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# Late Pleistocene–Holocene environmental and cultural changes in Primorye, southern Russian Far East: A review

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ABSTRACT

This article presents an analytical review of the available palaeoenvironmental and archaeological records from the southern part (ca. 42°18′–45°30′N) of Primorye spanning the last ca. 21,000 years. The outlined climate and environmental history of the coastal and continental zones of southern Primorye, based mainly on vegetation reconstructions derived from the study of fossil pollen from sedimentary deposits from various archives, is compared with the archaeological cultural sequence of the region. This shows synchronicity between several phases of climate change and cultural transition, migration and changes in population numbers and/or subsistence strategies. The pronounced warming trend during the Early Holocene (Preboreal and Boreal stages) is associated with increasing numbers of long-term camp sites of the Late Palaeolithic hunter-gatherers and a growing importance of aquatic food resources. The Holocene maximum temperature and moisture conditions during the Atlantic stage were paralleled by the emergence and flourishing of the Neolithic Rudnaya, Vetka and Boisman cultures (ca. 7.7–5.5 $^{14}$C ka BP/8.5–6.2 cal ka BP). The latter was a specialised maritime forager culture distributed along the Sea of Japan coast, which likely reflects climate conditions and sea water temperatures that promoted a broad spectrum of marine food resources. Towards the end of the Atlantic stage, sea levels decreased and transformed the coastal landscape of southern Primorye, which probably contributed to the decline of the Boisman culture. At the same time, the climate started to become cooler, which is likely related to the eastward migration of Zaisanovskaya culture groups from more continental (cooler) regions to milder southern Primorye. Continuous cooling during the Subboreal was accompanied by further immigrations of Zaisanovskaya people and an increase in millet cultivation, which probably occurred in the region between ca. 4.6–4.1 $^{14}$C ka BP/5.3–4.6 cal ka BP. With the emergence of the Palaeometal Epoch cultures (ca. 3.6 $^{14}$C ka BP/4.0 cal ka BP), food production diversified (growing number of cultivated crops, animal husbandry) and intensified, which probably decreased the people's dependence on climatic conditions unfavourable for food procurement. However, the maximum flourishing (ca. 2.8–2.6 $^{14}$C ka BP/2.9–2.6 cal ka BP) of the Palaeometal Epoch Yankovskaya culture, represented by a maximum number of documented settlement sites in Primorye's prehistoric sequence, was likely related to a coeval short phase of climate amelioration with higher air and sea water temperatures and an increased sea level, which promoted agriculture and a higher productivity of coastal waters.

## 1. Introduction

The geographical position of the Primorye (i.e. Maritime) region (Fig. 1) in the south-eastern part of Russia at the transition between the extreme continental climates of Central Asia and the monsoon-dominated Northwest Pacific played a key role in the emergence of a series of archaeological cultures ranging from the Palaeolithic to the late Middle Ages. The archaeological sites of Primorye have been studied for

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over six decades (Ganeshin and Okladnikov, 1956; Petrun, 1956). On the territory of the region, there are currently about 2200 archaeological sites belonging to different cultural periods. The distribution and density of these sites show spatial and temporal variability (Okladnikov and Derevianko, 1973; Derevianko, 1983; Krushanov, 1989; Kuznetsov, 1992; Kuzmin, 1995, 1998; Vostretsov, 1998; Krupyanko and Tabarev, 2015). This can be explained by the varying suitability of certain areas for living and economic activities for different cultural groups, but also by the spatially different degrees of archaeological exploration activities.

To date, most of the discovered prehistoric archaeological sites are located in places where natural aquatic and terrestrial food resources are concentrated, especially at the banks of rivers or lakes and on the sea coast, (e.g. Vostretsov et al., 2002; Kluyev et al., 2002; Komoto and Kumamoto, 2004; Vostretsov, 2005, 2013; Razzhigaeva et al., 2019). Starting from the early Middle Ages, which experienced the emergence of states, economic, political and military factors exerted a great influence on the choice of the place for settlement, in addition to environmental conditions.

The aim of this paper is to analyse the potential impact of changes in the regional climate and environmental conditions on the archaeological culture sequence in southern Primorye, starting from the Late Palaeolithic. Based on the authors' own research results and published palaeoenvironmental and archaeological data, we review the environmental and cultural history of the study region during the Late Pleistocene–Holocene interval (ca. 21 cal. ka BP to the present). The reconstructed changes in the regional climate and environments are then discussed in view of their potential impacts on the resource base of the local populations, changes in their subsistence strategies and migration movements.

## 2. Regional setting

Primorye occupies a large area (ca. 42°18′–48°28′N, 130°30′–139°00′E; Fig. 1A) in the southernmost part of the Russian Far East. This paper concentrates on its part situated south of 45°30′N and west of 136°40′E (Fig. 1B). The Sikhote-Alin and East Manchurian mountains are separated by the low-elevated Khanka lowland with Khanka Lake. The Sikhote-Alin Mountains are a natural barrier for the moist air masses coming from the Sea of Okhotsk and the Sea of Japan.

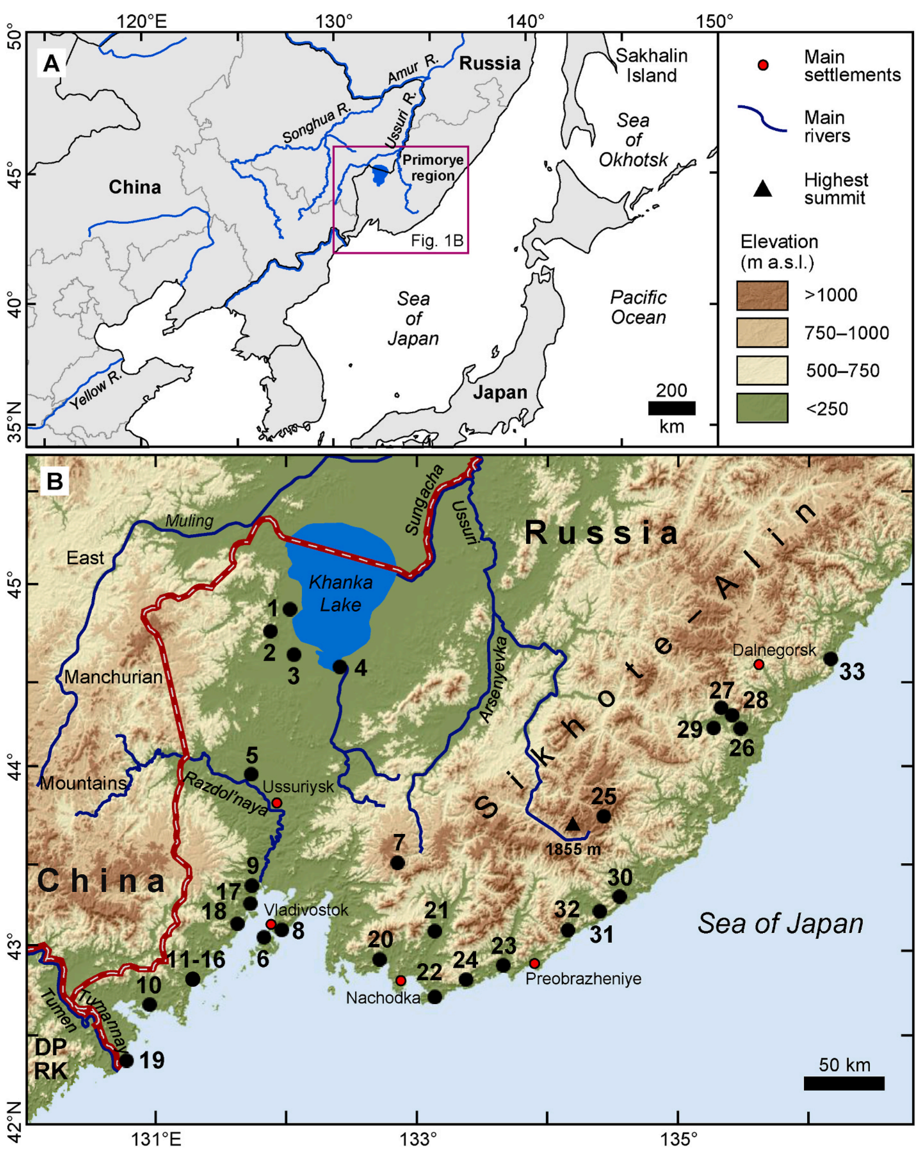


**Fig. 1.** Overview maps showing (A) the location (inset) of the study region (southern half of the Primorye region) in eastern Eurasia and (B) sites of palaeoenvironmental records mentioned in the text (see Table 1 for site names per number). The digital elevation model is based on 90-m-resolution Shuttle Radar Topography Mission (SRTM) v4.1 data (Jarvis et al., 2008).

The monsoon climate of the region is determined by its geographical location at the junction of mainland Eurasia and the Pacific Ocean. Generally, springs are cool, summers are rainy and foggy, autumns are sunny and dry and winters are cold, windy and not very snowy. The Liman Cold Current (Primorsky Current) runs from northern direction along the Sea of Japan coast, causing frequent fogs in maritime areas. The average annual temperature ranges from −1 °C in the northern part of Sikhote-Alin to +7 °C on the southern coast. The average temperature in August varies between +17 and +22 °C, while the average January temperature changes from −8/−14 °C in the coastal area to −14/−23 °C in the inner parts of the region. Most of the total annual precipitation of 600–900 mm falls in summer (Kobysheva, 1988).

In Primorye there are two main vegetation zones: coniferous-deciduous forests and forest-steppe. Southern Primorye (south of 42°18′N) is occupied by the subzone of southern coniferous-deciduous forests. There are many species here that are also found in the forests in the southern part of Northeast China and in North Korea. The mountainous relief of Primorye determines the presence of altitudinal vegetation zones. Broadleaved-Korean pine forests grow from the foot of the slopes to 400–800 m above sea level (a.s.l.). The northern border of their distribution reaches 50°N. Spruce-fir forests grow at 800–900 m a.s.l. in the south of the region (south of 43°N), at 600–700 m in the central part and at 400–500 m at the northern fringe of Primorye (north of 48°N). Above, there is a mosaic of stone birch (*Betula ermanii*) forests, dwarf alder shrubs, thickets of subalpine shrubs and tall-herb subalpine meadows. Thickets of Siberian dwarf pine (*Pinus pumila*) form a narrow and intermittent strip at altitudes of 1500–1600 m a.s.l. The forest-steppe zone covers the lowlands around Khanka Lake. Steppe meadows are accompanied by deciduous and small-leaved forests. Forests of Mongolian oak (*Quercus mongolica*) stretch almost continuously in a strip along the coast of the Sea of Japan (Kolesnikov, 1969).

The rich Holocene native fauna is represented by elk (*Alces alces*), Manchurian red deer (*Cervus elaphus xanthopygos*), roe deer (*Capreolus pygargus*), wild boar (*Sus scrofa*), Siberian musk deer (*Moschus moschiferus*), goral (*Nemorhaedus caudatus*), red squirrel (*Sciurus vulgaris*), Eurasian otter (*Lutra lutra*), Siberian weasel (*Mustela sibirica*), sable (*Martes zibellina*), ermine (*Mustela erminea*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), dhole (*Cuon alpinus*) and sika deer (*Cervus nippon*). The latter four species are rare today and protected by law from hunting. The coastal waters of the Sea of Japan are home to about 700 species of animals and algae. Many of them have unique taste and medicinal properties, such as sea urchin (Echinoidea), sea cucumber (*Apostichopus japonicus*), scallops (*Mizuhopecten yessoensis* and *Swiftopecten swiftii*) and kelp (*Laminaria* spp.) (Martynenko et al., 2008).

## 3. Materials and methods

This paper provides a review of available palaeoenvironmental records based on palynological analyses of radiocarbon ($^{14}C$)-dated Late Pleistocene and Holocene sediments from the study region. In total, 33 natural sedimentary sequences were analysed (Fig. 1B and Table 1), for which detailed reconstructions of climate and environmental changes were obtained. The reconstruction of changes in the Late Pleistocene–Holocene thermal conditions (Fig. 3) is based on the results of previous studies (Korotky, 1982; Kuzmina et al., 1987; Korotky et al., 1997; Korotky and Vostretsov, 2002; Razzhigaeva et al., 2014, 2018b, 2020). It represents changes in atmospheric annual temperature at sea level between 42 and 45°N based on pollen and spores spectra and $^{14}C$ dating of key palaeoenvironmental sediment sequences. The approach is based on the presence/absence of plant indicator taxa in the fossil spectra, on the principle of the invariability of the ecological requirements of plants and on the knowledge of the modern climatic geographical distribution of plants (Grichuk, 1969, 1985). This modern analogue approach follows Zagwijn (1996), Kershaw and Nix (1988) and Thompson et al. (1999) and the boundaries of the indicator taxa ranges are determined mainly by their temperature and moisture availability requirements. It is assumed that the climatic conditions in the area where most of the taxa contained in a fossil spectrum grow together today (the so-called analogue area or centre of concentration) corresponds to the climatic conditions at the study site at the time of the formation of the fossil spectra. The climate conditions at the centre of the analogue area are assigned to the respective fossil pollen/spores spectrum. The location of the centre is determined by mapping the modern area in which the indicator taxa is distributed today.

Changes in the Sea of Japan level were adopted from Korotky (1982, 1994), Kuzmina et al. (1982, 1987), Khershberg et al. (2013) and Bulgakov et al. (2020). The relative sea level reconstructions are based on micropalaeontological (diatoms, benthic foraminifera) analyses and marine molluscs shell records from marine sediments and $^{14}C$ dating. In addition, lower-than-present sea levels were inferred from the ancient settlement structures located at the modern sea level (Bulgakov et al., 2020).

For comparison of the regional natural history with the cultural sequence and evaluation of possible environmental impacts on the prehistoric human populations, we compiled the available information from 14 Late Palaeolithic and 33 Neolithic archaeological sites (Fig. 2A) as well as from 30 sites dated to the Palaeometal Epoch and 15 sites of the Middle Ages (Fig. 2B). All these sites were investigated by a combination of archaeological and palaeoenvironmental methods, including palaeozoological, palynological and palaeocarpological approaches and $^{14}C$ dating.

Until recently, chronologies of the absolute majority of the palaeoenvironmental and archaeological records from the study region were presented in uncalibrated $^{14}C$ years ($^{14}C$ a BP), following the Blytt–Sernander postglacial bioclimatic zonation scheme adapted to Northern Eurasia (Khotinsky, 1977, 1987). For an adequate comparison of the compiled information extracted from different sources and compatibility with earlier publications, we are using the same approach. For convenience, age ranges of calibrated $^{14}C$ dates are presented in Table 1. For conversion of $^{14}C$ dates to calendar ages OxCal v4.4.4 software (Bronk Ramsey, 1995) and the calibration curve IntCal20 (Reimer et al., 2020) were used. Geographical features, such as rivers, bays and mountains, mentioned in the text are indicated in the map figures (Figs. 1 and 2) or can be traced in the maps via the information provided in Table 1. To facilitate description and discussion of spatio-temporal trends in the palaeoenvironmental records and cultural sequence of the study region (i.e. the southern half of Primorye), we use the geographical terms (i) southern, (ii) western and (iii) eastern Primorye, which respectively represent (i) the coastal areas from to the Tumannaya River to the lower reaches of the Razdol'naya River, the coastal areas around Vladivostok and Nachodka and the south-western end of the Sikhote-Alin, (ii) the lowlands around Khanka Lake (Khanka-Ussuri Plain) up to the area around Ussuriysk and (iii) the coastal areas stretching from Preobrazheniye to around Dalnegorsk (Fig. 1B).

## 4. Results

### 4.1. Palaeoenvironments

#### 4.1.1. Late Pleistocene (ca. 17.0–10.3 $^{14}C$ ka BP/21.0–11.8 cal ka BP)

By the end of the Late Pleistocene, abrupt changes occurred in the regional environments due to severe cooling and drying of the climate. The latitudinal shift of vegetation zones to the south was almost 1000 km, which implies a decrease in average annual temperatures by at least 8–9 °C and in the amount of annual precipitation by 400–500 mm (Korotky et al., 1997). The vegetation was uniform and extremely poor in composition (Korotky et al., 1997). An approximate modern analogue of the Last Glacial Maximum (LGM) vegetation is located at 55–56°N in the northern Sea of Okhotsk region where the northern limit of spruce distribution is located today (Korotky et al., 1988; Belyanin and Belyanina, 2012). The Sea of Japan level during the LGM was 110–130 m lower than today (Khershberg et al., 2013). At the same time, the level of

**Table 1**
Radiocarbon dates of key palaeoenvironmental records from southern Primorye compiled from available publications (see References). Calendar (Cal) ages were obtained using OxCal v4.4.4 software (Bronk Ramsey, 1995) and the calibration curve IntCal20 (Reimer et al., 2020). In the 7th column, the minus signs indicate year before common era (BCE). Explanation on the lab codes is provided in Supplementary Table S1 and location of the records is shown in Fig. 1B.

| Site, geomorphological position, dated material | Site no. (Fig. 1B) | Depth, cm | Lab code | $^{14}$C date, a BP | Cal age, a BP | Cal age, BCE/CE | References |
|---|---|---|---|---|---|---|---|
| Komissarovka River, flood plain, soil | 1 | 36–38 | SOAN-9018 | 1135±45 | 1178 – 955 | 773 – 995 | Bazarova et al. (2018a) |
| Novoselyshchenskoye-gorodishche, sloping hill, soil | 2 | 34 | IMCES-14C1575 | 1535±90 | 1686 – 1291 | 265 – 659 | Piskareva et al. (2019b) |
| | | 44 | IMCES-14C1570 | 1556± 95 | 1692 – 1295 | 258 – 655 | |
| Melgunovka River, flood plain, soil | 3 | 41–42 | SOAN-9008 | 2190±55 | 2336 – 2009 | -387 – -60 | Bazarova et al. (2018b) |
| | | 56–58 | SOAN-9009 | 3830±120 | 4570 – 3885 | -2621 – -1936 | |
| | | 63–65 | SOAN-9010 | 4710±100 | 5654 – 5055 | -3705 – -3106 | |
| | | 70–72 | SOAN-9011 | 5690±120 | 6780 – 6280 | -4831 – -4331 | |
| | | 98–100 | SOAN-9012 | 7920±135 | 9124 – 8421 | -7175 – -6472 | |
| Khanka Lake, onshore bar, soil | 4 | 148–152 | SOAN-5527 | 1525±45 | 1521 – 1312 | 429 – 639 | Mikishin et al. (2007) |
| Valley of Razdol'naya River, flood plain, soil | 5 | 125–130 | LU-8855 | 5150±140 | 6267 – 5601 | -4318 – -3652 | Razzhigaeva et al. (2020) |
| | | 90–95 | LU-8854 | 2110±80 | 2319 – 1889 | -370 – 62 | |
| Russian Island, north coast, lagoon terrace, gyttja, peat | 6 | 240–245 | SOAN-7675 | 5355±85 | 6296 – 5937 | -4347 – -3988 | Mikishin and Gvozdeva (2014) |
| | | 220–225 | SOAN-7674 | 5105±75 | 5999 – 5608 | -4050 – -3659 | |
| | | 200–205 | SOAN-7673 | 4750±80 | 5600 – 5314 | -3651 – -3365 | |
| | | 112–117 | SOAN-7669 | 2605±65 | 2859 – 2490 | -910 – -541 | |
| | | 97–102 | SOAN-7668 | 2040±65 | 2292 – 1825 | -343 – 125 | |
| Shkotovskoe Plato, southern part of Sikhote-Alin, peat | 7 | 100–110 | LU-7355 | 3770±140 | 4527 – 3723 | -2578 – -1774 | Razjigaeva et al. (2017) |
| | | 85–95 | LU-7354 | 3540±110 | 4149 – 3496 | -2200 – -1547 | |
| | | 75–80 | LU-7353 | 2220±90 | 2430 – 1946 | -481 – 4 | |
| | | 45–50 | LU-7352 | 1510±80 | 1546 – 1286 | 404 – 664 | |
| Cherepashye Lake, Murav'inaya Bay, peat, mollusk shell | 8 | 215–220 | D-AMS-16826 | 5550±21 | 6395 – 6296 | -4446 – -4347 | Razzhigaeva et al. (2019) |
| | | 115–120 | LU-8026 | 1610±80 | 1699 – 1319 | 251 – 632 | |
| | | 95–100 | LU-8025 | 2010±90 | 2296 – 1719 | -347 – 232 | |
| | | 70–75 | LU-8023 | 1080±90 | 1244 – 788 | 706 – 1163 | |
| | | 45–50 | LU-8024 | 820±80 | 917 – 652 | 1034 – 1299 | |
| Utinoe Lake, lagoon terrace in the mouth of the Razdolnaya river valley, charcoal, wood, vegetable detritus | 9 | 468–471 | CAMS-73295 | 5000±80 | 5905 – 5595 | -3956 – -3646 | Belyanin et al. (2019) |
| | | 345–347 | CAMS-76800 | 3920±40 | 4515 – 4188 | -2566 – -2239 | |
| | | 221–223 | CAMS-76799 | 2510±60 | 2744 – 2369 | -795 – -420 | |
| Karas'e Lake, marine terrace, lacustrine deposits, charcoal, wood, seeds | 10 | 163-166 | CAMS-73291 | 17160±40 | 20,856 – 20,558 | -18,907 – -18,609 | Anderson et al. (2017) |
| | | 140–137 | CAMS-73290 | 7550±40 | 8420 – 8210 | -6471 – -6261 | |
| | | 121–130 | CAMS-74347 | 5780±40 | 6672 – 6454 | -4723 – -4505 | |
| | | 103–104 | CAMS-71814 | 5050±40 | 5907 – 5662 | -3958 – -3713 | |
| | | 74–77 | CAMS-74346 | 4890±40 | 5722 – 5489 | -3773 – -3540 | |
| | | 43–45 | CAMS-74344 | 3870±40 | 4414 – 4155 | -2465 – -2206 | |
| Mouth of Ryazanovka River, river terrace, right bank, peat | 11 | 80–85 | SOAN-285 | 1310±20 | 1292 – 1176 | 658 – 775 | Mikishin et al. (2008, 2019) |
| | | 135–139 | SOAN-3937 | 4225±50 | 4865 – 4581 | -2916 – -2632 | |
| Ryazanovka River, terrace of 'Right Coast' section, peat, wood | 12 | 100–115 | SOAN-5054 | 3715±60 | 4240 – 3891 | -2291 – -1942 | |
| | | 220–225 | SOAN-4995 | 4560±35 | 5439 – 5051 | -3490 – -3102 | |
| Ryazanovka River, terrace of 'Doroga' section, peat, mollusk shell | 13 | 151–154 | SOAN-4999 | 3425±35 | 3825 – 3571 | -1876 – -1622 | |
| | | 0–30 | AA-36904 | 5080±40 | 5918 – 5730 | -3969 – -3781 | |
| Mouth of Ryazanovka River, river terrace, right bank, wood | 14 | 210–220 | SOAN-286 | 2595±20 | 2754 – 2723 | -805 – -774 | |
| Ptich'e Lake, marine terrace, walnut, mollusk shell, wood, vegetable detritus | 15 | 315–320 | AA-32675 | 6195±60 | 7255 – 6945 | -5306 – -4996 | |
| | 16 | 305–310 | AA-36383 | 6170±40 | 7166 – 6946 | -5217 – -4997 | |
| | | 295–300 | AA-32673 | 5860±65 | 6845 – 6495 | -4896 – -4546 | |
| | | 65–80 | SOAN-3943 | 2510±45 | 2743 – 2427 | -794 – -478 | |
| Amba River, accumulative terrace, vegetable detritus | 17 | 420–430 | Ki-1056 | 5100±110 | 6176 – 5596 | -4227 – -3647 | Korotky (2002) |
| Barabashevka River, flood plain, peat with wood | 18 | 340–350 | MGU-229 | 7360±180 | 8537 – 7840 | -6588 – -5891 | |
| Tumannaya River, lower flow, terrace, hole (depth 48 m), mollusk shell | 19 | 2700–2720 | Ki-2510 | 8100±100 | 9398 – 8645 | -7449 – -6696 | |
| Vostok Bay, mouth of Tikhangou River, terrace, peat | 20 | 50–55 | SOAN-136 | 575±75 | 669 – 503 | 1281 – 1448 | |
| | | 120–125 | SOAN-137 | 4195±50 | 4850 – 4577 | -2901 – -2628 | |
| Partizanskaya River, middle flow, terrace, wood | 21 | 330–340 | Ki-2917 | 17,400±125 | 21,403 – 20,670 | -19,454 – -18,721 | |
| | | 230–240 | SOAN-288 | 11500±130 | 13,601 – 13,119 | -11,652 – -11,170 | |
| Spokoinaya Bay, bottom marine deposits, mollusk shell, peat | 22 | 190–210 | Ki-1050 | 8700±320 | 10,655 – 8995 | -8706 – -7046 | |
| | | 290–300 | MGU-63 | 8020±280 | 9544 – 8327 | -7595 – -6378 | |
| Razgradsky Cape, Peter the Great Bay, shelf, borehole, mollusk shell | 23 | 160–180 | Ki-1456 | 8700±60 | 9893 – 9541 | -7944 – -7592 | |
| Skala Bol'shoy Kreyser Island, Triozerye Bay, soil | 24 | 50–60 | LU-7526 | 2480±120 | 2846 – 2183 | -897 – -234 | Lyashchevskaya et al. (2017) |
| Muta Urotshistshe, southern Sikhote-Alin, peat | 25 | 75–80 | LU-7712 | 3200±80 | 3619 – 3214 | -1670 – -1265 | Razzhigaeva et al. (2018b) |
| | | 45–50 | LU-7711 | 1070±100 | 1247 – 745 | 703 – 1206 | |
| Suvorovo-4 site, charcoal | 26 | 25-30 | AA-9463 | 15105±100 | 18,660 – 18,232 | -16,711 – -16,283 | Kuzmin (1998) |
| Ustinovka-7 site, Zerkal'naya River terrace, soil | 27 | No data | MAG-1537 | 11461±187 | 13,767 – 13,004 | -11,818 – -11,055 | Korotky (2009) |

(*continued on next page*)

**Table 1** (*continued*)

| Site, geomorphological position, dated material | Site no. (Fig. 1B) | Depth, cm | Lab code | $^{14}$C date, a BP | Cal age, a BP | Cal age, BCE/CE | References |
|---|---|---|---|---|---|---|---|
| Site Ustinovka-6, Zerkal'naya River terrace, charcoal | 28 | 70-75 | GEO-1412 | 11550±240 | 14,218 – 13,116 | -12,269 – -11,167 | |
| Near Zerkal'naya Village, meadow terrace, soil | 29 | No data | SOAN-288 | 11500±130 | 13,601 – 13,119 | -11,652 – -11,170 | |
| Neprimetnaya Bay, lagoonal terrace, wood | 30 | 95–105 | Ki-1966 | 2220±60 | 2347 – 2058 | -398 – -109 | Korotky (2002) |
| Chernaya River, terrace, peat | 31 | 50–55 | MGU-323 | 2880±200 | 3557 – 2495 | -1608 – -546 | |
| | | 30–35 | TIG-43 | 1880±60 | 1940 – 1625 | 10 – 325 | |
| Kit Bay, lagoon terrace, peat, wood | 32 | 137–142 | LU-7067 | 4990±60 | 5895 – 5598 | -3946 – -3649 | Razzhigaeva et al. (2018a) |
| | | 107–112 | LU-7066 | 4550±70 | 5461 – 4972 | -3512 – -3023 | |
| | | 73–75 | LU-7338 | 3810±190 | 4815 – 3700 | -2866 – -1751 | |
| | | 39–40 | LU-7065 | 2290±80 | 2693 – 2057 | -744 – -108 | |
| | | 55–57 | LU-7333 | 1820±80 | 1922 – 1540 | 28 – 410 | |
| Oprichnik Bay, terrace, peat | 33 | 40–45 | LU-6958 | 1610±90 | 1701 – 1315 | 250 – 636 | Lyashchevskaya (2013) |
| | | 25–28 | LU-6889 | 860±50 | 906 – 680 | 1044 – 1270 | |
| | | 20–23 | LU-6894 | 610±60 | 667 – 529 | 1283 – 1421 | |

Khanka Lake was about 1.5–2.0 m higher than at present, causing flooding of the Khanka Plain and formation of extensive swamps (Korotky et al., 1997).

About 17,160 ± 40 $^{14}$C a BP, the coastal plains of Peter the Great Bay in southernmost Primorye were dominated by swampy meadows and *Sphagnum* bogs with thickets of birch, alder and willow trees. Dark coniferous taiga composed of fir, birch and Korean pine covered the low-elevated mountain slopes (Anderson et al., 2017). Further inland, in the middle reaches of the Partizanskaya River, open forests composed of birch and larch trees with dwarf birch and alder undergrowth grew at about 17,400 ± 125 $^{14}$C a BP (Korotky, 2002).

The pollen records from the Ustinovka-6 and Ustinovka-7 sites in eastern Primorye (11,750 ± 240 $^{14}$C a BP and 11,461 ± 187 $^{14}$C a BP, respectively) indicate light birch and larch forests with an abundance of dwarf birch in the understorey, which could be a sign of permafrost (Korotky, 2009). Around the Ustinovka-1 site, the vegetation was dominated by shrubby forms of birch and alder and species of Asteraceae, Poaceae and *Artemisia* in the herbaceous cover (Alekseev and Golubeva, 1973; Golubeva and Karaulova, 1983). In the coastal zone, birch and spruce forests with dwarf birch and alder undergrowth were spread. Pollen studies suggest that cold tolerant broadleaved tree and shrub taxa, including hazel, were present in the region during the Lateglacial interstadial, as indicated by the record from the Ustinovka-6 site dated to 11,550 ± 240 $^{14}$C a BP and from the Suvorovo-4 site dated to 15,105 ± 100 $^{14}$C a BP (Kuzmin, 1998).

#### 4.1.2. *Early Holocene (ca. 10.3–8.0 $^{14}$C ka BP/11.8–8.8 cal ka BP)*

At the beginning of the Holocene, the global temperature increase caused a quick rise of the sea level (Korotky, 1982, 1994). The level of the Sea of Japan rose to about −48/−49 m by ca. 9.6 $^{14}$C ka BP/10.9 cal ka BP (Kuzmina et al., 1987). In southern Primorye birch and elm forests became widespread. Temperatures were below modern ones (Kuzmina et al., 1987; Shumova and Klimanov, 1989). Broadleaved species such as oak, cork tree, Manchurian walnut and linden appeared in the lowland vegetation, while Korean pine quickly spread in the mountains. In the valley of the Tumannaya River, oak-birch forests with dwarf birch and alder in the understorey were reconstructed at 8100 ± 100 $^{14}$C a BP (Korotky et al., 1980; Korotky, 2002). The available pollen-based climate reconstructions suggest instability of the Early Holocene climate and several century-scale temperature fluctuations (Khotinsky, 1977, 1987; Korotky et al., 1980, 1997).

In the coastal zone of eastern Primorye, cold deciduous birch and alder forests prevailed in the Early Holocene, at 8700 ± 320 $^{14}$C a BP, indicating a cooler and wetter climate compared to the more continental areas. At 8020 ± 280 $^{14}$C a BP, broadleaf temperate deciduous tree species (oak, Manchurian walnut, linden, hornbeam) appeared in the birch-alder forests, reflecting the onset of warmer climate conditions (Korotky, 2002).

#### 4.1.3. *Middle Holocene (ca. 8.0–2.6 $^{14}$C ka BP/8.8–2.6 cal ka BP)*

The Atlantic period (8.0–4.6 $^{14}$C ka BP/8.8–5.3 cal ka BP) was the warmest and wettest interval of the entire Holocene in the study region. Average annual air temperatures were 2–5 °C higher than modern ones. The amount of annual atmospheric precipitation was 1000–1200 mm (Korotky and Vostretsov, 2002). The mean annual temperatures of the Sea of Japan surface waters were also 3–6 °C higher (Korotky et al., 1997). The sea level rise was rapid and reached its maximum (ca. 2–3 m above the present level) about 6.0 $^{14}$C ka BP/6.7 cal ka BP. The transgression of the sea water reached the inland sites located ca. 1–1.5 km away from the modern shoreline (Korotky and Vostretsov, 2002), resulting in the formation of numerous warm shallow bays and lagoons and coastal lakes. Boreal forest formations with an admixture of temperate deciduous broadleaved species reached much further north, i. e. to the Amur River delta at ca. 53°N (ca. 850 km north of Khanka Lake) (Bazarova et al., 2008).

At the beginning of the Atlantic period (7550 ± 40 $^{14}$C a BP), southern Primorye experienced the spread of species-rich cool mixed and temperate deciduous forests with oak, elm, walnut, hornbeam, birch, Korean pine, Manchurian fir and other species (Mikishin et al., 2008). In the coastal lowlands, alder thickets and *Sphagnum* bogs disappeared and were predominantly substituted by oak forests with a high proportion of hornbeam, walnut and elm (ca. 6195 ± 60/5860 ± 65 $^{14}$C a BP). In the vicinity of the Boisman-2 archaeological site, the vegetation was represented by hornbeam-oak forests with an admixture of linden, elm, ash, Manchurian walnut and other broadleaved species (Verkhovskaya and Kundyshev, 1993), indicating a warm and humid climate.

The interval from 7920 ± 135 to 5690 ± 120 $^{14}$C a BP in western Primorye was characterised by a development of coniferous-broadleaf forests with a greater-than-present participation of warmer broadleaf taxa, such as Mongolian oak, elm, Manchurian walnut, linden, ash, spindle tree, *Eleutherococcus* spp., prickly castor-oil tree and hornbeam (Bazarova et al., 2018a). The coastal areas of eastern Primorye experienced spread of mixed forests composed of Korean pine, oak, walnut, hornbeam, cork tree, elm, linden, maple, hazel, *Eleutherococcus* spp. and lilac.

Climate cooling (5775 ± 80/5625 ± 160 $^{14}$C a BP) at which conditions approached modern ones, was recorded in the pollen spectra from the mire sediments at the coast of the Boisman Bay and from the lagoon-marine sediments at the coast of the Amur Bay (Mikishin et al., 2019). The results of diatom analysis indicate a decrease in sea level at that time (Mikishin et al., 2008). In the coastal area, oak and alder forests

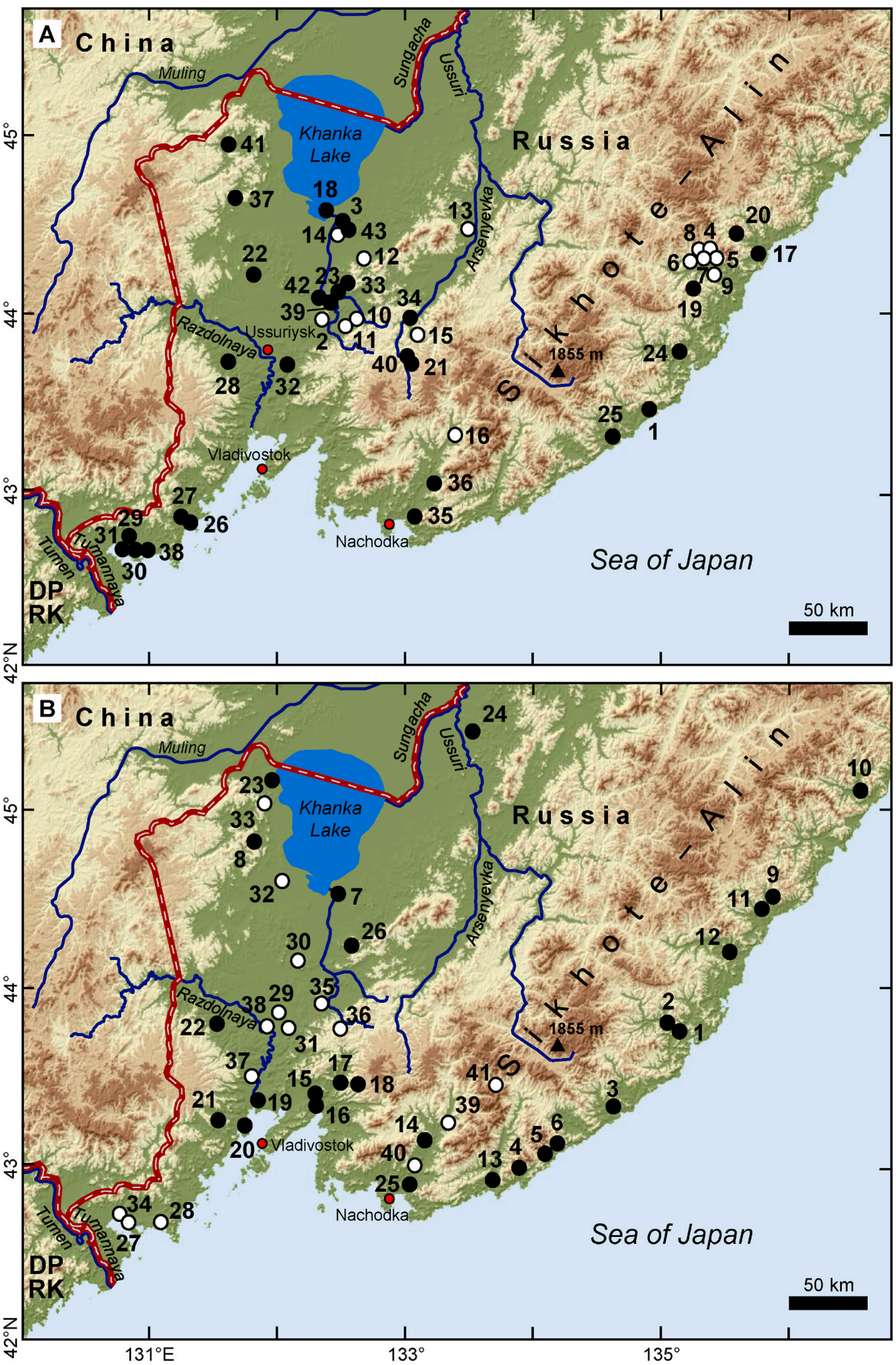


**Fig. 2.** Topographic maps showing the locations of (A) Palaeolithic (white symbols) and Neolithic (black symbols) sites: 1 – Evstafiy-4, 2 – Osinovka, 3 – Sinii Gai-4, 4 – Ustinovka-1, 5 – Ustinovka-3, 6 – Ustinovka-4, 7 – Ustinovka-6, 8 – Ustinovka-7, 9 – Suvorovo-4, 10 – Ilistaya-1, 11 – Gorbatka-3, 12 – Gorny Khutor-11, 13 – Risovoe-1.4, 14 – Chernigovka-1, 15 – Novovarvarovka, 16 – Monakino-3, 17 – Rudnaya Pristan, 18 – Luzanova Sopka-2.5, 19 – Ustinovka-8, 20 – Chertovy Vorota, 21 – Sheklyaevo-7, Novotroitskoe-2, 22 – Sergeevka–1, 23 – Katerinovka–1, 24 – Vetka–2, 25 – Moryak-rybolov, 26 – Boisman-2, 27 – Boisman-1, 28 – Krounovka-1, 29 – Gvozdevo-4, 30 – Zaisanovka-1, 31 – Posyet-1, 32 – Bogolyubovka-1, 33 – Rettikhovka Geologicheskaya, 34 – Anuchino-29, 35 – Sopka Bolshaya, 36 – Vodopadnoe-7, 37 –Novoselishche-4, 38 - Zaisanovka-7, 39 – Mustang-1, 40 – LZP-3-6, 41 – Dvoryanka-1, 42 – Petrovichi, 43 – Sirotinka and (B) Palaeometal (black symbols) and Middle Ages (white symbols) sites: 1 – Olga-10, 2 – Sinie skaly, 3 – Moryak-rybolov, 4 – Preobrazhenie-1, 5 – Zarya-3, 6 – Glazkovka-2, 7 – Sinii Gai, 8 – Pad Kharinskaya, 9 – Lidovka-1, 10 – Blagodatnoe-3, 11 – Monastyrka-2, 12 – Suvorovo-6, 13 – Kievka, 14 – Berezovaya-2, 15 – Oleniy-1–3, Kirovsky, 16 – Cherepakha-6, 7, 13, 17 – Malaya Podushechka, 18 – Solontsovaya-2, 19 – Chapaevo, 20 – Peschany-1, 21 – Barabash-3, 22 – Krounovka-1, 23 – Pad Semipyatnaya, 24 – Glazovka-gorodishche, 25 – Sopka Bulochka, 26 – Rettikhovka Geologicheskaya, 27 – Posiet-grot, 28 – Troitsa-5, 29 – Mikhailovka-2, 30 – Abramovka-3, 31 – Rakovka-10, 32 – Novoselyshchenskoye-gorodishche, 33 – Kurkunikha, 34 – Kraskinskoe-gorodishche, 35 – Gorodishche Gorbatka, 36 – Nikolaevskoe-gorodishche-1, 37 – Ananievskoe-gorodishche, 38 – Krasnoyarovskoe-gorodishche, 39 – Shaiginskoe-gorodishche, 40 – Ekaterinovskoe-gorodishche, 41 – Lazovskoe-gorodishche. The digital elevation model is based on 90-m-resolution Shuttle Radar Topography Mission (SRTM) v4.1 data (Jarvis et al., 2008).

developed and Korean pine became a more significant component in the mountain cool mixed forests (Mikishin et al., 2008). Polydominant broadleaf forests with oak, linden, hornbeam and iron birch were reconstructed at the Boisman Bay site (5780 ± 40 $^{14}$C a BP) and the Karas'e Lake (5050 ± 40 $^{14}$C a BP), located near the archaeological sites Zaisanovka-1, Posyet-1 and Gvozdevo-4, where oak was represented by two species, Mongolian oak and Japanese emperor oak (*Quercus dentata*) (Belyanin et al., 2019). A significant part of the modern analogue area of this type of forests is located in regions with climate warmer than that of the study region, such as the Korean Peninsula and the northeastern Chinese provinces of Jilin and Liaoning (Ogureeva et al., 2012). At 5150 ± 140 $^{14}$C a BP, broadleaved forests were widespread in the valley of the Razdol'naya River. The floodplain areas were occupied by meadow vegetation communities (Razzhigaeva et al., 2020).

At the end of the Atlantic period (4990 ± 60 to 4550 ± 70 $^{14}$C a BP), the climate became cooler, although it was still warmer than today, and Korean pine-broadleaf forests covered the low-elevated slopes of the coastal mountain ranges along the Kit Bay. At the same time, the areas occupied by coastal oak forests with hazel and hornbeam decreased (Razzhigaeva et al., 2016).

The shift towards cooler and drier conditions during the early stage of the Subboreal period (i.e. ca. 4.6–3.6 $^{14}$C ka BP/5.3–4.0 cal ka BP) in the western part of Primorye is associated with a reduction in forested area and a depletion of the floristic composition. The participation of oak, elm and Manchurian walnut significantly decreased, while linden, ash, spindle tree, *Eleutherococcus* spp., prickly castor-oil tree and

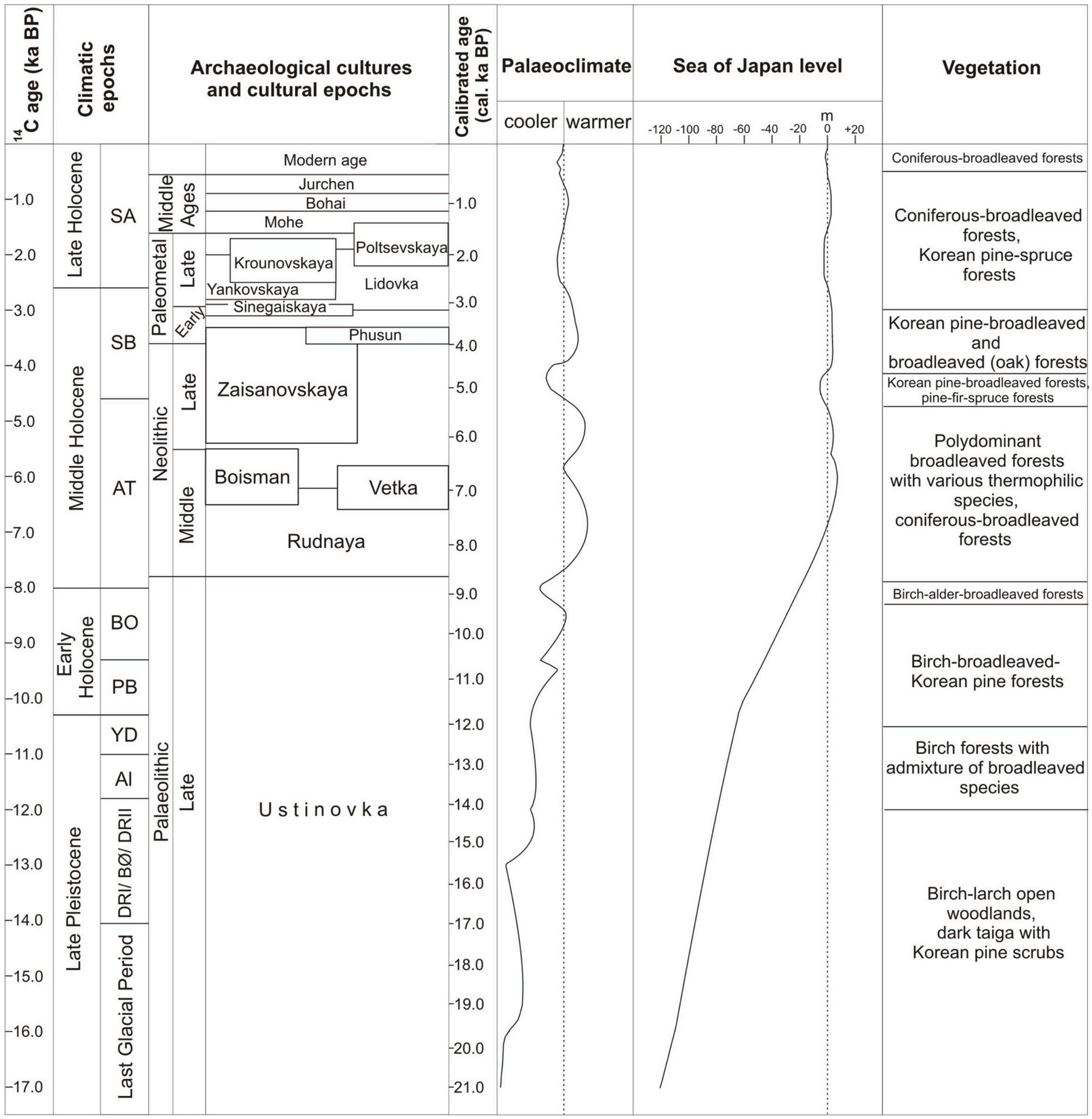


**Fig. 3.** Main palaeoclimatic trends (after Korotky, 1982; Kuzmina et al., 1987; Korotky et al., 1997; Korotky and Vostretsov, 2002; Razzhigaeva et al., 2014, 2018b, 2020), changes in sea level (after Korotky, 1982, 1994 and Khershberg et al., 2013) and vegetation composition (after Golubeva and Karaulova, 1983; Korotky et al., 1997; Mikishin et al., 2007, 2008) and the archaeological culture sequence of southern Primorye. Abbreviations: Al – Allerød, YD – Younger Dryas, PB – Preboreal, BO – Boreal, AT – Atlantic, SB – Subboreal, SA – Subatlantic.

hornbeam disappeared from the vegetation at 4710 ± 100 $^{14}$C a BP. In local depressions, the low water permeability of soils promoted the development of wet floodplain meadows (Bazarova et al., 2018a).

The mean annual temperatures dropped to 1.5–2 °C below the modern ones. Geomorphological studies also suggest increased flood activity, which caused intensified paludification processes in the river valleys and delta areas (Korotky, 1982; Razzhigaeva et al., 2018b, 2020). The level of the Sea of Japan dropped by 2–4 m, while the level of Khanka Lake became higher than during the Atlantic period (Korotky et al., 1980, 2007).

During the initial Subboreal cooling (4750 ± 80 $^{14}$C a BP), southern Primorye experienced the spread of oak-dominated forests and the expansion of alder forests (Mikishin and Gvozdeva, 2014; Mikishin et al., 2019; Razzhigaeva et al., 2019). On the coast of the Boisman Bay 4560 ± 35 $^{14}$C a BP, the vegetation was represented by birch forests and alder thickets, while spruce and Korean pine forests were of subordinate importance (Mikishin et al., 2008). The expansion of dark coniferous and birch forests occurred in the East Manchurian Mountains, while birch shrubs and *Sphagnum* bogs developed in the coastal areas 4890 ± 40 $^{14}$C a BP (Belyanin et al., 2019).

Eastern Primorye experienced deforestation and paludification processes in the upper reaches of the Ussuri River at the beginning of the Subboreal. The Korean pine-fir-spruce forests occupied lower elevations than at present (Razzhigaeva et al., 2018b). A forest-steppe landscape developed near the Novoselishche-4 archaeological site, which indicates a drier-than-present climate (Verkhovskaya and Esipenko, 1993; Kluyev et al., 2002).

Between ca. 3.6–2.6 $^{14}$C ka BP/4.0–2.6 cal ka BP, the regional climate once again became warmer than at present and the sea level rose to 1.5 m above the present one (Korotky et al., 1980, 1997; Kuzmina et al., 1987). During the following warmer phase, the participation of temperate taxa, primarily hornbeam, increased in the forest vegetation on the Muravyov-Amursky Peninsula. Limited areas were occupied by broadleaf forests mixed with Manchurian fir (Razzhigaeva et al., 2019).

On the Boisman Bay coastal plain, oak forests with hornbeam and other broadleaf species spread and Korean pine-broadleaf forests dominated in the adjacent mountains about 3715 ± 60 to 3425 ± 35 $^{14}$C a BP (Mikishin et al., 2008). In the East Manchurian Mountains, the Subboreal warming phase led to the development of polydominant forests with a large proportion of Korean pine, Japanese pine, Manchurian fir, oak, linden, birch, elm, heartleaf hornbeam and maple. Similar polydominant broadleaf forests with Korean pine and birch were widespread on the Shkotovskoe Plateau 3770 ± 140 to 3540 ± 110 $^{14}$C a BP (Razzhigaeva et al., 2016). Sedge-forb-grass meadows were common vegetation on the coastal plains (Belyanin et al., 2019).

In Eastern Primorye (around 3810 ± 190 $^{14}$C a BP), Korean pine forests with oak, hornbeam, maple and linden were widespread in the mountains surrounding the Kit Bay, and hazel shrubs grew in the valley forests. The areas of spruce-fir forests expanded to higher elevations (Razzhigaeva et al., 2018a). About 3320 ± 70 $^{14}$C a BP, oak-dominated broadleaf forests with a rich species composition grew on the coast around the Triozerye Bay (Lyashchevskaya et al., 2017).

The end of the Subboreal (2605 ± 65 $^{14}$C a BP) experienced a new phase cooling and a drop in sea level of 3–4 m (1.5–2.5 m below modern sea level) occurred. This led to the filling of lagoons and bays with alluvial sediments, the advancement of alluvial deltas and general decrease in the ruggedness of the coastline (Korotky et al., 1980).

#### 4.1.4. *Late Holocene (ca. 2.6 $^{14}$C ka BP to the present/2.6 cal ka BP to the present)*

At the beginning of the Subatlantic period (2.6–1.9 $^{14}$C ka BP/2.6–1.9 cal ka BP), the climate became cooler. The cooling was accompanied by a decrease in the level of the Sea of Japan to 0.8–1.5 m below the current level (Korotky and Vostretsov, 2002).

In southern Primorye, birch and alder trees expanded in the forests and mixed forests with Korean pine, Japanese pine and fir formed about 2540 ± 130/2589 ± 109 $^{14}$C a BP (Belyanin et al., 2019). On the coast of the Boisman Bay, grasslands and meadows were widespread 2595 ± 20/2510 ± 45 $^{14}$C a BP. While alder became more common, the other temperate deciduous broadleaf trees became very rare (Mikishin et al., 2008).

About 2220 ± 90 $^{14}$C a BP, dark coniferous forests dominated on the Shkotovskoe Plateau in the Sikhote-Alin, while the marginal parts of the plateau were occupied by mixed forests dominated by broadleaf taxa and Korean pine (Razjigaeva et al., 2017). The same type of mixed forests spread on the coast of the Muravyinaya Bay 2010 ± 90 $^{14}$C a BP. Korean pine, spruce and broadleaf trees resistant to frost occupied higher-elevated sites (Razzhigaeva et al., 2019). Around the same time (2110 ± 80 $^{14}$C a BP), in the Razdol'naya River valley small areas were occupied by birch woodlands and alder thickets on the floodplain. However, wormwood-dominated associations and grass meadows became more common. Fragments of broadleaf forests existed in the low mountain ranges there (Razzhigaeva et al., 2020).

During the so-called Medieval Climate Optimum (8th–13th centuries CE), Primorye experienced an increase in average annual temperature by 1–1.3°C, mainly due to warmer winters (Razzhigaeva et al., 2014). The annual amount of atmospheric precipitation also increased due to an increase in winter precipitation, which indicates a weakening of the winter monsoon (Korotky et al., 1999). During this time interval, three activity peaks of the warm Kuroshio Current were reconstructed (Koizumi et al., 2003). The estimated rise in the Sea of Japan level was approximately 1 m above today's level (Korotky and Khudyakov, 1990; Korotky, 1994). On the sea coast and in the Razdol'naya River valley, oak forests rich in temperate deciduous species (e.g. walnut, elm, maple, hornbeam, linden, lilac, cork tree and members of the ginseng family) flourished. In the East Manchurian Mountains, coniferous-broadleaf forests predominated (Mikishin et al., 2008). The pollen record from the Ryazanovka River terrace indicates a warming trend around 1310 ± 20 $^{14}$C a BP (Korotky et al., 1980; Golubeva and Karaulova, 1983; Mikishin et al., 2008). In some places, the recorded decline in the Korean pine percentages and the emergence of secondary forests were most likely a result of forest fires associated with human activities (Razzhigaeva et al., 2014).

In western Primorye, on the plains around Khanka Lake, open meadow and steppe-like vegetation with grass, wormwood, sedge and forb species became widespread. The open landscapes occupied a larger area than at present. In the mountains and foothills, there were birch forests with a small amount of Korean cedar, fir and broadleaf trees (Mikishin et al., 2007; Bazarova et al., 2018b). During the Medieval Climate Optimum (1135 ± 45 $^{14}$C a BP), the forest vegetation expanded and the role of thermophilic species (linden, arrowwood and ash) slightly increased in the forests growing in the foothills of the East Manchurian Mountains. The average level of Khanka Lake was 0.8–1.0 m higher than at present (Bazarova et al., 2008, 2018a).

Under cold conditions reconstructed for 2480 ± 120 $^{14}$C a BP, wormwood-forb-shrub vegetation communities spread in eastern Primorye, as demonstrated by the pollen record from the Triozerye Bay (Lyashchevskaya et al., 2017). The slopes and hills in the vicinity of the Kit Bay were covered with sparse oak forests around 2290 ± 80 $^{14}$C a BP (Razzhigaeva et al., 2018a). Birch forests with an admixture of oak were widespread on the coast of the Oprichnik Bay about 1610 ± 90 $^{14}$C a BP. In the mountains, the upper forest limit moved downslope and Korean pine forests dominated. During the Medieval Climate Optimum (860 ± 50 $^{14}$C a BP), the forest cover of the territory increased and oak trees became more common in the Korean pine-dominated forests (Lyashchevskaya, 2013).

### 4.2. *Cultural epochs and archaeological cultures*

#### 4.2.1. *Late Palaeolithic*

The existence of land bridges between the Asian mainland and Sakhalin and Hokkaido islands in the Late Pleistocene promoted migrations and close ties between populations and the appearance of the first hunter-gatherer sites on the territory of Primorye in the Late Palaeolithic (Kuznetsov et al., 2005; Tarasov et al., 2021 and references therein). The study of the Primorye Palaeolithic began in the mid-1950s (Ganeshin and Okladnikov, 1956; Petrun, 1956). In the 1970s–1990s, the archaeological sites in the valleys of the Zerkal'naya, Ilistaya, Arsenyevka and Razdol'naya rivers were actively studied. In recent years, the number of studied Palaeolithic sites rose significantly. The most representative are Gorny Khutor-11, Monakino-3, Risovoe-1, Novovarvarovka and several others located in the central and southern parts of Primorye (Fig. 2A).

Despite a long period of research and a large number of studied sites, the timing of the first appearance of anatomically modern human population in the Primorye region is still a subject of controversy among archaeologists. However, there is no doubt that people settled the territory of Primorye at the end of the Late Pleistocene and even during the LGM (Tarasov et al., 2021), as indicated by the $^{14}$C-dated multi-layered site Ogonki-5 (46.78°N, 142.48°E) on Sakhalin Island (Rudaya et al., 2013) and the sites from the Selemdzha River basin in the Amur region (Gladyshev, 2019, 2020). This is confirmed by pebble tools and other finds from the Upper Palaeolithic sites in the valleys of the rivers Zerkal'naya, Ilistaya and Sergeevka (Kuznetsov, 1992; Dyakov, 2000; Dorofeeva, 2013).

To date, more than 40 archaeological sites attributed to the Ustinovka cultural tradition of the final Palaeolithic are known in the eastern, southern and central parts of Primorye. The sites are characterised by a combination of macro- and microblade technology as well as a characteristic stone toolkit (e.g. burins, scrapers, large bifaces). More than 30 sites are situated in the valley of the Zerkal'naya River, eastern Primorye. This concentration of seasonal camp sites with evidence for processing of stone materials in a relatively small area is associated with outcrops of siliceous shales, the main regional source of raw material for the stone industry. The age of these sites ranges between 15.9 and 7.8 $^{14}$C ka BP/19.5–8.6 cal ka BP (Krupyanko and Tabarev, 2015; Chlachula and Krupyanko, 2016). Among the most important oldest sites (of LGM age) are Ustinovka-6, Suvorovo-4 and Gorbatka-3 (Fig. 2).

The stone industry of the sites in southern Primorye is characterised by the use of small obsidian pebbles and the dominance of microblade technology, which is reflected in the small size of raw pebbles. The toolkit of the sites includes burins, scrapers, bifaces and spear points (Kuznetsov, 1992). The subsistence economy at these sites was long based on hunting large terrestrial mammals (Okladnikov and Derevianko, 1973; Derevianko, 1983; Krushanov, 1989; Andreeva, 1994). In the Late Pleistocene, wild boar, roe deer, elk, Manchurian red deer, reindeer (*Rangifer tarandus*), sika deer, goral, musk deer and four other herbivorous species from the genera *Mammuthus* (mammoth), *Coelodonta* (woolly rhinoceros), *Bison* (bison) and *Equus* (horse) that became extinct at an as yet unknown time were widespread in Primorye (Sheremetev and Panasenko, 2013).

At the final stage of the Late Palaeolithic, significant changes took place in the life of the hunter-gatherer population in the region, which are indicated by the appearance of permanent habitation sites (e.g. Ustinovka-4 and Ustinovka-3) with ground and deep dwellings (Dyakov, 2000) and small-size bifacial spear points for long-distance hunting. Seasonal fishing played an important role, which is indicated by the location of sites near rivers used by spawning fish and the finds of stone fish figurines at the Ustinovka-1, Ustinovka-3, Suvorovo-4 and Gorbatka-3 sites (Krupyanko and Tabarev, 2015). A broader range of stone tools characteristic for this time may point to a wider range of natural resources used by the ancient population, including hunting land and sea animals, river and coastal fishing and collecting mollusks and wild plants.

#### 4.2.2. Neolithic

An important feature of the Neolithic in the study region is the appearance of ceramics. Fragments of early pottery found at the sites Ustinovka-3, Chernigovka-1, Monakino-3 and Risovoe-4 fall into the chronological interval ca. 10.5–9.5 $^{14}$C ka BP/12.0–10.8 cal ka BP (Kononenko, 2001). However, in all cases, the finds of ancient pottery are associated with a macro and microblade technology typical for the Late Palaeolithic sites. The co-appearance of Palaeolithic and Neolithic implements (e.g. polished tools, small bifacial points and ceramics) in the archaeological layers sparked a discussion about a transitional Mesolithic period (Dyakov, 2000).

The earliest well-documented Neolithic culture in Primorye is Rudnaya dated to ca. 7.7–6.2 $^{14}$C ka BP/8.5–6.9 cal ka BP (Batarshev, 2009). According to the features of pottery and stone implements, two cultural stages were distinguished (Batarshev et al., 2010). The early stage was identified at several rather distant sites, e.g. Rudnaya Pristan and Luzanova Sopka-2 (Fig. 2A). The sites attributed to the late stage are spread across a wide geographic area. The best studied sites are Sergeevka-1, Dvoryanka-1, LZP-3-6, Luzanova Sopka-5, Novotroitskoe-2, Osinovka, Katerinovka-1, Petrovichi, Sinii Gai-4, Sirotinka and Chernigovka-1 in western Primorye, Sheklyaevo-7 and Boisman-2 in southern Primorye and Ustinovka-8 and Chertovy Vorota in eastern Primorye. These sites are characterised by developed pottery traditions and a wide range of stone tools, including numerous retouched and polished arrow points, scrapers, drills, adzes and chisels (Batarshev, 2009). Rudnaya is part of a wide range of stamped pottery cultures known in Primorye, Amur and north-eastern China. Its most striking feature is the ornament on ceramics made by rhombic imprints sometimes called the ‘Amur braid’ (Batarshev et al., 2010). Archaeological research demonstrates that people at this time lived in small settlements, consisting of semi-dugouts with hearths for heating and cooking. Among the most important hunted animals were ungulates, including elk, Manchurian red deer, roe deer and sika deer as well as wild boar, raccoon dog (*Nyctereutes procyonoides*), Asian badger (*Meles leucurus*), bear (*Ursus* sp.) and tiger (*Panthera tigris*). At the site Chertovy Vorota, the number of dog (*Canis lupus familiaris*) and wolf (*Canis lupus*) bones increased dramatically in the upper part of the Rudnaya cultural layer. The predominant game birds were ptarmigan (*Lagopus muta*), hazel grouse (*Tetrastes bonasia*), Daurian partridge (*Perdix dauurica suschkini*) and hill pigeon (*Columba rupestris*) (Alekseeva, 1991). The identified fish bones belong to the salmon group (Kononenko, 2003).

The Middle Neolithic Vetka culture in Primorye is well-represented by the Vetka-2 site (Fig. 2A) located in the Avvakumovka River valley, eastern Primorye (Batarshev et al., 2017). This culture is dated to ca. 6.6–5.8 $^{14}$C ka BP/7.4–6.5 cal ka BP. The sites are located both on the eastern coast (Vetka-2, Moryak-rybolov, Ustinovka-8) and in the western and southern parts of the region (Luzanova Sopka-2, Sheklyaevo-7). The Vetka culture people lived in deep, roundish dwellings with a hearth in the centre. One of the main features of the culture is the lamellar stone splitting technique and a set of stone implements made of thin plates (knives, arrowheads, carvers, inserts, scrapers, etc.). Their ceramic vessels are flat-bottomed, with a slightly convex body, the upper part of the vessel is ornamented with imprints of a small stamp of rhombic, triangular or oval shape and the tops of the triangles in the ornaments facing the bottom of the vessel. Both permanent settlements and temporary camps were located near large rivers and lakes. The main occupations of their inhabitants were hunting, fishing and gathering (Batarshev et al., 2017).

At about the same time (ca. 6.5–5.5 $^{14}$C ka BP/7.3–6.2 cal ka BP), representatives of the Boisman culture appeared in the southern half of Primorye. This culture was spread along the coast of the Sea of Japan; from Rajin Bay in North Korea to the Slavyansky Gulf in Primorye. Most of the sites are confined to the shores of lagoons that existed during the Atlantic transgression of the Middle Holocene (Besednov and Vostretsov, 1997). For example, the type sites Boisman-1 and Boisman-2 are located at the Boisman Bay, ca. 500 m from the modern coast (Dzhall et al., 1994; Popov et al., 1997). The cultural layer at Boisman-2 is represented by a shell midden, under which there were groups of burials (Popov et al., 1997; Popov, 2008). For the Middle Neolithic layer, more than 20 $^{14}$C dates of charcoal, animal bone and human bone remains from burials were recovered spanning a one-thousand-year interval (Dzhall et al., 1994; Jones and Kuzmin, 1995; Yoneda et al., 1998; Kuzmin et al., 2002; Popov et al., 2002). Based on the archaeological finds, the main occupation of the Boisman population was fishing and oyster (*Crassostrea gigas*) gathering. Inhabitants of the surveyed sites caught at least 15 fish species (Vostretsov, 1998), among them are moderately cold-water species such as redlip mullet (*Planiliza haematocheilus*), Pacific redfin (*Tribolodon brandtii*), cottids (Cottidae), Pacific herring (*Clupea pallasii*), rockfish (*Sebastes* sp.), Pacific salmons and flounders (Pleuronectidae). At five sites with shell middens, 26 gastropod and 21 bivalve mollusk species were identified (Rakov, 2014). The presence of harpoons and bones of marine mammals in the cultural layers indicates hunting of these animals. Boisman populations of the Peter the Great Gulf hunted spotted seals (*Phoca largha*), Steller sea lions (*Eumetopias jubatus*) as well as dolphins (Delphinidae) and possibly grey whales (*Eschrichtius robustus*) (Vostretsov and Toizumi, 1998; Alekseeva et al., 1999). In addition to hunting marine mammals, hunting of terrestrial mammals (e.g. Manchurian red deer, roe deer, Asian badger, bear) and waterfowl also played an important role (Alekseeva et al., 1999).

In the Late Neolithic, sites of the Zaisanovskaya cultural tradition became widespread in Primorye. The lack of cultural continuity suggests the emergence of a new population on the territory of the region with its own ceramic tradition and a new set of stone tools (Vostretsov, 2005; Sergusheva et al., 2022) around 5.4 $^{14}$C ka BP/6.1 cal ka BP (Vostretsov, 2018). The characteristic feature of this tradition in the region are flat-bottomed vessels of a simple truncated-conical shape with a zigzag ornament made by tracing or stamping. The early stage of the Zaisanovskaya culture (5.4–4.3 $^{14}$C ka BP/6.1–4.8 cal ka BP) is represented by sites of the cord-decoration tradition of ceramics ornamentation. The earliest of them are located in western (e.g. Krounovka-1) and southern Primorye (e.g. Posyet-1) (Moreva et al., 2002). Apparently, they are associated with the first migration wave, which probably came through the Razdol'naya River valley from Manchuria. Some authors have suggested that the first agricultural activities (i.e. millet cultivation) have been introduced to the study region during the first Zaisanovskaya stage (i.e. 4671 ± 31 $^{14}$C ka BP). By contrast, the results of direct $^{14}$C dating of millet remains suggests that millet arrived in the study region around 4130 ± 35 $^{14}$C ka BP and thus during the middle stage (4.3–4.0 $^{14}$C ka BP/4.8–4.5 cal ka BP) of the Zaisanovskaya culture, also known as the Khasan variant (Sergusheva et al., 2022). This stage is represented by sites (e.g. Zaisanovka-1, Gvozdevo-4) located on the coast of Peter the Great Gulf, which were likely the result of a second migration wave along the valley of the Tumannaya River (Krutykh, 2012). This scenario is supported by the sudden emergence of a new type of raw material for the manufacture of stone tools, black obsidian, the source of which is located in the middle reaches of the river (Sergusheva, 2013). Access to the sea promoted sea fishing and gathering, as evidenced by shell midden in settlements along the coast, e.g. at the Zaisanovka-7 site. The final stage of the culture (4.0–3.3 $^{14}$C ka BP/4.5–3.6 cal ka BP) is represented by the group of sites located near Khanka Lake (e.g. Novoselishche-4, Mustang-1, Bogolyubovka-1, Anuchino-29, Rettikhovka Geologicheskaya) and in the south-eastern part of the region (e.g. Vodopadnoe-7, Sopka Bolshaya, Evstafiy-4). The sites of this stage demonstrate an increase in the complexity of the settlements and rising importance of millet cultivation in the complex subsistence economy of the Late Neolithic inhabitants of Primorye (see Krutykh, 2011, 2012; Sergusheva, 2013; Sergusheva et al., 2022 for primary data and references).

#### 4.2.3. Palaeometal Epoch

The next stage in the archaeology of Primorye is broadly known as the Palaeometal Epoch, which formally represents Bronze and Iron Ages in the region, but reveals very few bronze and iron objects, especially during the early stages (Sergusheva et al., 2022). There is no agreement about the beginning of the Palaeometal Epoch in Primorye. The traditional view, which is followed in the current study, includes besides the Sinegaiskaya, Lidovka, Yankovskaya, Krounovskaya and Poltsevskaya cultures (3.1–1.5 $^{14}$C ka BP/3.3–1.5 cal ka BP) also the Margaritovskaya culture (3.6–3.3 $^{14}$C ka BP/4.0–3.6 cal ka BP).

The sites of the Margaritovskaya culture (e.g. Olga-10, Moryak-rybolov, Preobrazhenie-1, Zarya-3, Glazkovka-2, Sinie Skaly Grotto) are located in the eastern coastal part of the region (Fig. 2B) (Sidorenko, 2016). The culture is characterised by closed vessels of simple shapes, ornamented only along the rim and retouched stone tools (arrowheads, scrapers, knives, inserts) and disc-shaped 'chips', possibly for playing games. The economy was based on hunting, fishing and gathering. The inhabitants of the Sinie Skaly settlement were engaged in hunting deer, roe deer, wild boar and bear, fishing salmon, cod (*Gadus macrocephalus*), Alaska pollock (*Theragra chalcogramma*) and flounders and also harvesting shellfish (scallop). At the Zarya-3 and Olga-10 sites, there is evidence of millet farming (Batarshev et al., 2015; Sergusheva et al., 2022).

The following archaeological cultures of the Early Palaeometal Epoch were Sinegaiskaya (3.1–2.9 $^{14}$C ka BP/3.3–3.1 cal ka BP) and Lidovka (3.0–1.9 $^{14}$C ka BP/3.1–2.0 cal ka BP). The population of the Sinegaiskaya culture settled in southern Primorye and around Khanka Lake (e.g. Sinii Gai, Pad Kharinskaya, Kirovsky) and was engaged in agriculture, animal husbandry, hunting and gathering. The bone assemblage at the Sinii Gai settlement contained significant proportion of domesticated (e.g. pig and dog) and wild (roe deer, Manchurian red deer, elk, seal) mammals and birds, predominantly waterfowl (Alekseeva et al., 1999). This culture is characterised by half-moon-shaped reaping knives, polished axes, non-decorated vessels with a pronounced neck and numerous bone tools. At Sinii Gai, imported bronze objects (knives, pendants, buttons) were found.

The Lidovka culture was identified in eastern Primorye (settlements Lidovka-1, Blagodatnoe-3, Monastyrka-2, Suvorovo-6). Some researchers believe that this culture originated in the south-eastern part of the region and spread northward along the coast (Dyakova and Sidorenko, 2020; Moreva and Dorofeeva, 2020). The population was engaged in agriculture and exploitation of coastal and marine resources. It is characterised by well-profiled amphora-shaped vessels, polished stone tools (including stone replicas of bronze objects) and retouched tools made of siliceous rocks and chalcedony. The coastal settlements were located in strategically important places and designed to protect against attacks from the sea. In the easternmost part of the region, this culture existed until the 4th century CE (Sidorenko, 2016).

Over 200 settlement sites of the Yankovskaya archaeological culture (ca. 2.8–2.0 $^{14}$C ka BP/2.9–2.0 cal ka BP) were identified in the southern and south-eastern coastal zones of the region. Among them, the settlements Peschany-1, Malaya Podushechka, Chapaevo and Oleniy-1 to 3 are well-studied. More recently, the Barabash-3, Berezovaya-2 and Solontsovaya-2 sites and the sites near Cherepakha Lake (Cherepakha-13, Cherepakha-6, Cherepakha-7) were excavated. In Primorye, the monuments of the Yankovskaya culture are the most abundant, which indicates a successful adaptation strategy of its population. The settlements consisted of frame-type semi-dugouts with an area of up to 120 m$^2$ arranged in rows. The economy was mainly based on coastal sea and river fishing; however, a significant share was cattle breeding, hunting and gathering. A common feature of coastal settlements are huge shell middens, 80–95% of which are oyster shells. Fish bone remains from the investigated shell middens belong to 49 species, among them are schooling pelagic species preferring warm waters, such as Pacific mackerel (*Scomber japonicus*), needlefish (*Strongylura anastomella*) and to a lesser extent cold-water species, such as Pacific herring (Besednov and Vostretsov, 1997). Agriculture became progressively more important as indicated by the finds of agricultural tools and archaeobotanical data. At a later stage, the species composition of cultivated plants became richer and included besides millet also barley and soybean (Sergusheva and Moreva, 2017). Breeding of pigs and, possibly, dogs (Peschany-1) supplemented the food economy. However, hunting of wild game (Manchurian red deer, roe deer, elk) also remained part of the subsistence (Alekseeva et al., 1999). The archaeological evidence suggests that the Yankovskaya culture people were skilled craftsmen engaged in processing wood, horns, bones, skins, pottery and textile making. Yankovskaya culture ceramic ware is characterised by high-quality surfaces obtained by smoothing and glassing; the vessels were often decorated with mortise and molded ornaments. Despite the fact that the Yankovskaya culture belongs to the Early Iron Age, finds of iron tools are rare and most often associated with the late stage of the culture (Barabash-3, Malaya Podushechka, Cherepakha-7) (Kluyev and Gridasova, 2013; Nikitin, 2017).

About 2.3 $^{14}$C ka BP/2.3 cal ka BP, there was a sharp decline in the number and density of sites in the coastal zone of Primorye. At the same time, in the western, continental part of the region the new Krounovskaya culture developed, whose economy was dominated by agriculture supplemented by hunting and fishing (Vostretsov, 1996). The emergence of the Krounovskaya culture on the territory of the region is dated to ca. 2.5 $^{14}$C ka BP/2.5 cal ka BP and the sites occurred on the western side of Khanka Lake and in the middle reaches of the Razdol'naya River (Vostretsov, 2013). Judging from the archaeological evidence, these sites were occupied by developed agricultural communities without noticeable social stratification. For the cultivation of millet, legumes, barley and wheat, raised-bed cultivation was practiced, traces of which were found at the Krounovka-1 settlement (Vostretsov, 1987; Yanushevich et al., 1990; Komoto and Kumamoto, 2004). In addition to farming, they were engaged in breeding pigs, cows and horses and hunting and fishing. The settlements of the Krounovskaya culture tend to be located in river valleys and their populations reached up to 150–500 people living in semi-dugout houses (up to 100 m$^2$) with wooden walls and a frame supporting the roof. To date, about 80 settlements of the Krounovskaya culture are known in Primorye. The most studied are Krounovka-1, Kievka and Pad Semipyatnaya. The ceramics of the Krounovskaya culture are characterised by simple-shaped vessels with symmetrically arranged stub-handles. The share of iron tools in the inventory increases, while the number of stone artefacts sharply declines during the Krounovskaya period.

About 2.2 $^{14}$C ka BP/2.2 cal ka BP, the bearers of the Poltsevskaya culture moved to Primorye from the Amur region along the Ussuri River valley (Kolomiyets, 2005; Hon Hyun, 2008). The Glazovka-gorodishche, Sopka Bulochka, Sinie Skaly, Malaya Podushechka and Rettikhovka Geologicheskaya sites are assigned to this culture. The earlier sites are located in the central part of Primorye. At the Glazovka-gorodishche site, storage pits with container vessels and carbonised millet grains were excavated. For this culture, a significant increase in the number of iron tools (socketed axes, knives, arrowheads) was noted (Kolomiyets et al., 2002). Later sites of the Poltsevskaya culture are common in the southern and eastern parts of Primorye (Sinie Skaly, Malaya Podushechka, etc.). According to the typological features of the ceramic material, they were assigned to the separate Olginskaya culture within the Poltsevskaya cultural community (Kolomiyets et al., 2002). Their economy was mainly based on agriculture. The level of pottery elaboration and the manufacture of tools from iron presupposes developed handicraft skills. The bearers of the Poltsevskaya culture persisted until the early Middle Ages.

#### 4.2.4. Early Middle Ages

In the 3rd and 4th centuries CE, Mohe tribal groups spread to Primorye from Manchuria. Based on the classification of ceramic material, four local-chronological groups of sites of the 5th–7th centuries are distinguished: Khanka (e.g. Novoselishche-gorodishche, Kurkunikha), southern coastal (e.g. Troitsa-5, Posiet-grot), Rakovskaya (e.g. Abramovka-3, Rakovka-10, Mikhailovka-2) and Kavalerovskaya, which includes sites on the eastern coast of Primorye (Piskareva, 2013). The concentration of Mohe sites in the southern part of the Khanka lowland is possibly due to several favourable environmental factors, such as the presence of iron ore and clay deposits lying close to the surface, the absence of large floods from the rivers of the Khanka lowland and fertile floodplain soils well suited for crop cultivation. The settlements of the Mohe culture were confined to higher-elevated sites, terraces and hills (Piskareva, 2013). Archaeological data confirm the presence of agriculture and animal husbandry as well as hunting, fishing and gathering of wild plants by the Mohe populations. Archaeobotanical data indicate a dynamic farming system manifested in the increase of the number of cultivated plants and the rising scale of agricultural production (Piskareva et al., 2019a).

In the 7th century, the Sumo Mohe tribes dominating in Primorye formed the Bohai State (698–926 CE), which included Manchuria, Primorye and North Korea. With the formation of the Bohai State, the Mohe culture underwent significant changes, but some features of continuity can be observed, for example, the presence of Mohe-type ceramics. Bohai cities and settlements in Primorye (Kraskinskoe gorodishche, Gorodishche Gorbatka, Nikolaevskoe gorodishche 1, etc.) were located in river valleys on fertile lands with a very high agroclimatic potential (Kovaleva and Plokhikh, 2002). In addition to agriculture, the Bohai population was engaged in animal husbandry, horse breeding, hunting and gold and silver mining. The Bohai State maintained trade and cultural exchange with Japan via a maritime route starting in the Posiet Bay.

In 926 CE, Bohai was destroyed by the Khitans. After 926, a part of the Mohe tribes united under the name Jurchen. The state of Jin (1115–1234 CE) formed by them defeated the Khitan Empire of Liao (916–1125 CE) and conquered large parts of northern China during the wars with the Chinese Song empire. On the present-day territory of Primorye was the Jin province of Xuipin with its centre in the area of the modern city of Ussuriysk. At the beginning of the 13th century, the Jurchen independent state of Du Xia was founded. The fortified cities built on the territory of Primorye, e.g., Shaiginskoe, Ekaterinovskoe, Krasnoyarovskoe, Ananievskoe, Lazovskoe and others, provide very rich materials for the study of their economy, culture and socio-political system.

## 5. Discussion

To date, the origin of the Upper Palaeolithic hunter-gatherers in southern Primorye is still controversial. Similar cultural complexes with the same set of cores and tools, including the 'bifaces–burins–chopping tools' package, have been found at archaeological sites in the Selemdzha River basin (lower Amur region) and at the Ogonki-5 site in the southern part of Sakhalin Island. These complexes are of slightly older age (ca. 19–18 $^{14}$C ka BP/23–22 cal ka BP) than the sites in Primorye (ca. 15.9 and 7.8 $^{14}$C ka BP/19.5–8.6 cal ka BP). Thus, based on the available materials and chronology, both regions could be the origin of Late Palaeolithic migrants to Primorye (Gladyshev, 2019, 2020). The archaeological sites assigned to the post-LGM interval (ca. 16–11 $^{14}$C ka BP/19–12 cal ka BP) corroborate the onset of climate warming, during which the role of dark coniferous tree taxa in the landscape increased (Fig. 3; Korotky et al., 1997).

The final stage of the Ustinovka cultural tradition falls into the cooling phase associated with the Younger Dryas, when birch-larch woodland and forest-tundra communities spread in the region (Shumova and Klimanov, 1989; Korotky et al., 1997). During this period, most of the known archaeological sites were located in areas with easy access to raw material for the manufacture of stone tools (siliceous shale, tuff, obsidian, etc.) and occupied various ecological niches (coastal, riverine, continental, mountainous) with seasonally or annually available plant and animal resources (Krupyanko and Tabarev, 2015).

In the Preboreal period of the Early Holocene, a quick and well-pronounced climate warming and sea level rise led to a significant change in the adaptation strategy of the hunther-gatherers in the region, which was manifested in the emergence of long-term camps with above-ground or recessed dwellings and an increasing role of fishing in the subsistence. The change in the composition of the terrestrial fauna also led to a change in the hunting strategies and to the appearance of new types of weapons.

The development of warmer and moister climate conditions during the onset of the Atlantic period was paralleled by the spread of Neolithic cultures across the region. During this thermal maximum stage of the Holocene, the Neolithic cultures Rudnaya, Boisman and Vetka flourished. This period, with a warmer and milder climate and higher sea water temperatures than today, represents the time of maximum productivity of the Sea of Japan coastal landscapes, which provided the subsistence basis for the Boisman culture communities, who left the earliest known evidence for intensive exploitation of marine resources in the archaeological record of Primorye (Vostretsov, 1998). In Boisman shell middens, remains of the warm-water Asian hard clam (*Meretrix lusoria*) and *Anadara subcrenata* were found, which do not occur in the waters off the coast of Primorye today. The northern boundary of their modern habitat is located about 500 km south of Peter the Great Gulf (Rakov, 2014). According to the species' temperature requirements, during the Boisman period the coastal waters did not freeze in winter and if the air temperature fell below zero, then for a short time.

A moderate cooling and drying of the regional climate around 5.7 $^{14}$C ka BP/6.4 cal ka BP occurred almost synchronously with a decrease in sea level and the filling of shallow-water lagoons with sediments, peat accumulation in the coastal lowlands and significant changes in the vegetation cover. At this time, a fundamental change in the fishing strategy of the coastal Neolithic Boisman population occurred, which was characterised by a turn from fishing in lagoons to fishing in the open sea (Besednov and Vostretsov, 2010). This shift and the termination of the Boisman culture was likely a response to the change in marine resource availability linked to changing coastal environments. Evidence for the lack of food is enamel hypoplasia of deceased found in burials at the Boisman-2 settlement. Group-burials of male and female deceased with traces of violent death have been discovered. Most of the deceased died clearly at premature age. This record may indicate conflicts as a result of competition for diminishing traditional marine food resources. Another sign of a food crisis is the intensification of the use of fry of the main species of fish and shellfish caught (Vostretsov, 1998).

Cooling and drying (more pronounced in the inner, more continental regions) possibly also promoted the migration of the communities representing the Zaisanovskaya cultural tradition from eastern and south-eastern Manchuria to the adjacent regions of western Primorye via the valleys of the Razdol'naya and Krounovka rivers.

A more pronounced climate cooling and a weakening of the East Asian summer monsoon at the beginning of the Subboreal (ca. 4.7–4.2 $^{14}$C ka BP/5.4–4.7 cal ka BP) in the continental regions were accompanied by severe droughts, which possibly stimulated a further advancement of agricultural communities from eastern Manchuria and a further spread of agriculture within the Primorye region and to the areas previously occupied by Boisman culture people (Besednov and Vostretsov, 1997). Around 3.3 $^{14}$C ka BP/3.6 cal ka BP, the Zaisanovskaya culture disappeared in the region and gave way to the new cultures of the Palaeometal Epoch.

During the second half of the Subboreal, the climate became warmer and the sea level rose. The warming likely caused an increase in the temperature of coastal waters, which led to a higher productivity in the littoral zone. These processes probably stimulated an increase in coastal populations, as suggested by the rising numbers of Yankovskaya culture settlements in the southern and south-eastern coastal zones of Primorye during the early phase of this cultural period. Frequent finds of the bivalve *A. subcrenata* and the closely related species *A. inaequivalvis* in shell middens indicate that the water temperature was warmer than today, but colder than during the time of the Boisman culture (Alekseeva et al., 1999). The catch was predominated by warm-water species, such as Pacific mackerel, tuna (*Thunnus thynnus*), needlefish and pufferfish (*Takifugu* spp.), which are now found further south (Besednov and Vostretsov, 1997). The number of known Yankovskaya culture sites on the coasts of Primorye far exceeds the number of sites of any previous archaeological cultures, thus indicating a successful adaptation strategy based on the exploitation of marine resources under favourable environmental conditions.

It is conceivable that climate cooling at ca. 2.5 $^{14}$C ka BP/2.5 cal ka BP and a decrease in the level of the Sea of Japan below the modern one negatively influenced the coastal marine resources and challenged the life of the Yankovskaya culture communities. Archaeological records indicate a sharp decline in the number and density of Yankovskaya culture sites in the coastal areas and a shift to areas located further inland along the valleys of large rivers, such as Partizanskaya, Razdol'naya and Sukhodol during the second half of the Yankovskaya period (Vostretsov, 2013).

At the same time, the Krounovskaya culture groups migrated from southern Manchuria to Primorye and the Korean Peninsula. Along the Ussuri River corridor, the bearers of the Poltsevskaya culture move to the southern Primorye from the Amur region.

Climate cooling and its associated environmental changes forced the local populations to adapt their subsistence strategies, which is reflected in a shift towards more intensive and efficient farming and animal husbandry and thus a strengthening of food production. This process was supported by a widespread use of metal tools. Around 1800–1700 years ago, there was a sharp decrease in the number of Krounovskaya culture sites and the emergence and spread of the new Mohe culture, characterised by a highly adaptive multicomponent economy (Piskareva et al., 2019a). However, whether these cultural developments were related to climate change remains unknown. The formation of the Bohai state coincided with a phase of climate amelioration during the Medieval Climate Optimum. These favourable conditions and the state organisation of the Mohe tribes contributed to the further spread of agriculture and its increasing role in the economy, as seen in the archaeological and archaeobotanical records (Sergusheva, 2014).

## 6. Conclusions

The review of the published archaeological data and environmental reconstructions from the southern half of Primorye suggests a certain synchronicity between natural environmental changes and changes in the regional archaeological culture sequence. The early stages of human occupation in the study region and their possible relationships with global climatic changes during the Lateglacial still require more careful investigation, both in terms of archaeological and environmental data. The available Late Palaeolithic archaeological data from southern Primorye suggest that the human population distribution reflects availability of food resources and stone material for making tools and that the populations had far-distant contacts to the ancient cultures of the Amur River basin, Sakhalin, the Korean Peninsula and Northeast China. It is possible that the similarities in the material cultures of these regions were predetermined by a similarity in climate conditions and plant and animal communities in the eastern part of Northern Asia during the LGM and the early phase of the Lateglacial.

The Lateglacial warming culminated during the Allerød interstadial, which interrupted the long glacial environmental stability and probably forced the Late Palaeolithic hunter-gatherers to adapt their lifestyle to the new and quickly changing environments and faunal composition. This diversity of the post-glacial landscapes and associated major changes in the regional terrestrial and aquatic biomes may explain the diversity of the archaeological cultures during the Neolithic period, including changes in the material complexes and subsistence strategies. The broadening of the wild food spectrum during the Holocene thermal maximum contributed to the wide spread of highly adaptive Neolithic populations in both the continental and coastal parts of Primorye. However, the following climate deterioration and associated changes in the environments and available food resources posed a challenge that led to the disappearance of several Middle Neolithic cultures and the emergence of a new cultural tradition possessing agriculture in the Late Neolithic. During the following Late Holocene period, including the Bronze, Iron and Early Medieval ages, the role of animal and plant food production progressively increased, although hunting, fishing and gathering retained their importance during the entire period.

The existence of causal relationships between climatic and environmental changes and reconstructed human population dynamics in the region, including inter-regional migrations, spatio-temporal fluctuations in the settlement site and population numbers, changes in the adaptation and subsistence strategies and in the economic activity and cultural features, have been suggested and discussed in numerous publications. However, it is difficult to reach a definitive conclusion without additional research based on robustly dated and high-resolution environmental records and comparably well-dated archaeological material, including archaeobotanical and zooarchaeological records. A systematic use of the accelerator mass spectrometry (AMS) technique, which allows for radiocarbon dating of very small amounts of short-living organic material free of reservoir effects (e.g. terrestrial plant seeds and pollen concentrates) and high-resolution continuous pollen records, may be of great value in addressing this issue in future studies.

## Author contributions

Conceptualization: M.S.L., V.B.B., N.A.D.; Material and data collection: M.S.L., V.B.B., N.A.D.; Methodology: M.S.L., V.B.B., N.A.D.; Analysis: M.S.L., V.B.B., N.A.D.; Writing (original draft): M.S.L., V.B.B., N.A.D.; Writing (review and editing): M.S.L., V.B.B., N.A.D, C.L.; Visualization: M.S.L., V.B.B., N.A.D, C.L.

## Data availability

All data used to support the findings of this study are available in the paper.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

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