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Rethinking the Disappearance of Microblade Technology in the Terminal Pleistocene of Hokkaido, Northern Japan: Looking at Archaeological and Palaeoenvironmental Evidence

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Abstract: Archaeological research, for several decades, has shown that various microblade technologies using obsidian and hard shale appeared and developed from the Last Glacial Maximum to the terminal Pleistocene (Bølling–Allerød–Younger Dryas) in Hokkaido, Northern Japan. It is well accepted that microblade technology was closely related to the high mobility of foragers to adapt to harsh environments. Recent archaeological and palaeoenvironmental evidence from Hokkaido demonstrates that the disappearance of microblade technology occurred during the terminal Pleistocene, influenced by a wide range of factors, including changes in landscape, climate, subsistence and human populations. The goal of this paper is to provide an overview of the current state of research on the process and background of the disappearance of microblade technology and to discuss prospects for future research. This paper will (1) review palaeoenvironmental research in Hokkaido on changes in climate and biological composition from the terminal Pleistocene to the initial Holocene; (2) survey changes in the technological adaptations and resource use of humans based on the archaeological evidence; and (3) discuss how the abrupt fluctuations of climate that occurred in the terminal Pleistocene affected human behaviour and demographics in Hokkaido.

Keywords: microblade technology; palaeoenvironment; Hokkaido; terminal Pleistocene; initial Holocene

1. Introduction

The accumulation of Upper Palaeolithic studies in Hokkaido, for several decades, has revealed that there are numerous lithic assemblages characterised by various microblade technologies using raw materials such as obsidian and hard shale [1–3]. Detailed lithic technological analyses and chronological reconstructions in Hokkaido have made it clear that the various microblade technologies that appeared and developed were closely related to the behavioural strategies of mobile hunter-gatherers adapted to living in harsh environments from the Last Glacial Maximum (LGM; 26,500–19,500 years ago) [4] to the terminal Pleistocene (Bølling–Allerød–Younger Dryas) [1–3]. In this paper, 'microblade' refers to parallel-sided small artefacts possessing one or more ridges running parallel to their long axes, generally 15–60 mm long, 4–10 mm wide, and 1–2 mm thick [5–9]. Systematic observation of the techno-typological characteristics of microblade cores and lithic refitted pieces has demonstrated that highly standardised microblades were produced through complicated lithic reduction sequences from lithic raw materials [2,10,11]. Microblade technology enables the production and maintenance of compact and lightweight stone tools that can be used as part of composite tools. For humans adapted to a cold and dry environment in the Upper Palaeolithic, the manufacturing and use of microblades can be considered an important technological choice for behavioural adaptation in terms of efficiently using and transporting lithic raw materials collected during foraging [3,12,13].

It is widely known that microblade technology was distributed across regions of northeast Asia, such as North China, the Korean peninsula, the Russian Far East, Mongolia and Siberia [13–22]. Many researchers have made advances with comparing the techno-typological features of microblade assemblages and accumulating radiocarbon dates. As a result, we are currently in the process of getting a better understanding of the spatiotemporal patterns of microblade technology in northeast Asia. Understanding when and how microblade technology appeared and disappeared in each region has been a topic of debate in northeast Asian Upper Palaeolithic research. Although several hypotheses on the origin(s) of microblade technology in northeast Asia have been presented and debated until recently [6,13,15,16,22,23], the disappearance of microblade technology in each region has received less attention.

According to records from ice cores from Greenland, drastic and abrupt environmental changes occurred repeatedly from the terminal Pleistocene to the initial Holocene [24]. A warming period occurred from 14,700 years ago until 12,900 years ago called the Bølling–Allerød, followed by a cooling period called the Younger Dryas. The Younger Dryas is designated as lasting until 11,650 years ago. After the end of the Pleistocene, a period of global warming began. The Preboreal is designated as lasting from 11,650 years ago until 8500 years ago. Quaternary scientists have long demonstrated that episodes of glacial readvance and retreat, shifts in precipitation and forest destruction and re-growth occurred during the transition from the terminal Pleistocene to the initial Holocene [25].

Techno-typological comparisons and some radiocarbon dates show that microblade technology disappeared in Hokkaido during the terminal Pleistocene [2–4,26,27]. To explain the background of the disappearance of microblade technology in terms of relationship to palaeoenvironment change would offer valuable insights into the nature of the technological and behavioural characteristics of microblade technology in Hokkaido, as would identifying the differences with regions such as Siberia, Mongolia and North China, where microblade technology continued after the onset of the Holocene [8,21]. Furthermore, recent archaeological research in eastern Hokkaido shows that different techno-complexes, including not microblades but various bifacial points and burins associated with potteries, emerged during the terminal Pleistocene [27–29]. Did the appearance of these techno-complexes play a role in the end of microblade technology in Hokkaido? Or should we expect a significant overlap for some time? The archaeological sequence of Hokkaido in the transition from the terminal Pleistocene to the initial Holocene and its implication for the process of how the palaeoenvironment related to the changes in human adaptive systems are rarely a subject of major agreement among scholars working in the region [27,29]. Understanding the relationship between them will be beneficial to any final interpretation of past human adaptations. This will provide insights into the process through which hunter-gatherers who had adapted to the warming of the natural environment after the Preboreal adopted sedentary lifestyles and highly diversified subsistence, making use of marine-based and other stable food sources [28,30,31].

Recently, there have been some important archaeological achievements that suggest how hunter-gatherers in Hokkaido accomplished technological adaptations and resource use during the transitional period from the terminal Pleistocene to the initial Holocene. Based on these studies, this paper will survey the process through which microblade technology disappeared in Hokkaido and the background behind this process, influenced by a wide range of factors, including changes in landscape, climate, subsistence and human populations. This paper will (1) review research on the palaeoenvironment carried out in Hokkaido regarding changes in climate and biogeography from the terminal Pleistocene to the initial Holocene; (2) assess changes in the technological adaptations and resource use of humans by focusing on lithic production technology and patterns of land use; and (3) discuss the ways in which sudden cooling affected human behaviour and demographics, particularly during the Younger Dryas.

2. Palaeoenvironment

Hokkaido is a large island located in the northern tip of the Japanese archipelago (Figure 1). During the LGM, lower sea levels caused by a cooler climate meant that Hokkaido was connected to the island of Sakhalin via the Soya land bridge and to Siberia via the Tatar land bridge. Humans and the faunal community were able to disperse from the Eurasian continent to Hokkaido without any straits to interrupt their migration. The resulting palaeoenvironment of Hokkaido during the LGM was somewhat more continental in character than it is at present. On the contrary, there was no land bridge across the Tsugaru Strait dividing Hokkaido and Honshu, thus, creating a barrier for humans and the faunal community [32]. This brought about disparity between Hokkaido and Honshu in terms of various cultural features and the composition of the faunal community during the Upper Palaeolithic [33–35]. Some researchers suggest that by the onset of the Bølling–Allerød interstadial the bridge between Sakhalin and Hokkaido had disappeared and Hokkaido was surrounded by ocean [26].

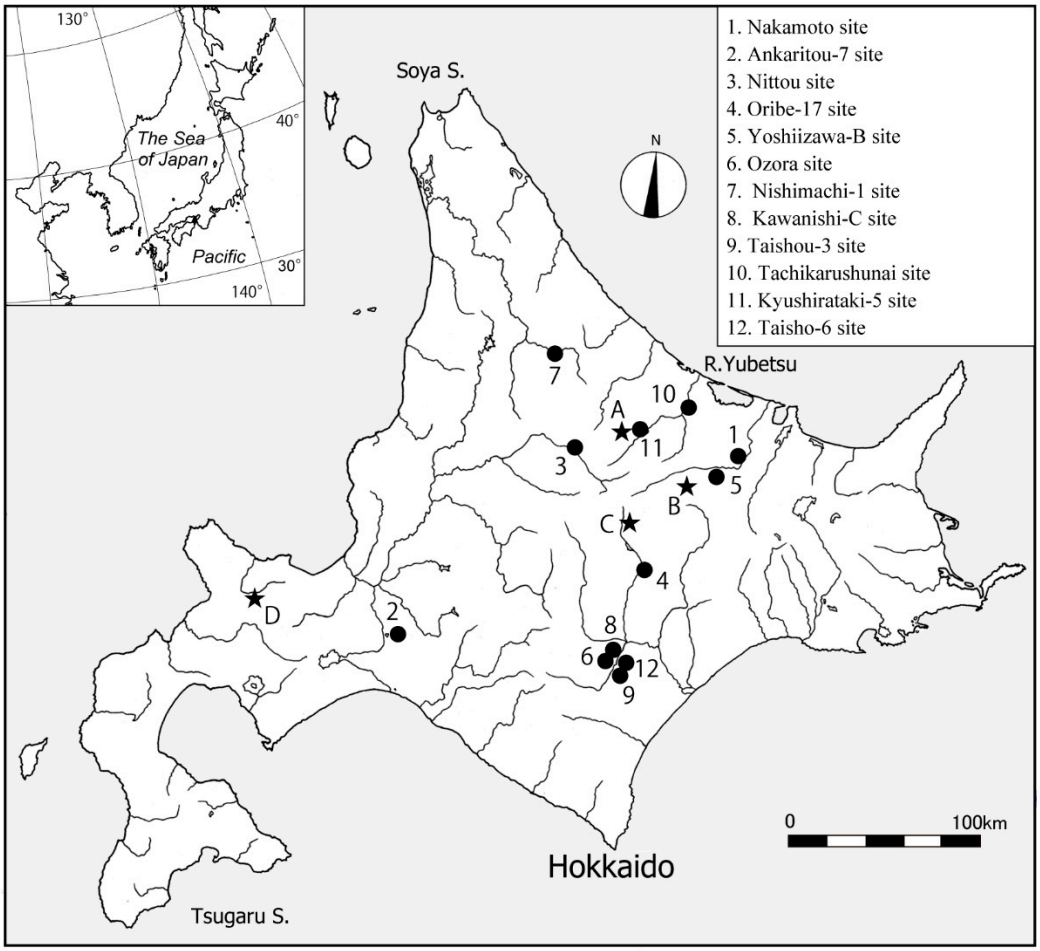

Figure 1. Locations of the sites referenced in this text. Major obsidian sources: (**A**) Shirataki; (**B**) Oketo; (**C**) Tokachi-Mitsumata; (**D**) Akaigawa.

The analysis of oxygen isotope ratios and dust in varved sediment has led to highly detailed explanations of climate changes from the Last Glacial, which experienced drastic fluctuations in temperature, to the Holocene. The analysis of varved sediment in Lake Tougetsu and Lake Suigetsu in western Japan shows that a cooling event occurred corresponding with the Younger Dryas [36–38]. The palaeoenvironment changes occurring on Hokkaido have been approached by many fields, including geology, topography, palaeopedology, palaeoecology and microfossils. In particular,

there has seen plentiful research focusing on the changes in vegetation via pollen analysis since the 1960s [39,40].

The analysis of pollen deposits at Kenbuchi, northern Hokkaido, shows that during the latter stage of the Marine Isotope Stage (MIS) 3, about 30,000 years ago, *Picea jezoensis* and/or *Picea glehnii* were predominant and boreal forests mixed with *Pinus pumila* were widespread. Starting from around 25,000 years ago, cooling led to the spread of steppes, where *Pinus pumila* was mixed with *Larix gmelinii*. Beginning around 21,000 years ago, *Pinus pumila* suddenly decreased, while *Picea jezoensis* and/or *Picea glehnii* increased. From around 17,000 years ago, there was another cooling period, and the appearance of *Pinus pumila* and *Microcachrys tetragona* increased. Beginning around 14,000 years ago, the ratio of *Pinus pumila* pollen in the record suddenly declined; however, a temporary recovery has also been observed. This period is thought to be the Younger Dryas. The prevalence of the *Quercus* subgenus increased around 10,000 years ago [41–43]. Pollen analyses conducted at Nakafurano in central Hokkaido show that although *Pinus pumila* and *Microcachrys tetragona* declined when *Picea jezoensis* and/or *Picea glehnii* increased between 14,000 and 12,000 years ago, there was a temporary period of cooling from 12,000 to 11,500 years ago, during which *Pinus pumila* increased. After this, conifer forests declined, and *Betula* forests expanded. Around 10,000 years ago, they were joined by *Juglans*, and around 9000 years ago, temperate, broad-leaf, mostly *Quercus* forests were formed [41]. Thus, it was only from around 10,000 years ago that humans in Hokkaido could begin to make intensive use of nuts as a stable food source.

According to pollen analysis, a significant expansion of subarctic conifer forests occurred in the mountainous areas of northern Honshu and in Hokkaido during the Younger Dryas. However, we know significantly less about the mammals that humans hunted relative to our knowledge of contemporaneous flora, due to the lack of palaeontological and zooarchaeological records describing the faunal community of the terminal Pleistocene. Palaeontological records from Hokkaido show that mammoths and bison existed there during the LGM, around 25,000 to 17,000 years ago [33,34,44]. However, the woolly rhinoceros and other species of large ungulates, such as the *Equus* and *Gazella* genera, common to the steppe and frequently observed during the Last Glacial in northeast China, are not attested at all in Hokkaido and neither are the *Hyaena*. Hokkaido is, thus, thought to have been less cold and dry than the northeastern part of the Eurasian continent, placing it near the edge of the distribution area for mammoths, which were distributed mainly across the mammoth steppe [34,44]. It is not known exactly when mammoths, bison, and other large mammals disappeared from Hokkaido. Taking into account the abovementioned changes in vegetation, it seems that climate warming gradually shifted their habitat north after the end of the LGM [45,46]. Therefore, we can estimate that at the time of the terminal Pleistocene, after large fauna such as mammoths and bison declined and were no longer a stable and dependable source of human food, the faunal community was composed mainly of mammals that were small, or of medium size, such as deer [47]. This, then, was the faunal community that would continue into the Holocene and that Jomon hunter-gatherers would rely on for diet [26,48].

Regardless of when the large fauna disappeared from Hokkaido, it appears that there were major changes in the faunal communities targeted by hunter-gatherers with microblades before the onset of the terminal Pleistocene. Interestingly, recent zooarchaeological analysis at the Yujiagou site (Layer 4 and Layer 3b), part of the Hutouliang Site Complex in North China, shows that the terminal Pleistocene hunters with microblades preferred juvenile gazelles and horses and used bone marrow as a significant source of energy [49]. Therefore, this analysis highlights that there were differences between the animal resources available in Hokkaido and North China during the terminal Pleistocene, although human foraging behaviours using microblade technology were dispersed in both regions. It is necessary to note that the terminal Pleistocene hunter-gatherers with microblades in Hokkaido had to adapt differently to changing environments.

3. Microblade Technology in the Terminal Pleistocene

From the LGM to the terminal Pleistocene, microblade assemblages, including microblades and various types of microblade cores mainly made from obsidian and hard shale, continued to exist in Hokkaido. Researchers have long focused their attention on the construction of a chronological framework and a techno-typological classification system for microblade technology [10,50,51]. In the study of microblade technology in northeast Asia, the Yubetsu method is most commonly seen in which a microblade was produced from a bifacial core blank with symmetrical cross sections and forming platforms by removing spalls [52,53]. Moreover, the Rankoshi, Tougeshita, Pirika, Oshorroko, Hirosato, Horoka and Momijiyama methods are also defined in Hokkaido and relate to differences in the manufacturing processes of microblade core blanks [10]. These microblade reduction methods are used as indices to locate lithic assemblages chronologically. The Rankoshi, Tougeshita and Pirika methods appeared around 25,000 to 24,000 years ago during the LGM [1,2].

There are few reliable radiocarbon dates available to determine the period to which microblade assemblage continued, which was at some point in the terminal Pleistocene [54]. Lithic assemblages associated with the Hirosato method (the Hirosato techno-complex) (Figure 2) obtained from the Nakamoto site indicate radiocarbon dates of around 15,200 to 13,700 years ago [1]. These dates were obtained from charcoal associated with hearths. This definitively shows that the lithic assemblage associated with the Hirosato method continued until the period of warming known as Bølling–Allerød in the terminal Pleistocene. The Hirosato techno-complex is confirmed in the Ankaritou-7 site [55], the Nakamoto site [1], the Nittou site [56], etc. Lithic artefacts, such as bifacial stemmed points, bifacial points and stone axes, associated with the Hirosato method have been found to show commonalities with artefacts associated with the Oshorroko method (Figure 3). As a result, lithic assemblages associated with the Oshorroko method (the Oshorroko techno-complex) have also been chronologically located during the same warm period (the Bølling–Allerød) [1,3,47,57]. The Oshorroko techno-complex has been confirmed in the Oribe-17 site [58], the Yoshiizawa-B site [57,59,60], the Ozora site [61], etc. Furthermore, lithic assemblages with small boat-shaped tools (the boat-shaped tool techno-complex) (Figure 4) have also been chronologically located during the terminal Pleistocene [47]. The boat-shaped tool techno-complex has been confirmed in the Nishimachi-1 site [62], the lithic concentration No.17 at the Kawanishi-C site [63], etc. Microblade technology is not seen in the lithic assemblages with the boat-shaped tools. However, the techno-typological features of burins, end-scrapers, bifacial points and bifacial stemmed points included in the lithic assemblage, as well as the technical features of the reduction sequence of the blades that serve as their materials, have recognised some commonalities with both the Hirosato and Oshorroko techno-complexes. Thus, the assertion that they should be placed at the same chronological stage is convincing [64].

Researchers have come to no agreement regarding the chronological relationship of these different techno-complexes [54]. Recently, it has been proposed that they appeared together and co-existed for some time. Some researchers have focused on the presence of newly invented tools, such as bifacial stemmed points and stone axes, that have been recognised in these techno-complexes [1,47,65]. A further accumulation of reliable radiocarbon dates showing clear relationships with lithic assemblages is urgently needed to resolve this issue of chronology. However, such additional research is hampered by the lack of any features, such as hearths, and complex post-depositional disturbances that are characteristic of the terminal Pleistocene sites in Hokkaido.

It is possible to identify flaking techniques from the assessment of crack velocity through the analysis of fracture wings observed on flaking surfaces [66]. In a large proportion of cases in Hokkaido, microblades were systematically detached by pressure flaking, with the exception of some cases [67–71]. The results of use-wear analyses based on materials from the Yubetsu method dated to around 18,000 to 17,000 years ago illustrate that standard and formal microblades were used as hunting implements, with many of them generally hafted on the side of bone/antler tools, according to the parallel striations identified along the sides of the microblades [72,73]. Low discovery rates and weak development of the use-wear observed on the microblades can be interpreted as indicating that they were not used

as processing tools, such as burins and end-scrapers [73]. It allows us to infer that the microblades from the terminal Pleistocene sites were probably used as weapon insets, although further functional research will be needed.

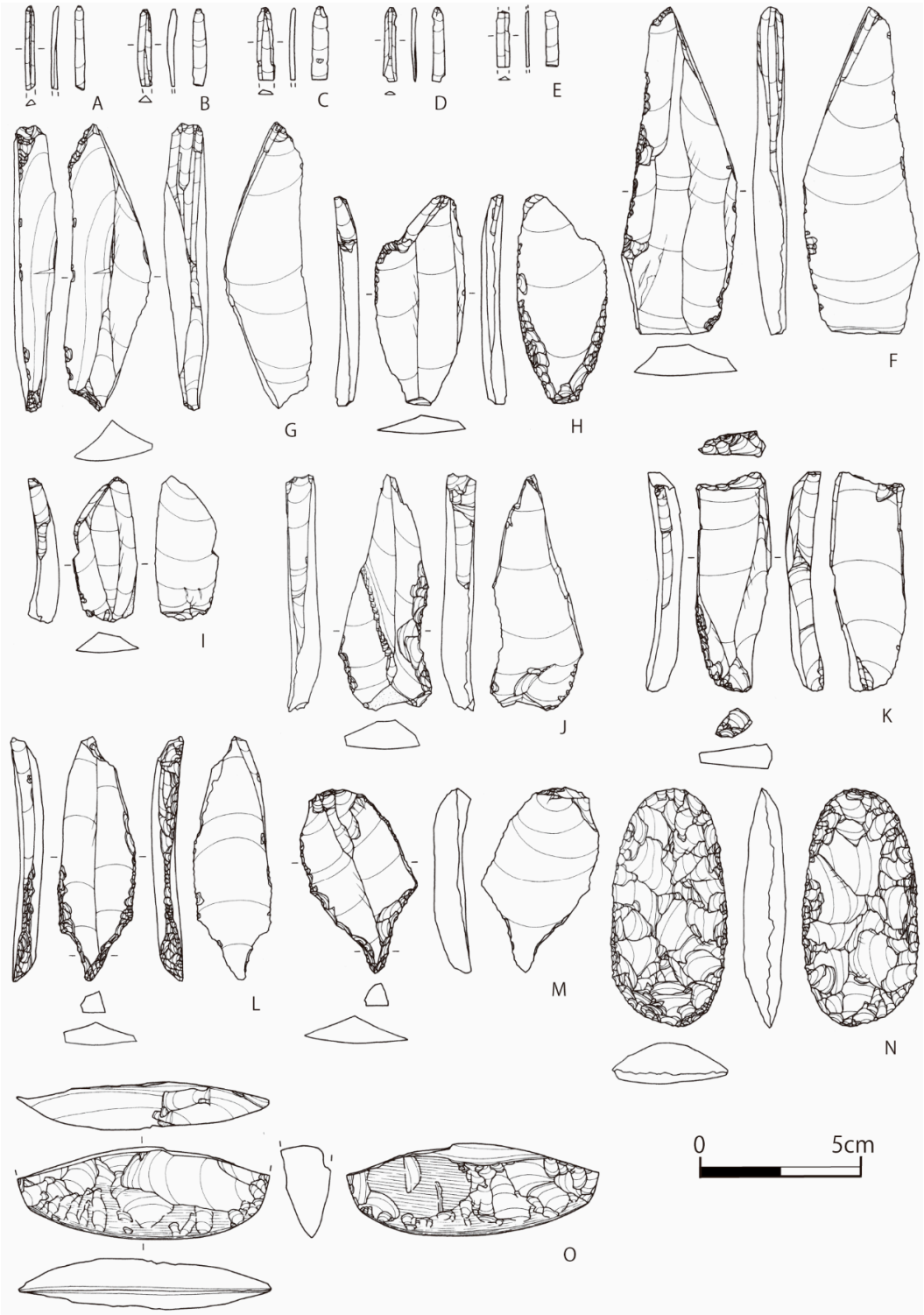

Figure 2. Stone artefacts in the Hirosato techno-complex. Examples from the Ankaritou-7 site in central Hokkaido: (**A–E**) microblades; (**F**,**G**) Hirosato-type microblade cores; (**H–K**) burins; (**L**,**M**) drills; (**N**) bifacial tool; (**O**) broken edge-ground stone axe. Reproduced from [55].

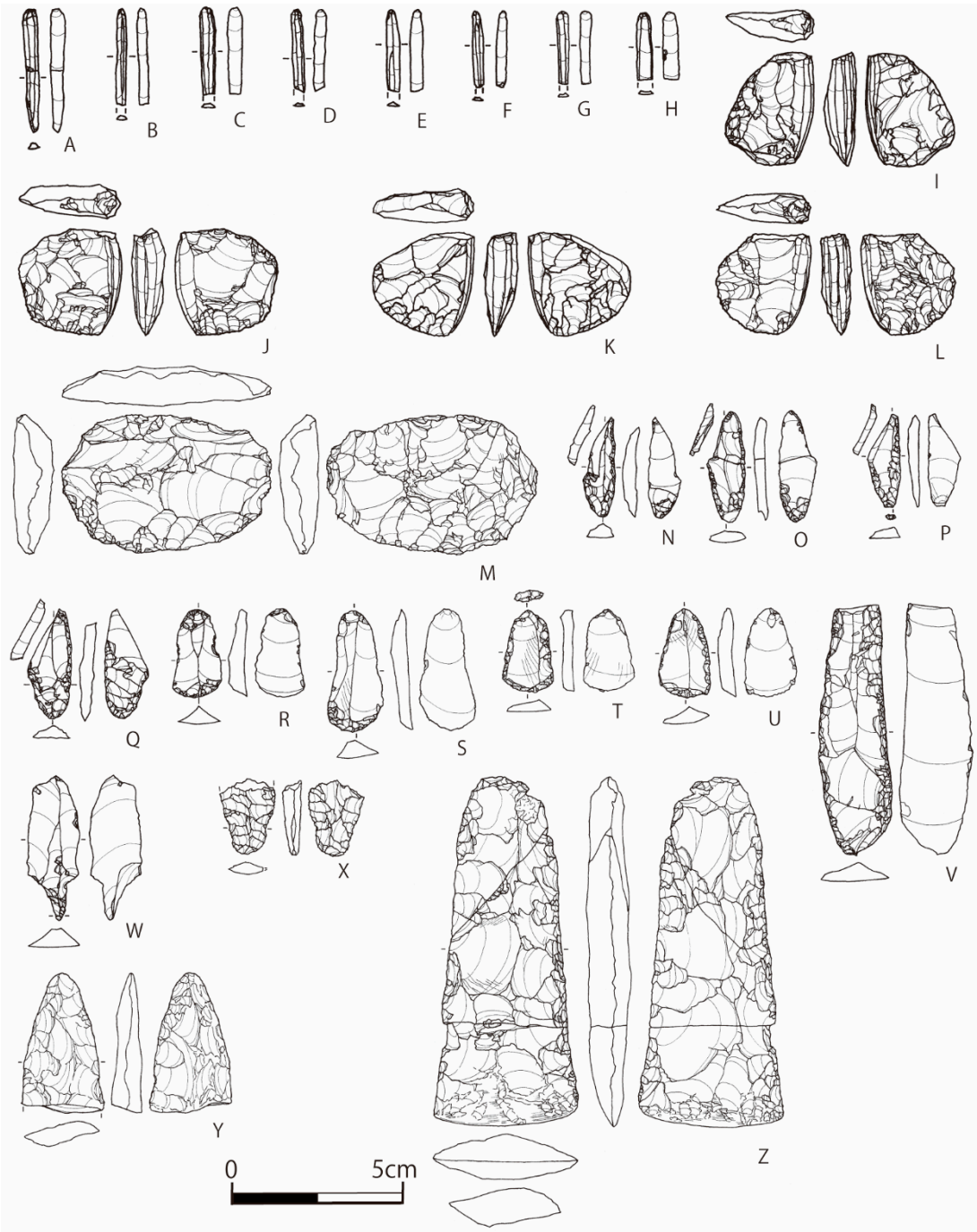

Figure 3. Stone artefacts in the Oshorroko techno-complex. Examples from the Oribe-17 site in eastern Hokkaido: (**A–H**) microblades; (**I–L**) Oshorroko-type microblade cores; (**M**) bifacial blank; (**N–Q**) burins; (**R–U**) end-scrapers; (**V**) side-scraper; (**W**) drill; (**X**) broken bifacial stemmed point; (**Y**) broken bifacial point; (**Z**) edge-ground stone axe. Reproduced from [58].

Figure 4. Stone artefacts in the boat-shaped tool techno-complex. Examples from the Nishimachi-1 site in northern Hokkaido: (**A–E**) boat-shaped tools; (**F–I**) burins; (**J**,**K**) end-scrapers; (**L**) side-scraper; (**M**) drill; (**N**,**Q**) broken bifacial points; (**O**,**P**) bifacial stemmed points. Reproduced from [62].

Microblade assemblages in the terminal Pleistocene are frequently accompanied by standard and abundant burins and end-scrapers made of blades. High proportions of formally shaped tools indicate the preparation of curated tool kits. The use-wear analysis of these burins shows that use-related traces are mainly located on burin facet edges and that they were often used in the manufacture and

maintenance of bone/antler tools [65,74]. Burins have often been observed in lithic assemblages before the appearance of microblade assemblages in Hokkaido. However, use-wear analysis has not detected any signs of the manufacture and maintenance of bone/antler tools from these assemblages [75]. Accordingly, the beginning of intensive manufacture and the use of bone/antler tools is thought to be closely related to the emergence of microblade assemblages [76,77].

The use-wear analysis of end-scrapers from the microblade assemblages in the terminal Pleistocene suggests that they were intensively used in hide processing [65]. In addition, the traces of intensive rejuvenations of edges on end-scrapers can often be observed in these microblade assemblages [78,79]. Such evidence enables us to infer that foragers using microblade technology in the terminal Pleistocene conducted the production and maintenance of a diversified set of relatively specialised tools, reflecting the occurrence of task-specific occupation. It seems that this behavioural strategy brought about the inter- and intra-site variability of stone toolkits among the microblade assemblages in the terminal Pleistocene of Hokkaido [1,47,65,80].

It is widely known that many obsidian artefacts have been recovered from the Upper Palaeolithic sites in Hokkaido. There are twenty-one obsidian sources on Hokkaido [81]. In particular, four major sources, namely Shirataki, Oketo, Tokachi-Mitsumata and Akaigawa (Figure 1), had been mainly exploited for acquiring lithic raw materials throughout the Upper Palaeolithic. The provenance studies of Shirataki obsidian, including the results from the Sokol site in Sakhalin, show that the extra-regional transportations associated with the Yubetsu method extended throughout the Hokkaido and Sakhalin islands [82–88]. The long-distance transport of complete toolkits made from a single obsidian source can inform us of the long-distance movements (about 400 km) that the hunter-gatherers with microblade technology accomplished before the onset of the terminal Pleistocene. Several authors have attempted to discuss the diachronic change of the obsidian usage pattern during the Upper Palaeolithic based on the compiled data from which obsidian provenance studies have been carried out thus far [82,86–88]. The results of analyses from the Oshorroko and the boat-shaped tool techno-complexes demonstrate that these were dominated by obsidian from the nearest and various major sources, typically procured within 100 km. Debitage analyses and studies of technological activities among these techno-complexes indicate that preforms and finished tools were often transported a relatively limited distance, and secondary reduction and tool refurbishing were the most common activities observed in a number of sites [57,60,64,78,79]. In contrast, the results of analyses from the Hirosato techno-complex show that obsidian and/or artefacts from Oketo were frequently transported and used for producing various stone tools including large blades (up to 30 cm long) [87]. Extra-regional raw materials in the terminal Pleistocene microblade assemblages occur primarily as finished points and/or other tools that most likely moved through social networks. These trends of obsidian usage may be consistent with changes in the faunal community and subsistence during the terminal Pleistocene.

4. Techno-Complex with Potteries in the Terminal Pleistocene

In recent years, it has been shown that there were hunter-gatherers in Hokkaido during the Bølling–Allerød who produced and used potteries but did not use microblades [27,89,90]. From the excavation at the Taisho-3 site in eastern Hokkaido, a lithic assemblage composed mainly of small obsidian bifacial points associated with potteries has been discovered (Figure 5). Based on such techno-typological features, the Taisho-3 techno-complex can be defined. There are no lithic tools made from blades in the Taisho-3 techno-complex. This clearly differs technically and typologically from the microblade assemblages described earlier, showing that two distinct cultural groups existed. Although this may be somewhat influenced by the marine reservoir effect, we know from radiocarbon dating of charred residues from potteries at the Taisho-3 site that the Taisho-3 techno-complex dates between 15,000 and 13,700 years ago (Table 1).

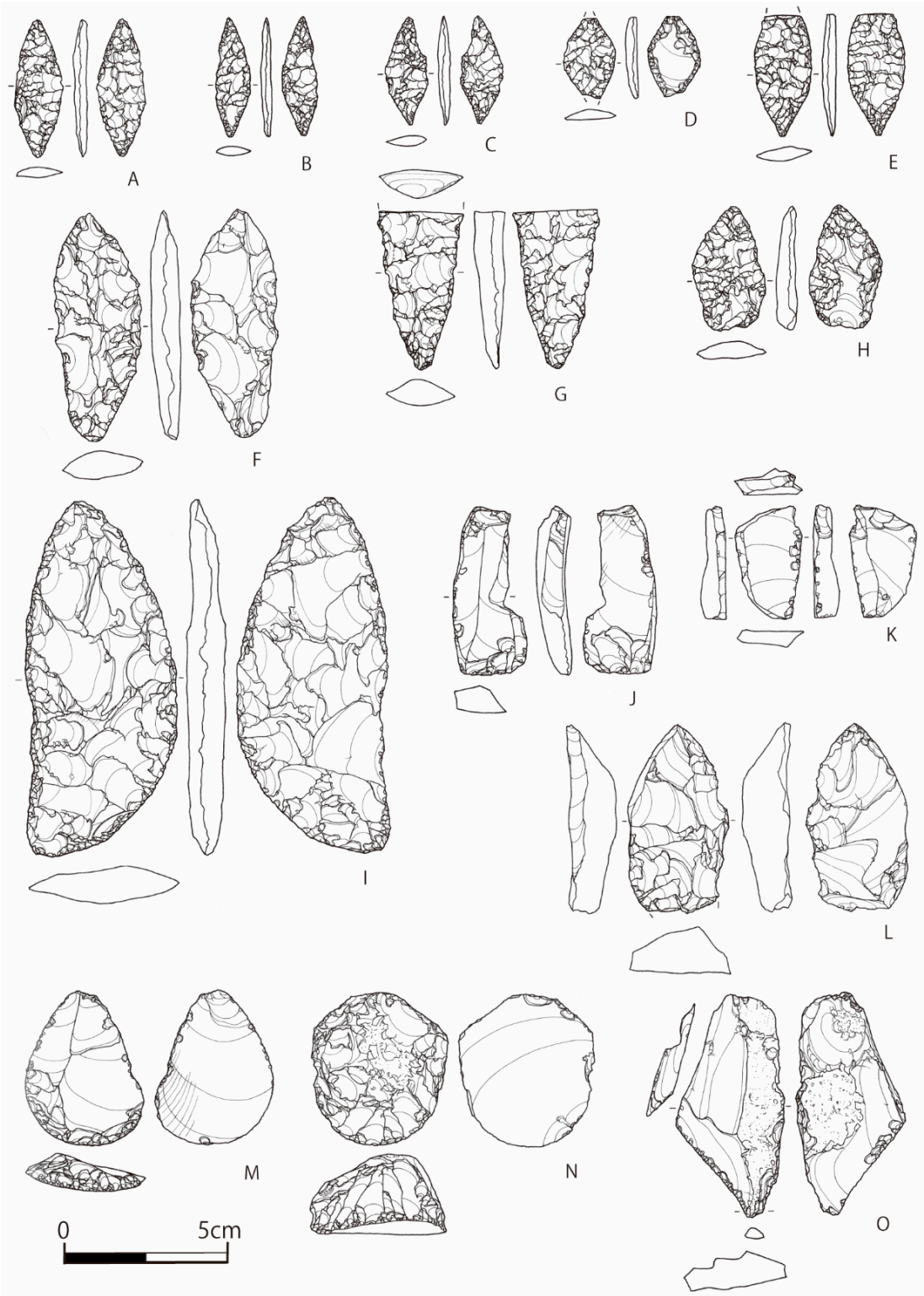

Figure 5. Stone artefacts in the Taisho-3 techno-complex. Examples from the Taisho-3 site in eastern Hokkaido: (**A–D**,**F**) bifacial points; (**E**,**G**) broken bifacial points; (**H**,**I**) bifacial tools; (**J–L**) burins; (**M**,**N**) end-scrapers; (**O**) drill. Reproduced from [90].

Table 1. AMS radiocarbon dates from the Taisho-3 site (calibrated using IntCal 13).

Lab Number	Material	14C BP	1σ	δ13C	Calibrated date, cal BP (2σ) upper	Calibrated Date, cal BP (2σ) Lower	References
Beta-194626	Charred remains inside pottery	12,400	40	−23.5	14,780	14,170	[90]
Beta-194627	Charred remains inside pottery	12,220	40	−24.0	14,260	13,980	[90]
Beta-194628	Charred remains inside pottery	12,350	40	−23.7	14,675	14,120	[90]
Beta-194629	Charred remains inside pottery	12,460	40	−22.6	14,960	14,265	[90]
Beta-194630	Charred remains inside pottery	12,210	40	−23.4	14,240	13,970	[90]
Beta-194631	Charred remains inside pottery	12,130	40	−23.3	14,140	13,830	[90]
IAAA-41603	Charred remains inside pottery	12,290	60	−21.6	14,630	14,025	[90]
IAAA-41604	Charred remains inside pottery	12,330	70	−23.2	14,745	14,060	[90]
IAAA-41605	Charred remains inside pottery	12,120	60	−22.1	14,145	13,780	[90]
IAAA-41606	Charred remains inside pottery	12,470	60	−21.7	15,025	14,250	[90]
IAAA-41607	Charred remains inside pottery	12,160	60	−22.5	14,210	13,815	[90]

The Taisho-3 site is located on a slightly elevated terrace that forms a natural embankment adjacent to a river (Figure 6). Just below the stratum containing the cultural horizon during the terminal Pleistocene is a gravel layer that was formed by river flooding; thus, human activity was conducted in a riverbed-like environment [90]. Unlike the Taisho-3 site, almost all other sites where microblade assemblages have been discovered are located on river terraces at a distance from rivers. The environmental setting of the Taisho-3 site demonstrates that aquatic resources were important for the daily activities of the hunter-gatherers who lived there. Stable carbon and nitrogen isotope analysis and gas chromatography–mass spectrometry analysis using charred residues from the potteries at the Taisho-3 site have shown that fish and other aquatic resources were exploited by the terminal Pleistocene hunter-gatherers [28,91]. These results are consistent with the patterns of land use inferred from the location of the Taisho-3 site.

In recent years, the Taisho-3 techno-complex has also been discovered from the excavation at the location M–I of the Tachikarushunai site, located in the Yubetsu River basin [92]. Nevertheless, it is apparent that sites with a Taisho-3 techno-complex are extremely rare compared to those with microblade assemblages in the terminal Pleistocene, although a taphonomic bias cannot be excluded for this record. The potteries discovered at the Taisho-3 site include the so-called nail-impressed wares (Figure 7). This pottery type has been found in several terminal Pleistocene sites in Honshu [93]. Some researchers argue that the technological characteristics of bifacial points have also been found to show commonalities with lithic artefacts among the Incipient Jomon from Honshu [94]. Accordingly, there is a strong possibility that the archaeological materials from the Taisho-3 site and the location M–I of the Tachikarushunai site indicate the results of small-scaled migrations from Honshu and adaptations to Hokkaido [27,29,89,94].

Lithic assemblages, composed mainly of leaf-shaped, foliate denticulate bifacial points (the Kyushirataki-5 techno-complex), have also recently been discovered [54,95]. Techno-typological comparisons of bifacial points have shown that they have significant commonalities with lithic assemblages from the first half of the terminal Pleistocene in Honshu [29,95]. However, there has been no radiocarbon dating of samples that clearly correspond to the Kyushirataki-5 techno-complex. In addition, it is necessary to note that there are also very few sites confirmed to be of this techno-complex. This can be explained by the reflection that group migration from Honshu most likely occurred on a small scale. It is apparent that we need to obtain reliable radiocarbon dates from future excavations to determine the chronological position of this techno-complex.

Figure 6. Distant view of excavation at the Taisho-3 site. Reproduced from [90], with the permission of the Obihiro Centennial City Museum.

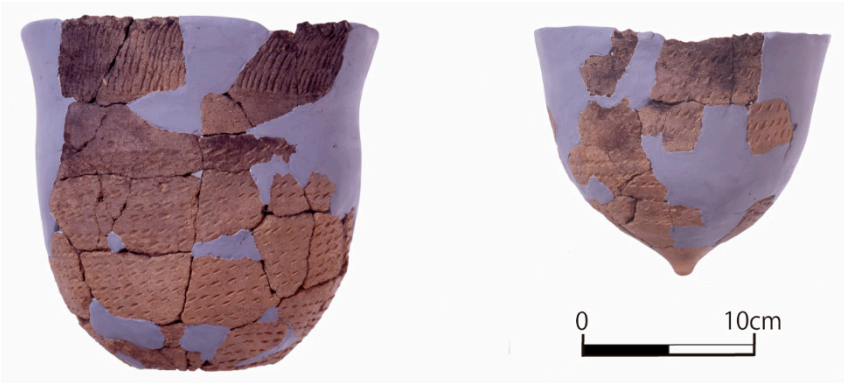

Figure 7. Potteries from the Taisho-3 site. These are the so-called nail-impressed wares. Reproduced from [90], with the permission of the Obihiro Centennial City Museum.

Based on radiocarbon dates obtained from the Taisho-3 techno-complex and those from the microblade assemblages in the terminal Pleistocene, it is difficult to assume that there was a temporal gap between the two. However, there are contrary views that they were not parallel in time [96]. As mentioned, if we are to consider the disparity in the patterns of land use, it is quite possible that they coexisted in Hokkaido during the same period of time [29,89]. Migratory communities new to the area might have developed a niche that had not been used among the hunter-gatherers in the area, who had until then, relied upon microblade technology. In other words, the investigation of the Taisho-3 site suggests that these communities migrated into eastern Hokkaido and made use of the aquatic resources they found there. The small size of the community, in addition to the fact that they explored new resources for their subsistence, could explain their ability to coexist with indigenous groups in the same region who produced and used microblades. It is noteworthy that Hokkaido

provided a setting for multiple groups, with different cultural lineages developing different niches, to coexist during the warming phase in the terminal Pleistocene.

5. Disappearance of Microblade Technology

We have no reliable radiocarbon dates from archaeological sites to fill the gaps beginning from around 13,700 years ago in Hokkaido to the time when the Holocene began [26,54,97,98]. Using techno-typology, some argue that the lithic assemblages accompanying the small boat-shaped tools can be chronologically located to the period from around 13,700 years ago to 11,650 years ago [54]. At the present stage of knowledge, this possibility cannot be completely excluded. Regardless of its validation, there are apparently very few sites where lithic assemblages have been discovered that support this hypothesis [54]. Remarkable differences clearly exist in comparison to the number of sites, until the warming phase in the terminal Pleistocene.

Based on these trends, we can conclude that there was most likely a large change in the population of humans residing in Hokkaido during the Younger Dryas. The intense cooling of the Younger Dryas made adaptation to the environments in Hokkaido difficult for groups that had survived throughout the long period of the Last Glacial using microblade technology. As suggested above, it seems that mammoths and other large fauna declined or no longer existed in Hokkaido during this period. The large animal resources that the hunter-gatherers using microblade technology had stably exploited became scarce before the onset of the terminal Pleistocene. It seems that the re-cooling of the Younger Dryas period brought about the abrupt decrease of resources, such as small- or medium-sized mammals, including deer, that the hunter-gatherers maintaining microblade technology during the Bølling–Allerød had adapted to. This may have been the trigger for the end of microblade technology in Hokkaido. As suggested from the palaeoenvironment and archaeological evidence, the exploitations of large mammals and long-distance foraging could be maintained during the Younger Dryas in North China and Siberia [21,49,99], but not in Hokkaido.

Here, it is interesting to note that the clear failure of the traditions that were brought by the groups that migrated from Honshu reflects the Taisho-3 and Kyushirataki-5 techno-complexes during the terminal Pleistocene. Beyond one temporal gap, archaeological sites with potteries did not appear in eastern Hokkaido until the Holocene [98]. After the second half of the Preboreal, the number of sites suddenly increased in Hokkaido [27,89,100,101]. It is presumed that the abrupt cooling of the Younger Dryas period in Hokkaido made resource use difficult for human adaptations, regardless of whether human groups could use aquatic resources for subsistence or not. Therefore, this means that the migration from Honshu with the non-microblade tradition did not play a significant role in the disappearance of microblade technology.

Reliable evidence of human activity in eastern Hokkaido in the initial Holocene has been found through excavations at the Taisho-6 site [102]. This site includes lithic assemblages composed of stone arrowheads, burins, side-scrapers and polished stone axes associated with flat-bottom potteries, defined as the Tenneru-Akatsuki type [27,89,100–102]. Radiocarbon dating of the charred materials from potteries shows that human activities at the Taisho-6 site began around 11,000 years ago. Many pit dwellings have also been discovered in sites in eastern Hokkaido, where the Tenneru-Akatsuki-type pottery was found, so we can assume that a more sedentary way of life followed in the second half of the Preboreal. A more intensive use of aquatic resources and nuts has been shown at the stage where the Tenneru-Akatsuki-type pottery appears and spreads [27,101,103].

Despite a few claims to the contrary [27,89], many argue that the appearance of Tenneru-Akatsuki-type pottery in eastern Hokkaido reflects the migration of groups from Honshu and their adaptation to Hokkaido [101,104]. At present, it is unreasonable to expect that the various cultural features observed in potteries and stone tools in the initial Holocene sites of Hokkaido originated in the Younger Dryas period. Though, archaeological sites chronologically located during the Younger Dryas may be discovered in the future. However, even if such discoveries become possible, it would not change the conclusion that a sudden decrease in the number of sites occurred

during the Younger Dryas compared to other periods. In Honshu, there are some fluctuations in the number of sites, but human activities continued across all periods of the terminal Pleistocene without interruption [94,105]. No definite break in the archaeological record can be seen, distinguishing it from the trends seen in Hokkaido.

6. Conclusions

Advancements in the investigation of archaeological sites across northeast Asia have revealed changes in human adaptations from the terminal Pleistocene to the initial Holocene. Radiocarbon dating has allowed a highly precise chronological framework to be constructed. Moreover, the analysis of nitrogen and carbon isotope ratios in charred materials from potteries has provided important information on the emergence of new subsistence activities. A systematic discussion of the disappearance and continuation of microblade technology and its various developments, as well as the background to these events following the LGM, is now becoming possible, based on archaeological studies of stone tools and potteries as well as the accumulation of evidence from bioarchaeology and palaeoenvironmental studies.

This paper has discussed the period during which microblade technology in Hokkaido disappeared, as well as the background to this. Microblade technology, seen until the Bølling–Allerød in the terminal Pleistocene, disappeared during the Younger Dryas. It may be that continued habitation in Hokkaido was made difficult due to the significant re-cooling of the climate, which caused a striking decline or extinction of the resources that humans had relied upon for food. Despite some drastic changes caused by the Younger Dryas, long-lasting developments in human behaviour such as high mobility and the hunting of large mammals in North China and Siberia, indicating open forest and grassland zones, seemed to have been unaffected by the impact of this event. In contrast, discontinuity rather than continuity in human behaviour and populations during the Younger Dryas has been observed in the archaeological records from Hokkaido. It is apparent that this process occurred during the terminal Pleistocene and was influenced by a wide range of factors, including changes in landscape, climate, faunal community, subsistence and human populations.

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