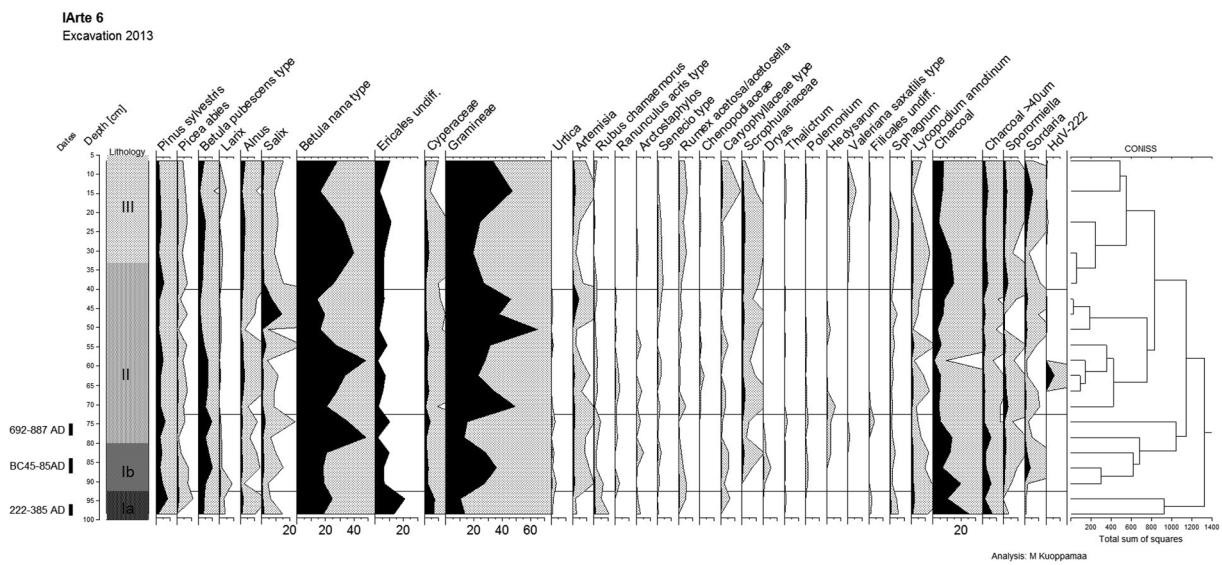

Fig. 10. Pollen and spore diagram from a monolith tin taken from the east wall of the 2013 excavation. Horizons II and III can be directly compared to Horizons 2 and 3 of the Panova monolith tin taken from the 1996 excavation. Horizon I, and subhorizons Ia and Ib, represent new layers identified for this study.

revealed another subtle colour change in the lowermost horizon at c. 82.5 cm depth (Fig. 8). A change in pollen concentrations at this depth was also registered by our Constraifed Cluster Analysis (CONISS), which, when applied to the raw pollen counts, distinguished two separate stratigraphic zones (Grimm, 1987). We therefore labelled these Layers Ia and Ib. In the lowest zone, Layer Ia, the pollen types indicate a warmer climate with a higher percentage of tree and Ericaceae type pollen. This unique climate type, missing in the Panova study, suggests that the 2013 monolith stretches further back in time. Phase Ib is associated with a cooler climate characterized by a decreasing proportion of tree pollen and an increase in *Artemisia* and *Poaceae* pollen. This cold and damp climate phase appears to correlate with Layer 1 of Panova's pollen diagram (Supp Mat S2c). Importantly, Layer Ib also has indications of human impact on the site. For example, the pollen of *Ranunculus acris*-type and *Senecio*-type, which are usually associated with human impacts, emerge at this level. Further, the continuous curve for a strictly coprophilous fungal spore type *Sporormiella* begins here, indicating that herbivores – likely *Rangifer* – gathered together, and deposited their faeces no more than 15 m away from the site (Jackson and Lyford, 1999). Higher up, Layer II is characterized by a gradual increasing trend in *Poaceae* pollen, and a 'double-peak' in *Betula nana*-type. The same was also recorded by Panova in her layer 2. The increase in *Poaceae* pollen can be connected to the intensification of activities on site, which may have raised the nutrient quality of the soils.

In order to confirm the chronology of these distinct changes in climate, we dated three samples of humic material from Layers Ia, Ib, and II (Sup Mat S2, S3). There were no identifiable bone fragments or macrofossils from these layers. Therefore the alkali-soluble fraction of the sediment was extracted by Johan Linderholm at the Umeå Environmental Archaeology Laboratory. The calibrated results confirm that the lowest horizon, our Horizon Ia (which was missing in the Panova study) is at least 400 years older than Horizon II and therefore overlapping with a well-documented short and very warm period between AD 200 and 300 (Fig. 11). Radiocarbon assays on humic matter must always be treated with caution because of the risk of residual carbon making the dates too old. In this case, however, the radiocarbon date supports the climate signatures from the pollen sequence, and suggests that there was a much older, warmer-period occupation of this site than has previously been documented.

The upper half of Layer II has a slight increase in *Salix* percentages, which suggests that the ravines surrounding the site may have supported a taller, bushy vegetation. The *Salix* percentages are very low, but the relative pollen productivity of *Salix* is more than 50 times lower than that of *Betula nana*, which can lead to the under-estimation of the presence of willows in the landscape (Niemeyer et al., 2015). The fact that at least some willows grew thick enough to use as a fuel is confirmed indirectly by our analysis of the charcoal recovered from hearths, pit fills, and buried soils (Supp Mat S3b). The dramatic spike in *Poacea* and *Caryophyllacea* at the top of Panova's pollen diagram is likely to be associated with development of the distinct grass cover that still covers the site. The fact that this thick signature starts at the top of the column suggests that the grass-herb cover developed late in the occupation, and that the original settlers of the site were not drawn to a pre-existing, *Rangifer*-created meadow. There is a curious spike in *Cyperaceae* beginning in Panova's Layer 3 that builds to a spike towards the top of that layer. According to our reconstruction of the stratigraphy, it is possible that the monolith tin struck the remains of a dwelling, and the elevated sedge signature may have captured the plants brought onto the site for use as flooring.

The most authoritative dendroclimatological model for the region is that of Briffa et al. (2013), which is based on 265 sub-fossil samples of larch (*Larix sibirica*) excavated from riverbanks from a variety of sites, some of which are only 150 km southeast of Íarte 6. Fig. 11 shows the calibrated Briffa record of two millennia of June-July temperature averages overlain with the dates of the northerly 'ditch-filling' phase of occupation at Íarte 6, as well as the dates of the older soil-formation events, which suggest an older set of occupations. The results in Fig. 11 indicate that the "ditch-filling" phase of Íarte 6 began at the peak of a 300-year phase of warmer summers, and continued as the summers became marginally cooler. Our dates from the monolith tin also suggest that there was a previously unknown occupation of the headland that corresponded with a short peak of warm temperatures at about AD 300. In additon, our dates from the soil survey southeast of the site, show that some sort of smaller scale occupation of the plateau behind the headland occurred during periods of time that were considerably colder (on average by two degrees in comparison with the late-20th century, or one degree in comparison with the peak temperature in CE 1050). The 5th or early 6th-century buried soil also seems to coincide with a temporary warming – although with a climate that was nevertheless cooler than today.

5.4. Grass-herb meadow and shrub cover at Íarte 6

The distinctive grass and herb vegetation at Íarte 6 has been used by

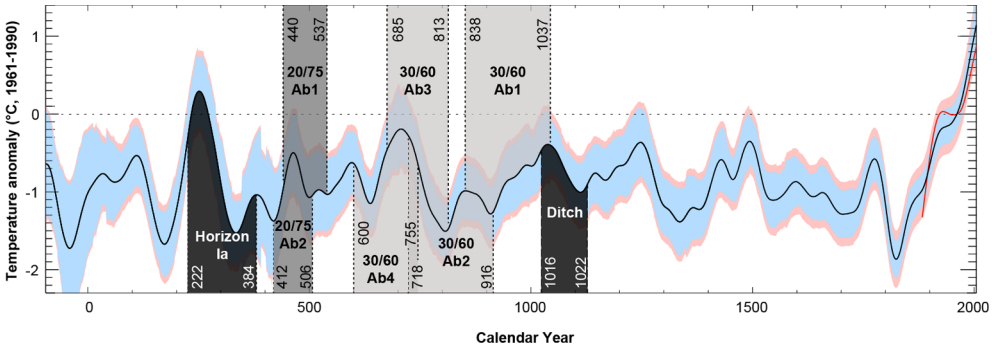

Fig. 11. A graph of June-July temperature anomalies as determined from the analysis of tree rings in fossil larch specimens adapted from Briffa et al. (2013: Fig. 11d). The light grey bars show the four sets of dates taken from Pit 30/60. The middle grey of bars show the two dated horizons in Pit 20/75. The darkest section show the dates corresponding to the archaeology of the site. To the left are the set of dates corresponding to a warm period that came from horizon Ia from the monolith tin taken from the south wall of the 2013 excavation. To the right, are the date ranges for our dates published by Nomokonova et al. (2018) for that portion of the ÍÂrte 6 site associated with the in-filling of the ditch.

Nenetses and scientists alike as a marker for the existence of a previous encampment. There is some evidence that congregating wild *Rangifer* can create meadows by trampling, grazing and faeces deposition without human encouragement (Fredskild and Holt, 1993). The landscape at ÍÂrte 6 suggests that the escarpment might have been a preferential place for migratory *Rangifer* to rest and graze on a headland, while monitoring for predators, after crossing Lake ÍÂranto. Our palynological studies, however, suggest that the graminoid meadow appeared, and was perhaps intensively enriched with nutrients, only during the very last phase of occupation in the 11th century. This turned our attention to the factors that may have helped the meadow to persist, once established. The highly nutritious and often highly digestible plants common to anthropogenic patches typically attract herbivores of all types (e.g. lemming, ptarmigan, hare, *Rangifer* and muskox), whose activities often encourage the fast-growing rhizomatous graminoids (Forbes, 1994, 1996). That said, no herbivore indicators – such as grazed grass culms or faeces – were observed during detailed sampling of the site in the summer of 1996 (Forbes, unpublished data). What is often missing in many studies of the life courses of graminoid meadows is an exploration of the neighbouring shrub communities. When reindeer graze at modern ÍÂmal tundra Nenets camps, their combined grazing and trampling creates a radial pattern (Stammler, 2005: 65, Fig. 2). This has the effect of either killing or stunting the growth of shrubs within the grass/herb-rich area, while confining the growth of taller shrubs to the low-lying ravines encircling the site – which, as we will see, may have been an important feature for wild reindeer hunters. At low densities, *Rangifer* do not have a marked effect on either erect shrubs or ground-level vegetation. However, at higher densities, the negative impacts of more intensive grazing and trampling can become clear within as little as six years (den Herder et al., 2008). During summer grazing and browsing, *Rangifer* remove green leaves, as well as first- and second-year tips from twigs, while also trampling, breaking down erect shrubs, and even killing them if they remain in one place long enough (Fredskild and Holt, 1993; Olofsson et al., 2001; Pajunen, 2009). For the shrubs that survive, this process reduces them to a stunted growth form (den Herder et al., 2008; Kitti et al., 2009). While herbivores can help to preserve meadows by grazing the shrubs, their grazing is not essential when the graminoid-herb cover is so dense – as it is at ÍÂrte 6 – that it prevents the germination of shrub seedlings (Forbes et al., 2001). The establishment and long-term persistence of this grassy feature amongst well-grazed shrubs does indicate, however, that the activities of people and *Rangifer* had once been intense.

5.5. Palaeosols adjacent to ÍÂrte 6

The plateau southeast of ÍÂrte 6, bounded on three sides by ravines, would be a place where domestic reindeer could be marshalled. Our geoarchaeological survey, soil mapping, sampling, and analytical strategy was designed to look for and date evidence of human and animal activity areas in close proximity on the plateau.

The results of the soil survey on the plateau southeast of ÍÂrte 6 are summarized in Supp Mat S4. The soils on the plateau are mineral cryosols developed on loess and redeposited loess. The loess parent material is a perfectly sorted very fine to fine sand (50–200 μm), rounded to subrounded in shape, and dominated by quartz minerals (c. 80%), with minor amounts of plagioclase, olivine, chlorite, and rock fragments. The dominance of acidic minerals created acidic conditions in the soils, whose pH ranged from 3.94 to 5.60 (Supp Mat S4b). In most test-pits, the soils that developed on this loess consisted of thin A horizons (5–10 cm thick), and often with two to four thin buried A horizons (Ab), usually only 3–8 cm thick (Fig. 12). The depths of these Ab horizons was variable, with the deepest recorded at 36 cm below the current ground surface. Labelled in each test-pit as Ab1-Ab4 with increasing depth, each was buried by re-deposited loess. In some test-pits, a thin (0.5–2 cm) organic horizon was identified immediately above one or more of the Ab horizons. These were labelled Ahb1-Ahb4, respectively, and, when available, they were sampled separately in order to maximise the chances of finding preserved faecal lipids. In contrast to the well-drained soils on the plateau immediately to the southeast of ÍÂrte 6, the off-site soil test-pits on the alluvial terrace south of the site, and in the hinterland of the site to the southeast, were very wet, humic, and lacked buried A horizons.

Human and animal activity, and wind erosion, has created a discontinuous soilscape (Fig. 13). Fine sands, exposed in erosion scars in the wider region, are picked up in windy weather and spread over the landscape, burying vegetated surfaces – the browner, more organic soils seen in the soil profiles. However, windblown sands are less likely to be deposited where there is no vegetation or uneven (deeper) topography or microtopography to capture them. Therefore, at any one site, the thickness and extent of wind-blown sand deposits can be very variable, and this may explain the lack of continuity of the buried soils at ÍÂrte 6. Even though the soils associated with the earliest activities are not continuous, fortunately they are preserved in patches. On that basis, we feel that our diagrams of phosphate concentrations and faecal lipid signatures give a reliable picture of past human and animal activity (Supp Mat S4a).

5.6. Magnetic susceptibility, artefact, and ecofact distributions

The high resolution magnetic susceptibility surface survey of the plateau adjacent to ÍÂrte 6 identified at least nine near-surface hearths that were hidden up to ca. 10 cm below the current ground surface, in the Ahb1 and Ab1 horizons (dark red spots in Fig. 14). Most of these near-surface hearths are clustered within 10 m of the main excavation area, and were associated with a scattering of charcoal, ceramics, and bones, but not the same high density of artefacts and bones characteristic of the main excavation area. In comparison, the magnetic

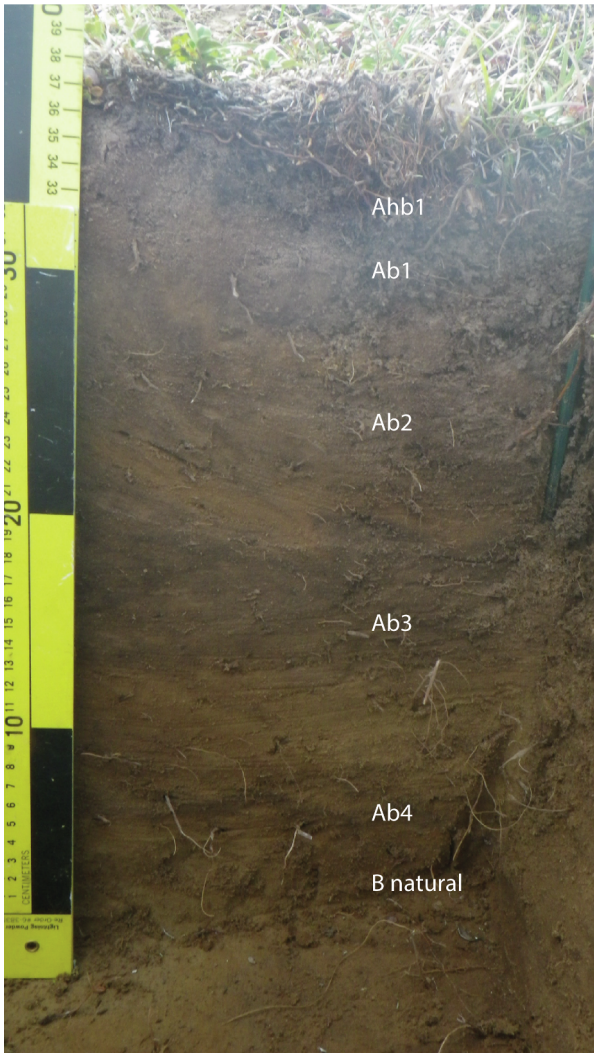

Fig. 12. Photograph of Pit 30/60 showing labelled buried soil horizons (A_{b1}-A_{b4}).

Fig. 13. Wind erosion scars in the interior of the ÍÂrte headland with Natal'ía Fedorova in the foreground summer 1996. (S. Haakenson: Photo 131_005).

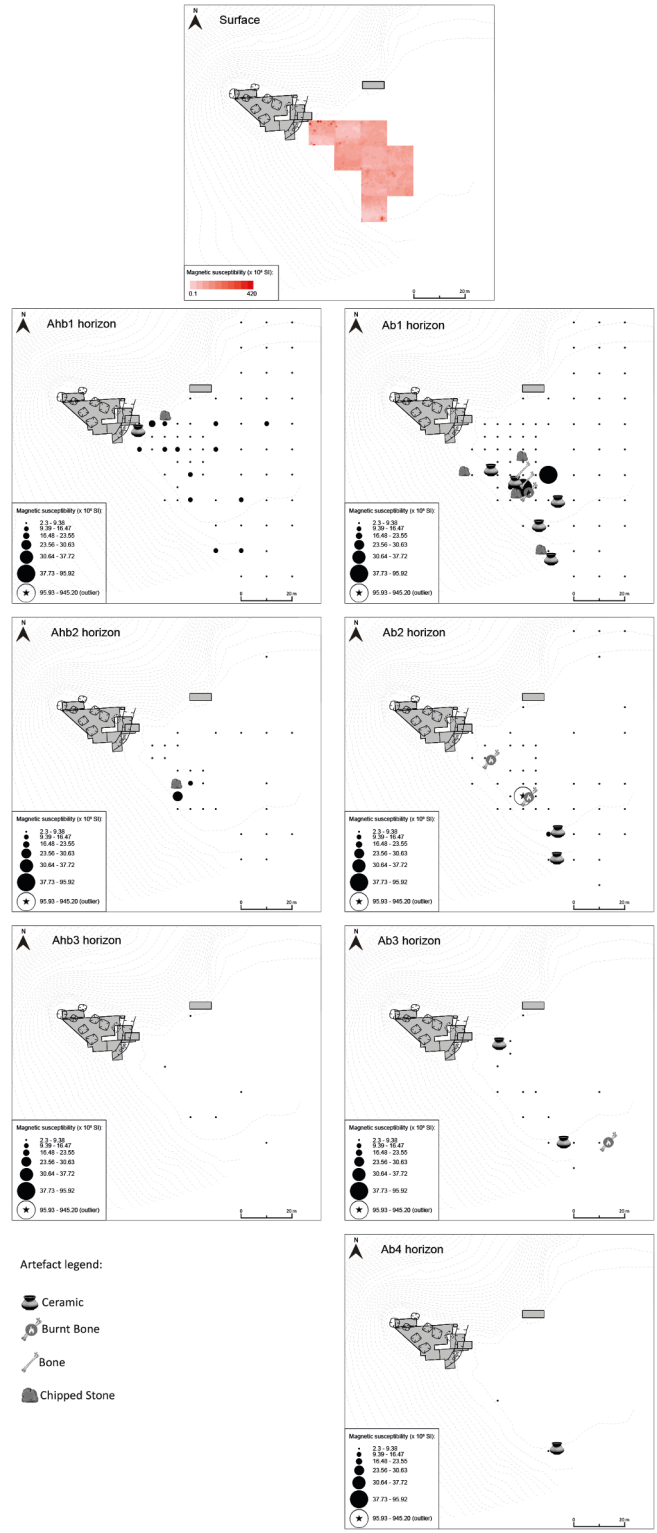

Fig. 14. MS map with ceramics, charcoal artefacts.

susceptibility map produced by conducting low frequency magnetic susceptibility analysis in the lab on bulk samples taken from the test-pits, at intervals 5–10 m apart, was less productive, missing most of the near-surface hearths (Fig. 14). However, this technique did reveal two test-pits presenting elevated levels of magnetic susceptibility, which are also associated with high levels of charcoal, and in one case a large number of ceramic fragments, chert flakes, and burnt and unburnt bones. Test-pit 20/75, which is situated at the centre of the magnetic susceptibility anomaly, was one of the two test-pits subjected to intensive dating of all soil horizons. The modelled date associated with the Ab1 layer is 440 CE*–537 CE* (95% confidence), which suggests that the main site sits alongside a very long history of human occupation in this area.

The surface magnetic susceptibility survey also revealed a hearth at test-pit 30/60, just above the break of slope on the southern edge of the survey area, whose Ab1 horizon was dated to 838 CE*–1037 CE* (95% confidence) (Fig. 14). This test-pit, which was widened to 1x1 m to explore the spot in more detail, also contained an abundance of pottery fragments and charcoal. It is clearly the location of a campsite – its later phases possibly contemporary with the main ÍÂrte 6 site, but its earlier phases dating as far back as 600 CE*–755 CE*.

5.7. Phosphate distributions

At ÍÂrte 6, phosphate signatures elevated above 1 mg P/g soil from diverse locations and buried horizons on the plateau southeast of the main excavation area may be interpreted as potential places where animals congregated and deposited their dung. Even though the dates of the buried soil horizons cannot be correlated across the plateau, when shown in sequence, the phosphate maps in Fig. 15 give an impression of a progression of human/animal impact from a few isolated spots in Ab4 to an intense and widely spread impact at Ahb1 and Ab1. In particular, the Ab1 horizon – whose date range overlaps with the ditch-infilling phase of ÍÂrte 6– shows a hitherto unknown phosphate-rich activity area close to ÍÂrte 6. The phosphate map for Ab2, on the other hand, shows a significant but much more spatially restricted locus of activity further to the southwest, in test-pit 20/75, in which the buried A horizons date back to the 5th century. It is notable in both cases that some distinct anomalies also exist at other locations, suggesting that there may have been other human/animal activity areas on the plateau. The phosphate maps for lower horizons do not show any distinguishable pattern. Nevertheless, it is significant that zones of elevated phosphate are present in every layer to some degree, suggesting a very long history of human and/or animal impact on the soils.

5.8. Faecal lipid biomarkers

A major innovation in this study is the use of faecal lipid biomarkers (5β-stanols) to determine if the elevated phosphate levels discussed above could be attributed to the addition of animal faeces to the soil, and, if so, to which species. The stanols can also suggest the main diet of the animal, which, for reindeer, can in some circumstances suggest the season when the animals congregated. As described above, a small subset of 36 soil samples, in addition to one reference sample from far away from the site and free from human/animal inputs, were selected for the analysis of 5β-stanols on the basis of their high phosphate content. The summarised results are presented in Fig. 15, indicated on top of the phosphate results as presence or absence of faecal lipids. The results suggest that the soil samples analysed for faecal lipids, with relatively elevated phosphate signatures, showed the presence of faecal material inputs originating mainly from reindeer, with one sample from dogs (see Sup Mat S5b). When the reindeer lipid results are compared with the reference samples documented in Harrault et al. (2019: Table S2) they come closest to matching the diet of modern forest reindeer in mid-winter with their characteristic blend of plants and lichen.

The results for 5β-stanols give a clear picture of the presence or absence of *Rangifer* and in one case dogs at a particular test pit. It is not possible to directly link elevated 5β-stanol concentrations to a higher concentration of animals. However, given that the lipid samples were taken from places with elevated phosphate concentrations – the results of which point to elevated levels of faecal input – the distinct species signature yielded by the 5β-stanols points to an elevated concentration of lichen-fed reindeer, and, in one location, dogs. On the basis of the lipid analysis, the cluster of elevated phosphate values in the Ab1 horizon close to the main ÍÂrte 6 site is likely to represent a reindeer marshalling area. In addition, the more localised phosphate spike in Ab2 in test-pit 20/75 is also associated with the presence of reindeer faeces, indicating that lichen-fed reindeer were present much earlier, and were standing in close proximity to a hearth (based on elevated magnetic susceptibility values) already in the 5th century CE.

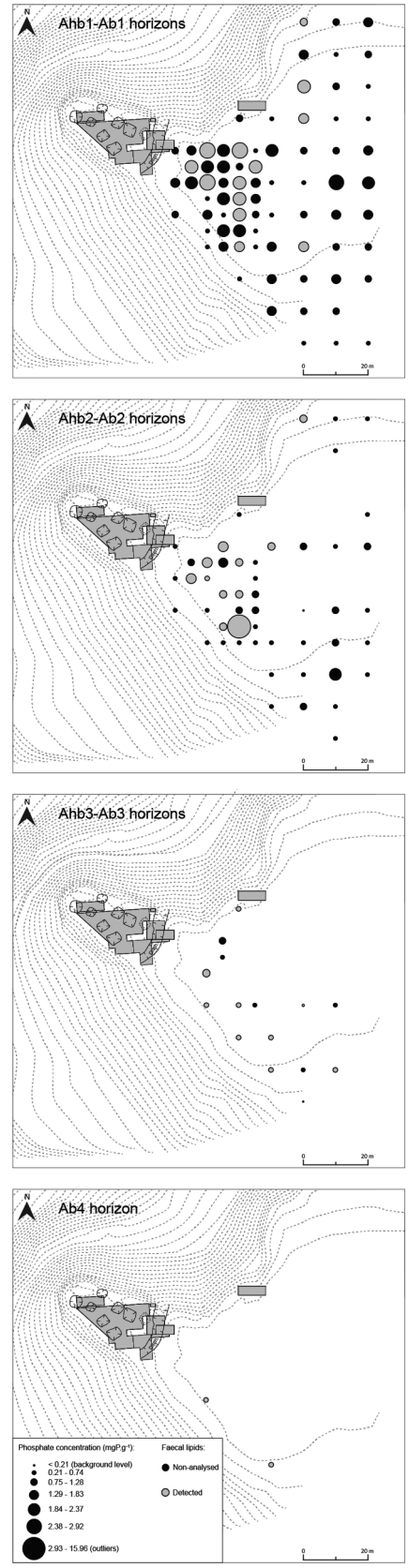

Fig. 15. Maps of phosphate and lipid anomalies by merged horizons.

The "winter-diet" seasonal signature produced by the lipids is, however, more controversial. The winter *Rangifer* signature in Harrault

et al. (2019) was derived from the analysis of modern faecal pellets either gathered in winter, or interpreted as being left-over from the winter in several sites in Northern Sweden, Northern Finland, the Saian mountains, and in the region of IÂrte 6 (5 km maximum from the site). Contemporary reindeer-herding practices assume that *Rangifer* move to a lichen-dominated diet in the autumn, mid-winter and early spring (Podkorytov, 1995). It is known, however, that if lichen is available, *Rangifer* will also consume high quantities of it in the summer (Bezard et al., 2015). Indeed some of the reference pellets gathered in the summer showed high proportions of lichestanol, the faecal biomarker thought to be derived from lichen consumption (Harrault et al., 2019: Table S2). It is also possible that the high proportion of lichestanol marks an intense period of dietary transition in the early spring or late autumn, when *Rangifer* often switch to a lichen diet. It must be remembered that the lipid signature taken from a thin soil horizon might capture a palimpsest of *Rangifer* use of perhaps some 150 years, and the signature therefore records an average use of the area over many seasons. Therefore, the stanol signatures in this case, without further research, do not help specify the season of use but they do specify which animal was congregated and grazing at the site. Further details on the interpretation of the stanol signatures are in Sup Mat S5d.

6. Discussion

Nearly 100 years of research into the history of animal domestication in northwestern Siberia have tended to favour two starkly different models, which in the imagination of archaeologists gave early hunter-herders a choice between using either harnessed dogs or harnessed reindeer. We argue here that the three tacit ethnoarchaeological narratives that lie behind these models imply several ecologically distinct models of how the landscape was impacted by standing reindeer, tethered dogs, or the waste resulting from the intense processing of wild *Rangifer*. By applying new geoarchaeological methods, with an ethnographic understanding of human/*Rangifer* interaction, we suggest that IÂrte 6 probably supported several differing types of relationship between people, *Rangifer*, and dogs spanning a much longer time range than had previously been assumed. Rather than favouring one or another style of animal domination, our results suggest that the peculiar landscape logic of IÂrte 6 encouraged a variety of ways of inviting and accommodating animals in the past – as it still does today. Placing at the forefront of analysis the strategies of how best to encounter and hold *Rangifer*, we can integrate the diverse strands of data offered by the IÂrte 6 site.

The most significant result of our study has been to increase vastly our awareness of how the IÂrte sites were organized spatially and chronologically. Our analysis of the palaeosols, and the palynology of the site itself suggest that the singular IÂrte 6 is now best broken up into a succession of sites, some built atop of one another, and others sitting beside the intensively occupied part of the promontory. Furthermore, IÂrte 6 should not be thought of as a fortress, but rather a platform for engaging with and holding animals. The geoarchaeological signatures in the layered soils tell a story of low-density and more-diverse adaptations giving way to a more standardized and pervasive *Rangifer* hunting economy over time.

What we have described as the "ditch-filling occupation phase", elaborating on Nomokonova et al. (2018), likely only refers to part of the uppermost archaeological horizon – that which is associated with large bone deposits, as well as a collection of worked *Rangifer* leather and skin-working tools. This intensive occupation is probably linked to the elevated phosphate and lipid signatures produced in the Ab1 layers of the test-pits on the surrounding headland. The phosphate anomalies and lipid biomarkers strongly suggest the presence of standing animals. These results support the hypothesis that early hunters at the site relied upon some form of transport reindeer husbandry.

However, there are many possible ways of holding domestic *Rangifer* for transport, of which the present large-scale and highly mobile tundra Nenets adaptation is only one. Our results suggest the type of animal husbandry supporting the intensive ditch-filling phase of IÂrte 6 was of a smaller scale than that of contemporary tundra Nenetses. The phosphate levels in buried soils Ab1 and Ab2 (Fig. 15) are distributed more or less evenly across the promontory, with elevated concentrations nearer the residential site, punctuated by one or two anomalies away from the site. The phosphate patterning does not immediately suggest the presence of pens, corrals, or any other physical structures – unlike similar studies in Fennoscandia or southern Siberia (Anderson et al., 2014; Karlsson, 2004, 2006). Rather, it suggests that the animals were confined only by the surrounding ravines. The high phosphate anomalies indicate that the animals stood more frequently near the pit-houses – perhaps after being assembled to be harnessed. Alternatively, small numbers may have been tethered 40–50 m away from the residential site. It is very difficult to put an exact number on the animals that created these soil changes. While the phosphate signatures of the lower buried soils – Ab3 and Ab4 – are consistent with very small groups of animals of five to six head, the patterns in the upper layers are not unlike those known to be produced by small herds of reindeer of approximately 40–60 head (Anderson et al., 2014). However, given the wide, open-ended structure of the promontory, it would be difficult to exclude the possibility that early hunter-herders might have held even a larger number of animals – perhaps even as many as 200 – in an open and diffuse form of domestication. The phosphate signatures in isolation cannot dismiss one or another of the ethnoarchaeological models.

Reindeer herders, even if they operate with smaller herds, also differ in their reliance on the domestic herd for subsistence. Hugh Beach (1981) distinguishes Sami reindeer pastoralism by extensive and intensive moments. Inger Storli (1996) and Ivar Bjørklund (2013), also working with Sami ethnography, distinguish reindeer pastoralism from reindeer taming by the dependence that the herders have upon the animals for milk or for meat. Large-scale tundra Nenets herders, who so heavily influenced interpretations of this site, are entirely dependent on their herds for subsistence, transport, and for skins with which to make tents and clothing. Their strategy, it is said, represents the "tundrification" of humans such that the people have been forced into a subsidiary position of following and catering to the seasonal desires of the animals (Stépanoff, 2017: 390; Golovnëv, 2004). This high level of *Rangifer* dependence does not seem to be a quality of the IÂrte 6 site. Although it might be possible to argue that the thick archive of *Rangifer* bones – most of which are cracked, broken or re-worked – represents the results of the systematic slaughter of domestic reindeer, the phosphate patterns do not suggest that animals were amassed, tethered and processed as if in an abattoir. Instead, they imply the presence of a relatively small number of animals who could be relied upon to willingly stay close to the camp without the use of confining structures. Several other strands of evidence support this. An important result of our palynological work are the fungal spore signatures, which show that domestic animals were present or perhaps wandered in amongst the dwellings on the headland. Pavel Kosintsev recalled that during the 1996 excavation a pile of reindeer faeces was excavated from within one of the dwellings – testifying to the intimacy of the domestic relationship (Golovnëv, 1998: 110). Scattered clues, taken together with the phosphate and lipid data, speak to an intensive form of taming – which most often relates to the presence of a small number of well-trained animals living close to humans.

The question of numbers is one of the key parameters that distinguishes each of the ethnoarchaeological models. Nomokonova et al. (2018), who have conducted the most thorough zooarchaeological analysis of the portion of the faunal remains recovered from one small part of the site, estimate that the minimum number of individuals (MNI) represented at that fraction of the site was 139 animals over roughly 106 years. Neither the MNI nor the age model can give an exact picture of the level and intensity of the total number slaughtered. If both estimates are generously extrapolated by a factor of five, this

would suggest that roughly 500 head were slaughtered over 20 consecutive seasons – an average of 25 per season. Even this relatively high estimate would, nevertheless, be more typical of a herd-following or decoy-mediated hunt of wild *Rangifer* than a large-scale river-mediated hunt. However, it would be also be too high a level to sustain if domestic *Rangifer* were being slaughtered, given that models of a "transport revolution" assume a minimum number of 200 head of trained and harnessed domestic reindeer. It must be remembered that the MNI estimate only applies to the portions of the site excavated in 2013 and 2015, and does not capture the faunal material excavated in earlier years. Nevertheless, together with Nomokonova et al. (2018), we feel it is reasonable to conclude that the deposited *Rangifer* bones are most likely those of hunted wild reindeer.

This leaves open the question of how wild *Rangifer* were hunted here. The seasonal signatures at the site offer some clues. Nomokonova et al. (2018) assume a summer occupation of the site, putting a great weight on the faunal remains of birds and fish. Their preliminary and unpublished analysis of the age-at-death profile of the *Rangifer* faunal remains indicates the presence of several calves younger than 7 months (Nomokovona pers.comm.). Since cows normally give birth in April, the site must have been occupied as late as the late summer or early autumn. Konstantin Oshchepekov, an archaeologist involved in the 1996 excavation, recalled finding a perfectly preserved pile of cloudberry seeds in the thawed excavation, which also suggests an early August occupation. The unpublished field notes of Bill Fitzhugh also record masses of feathers dug up from one of the lower levels of his test-pit. In addition, the I͡Arte 6 artefact catalogue includes fishing nets, floats and sinkers (Plekhanov, 2014: 30-2). These observations point to a warm-season occupation ranging from spring through late autumn. Intriguingly, in a separate study, Nomokonova et al. (2018), note the extremely high numbers of Arctic fox remains at the site, making that animal the most widely represented mammal after *Rangifer*. Their age-analysis suggests that many of the animals were killed in the early spring, mid-summer and late autumn (although to complicate the picture, some were also slaughtered in December-January) (Nomokonova et al., 2018: 102). These data suggest that the residents may have captured the bulk of the animals in their warrens during the summer and likely used them for some other purpose than harvesting their fur (such as for food). Perhaps some habituated foxes were kept tethered, and then slaughtered mid-winter for their furs, as historical Nenetses are known to have done (Klokov, 2011b). Although all of these observations on seasonality are ambiguous, they point to an adaptation more akin to the small-scale semi-sedentary Nenets hunter-fishers who still spend the summers and autumn along the banks of the I͡Uribeĭ river today (Haakanson, 2000). I͡Arte 6, therefore, may have been occupied in the snow-free season, similar to the mid-summer to late autumn herd-following strategies of the Taltheilei (Gordon, 1996), or the mid-summer occupation of Dolgans at Lake Bala-Turku, Taĭmyr (Popov, 1948). This small-scale wild *Rangifer*-following community may have used decoys to entice small numbers of animals into the surrounding lakes or up the headland. By contrast, a large-scale slaughter of migratory *Rangifer* crossing a major river would more likely than not be an unambiguous autumn activity.

In order to understand the role of reindeer and dogs in supporting this mixed economy of fishing, hunting birds, gathering berries – and attracting and slaughtering migratory wild reindeer in small numbers – the landscape logic of the site becomes important. As outlined above, the I͡Arte promontory, backed by a semi-circular headland, and situated next to a set of lakes, is a unique location which would have been attractive both to wild *Rangifer* and to hunters holding domestic *Rangifer*. The promontory's affordances are not unlike those cited in classic examples of reindeer following at Lake Bala-Turku (Popov, 1948) or KjnB7 along the Thelon River (Gordon, 2005). Small groups of migratory wild *Rangifer* could be easily spotted by hunters from their position on the top of the escarpment. Armed hunters could then watch the small groups of reindeer either swim across Lake I͡Aranto, or attempt to cross the narrow strip of land between the I͡Aranto lakes – a route that is still used today as a reindeer road by local herders. Alternatively, the animals could be driven towards the promontory with dogs, or enticed to approach the headland with the use of tethered decoy reindeer. As the wild animals mounted the side of the hill, early hunters might have concealed themselves in the brush-covered ravines – or even lay in wait on the lakeshore with small boats. Models of boats are among the miniatures recovered from the site (Plekhanov, 2014: 93). The fact that the hunter-herders concealed the butchered remains of their prey "like poachers" might also point to an attempt to keep the land clean of signs of predation, so as not to discourage future groups of wild reindeer approaching the site. The fact that the remains of the hunt were processed at the top of the headland – open to the wind – points again to a mid-summer or autumn occupation. Although there are no hard and fast rules about the numbers of domestic animals a mixed hunting, fishing, and herding community would keep, to have time for this range activities the numbers of reindeer kept would have to be in the region of 100 head or less.

Although there is no material evidence of barbed reindeer head-gear at I͡Arte 6, as described by Moshinskaia͡ (1953) for Ust'-Poluĭ, there are several other points of evidence that support the possibility of small-scale controlled hunting. First, there is wide evidence of the presence of domestic dogs at the site, ranging from buried dog remains and evidence of gnawing (Nomokonova et al., 2018), to the presence of canine coprolites (Vizgalov et al., 2013: 253–4). Our own geochemical work produced one strong lipid signature of dog faeces in a buried soil horizon adjacent to the site. As described above, dogs can be used to help drive migratory *Rangifer* into lakes and up escarpments. In addition, the extensive artefact collections recovered from the site indirectly support the presence of a hunting economy. Amongst the catalogue of collections one can find arrows or forms for making arrows, scaled miniature models [interpreted as toys] of bows and arrows, and archery armplates [interpreted as defensive armour] (Plekhanov, 2014: 100). Finally, as above, we suggest that barbed head-gear are not necessarily associated with the use of trained reindeer for decoys. Indeed, following Gusev et al. (2016), if the potential decoys doubled as transport reindeer one would expect the design of the gear to be more ambiguous and flexible.

In order for a successful herd-following and perhaps decoy-mediated hunting strategy to work, one needs to curate the environment to make it seem welcoming to migratory wild reindeer. As we have seen, this requires that the animals are not offended by extraneous noise and litter. It often implies choosing a site that makes it easy to hide or conceal the residential dwellings, the small groups of domestic animals, or the hunters waiting with their bows and arrows. The I͡Arte promontory has few shrubs today, and indeed it would be hard to imagine how the existing willow copses could conceal a campsite or hide a hunter. However, the palynological evidence suggests that the shrub cover was thicker in the centuries after 800 CE. During slightly warmer periods, willows grow taller and copses become more dense, as exemplified by the contemporary "shrubification" of I͡Amal, which is associated with the 21st-century warmer temperatures (Myers-Smith et al., 2015; Macias-Fauria et al., 2012). The growth of shrubs during warm periods in the past might also have been encouraged by deeper snow cover, which also seems to be associated with warmer periods (Bulygina et al., 2011; Bulygina et al., 2009). The increased cover helps to protect erect shrubs from wind abrasion by snow and ice crystals (Zeng et al., 2013; Xu et al., 2013).

To navigate the controversies over interpreting this site as one that supported a mixed hunting-herding economy, as opposed to one that supported a large-scale pastoralist adaptation, it is possible to employ our revised chronological and the palaeoclimatic evidence. Although it has proven difficult to anchor various phases of the I͡Arte 6 site in time, there is palynological evidence that there were several different occupations occurring at times of distinctly different climates, throughout the first millennium AD. Further, the combined phosphate and lipid

evidence from the buried palaeosols indicates that as far back as the 5th century early small-scale hunter-herders created encampments and held reindeer close to their camps. The distinctive signature of coprophilous fungal spores, which is likely associated with domestic reindeer, starts already in the earliest phases of the I͡Arte 6 excavation, now dated to 222 CE*–385 CE*. Therefore, there is substantial evidence that this distinctive headland had been used for a long time as a site of encounter between hunters, domestic reindeer and wild reindeer – and that the intensity of this activity grew over time. Much like the themes emerging from the contemporary Nenets folklore of the site, it seems that the scale of activity escalated until a sudden calamity ended the tradition of hunting and holding reindeer at I͡Arte 6.

Is it entirely possible that the early hunter-herders tried to over-intensify their hunt of migratory wild *Rangifer* – perhaps with a view to specializing in the production of skins – leading either to a population crash, or the abandonment of the migration route, or even the exhaustion of the shrub resources on the promontory. There are several indirect clues to such an intensification. The cooler phases documented in the Briffa curve (Fig. 11), and within the pollen record of the excavation itself, are important for understanding the relation between people and *Rangifer*. It is widely documented that both wild and tame *Rangifer* increase their populations during cold periods, since there is less heat stress on the young calves. For example, the Little Ice Age has been linked with the explosion of domestic reindeer numbers in the region and are often cited as the trigger for the "reindeer revolution", when larger herds began to be kept for meat (Golovnëv, 1993; Stépanoff et al., 2017; Golovnev and Osherenko, 1999). The paleoclimate data suggests that the "cooler periods" may have led to a seductive increase in the numbers of migratory wild *Rangifer* –indeed in both wild and tame *Rangifer* – leading early hunter-herders to make an attempt at specializing in large-scale *Rangifer* hunting and/or pastoralism. The "defensive ditch" bisecting the site may also have undergone dramatic changes in use. During an early, less-intensive occupation, the ditch may have been dug to delinate the habitation site symbolically. As the the number of pit-house increased over the summer months, the early residents probably encountered a problem with the thawing of the permafrost layer, leading them to adapt the ditch to drain the site. As the recent chronological model by Nomokonova et al. (2018) suggests, the ditch may have been transformed into a midden early in the 11th century in an attempt to dispose of, and conceal, the products of an ever-intensifying hunt of wild *Rangifer*.

The results of our multi-disciplinary analysis of this important site have to some degree raised more questions, rather than entirely eliminating older models. Nevertheless, they show that a sustained investigation of landscape affordances can provide new lines of evidence to query human/animal relationshps in the Arctic. The combined analysis of magnetic suseptibility, phosphates, and faecal lipid markers demonstrate moments of close proximity between people and both *Rangifer* and canines, strongly suggesting a domestic relationship. Neverthless the density of those signatures is somewhat less than what one would expect of full reindeer pastoralist economy. On the other hand, the unbalanced distribution of faunal remains located at the top of an escarpment near a lake suggests a mixed economy of mid-summer to late autumn hunting of many types of animals, including small numbers of wild reindeer. Without the development of new methods to perhaps genetically associate *Rangifer* remains with a wild or domestic population, it is impossible to rule out one or another type of strategy. However, a full ethnographic understanding of the logic of the site – its shape and position within the region – suggests that I͡Arte 6 was a good place to encounter free-ranging *Rangifer* as well as to hold domestic *Rangifer* who had entered into a closer relationship with early hunters. To quote Stépanoff et al. (2017), the landscape forms an "interspecific common ground" where humans and several semi-domestic animals come together. The landscape, therefore, facilitates both wild *Rangifer* hunting and holding domestic *Rangifer*. Rather than treating this as a further ambiguity, it has led us to question models of domestication, which rely too heavily on models of animals tethered, hobbled and confined by the tools of domestication. Instead, by treating the landscape form as one that encourages proximity between people and animals, we suggest a wider and more flexible model of human/animal relationships for north-western Siberia, and, by extension, other parts of the North.

7. Conclusion: Encountering and holding animals I͡Arte 6

There is no question that the I͡Amal peninsula has been, and remains, an important region for hunting and herding dogs and *Rangifer*. The iconic site of I͡Arte 6, among many in north-western Siberia, speaks to at least two millennia of relationships between people, animals, and a landscape that supports them. The strength and subtlety of this relationship is not served well by models which oversimplify these adaptations. This study, employing a multi-disciplinary environmental study, suggests that that humans, dogs, and *Rangifer* interacted in a variety of ways throughout the first millennium AD. These occupations range from relatively low-density, warm-season encounters of wild *Rangifer* supported by an ensemble of tamed reindeer and of dogs, to a much more intensive hunt and processing of wild *Rangifer* with specialized tools, which may have been supported by small-scale transport reindeer husbandry. On the one hand, what we identify as the over-interpretation of the human-*Rangifer* relationship may have been generated by an over-enthusiasm to present this region as a world-historical centre – much as Nikolaĭ Vavilov (1933) once identified several key "hearths" of domestication nearer to home. On the other hand, we feel that there is generally a misunderstanding of the intuitions of "following", "attuning" and "encountering" which distinguish successful strategies of Arctic domestication from imported ones (Anderson et al., 2017b). Much of the work done on the I͡Amal Peninsula has focussed on the role of evocative artefacts – tools which might be used to hobble or bind animals into a submissive role. Our comparative study of the circumpolar Arctic suggests that *Rangifer/Canine/Homo* assemblages are situated within a knowledge and an awareness of the affordances of the landscape. Rather than relying upon subterfuge, it is likely that early hunter-herders on I͡Amal in the past, as today, relied upon the aspects of the landscape that attracted and held animals. By placing this knowledge in the foreground, it becomes possible to imagine the multiple instances of life at I͡Arte 6 as chapters in a long-term story of human-animal survival in the North. The paleoclimate record suggests that warming and cooling periods continue to play an important role in the lushness of the shrub cover, and the vibrancy of reindeer herds. As industry and government forces consider new regulations to hobble and control tundra Nenets reindeer herders, this study suggests that the long-term signature of this ancient occupation is one of diversity and balance – one that can very much adapt to the changing climates of the 21st century – and which is best left to govern itself autonomously.

Declaration of Competing Interest

None.

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Co-author roles

DGA was the PI of the ESRC UK project providing funding for the fieldwork, led the writing of the article, planned the logistics of the fieldwork, and translated between Russian and English-speaking members of the team. LH was responsible for designing a new laboratory protocol for measuring lipids, taking soil samples in the field, analysing the soil, interpreting and graphing all laboratory results, and wrote the sections on phosphates, lipids, and MS. KBM was the co-PI to the ESRC UK project, designed the soil survey and sampling strategy, led the soil survey in the field, and wrote the methods and results sections of the manuscript. BCF was the leader of the JPI HUMANOR network within which the funding was provided. He performed the botanical study at ÎÂrte 6, supervised the palynological work, and wrote the paragraphs on vegetation. MK was responsible for the palynological fieldwork and analysis and wrote the section on palynology. AVP was the archaeologist responsible for the excavation and the license for the research and he analysed and interpreted the archaeological results from the main ÎÂrte 6 occupation, and read and commented on drafts of the manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jaa.2019.101079.

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