Turning Eastward: New Radiocarbon and Stable Isotopic Data for Middle Holocene Hunter-Gatherers from Fofanovo, Trans-Baikal, Siberia

J. Alyssa White[a]
Corresponding Author
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: julia.white@arch.ox.ac.uk

Rick J. Schulting[a]
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: rick.schulting@arch.ox.ac.uk

Peter Hommel[b]
[b] Department of Archaeology, Classics, University of Liverpool, 12-14 Abercromby Sq, Liverpool, L69 7WZ, UK
Email: peter.hommel@liverpool.ox.ac.uk

Vyacheslav Moiseyev[c]
[c] Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences, Universitetskaia Nab. 3, St. Petersburg, 199034, Russia
Email: vmoiseyev@mail.ru

Valeri Khartanovich[c]
[c] Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences, Universitetskaia Nab. 3, St. Petersburg, 199034, Russia
Email: vkhartan@kunstkamera.ru

Christopher Bronk Ramsey[a]
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: christopher.ramsey@arch.ox.ac.uk

Andrzej W. Weber[d,e,f]
[d] Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada T6G 2E5
[e] Aix Marseille Univ, CNRS, Minist Culture & Com, LAMPEA, Aix-en-Provence, France
[f] Research Centre “Baikal Region”, Irkutsk State University, Karl Marx Street 1, Irkutsk 664003, Russia
Email: aweber@ualberta.ca

Declarations of interest: none

Abstract

A considerable amount of bioarchaeological research – including AMS ^{14}C dating and stable carbon and nitrogen isotope analyses ($\delta^{13}C$ and $\delta^{15}N$) – has been undertaken on the hunter-gatherers from the area west of Lake Baikal, known as Cis-Baikal. No such work has previously been reported for the east side of the lake, Trans-Baikal. Here, we present new radiocarbon dates and isotopic results for twenty individuals from the Fofanovo cemetery, located along the Selenga River on the southeast coast of Lake Baikal.

Once corrected for an old carbon effect using regression equations developed for the Cis-Baikal, the radiocarbon results form 4 chronological clusters: 1) Late Mesolithic (LM), around 7950 cal BP (n=3); 2) Late Neolithic (LN), between ca. 6000 and 5500 cal BP (n=5); 3) LN to Early Bronze Age (EBA), between ca. 4900 and 4500 cal BP (n = 2); and the largest cluster 4) later EBA, around 3700 cal BP (n=10). The LM Cluster 1 dates indicate that formal cemetery use in Trans-Baikal may have begun earlier than in Cis-Baikal. Clusters 2 and 3 reveal a previously unidentified LN component to the cemetery. Additionally, the EBA Cluster 4 appears to be largely synchronous with the EBA in Cis-Baikal.

As a group, the Fofanovo individuals are isotopically distinct from the Middle-Holocene hunter–gatherers in the microregions of Cis-Baikal, exhibiting a combination of low $\delta^{13}C$ values (-19.4 ± 0.9‰) but high $\delta^{15}N$ values (15.2 ± 0.8‰). This likely reflects the distinctive isotopic ecology of the lower Selenga River, combined with use of aquatic resources from Lake Baikal itself. While further sampling is needed to test its robustness, a statistically significant difference between the LN (n = 6) and EBA (n = 11) was found, suggesting a greater reliance on the seasonal resources of the Selenga River during the EBA.

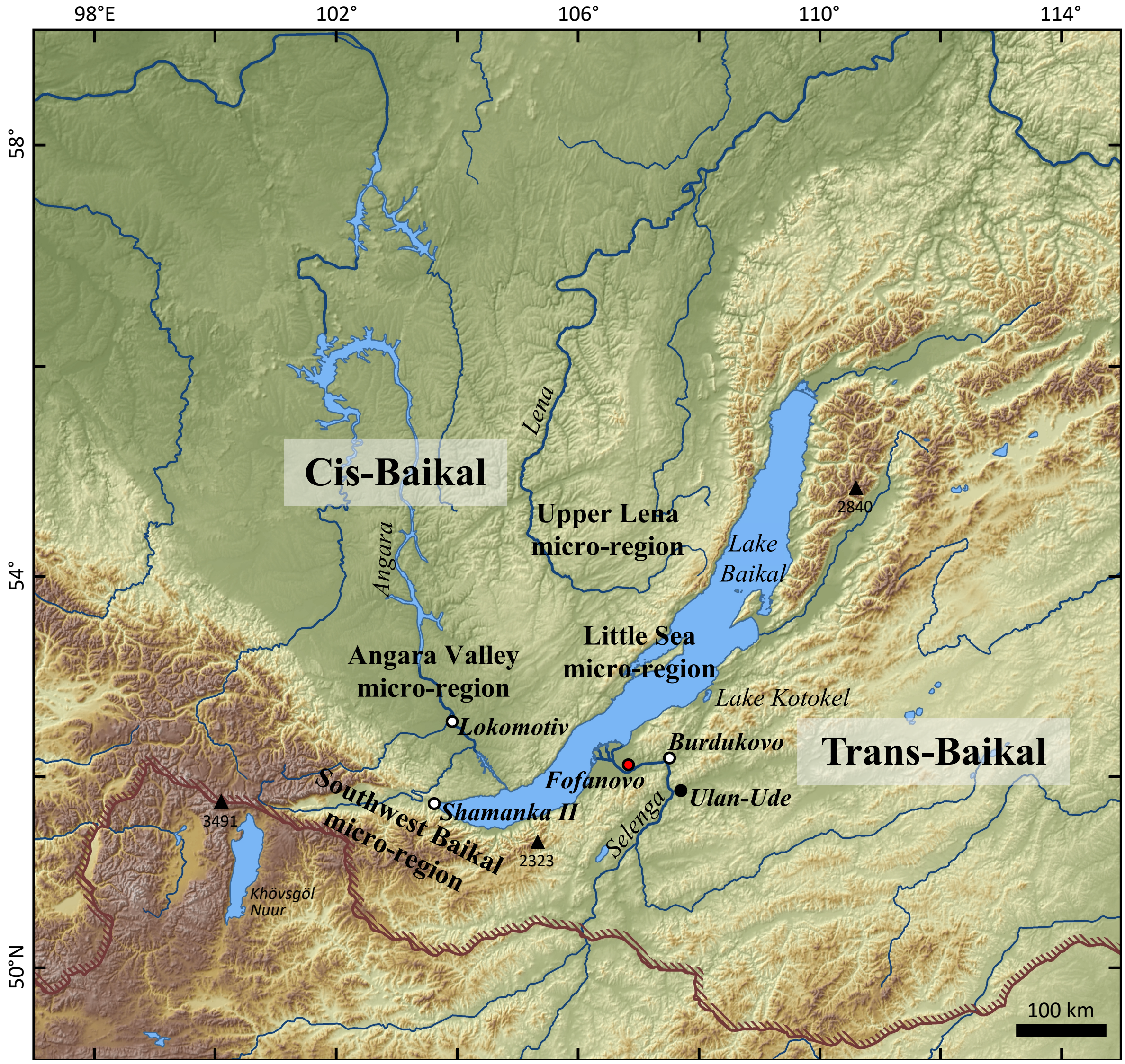
Further analyses on these and other individuals from the cemetery are planned and will undoubtably provide additional insights into hunter-gatherer subsistence adaptations and dietary variation in Trans-Baikal, highlighting both differences and similarities with those of Cis-Baikal.

Keywords: Trans-Baikal; Lake Baikal; Diet; Hunter-gatherers; Radiocarbon dating; Stable Isotopes.

1. Introduction

Since the late 19th century, archaeologists have extensively investigated prehistoric hunter-gatherers of the Baikal region, especially its particularly rich mortuary record (Michael, 1958; Okladnikov, 1950; 1955). In recent decades, the Baikal Archaeology Project (BAP, 1995–2011 and 2018–present) and Baikal–Hokkaido Archaeology Project (BHAP, 2011–2018) undertook fine-scale analyses of the diet, mobility, and chronology of Neolithic and Early Bronze Age individuals excavated from cemeteries on and around the western side of the lake, known as Cis-Baikal. Decidedly less is known about hunter-gatherer adaptations on the eastern side of the lake, Trans-Baikal. In this paper, we present radiocarbon dates and stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic results for 20 individuals from Fofanovo, a large, multi-period cemetery located near the delta of the Selenga River in Trans-Baikal (Figure 1). The aims are to better understand the cemetery's chronology and to characterise diet in relation to what is known about subsistence patterns in Cis-Baikal.

Figure 1: Map of the Lake Baikal Region (Cis- and Trans-Baikal) and the location of Fofanovo near the Selenga River delta. Topography is based on elevation Shuttle Radar Topography Mission (SRTM) v4.1 data (Jarvis et al., 2008). The map was created by Dr. Christian Leipe (FU Berlin).



2. Background

2.1.Region and Ecology

Lake Baikal is the oldest, deepest, and, by volume, largest lake in the world. The lake is fed by close to 400 tributaries, of which the Selenga River is the largest with an approximate length of 1,920 km. The Selenga River's drainage into Lake Baikal constitutes approximately half of the lake's inflowing water (Matveyev and Samusenok, 2015; Sampson et al., 2002).

The waters of Lake Baikal can be divided into five habitat zones: lagoons, expansive shallows, gulfs, deep-water (pelagic), and open coast littoral. There are three lagoons in the vicinity of the Selenga delta (Posol'skii, Cherkalovo, and Proval) and extensive shallows beyond the delta itself (Kozhov, 1963; Weber, 2003). The aquatic ecology of Lake Baikal has more in common with an ocean system than with most freshwater lakes (Matveyev and Samusenok, 2015). Fish common to the lagoons and coast of Lake Baikal are listed in Table 1. There is an endemic species of seal (*Phoca sibirica*) in the lake which may have contributed to the diets of the Fofanovo hunter–gatherers. This has been demonstrated for individuals from Cis-Baikal, primarily from the Little Sea microregion on the northwest side of the lake (Katzenberg et al., 2012; Nomokonova et al., 2013b; Nomokonova et al., 2015; Weber, 2003; Weber et al., 1998; Weber et al., 2011). Aquatic life in the Selenga River has not been studied archaeologically, but commercial, conservationist, and environmental studies have recorded the fish communities in different portions of the river (e.g., Sampson et al., 2002; Table 2). Most notably, the Selenga is a major spawning area for Baikal sturgeon and for one of the five main populations of the Baikal omul' (*Coregonus autumnalis migratorius*) (Dulmaa, 1999; Kozhov, 1950, 1963, 1972). The terrestrial environment of Cis- and Trans-Baikal is dominated by forest-steppe. Terrestrial fauna is rich throughout both regions, but vary in distribution depending on vegetation (Table 3).

Table 1: Fish common in the shallow lagoons and littoral open coastline of Lake Baikal (Weber, 2003; Kozhov, 1950, 1963, 1972). '+' denotes presence in the habitat zone.

Common Name	Species	Shallow Lagoons	Littoral Coastline
Burbot	*Lota lota*		+
Graylings	*Thymallus* spp.		+
Ide	*Leuciscus idus*	+	
Lenok	*Brachymystax lenok*		+
Northern pike	*Esox lucius*	+	
Omul'	*Coregonus autumnalis migratorius*		+
Perch	*Perca fluviatillis*	+	
Siberian dace	*Leuciscus leuciscus baicalensis*	+	+
Siberian roach	*Rutilus rutilus lacustris*	+	
Taimen'	*Hucho taimen*		+
Whitefish	*Coregonus lavaretus baicalensis*		+

Table 2: Fishes common in the lower Selenga River in recent times (Dulmaa, 1999; Matveyev and Samusenok, 2015; Sampson et al., 2002) and those sampled for isotopic study by Sampson et al. (2002) and Dufour et al. (1999).
*No isotopic data available

Common Name	Species
Amur catfish	*Parasilurus asotus*
Bluntnose minnow*	*Phoxinus phoxinus*
Burbot	*Lota lota*
Common carp	*Cyprinus carpio*
Giebel (Silver) carp	*Carassius auratus gibelio*
Ide	*Leuciscus idus*
Northern pike	*Esox lucius*
Omul'	*Coregonus autumnalis migratorius*
Perch	*Perca fluviatillis*
Siberian dace	*Leuciscus leuciscus baicalensis*
Siberian gudgeon*	*Gobio gobio*
Siberian roach	*Rutilus rutilus lacustris*
Spined loach	*Cobitis taenia*
Sturgeon	*Acipenser baerii baicalensis*
Taimen'	*Hucho taimen*
Whitefish	*Coregonus lavaretus baicalensis*

Table 3: Terrestrial fauna potentially available to Trans-Baikal Middle Holocene hunter–gatherers (Weber, 2003).

Common Name	Species	Preferred habitat
Boar	*Sus scrofa*	Forest and forest-steppe
Red deer	*Cervus elaphus*	Forest-steppe and taiga
Roe deer	*Capreolus capreolus pygargus*	Steppe and forest-steppe
Elk/Moose	*Alces alces*	Taiga wet valley
Mountain goat	*Capra siberica*	Eastern Sayan mountain valleys
Musk Deer	*Moschus moschiferus*	Highland and taiga
Reindeer	*Rangifer tarandus*	Mountain highlands

2.2.Archaeology and Chronology

Archaeologists have long classified Cis-Baikal Neolithic and Early Bronze Age (EBA) burials by their mortuary traditions. Recently, BAP/BHAP have refined the region's chronology through integrative studies of mortuary traditions, subsistence, diet, and radiocarbon dating corrected for the freshwater reservoir effect (FRE) (Table 4). Nevertheless, it is unclear to what extent Cis-Baikal's culture history is applicable to Trans-Baikal. Studies have highlighted significant variation in the style and timing of mortuary traditions between the different micro-regions of Cis-Baikal (Weber et al., 2016a). It is expected that similar, if not more, variation will be revealed in Trans-Baikal, especially considering that the earliest mortuary assemblages, Late Mesolithic (LM) and Early Neolithic (EN), at Fofanovo are distinct from their Cis-Baikal counterparts (Bazaliiskii, 2010).

Table 4: Chronology of the Cis-Baikal region (Weber et al., 2020). Chronological boundaries in the fifth column are based on Bayesian modelling of FRE-corrected radiocarbon dates on human skeletons using the trapezoidal distribution. Note that, due to the modelling, the mean Highest Posterior Density (HPD) dates are not directly comparable to mean cal BP dates.

Cis-Baikal period	Mortuary tradition	n	Range of mean cal BP ^{14}C dates	Start & End boundaries in mean HPD cal BP
Late Mesolithic	Khin	24	8427±56 to 7059±77	8633±160 to 7558±31
Early Neolithic	Kitoi	226	7756±75 to 6577±85	7558±31 to 6659±35
Middle Neolithic	N/A	0	N/A	N/A
Late Neolithic	Isakovo, Serovo	103	6110±81 to 4594±113	6060±57 to 4969±41
Early Bronze Age	Glazkovo	208	5014±110 to 3461±60	4969±41 to 3470±39

LM graves are relatively rare in Cis-Baikal, with 24 dated examples yielding corrected mean dates ranging from 8427±56 to 7059±77 cal BP, thus partly overlapping with the EN period (Table 4). These graves display substantial variation in mortuary but have been provisionally designated as the Khin Group (Weber et al., 2020). While some graves pre-date the EN Kitoi mortuary tradition from the Angara and Southwest Baikal, many, particularly in the Little Sea and on the Upper Lena, are clearly parallel to it. This implies regional asynchronicity in the development of these mortuary traditions (Weber et al., 2016a, 2020; Goriunova et al. 2020). The oldest large cemeteries in Cis-Baikal are primarily found in the Angara and SW Baikal micro-regions and date firmly to the EN.

The Middle Neolithic (MN) marks a long interruption in formal cemetery usage in Cis-Baikal, such that little is known concerning its mortuary practices. Although it is unlikely that this was a result of depopulation of the area (Weber, 2020), morphological and ancient DNA studies indicate that there is either genetic displacement between the EN and LN/EBA groups or greater admixture during the LN/EBA (de Barros Damgaard et al., 2018a, 2018b;Waters-Rist et al., 2016; Weber, 1995; Weber et al., 2002; Weber and Bettinger, 2010). Additionally, it has been posited that the incoming peoples were of western (i.e. the upper Yenisei) or southern (i.e. Mongolia or NW China) origin (Waters-Rist et al., 2016; Weber et al., 2002), though with little empirical support. Recent genetic analyses indicate that the LN and EBA component shows an increase in Ancient Northeast Asian (ANE) ancestry (de Barros Damgaard et al., 2018b). Some level of genetic continuity in the Angara micro-region has been proposed based on the cranial and dental evidence (Movsesian et al., 2014; Waters-Rist et al., 2016). The ancient DNA sample is still small, but the findings in Moussa et al. (2020) provide support for some regional genetic continuity through the MN. Examination of individuals from Trans-Baikal may provide important new insights on this matter.

In Cis-Baikal, formal cemeteries reappear in the Late Neolithic (LN) and continue into the EBA. Of the LN mortuary traditions, Isakovo is essentially only known from the Angara valley, while Serovo has been documented for the Angara, the Upper Lena (where it has also been called the Archaic variant; Okladnikov, 1978; Bazaliiskii, 2010), and the Little Sea, but with a few distinctive characteristics (Weber et al., 2016a; Goriunova et al. 2020).

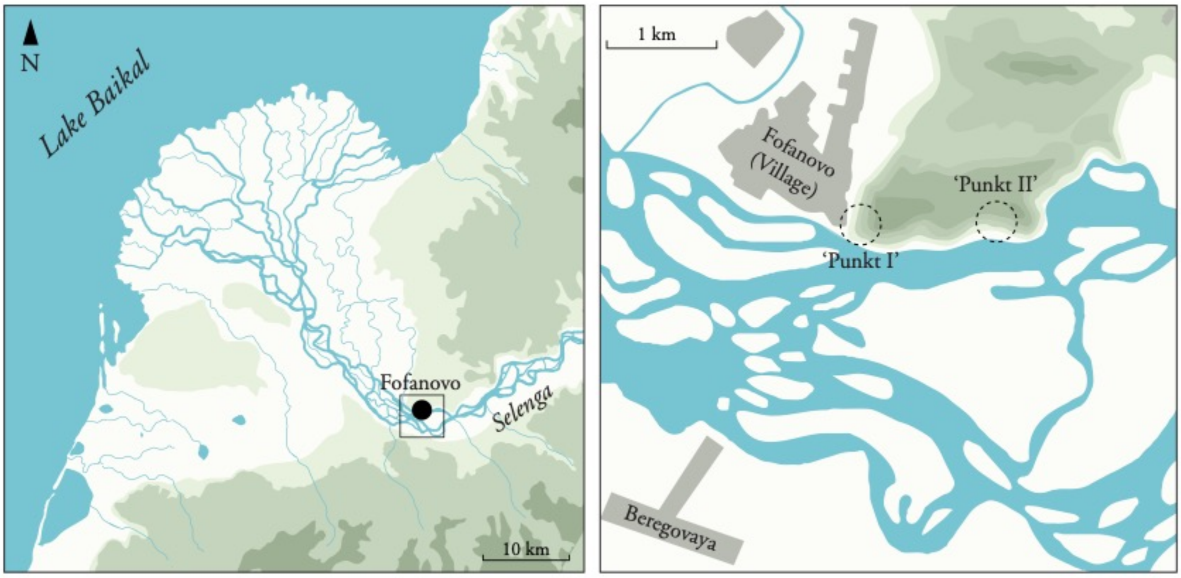
The relative chronological position of the EBA Glazkovo mortuary tradition is largely defined by the inclusion of copper and bronze grave goods, while retaining a hunter-gatherer economy (Weber and Bettinger, 2010). Glazkovo is also the most widespread mortuary tradition in Cis-Baikal showing a number of distinct mortuary characteristics across the micro-regions and is also archaeologically recognizable in Trans-Baikal.

Stable carbon and nitrogen isotope results unequivocally demonstrate a hunting, fishing and gathering subsistence economy throughout Cis-Baikal from the LM through the EBA (see Weber et al., 2016a for the most recent summary), as does the extensive archaeological evidence, such as zoomorphic art, subsistence-related stone and bone grave goods, including composite bone fishhooks, bone and stone arrowheads, and bone harpoons (Bazaliiskii 2010; Weber and Bettinger, 2010).

3. Fofanovo Cemetery

Fofanovo is located in the Selenga River valley, on the upper slopes of Fofanovskaia Gora (Fofanovo Mountain) on the right bank of the river. The prehistoric cemetery is ca. 0.5 km upstream from the village of the same name, ca. 45 km downstream from the city of Ulan-Ude (the capital of the Buryat Autonomous Republic), and ca. 45 km upstream from the coast of Lake Baikal (all distances as the crow flies). The Fofanovo cemetery (Figure 2) is separated into a “West Part” (“Punkt I”; 52.047286°N; 106.761650°E) occupying the SW slopes of the west end of Fofanovskaia Gora, and an “East Part” (“Punkt II”; 52.046672°N; 106.773333°E) on the SW and S slopes of its east end. Both are ca. 26–38 m above the river (Gerasimov and Chernykh, 1975: 23; Lbova et al., 2008: 29). Further details about the relevant excavations at the site carried out by A.P. Okladnikov and M.M. Gerasimov between 1926 and 1950 can be found in Supplementary Information (SI) section S1.

Figure 2: Map showing the location of Fofanovo along the Selenga River (Punkt I and II) and the surrounding area at the time of excavation. The description given in Lbova et al. (2008) places “Punkt I” just to the east of the village and immediately to the west of the modern cemetery. “Punkt II” is placed at the end of eastern end of the Fofanovo hills on the south western slope of Cape Shikhan. Adapted from Lbova et al. (2008, Fig. 2) by PH.



A history of the early and mid-twentieth century excavations at Fofanovo is provided in SI section S1. This work identified three groups of graves: Group 1, with affinity to the Kitoi mortuary tradition of the Angara valley in Cis-Baikal; Group 2 with affinity to EBA Glazkovo; and Group 3 of Early Iron Age Stone Cist Culture (Gerasimov and Chernykh, 1975). Of the 20 Fofanovo burials excavated by Gerasimov and Okladnikov in 1936, 1948, and 1950 examined in this study, one was classified as potentially Kitoi (then considered LN, but now known to date to the EN) six as EBA Glazkovo, and 13 were unclassified (SI Table S1). Noteworthy is the fact that none were thought to belong to the LN Isakovo or Serovo mortuary traditions, both well documented in Cis-Baikal (Bazaliiskii, 2010; Okladnikov, 1950, 1955, 1974, 1975, 1976, 1978).

3.1. Radiocarbon chronology

Prior to this study, only burials excavated by Gerasimov in 1959 had been radiocarbon dated. Mamonova and Sulerzhitskii (1989) published 10 dates for 9 burials (1 individual was dated twice) for Group 1 and 4 dates for Group 2 (Table 5). The paper also listed an additional 87 dates for Middle Holocene human burials from Cis-Baikal (see Weber, 1995). These dates predate the use of accelerator mass spectrometry (AMS) in radiocarbon dating and recent improvements in collagen extraction (Brock et al., 2010), have large errors ranges, and do not recognize the old carbon effect that was identified recently (Bronk Ramsey et al., 2014; Nomokonova et al., 2013a; Schulting et al., 2014). Nevertheless, there are a few patterns within them that are useful for general analysis and comparison.

First, the list published by Mamonova and Sulerzhitskii (1989) included 15 conventional ^{14}C dates for the Kitoi mortuary tradition from the Angara valley. These dates ranged from 6870±70 to 6040±100 BP, excluding two dates with very large errors (350 and 400 years), one of which was an outlier by a large margin (7990±350 BP). In comparison, the 9 dates for Fofanovo Group 1 ranged from 7040±100 to 6640±140 BP, excluding one outlier with a large error (7610±210 BP). This suggests that the two groups may not have been entirely synchronous. More specifically, the mortuary tradition represented by Fofanovo Group 1 could have started and ended earlier than the Kitoi tradition in the Angara valley.

Second, the four dates for Group 2 from Fofanovo (EBA Glazkovo) ranged from 4100±100 to 3670±40, while the 52 dates for Glazkovo burials from the entire Cis-Baikal (the Angara valley, Upper Lena valley, and Little Sea), excluding one date with large error (4500±600 BP), ranged from 4850±70 to 3390±60 BP. Although the sample size from Fofanovo was small, this evidence suggested similarity in the timing of the Glazkovo mortuary tradition on the east and west sides of the lake.

Third, no dates from Fofanovo indicated that there was a mortuary tradition present which dated to the long period separating Groups 1 and 2, i.e., synchronous with the Isakovo and Serovo mortuary traditions in Cis-Baikal. Additionally, no dates appear to relate to the Group 3 Stone Cist Culture graves (EIA) defined by Gerasimov and Chernykh (1975), which were likely deliberately excluded from the late 1980’s Russian dating project.

Table 5: Radiocarbon dating of human bone samples from Fofanovo reported by Mamonova and Sulerzhitskii (1989:23–24; see also Weber, 1995: Table 1). These are conventional radiocarbon dates using an estimated half-life of 5568 years rather than the more widely accepted 5730 ± 40 years. The dates are not corrected for the old carbon effect due to the lack of associated stable isotopic data, but can be assumed to be too old by some centuries. Fofanovo 7-7 (1) and (2) are samples from the same individual. Fofanovo 7-4 is italicized due to its large error term.

ID	Burial Complex	Lab No.	Date BP	±
Fofanovo 7-4	*Kitoi*	*GIN 4470*	*7610*	*210*
Fofanovo 7-5	Kitoi	GIN 4129	7040	100
Fofanovo 7-6	Kitoi	GIN 4139	7000	60
Fofanovo 7-1	Kitoi	GIN 4476	6830	60
Fofanovo 7-7 (2)	Kitoi	GIN 4478	6780	110
Fofanovo 7-7 (1)	Kitoi	GIN 4131	6450	50
Fofanovo 7-3	Kitoi	GIN 4471	6780	120
Fofanovo 2	Kitoi	GIN 4127	6720	70
Fofanovo 6	Kitoi	GIN 4472	6670	100
Fofanovo 5	Kitoi	GIN 4470	6640	140
Fofanovo 10	Glazkovo	GIN 4803	4100	100
Fofanovo 25	Glazkovo	GIN 4485	3890	50
Fofanovo 36	Glazkovo	GIN 4474	3740	50
Fofanovo 27	Glazkovo	GIN 4473	3670	40

3.2. Summary of previous typological and radiocarbon dating

There is a long tradition of assessing the mortuary variation and chronology of Fofanovo in the context of developments in Cis-Baikal archaeology. Nevertheless, the differences between the Kitoi in the Angara valley and the Group 1 graves at Fofanovo, noted by Gerasimov and Chernykh (1975: 23), have not been ignored. According to V.I. Bazaliiskii:

> While they share some similarities with Kitoi burials, the mortuary assemblages of the East Baikal (Fofanovo) group display important differences, including supine and side body positions, both with flexed legs, and southeast orientation of the head. The composite fishhooks of the Kitoi type, bifacially shaped arrowheads, and clay vessels are absent in graves of this group (Bazaliiskii, 2010: 71–72).

With regard to Group 2 graves, Gerasimov and Chernykh (1975: 43–44) noted numerous similarities in grave architecture, burial orientation, and grave good morphology with the EBA Glazkovo in Cis-Baikal. The list included the presence of surface stone structures, burial orientation along the river with heads pointing upstream, lithic triangular arrowheads with straight or concave bases, lithic spear-points/knives, bone shafts for composite daggers, bone or antler harpoons, shanks for composite fishhooks, and copper/bronze knives and fishhooks. The main difference between the two areas was the more frequent occurrence of clay vessels at Fofanovo relative to Glazkovo graves in Cis-Baikal, where they are rare. Furthermore, according to the authors, the pots with round or pointed bottoms at Fofanovo morphologically resembled Serovo vessels from the Angara valley. One other difference was the absence of white nephrite ornaments in EBA graves at Fofanovo, though this was attributed to grave looting in the past (Gerasimov and Chernykh, 1975: 44).

Thus, excluding from consideration the five EIA graves of Group 3, both radiocarbon and typological dating identified two main Middle Holocene chronological groups: Fofanovo Group 1, roughly parallel to, although perhaps older than the EN Kitoi in Cis-Baikal; and Fofanovo Group 2, quite consistent in terms of chronology and mortuary variation with the EBA Glazkovo in Cis-Baikal.

Of Fofanovo's ~102 Middle Holocene graves only eight were radiocarbon dated in the 1980's study, forming two temporal clusters with four graves in each. The remaining 94 graves, however, were dated only typologically or not at all. Classification of the remaining three graves from the 1959 excavations by Gerasimov and of the 17 graves excavated by Konev as from the older (EN) Group 1 appears to be sound, along with the classification of 25 Group 2 graves excavated by Gerasimov in 1959 as EBA Glazkovo. However, the similarities with pottery from the older Serovo graves, now dating to the Late Neolithic (LN), directly before Glazkovo, are suspicious (Goriunova et al., 2020). Additionally, 27 graves (10 from Gerasimov's early excavations, 15 from Okladnikov's fieldwork in 1948, and two from Okladnikov's 1950 excavations) have not been classified thus far. Lastly, classification of the remaining 22 graves excavated by Okladnikov (four in 1948 and 18 in 1950) should be considered tentative due to the lack of formal justification, despite his comprehensive knowledge of the material.

It is important to note that much of this chronological and mortuary assessment of the Fofanovo cemetery has been conducted explicitly in reference to the much more abundant and better documented materials from Cis-Baikal and in reference to the Middle Holocene culture history model whose boundaries and units were developed by Okladnikov. In this culture history model, as has only been understood since the mid-1990s, three (Kitoi, Isakovo, and Serovo) out of five mortuary traditions, or stages, were assigned an incorrect chronological position by Okladnikov (Weber, 1995). While generally quite accurate, the limitations of typological dating have been recently highlighted due to extensive radiocarbon dating (Weber et al., 2006; Weber et al., 2016a) and the accumulation of numerous new Middle Holocene cemetery materials in Cis-Baikal. Examination of these new materials helped identify several aspects of micro-regional and temporal variation in mortuary protocols that were previously unknown (e.g., Bazaliiskii, 2010; Goriunova and Novikov, 2010; Weber et al., 2016a).

Overall, there is much to learn from a systematic radiocarbon dating programme, coupled with other analyses, of a large multi-component cemetery covering a very long timespan like Fofanovo in Trans-Baikal.

4. Stable Isotopic Analyses

Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic analyses of bone collagen provide information on aspects of an individual's diet (Lee-Thorp 2008). Although rarely able to identify specific foods, the technique allows for semi-quantification of broad food groups, such as C_3 or C_4 plants, marine/freshwater fish, and terrestrial flora/fauna. Stable carbon isotopic ratios are affected by different photosynthetic pathways and by carbon pools (e.g., atmospheric vs. marine), whereas stable nitrogen isotopic ratios primarily reflect trophic level. Carbon isotopic values are influenced by the preferential routing of amino acids during the metabolic processes of the body, whereas nitrogen is only present in the protein component of the diet (Ambrose and Norr, 1993; Hedges and Reynard, 2007; Tieszen and Fagre, 1993). Measurements on adult bone collagen provide a dietary average of approximately the last decade of adult life, depending on the bone analysed and the age and health status of the individual (Hedges et al., 2007; Tieszen et al., 1983).

$\delta^{13}C$ values vary by C_3, C_4, and CAM photosynthetic pathways of primary producers, so that the animals reliant on them also reflect this differentiation. However, the taiga and forest-steppe surrounding Lake Baikal are overwhelmingly composed of C_3 plants so that C_4 and CAM pathways are not relevant to the present study. Marine sources reflect oceanic carbon pools that are more enriched in ^{13}C than atmospheric carbon pools (DeNiro and Epstein, 1978; Schoeninger and DeNiro, 1984). While it is a freshwater system, Lake Baikal's unique isotopic ecology results in a wide range of $\delta^{13}C$ values, from depleted, which are more typical of freshwater systems, to enriched, marine-like, values (Yoshii, 1999; Yoshii et al., 1999). This makes resources from terrestrial, lake, and riverine systems in the Baikal region isotopically distinguishable from one another to a greater degree than is usually possible, and hence offers greater potential for human dietary resolution.

^{15}N enrichment corresponds to increasingly higher trophic levels in a food chain. Aquatic predators tend to have very high $\delta^{15}N$ values due to their position within complex, extended food webs. The trophic level enrichment factor for humans is not precisely known, with a range of +3–5‰ often cited (DeNiro and Epstein, 1981; Hedges and Reynard, 2007; Minagawa and Wada, 1984; Schoeninger and DeNiro, 1984), though a value as high as +6‰ has been proposed (O'Connell et al., 2012). Additionally, there is a trophic level enrichment of approximately +1‰ in $\delta^{13}C$ (DeNiro and Epstein, 1978; Bocherens and Drucker, 2003).

5. Baikal's Isotopic Ecology

Lake Baikal's primary producers, phytoplankton and periphytic algae, have a $\delta^{13}C$ range greater than 20‰, which continues through the entire food chain (Yoshii, 1999; Yoshii et al., 1999). ^{13}C enrichment in fish varies by their preferred habitat. Pelagic fish species, such as the omul', tend to be depleted in ^{13}C while shallow water fishes tend to be enriched. Baikal's seal population largely preys on small pelagic fish, and therefore has low $\delta^{13}C$ values. Seal and pike are apex aquatic predators and have high $\delta^{15}N$ values, averaging ca. 14‰ and ca. 12‰, respectively (Table 6; Katzenberg and Weber, 1999; Katzenberg et al., 2010).

Since, with few recent exceptions (Losey et al., 2008; Losey et al., 2012; Nomokonova et al., 2010; Nomokonova et al., 2015), archaeological excavations in the Baikal region have rarely employed dry and wet screening techniques, few archaeological fish bones have been recovered and isotopic tests on them are correspondingly uncommon. Therefore, most studies rely on results from modern fish, including those done by BAP/BHAP. $\delta^{13}C$ values within an organism differ by tissue, such that measurements on fish muscle are not directly comparable to those derived from bone collagen, requiring a correction of +2.9‰ (Robson et al, 2012). Additionally, it is necessary to apply a correction of +1.2‰ to all modern samples to account for the burning of fossil fuels in modernity, which has introduced ^{13}C-depleted carbon into the atmosphere (Friedli et al., 1986).

Previously considerable effort has gone into creating a terrestrial and aquatic isotopic baseline, analysing modern and, when accessible, archaeological terrestrial and aquatic fauna for Cis-Baikal (Katzenberg et al., 2012; Weber, 2003; Weber and Bettinger, 2010; Weber et al., 2011) (Table 6). However, gaps in coverage do remain, most notably for Trans-Baikal. The lower Selenga River is a spawning ground for omul' and sturgeon, which could have potentially provided an important resource for those living along the river.

Table 6: Isotopic values for selected terrestrial and aquatic species reported in previous studies on Cis- and Trans-Baikal fauna. Stable carbon isotope results for modern samples have been adjusted for the 'Suess' (fossil fuel) effect (+1.2‰) while those obtained from flesh have been adjusted for a flesh to bone collagen fractionation factor (+2.9‰).

Location	Species (Common)	Tissue	Period	$\delta^{13}C$		$\delta^{15}N$		n	Source
				$\bar{x}$	sd	$\bar{x}$	sd		
Aquatic									
Lake Baikal	Omul'	Muscle and Bone coll	Modern	–22.0	1.8	10.7	1.1	33	Katzenberg et al. (2012); Kucklick et al. (1996); Weber et al. (2002); Yoshii et al. (1999)
Little Sea	Omul'	Bone coll	Modern	–15.1	2.0	9.4	0.1	4	Katzenberg et al. (2012)
Lower Selenga	Omul'	Bone coll	Modern	–23.0	0.5	8.9	0.8	19	Dufour et al. (1999)
Lake Baikal	Fish spp. (ex. omul')	Bone coll	Modern	–16.5	4.5	10.6	1.7	30	Katzenberg et al. (2012); Weber et al. (2002)
Lower Selenga	Fish spp. (ex. omul')	Bone and Flesh	Modern	–21.7	1.8	12.9	1.4	55	Sampson et al. (2002)
Lake Baikal	Seal	Bone coll	Archaeol	–22.5	0.8	14.2	1.4	10	Katzenberg et al. (2012); Weber et al. (2002)
Terrestrial									
Baikal Region	Terrestrial herbivores	Bone coll	Archaeol	–20.0	1.1	5.0	1.2	25	Katzenberg et al. (2012) Weber et al. (2002)
Baikal Region	Terrestrial Omnivores/ Carnivores	Bone coll	Archaeol	–18.8	1.0	10.7	3.0	9	Katzenberg et al. (2012) Weber et al. (2002)

Unfortunately, no isotopic measurements on archaeological fish are available from the Selenga River, but averages for modern fish are provided in Table 6. These may not accurately reflect those of the Neolithic and Bronze Age (e.g., due to industrial and agricultural impacts, and to overfishing; Sampson et al., 2002). Nevertheless, modern values indicate that fish, particularly the omul', from the Selenga are generally not ^{13}C-enriched, in contrast to some Baikal fish. Together with archaeological and modern values for fish, seals and terrestrial fauna from Cis-Baikal, these data provide a preliminary isotopic baseline for comparison with the human results.

6. Materials and Methods

Human bone from 22 individuals was sampled from collections stored at the Museum of Archaeology & Ethnography (Kunstkamera), St. Petersburg. Due to the variable degree of completeness, it was not possible to consistently sample the same skeletal element. Nevertheless, only cortical bone was sampled from long bones, crania, or mandibulae.

Samples were first surface-cleaned with an aluminium oxide shotblaster at the University of Oxford's Research Laboratory for Archaeology and the History of Art (RLAHA). Those weighing over 1 g were sub-sampled and prepared separately for stable isotopic analyses in both RLAHA's radiocarbon (ORAU) and palaeodiet laboratories. The pre-treatment and measurement methods between the two labs differed slightly; however, no significant differences were observed between the results obtained by the two methods, as has been demonstrated previously (White et al., 2020) and, consequently, the results were averaged.

Both sets of samples were ground and left to soak in 5°C hydrochloric acid (HCl, 0.5 M) for three days or until they no longer reacted to the acid. The ORAU protocol samples were then washed with sodium hydroxide (NaOH, 0.1 M) in order to remove any humic acids present and ultra-filtered using a 30kD filter to remove large molecular contaminants (Brock et al., 2007, 2010). This additional step is the main difference between the two lab protocols. Following this, all samples were washed with Milli-Q water and sonicated for 20 minutes. The samples were then gelatinized by soaking them in a pH 3 solution for 24 hours, and then sealed and heated in 70°C for three days. After this the remaining liquid was filtered out and the resulting 'collagen' was freeze-dried.

All collagen samples were analysed using a Sercon 20/22 Isotope Ratio Mass Spectrometer (IRMS). The samples prepared using the palaeodiet protocol were analysed in duplicate with alanine standards and in-house standards of cow ($\delta^{13}C$ = −24.21‰, $\delta^{15}N$ = 8.00‰) and seal ($\delta^{13}C$ = −12.00‰, $\delta^{15}N$ = 16.61‰) bone collagen, whereas the samples processed according to the ORAU protocol were measured in triplicate with alanine ($\delta^{13}C$ = −27.11‰, $\delta^{15}N$ = –1.56 ‰) and USGS40 ($\delta^{13}C$ = −26.39‰, $\delta^{15}N$ = –4.52 ‰) and USGS41 ($\delta^{13}C$ = 37.63‰, $\delta^{15}N$ = 47.57‰) standards. Alanine was used to correct for machine drift and the in-house cow and seal standards were referenced to international standards of VPDB for $\delta^{13}C$ and AIR for $\delta^{15}N$ through repeated measurement. Values were then drift-corrected, calibrated relative to the in-house and international standards (cf. Coplen et al. 2006), and averaged between runs. Measurement precision for both $\delta^{13}C$ and $\delta^{15}N$ is on the order of ± 0.2‰ based on repeat analyses of standards. Collagen quality was assessed based on collagen yield (>1%) and atomic C/N ratios (2.9–3.6) (Ambrose, 1990; DeNiro, 1985; van Klinken, 1999).

Samples prepared for radiocarbon dating were combusted using a Continuous Flow IRMS at which time their isotopic composition was assessed (Brock et al, 2010). Samples were then graphitised and their ^{14}C concentration measured using accelerator mass spectrometry (AMS) (Dee and Bronk Ramsey, 2000).

Based on previous research in Cis-Baikal, aquatic foods are expected to have played a significant role in the diets of those interred at Fofanovo. This, in turn, will lead to a varying but often considerable FRE through the introduction of old carbon from the lake and its surrounding rivers (Bronk Ramsey et al., 2014; Schulting et al., 2014; 2015; 2020; Weber et al., 2016a). Linear regression formulae have been calculated using paired human-terrestrial fauna radiocarbon dates for southwest Baikal and the Angara, Little Sea, and Upper Lena micro-regions, and for the Cis-Baikal region in general (Table 7) (Schulting et al., 2014; 2015). In the absence of knowledge of the precise reservoir offset that applies to the Fofanovo humans sampled, we have provisionally used the model developed for Cis-Baikal. While not ideal, this is undoubtedly preferable to applying no correction at all. With the exception of the Upper Lena, which has no connection to Lake Baikal, the other formulae factor in the offset caused by the consumption of aquatic resources from the lake. These will be at least partly relevant to the individuals from the Lower Selenga, since: 1) A number of fish species move between the lake and the river, especially for spawning (most notably the omul' and sturgeon); and 2) Hunter–gatherer groups using Fofanovo for burial likely lived close enough to the lake itself to have had either direct or indirect access to its aquatic food resources.

Table 7: FRE correction formulae (Schulting et al., 2014; Weber et al., 2016a). In the adjusted error calculation, the standard deviation (s.d.) is that of the conventional ^{14}C date. 'S' is the standard deviation of the residuals from the FRE correction formulae provided in the original publication.

Source	**Formula**
General Baikal "Excluding outliers, $\delta^{15}N$" FRE	$-732.8 + 76.6\ (\delta^{15}N)$
"Little Sea, $\delta^{13}C$ & $\delta^{15}N$" FRE	$-3329.5361 - 125.5967\ (\delta^{13}C) + 95.1091\ (\delta^{15}N)$
"SW Baikal/Angara" FRE	$-1388.8522 + 125.4503\ (\delta^{15}N)$
Adjusted error term (Weber et al. 2016a)	$\sqrt{(\mathrm{s.d.})^2 + \mathrm{S}^2}$

The FRE-corrected dates were calibrated in OxCal v.4.3.2, using IntCal13 (Bronk Ramsey, 2009; Bronk Ramsey et al., 2013; Reimer et al., 2013). Kernel Density Estimation (KDE) modelling, a way of summarising dates while reducing the noise and excessive spread of sets of five or more radiocarbon dates, was carried out in OxCal as well (Bronk Ramsey, 2017).

All statistical tests were carried out using IBM Statistical Package for the Social Sciences (SPSS) 24.0. Shapiro-Wilk tests were used to assess normality, and parametric or non-parametric tests were applied, as appropriate, to compare central tendencies between groups. Outliers were defined as exceeding 1.5 times the interquartile range (IQR).

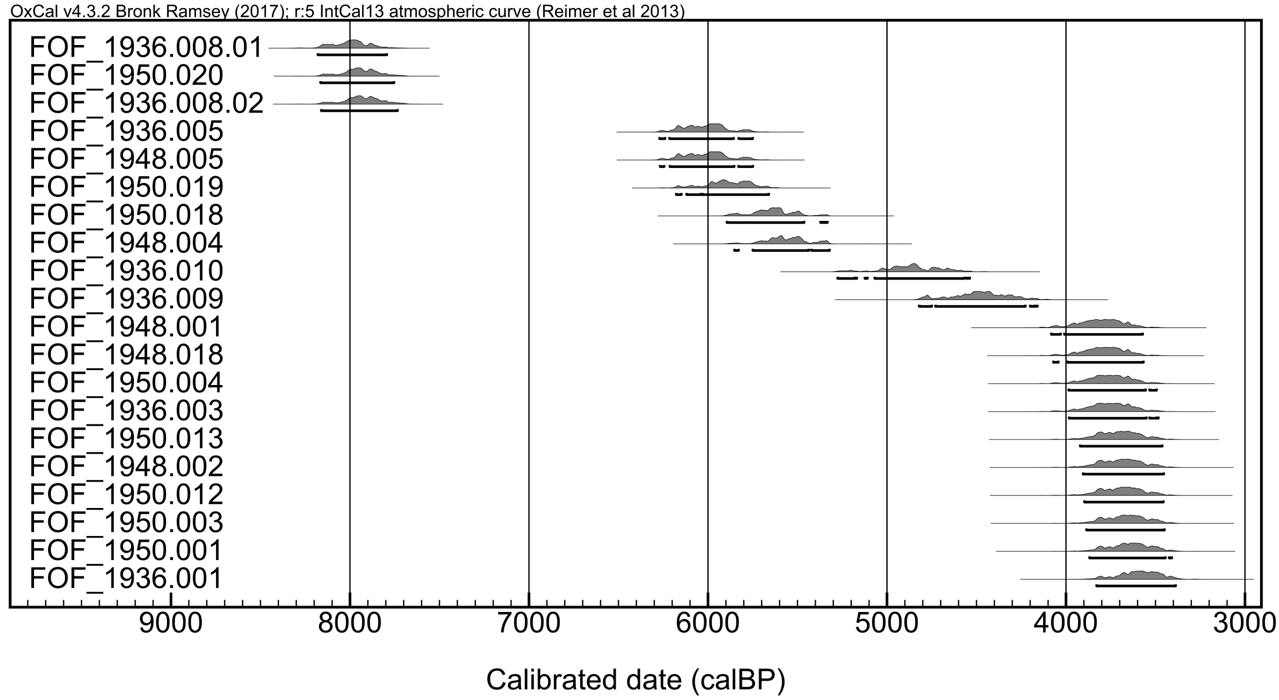
7. Results and Discussion

7.1. Analysis of new radiocarbon dates from Fofanovo

Two samples from Fofanovo failed the *in vivo* C:N criterion, with values of 12.5 (FOF_1948.003) and 4.25 (FOF_1948.010) and were excluded from analysis. All other samples had C:N values between 2.9 and 3.6 (DeNiro, 1985). One individual (FOF_1948.018) was dated twice as part of ORAU's standard procedure of randomly duplicating a certain number of measurements for quality control. Its radiocarbon dates were R_Combined in OxCal (see Weber et al. 2016a) and then corrected for the FRE offset (Table 8). A general FRE correction for consumers of Lake Baikal aquatic foods applied to the conventional radiocarbon dates from Fofanovo yields an average offset of 433 ± 59 ^{14}C years (Table 8; Figure 3). Using FRE correction equations developed for the Angara/SW Baikal and the Little Sea provide slightly larger average offsets of 521 ± 96 years and 550 ± 159 years, respectively.

Table 8: [Catalogue uploaded as separate file]

Figure 3: Calibrated radiocarbon dates from the Fofanovo cemetery corrected with the general Baikal FRE equation (see Tables 8 and 9).



The new ^{14}C dates from Fofanovo are assessed with reference to well-established comparanda from Cis-Baikal, where considerable data are available regarding Middle Holocene cemeteries. This includes Weber et al.'s (2020) comparative assessment of 561 AMS radiocarbon dates from the entirety of Cis-Baikal (see note in SI section S2). Additionally, comparisons are made to Weber et al.'s (2016b) detailed examination of Shamanka II, an EN and EBA cemetery located in the southwest corner of Lake Baikal, approximately 220 km west along the south coast of the lake from the Selenga delta. The 14 dates published for Fofanovo earlier by Mamonova and Sulerzhitskii (1989) are also used for comparison.

Unlike the 14 dates published by Mamonova and Sulerzhitskii, which form two temporal clusters, our dates suggest four clusters, the first two of which are separated by about 1,900 years and the later two by roughly 700 years each (Table 9). The oldest three dates clearly relate to Gerasimov and Chernykh's (1975) Group 1 graves. These dates correspond also with the expansion of the boreal forest and wet conditions at ca. 9.2–7.7 ka BP in the Selenga micro-region based on the analysis of paleoenvironmental proxies from the Burdukovo site, ca. 50 km from Fofanovo (White et al., 2013). The results of coring at Lake Kotokel support a ca. 7 ka cal BP maximum expansion of the boreal forest in the region (Kobe et al., 2020).

Table 9: Discrete chronological clusters of radiocarbon dates from Fofanovo (n = 20) in mean cal BP.

Chronological cluster	Range of mean cal BP ^{14}C dates	n	Period assignment
Cluster 1	7995±101 to 7930±102	3	LM
Cluster 2	6016±120 to 5561±116	5	LN?
Cluster 3	4864±160 and 4481±156	2	LN–EBA
Cluster 4	3805±124 to 3591±114	10	EBA

Conversely, the youngest 10 determinations seem to fit neatly within Gerasimov and Chernykh's Group 2, EBA Glazkovo. The intervening seven dates have no counterpart in the Mamonova and Sulerzhitskii dataset, but their number is small relative to the known size of the Fofanovo cemetery. None of these seven graves have been classified chronologically by the excavators or by Lbova et al. (2008), and will be discussed further below.

Okladnikov originally classified one of the burials in Cluster 1, the oldest group, (FOF_1950.020) as EBA Glazkovo. This was likely because no red ochre was found in the grave, which otherwise lacked any diagnostic characteristics typical of either mortuary tradition. The only grave goods were an unspecified number of small discs or beads (5–7 mm in diameter). The burial was supine with legs flexed to the left and the head pointing NE. The other two dates in this group are for burials excavated by Gerasimov in 1936, which have not been described or classified chronologically.

Among the 10 youngest dates, only one grave was originally assigned an incorrect chronological position (FOF_1950.012), 5 dates are consistent with the original classification, and 6 were not classified at all. This may suggest that EBA graves are the easiest to classify typologically; however, in cases where clear diagnostic characteristics are lacking, they are still subject to errors.

It can be inferred from this comparison that the three oldest dates in our dataset, considered together with some of the 1989 Russian dates, suggest that the beginning of the Fofanovo cemetery predates beginnings of Kitoi cemeteries on the Angara and Southwest Baikal by quite a large margin.

Comparison with the mean cal BP dates from Cis-Baikal provides more insights (Table 4). The oldest three Fofanovo dates fit comfortably within the Late Mesolithic and the youngest 12 match well with the EBA in Cis-Baikal. The youngest cluster of 10 dates (Table 9, Cluster 4) match very closely the distribution of six EBA Glazkovo dates from the Shamanka II cemetery (3593±67 to 3409±72; Weber et al., 2016a). Furthermore, these 10 dates can be R_Combined (3705±57 cal BP, χ^2-Test: df=9, T=3.2, 5% 16.9) in OxCal. That these 10 graves come from three different excavations at Fofanovo— two from 1936, three from 1948, and five from 1950 – demonstrates that they did not form a spatial cluster, yet form a tight chronological cluster. The entire EBA component from Fofanovo needs to be dated to address this matter further.

Assessment of the remaining five dates from Cluster 2 requires more attention. Relative to the culture history for Middle Holocene Cis-Baikal presented in Weber et al. 2016, these dates appear to be somewhat older than the lower LN boundary. However, at the time the LN boundary was defined by only 22 dates, which acted as a proxy for another 227 LN burials archaeologically documented (Weber and Bettinger, 2010). In a more recent study, the LN dataset has been expanded to 103 radiocarbon dates and the 5 dates from Fofanovo seem to fit well within the early stages of the LN Isakovo and Serovo mortuary traditions in Cis-Baikal (Weber et al. 2020). Continued dating of these materials may make the lower Isakovo and Serovo boundary still somewhat older. The matter will need to be reassessed once the freshwater reservoir correction applicable to the Selenga River is fully addressed.

7.2. Summary of new radiocarbon dating

The most important points emerging from the assessment of 20 new AMS dates on human remains from the Fofanovo cemetery are the following:

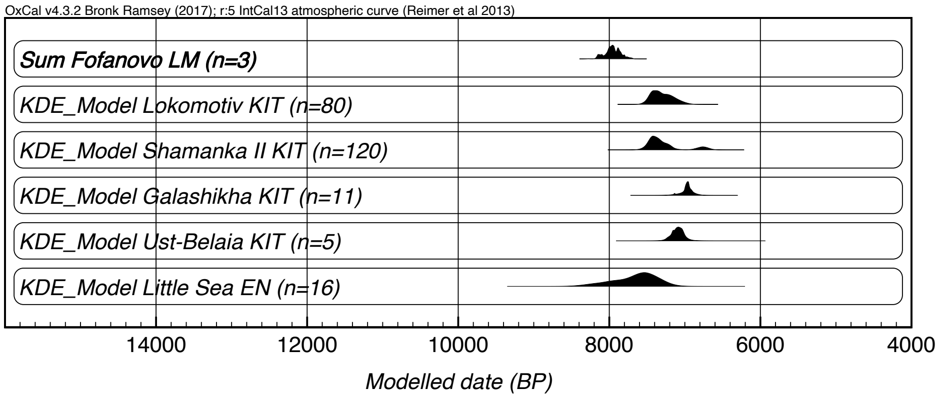
- Development of formal cemeteries in Trans-Baikal may predate similar developments in Cis-Baikal by a large margin. In Cis-Baikal, LM cemeteries are small and rare, and their mortuary protocol is variable to the extent that a cohesive and coherent mortuary tradition cannot be defined. Formal cemeteries with such mortuary protocols (i.e., the classic Kitoi) mark the beginning of the EN period, but at Fofanovo these developments appear to be much older.
- Fofanovo may have a substantial LN component which, to date, has gone entirely undetected by any typological assessment.

- The timing of the EBA Glazkovo mortuary tradition appears to be roughly similar on both sides of the lake.

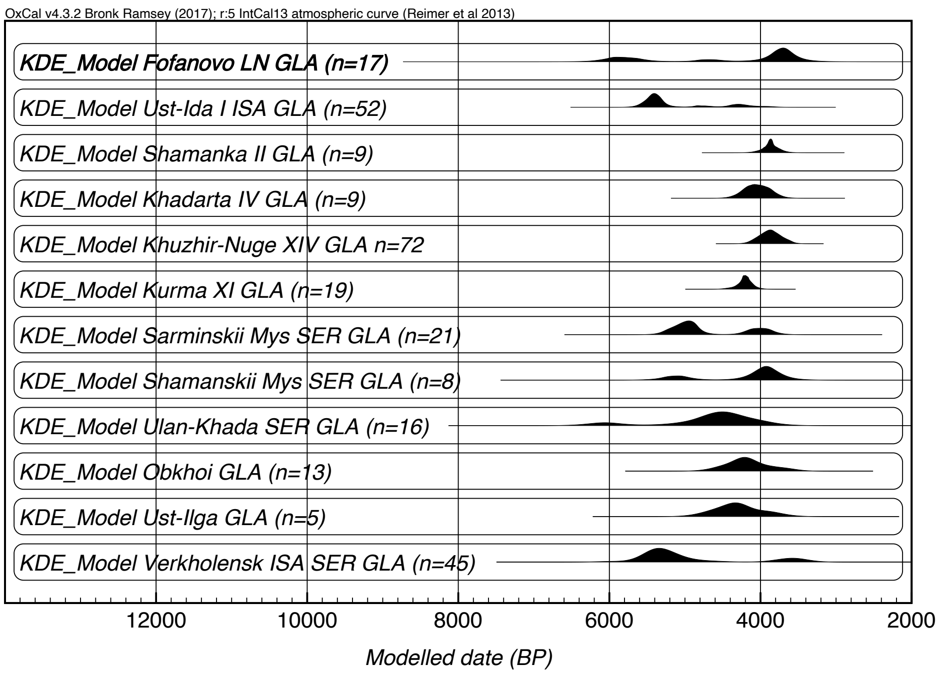
This analysis thus defines three chronological groups for the assessment of dietary patterns using stable isotope data: LM (n = 3), LN (n = 6), and EBA (n = 11). The chronological position of these three groups relative to several better-dated Middle Holocene cemeteries from Cis-Baikal is presented in Figure 4.

Figure 4: Chronological position of the three main analytical units from the Fofanovo cemetery relative to several well-dated Middle Holocene hunter–gatherer cemeteries in Cis-Baikal: (A) Late Mesolithic and Early Neolithic cemeteries; (B) Late Neolithic and Early Bronze Age cemeteries (Weber et al., 2020). Their relative chronological positions are directly comparable unlike the period boundaries expressed in HPD dates generated through Bayesian modelling (Table 4).

A. KDE model of LM and EN Trans- and Cis-Baikal dates



B. KDE model of LN and EBA Trans- and Cis-Baikal dates



7.3. Analysis of new stable isotope data from Fofanovo

A statistical and visual summary of the $\delta^{13}C$ and $\delta^{15}N$ values from Fofanovo is provided in Table 10 and Figure 5. Overall, the isotopic signatures of the individuals from Fofanovo are marked by relatively low $\delta^{13}C$ and high $\delta^{15}N$ values, as one would expect for individuals reliant on aquatic resources from the Selenga river, including spawning runs of some Baikal fishes, such as the omul' and the sturgeon (Figure 5). This results in an isotopic signature that is distinct from all other hunter-gatherer groups of Cis-Baikal, and thus constitutes a new microregion (Figures 6–8).

Table 10: Statistical summary of the isotopic results from Fofanovo by period.

Period	$\delta^{13}C$		$\delta^{15}N$		n
	$\bar{x}$	sd	$\bar{x}$	sd	
All	-19.4	0.9	15.2	0.8	20
LM	-19.2	0.3	15.5	1.4	3
LN	-18.6	0.9	14.6	0.7	6
EBA	-19.8	0.6	15.5	0.4	11

Figure 5: Stable isotopic results from all humans analysed at Fofanovo and local fauna data (Table 6). All modern values have been corrected for the Suess effect and flesh values have been corrected to be comparable to bone collagen isotopic values.

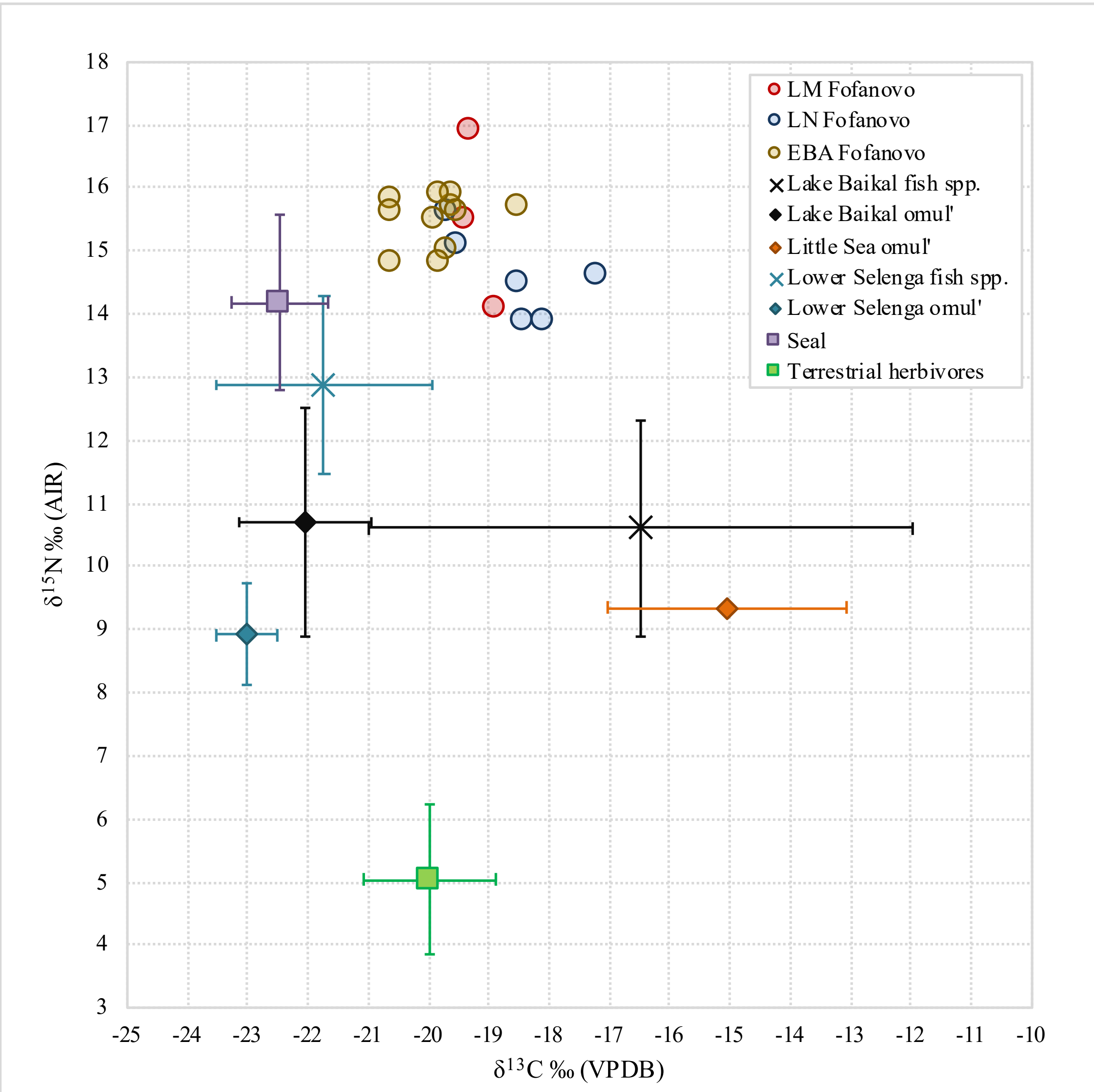


Figure 6: LM and EN individuals (age ≥ 5) from the Baikal region in the current BAP/BHAP database.

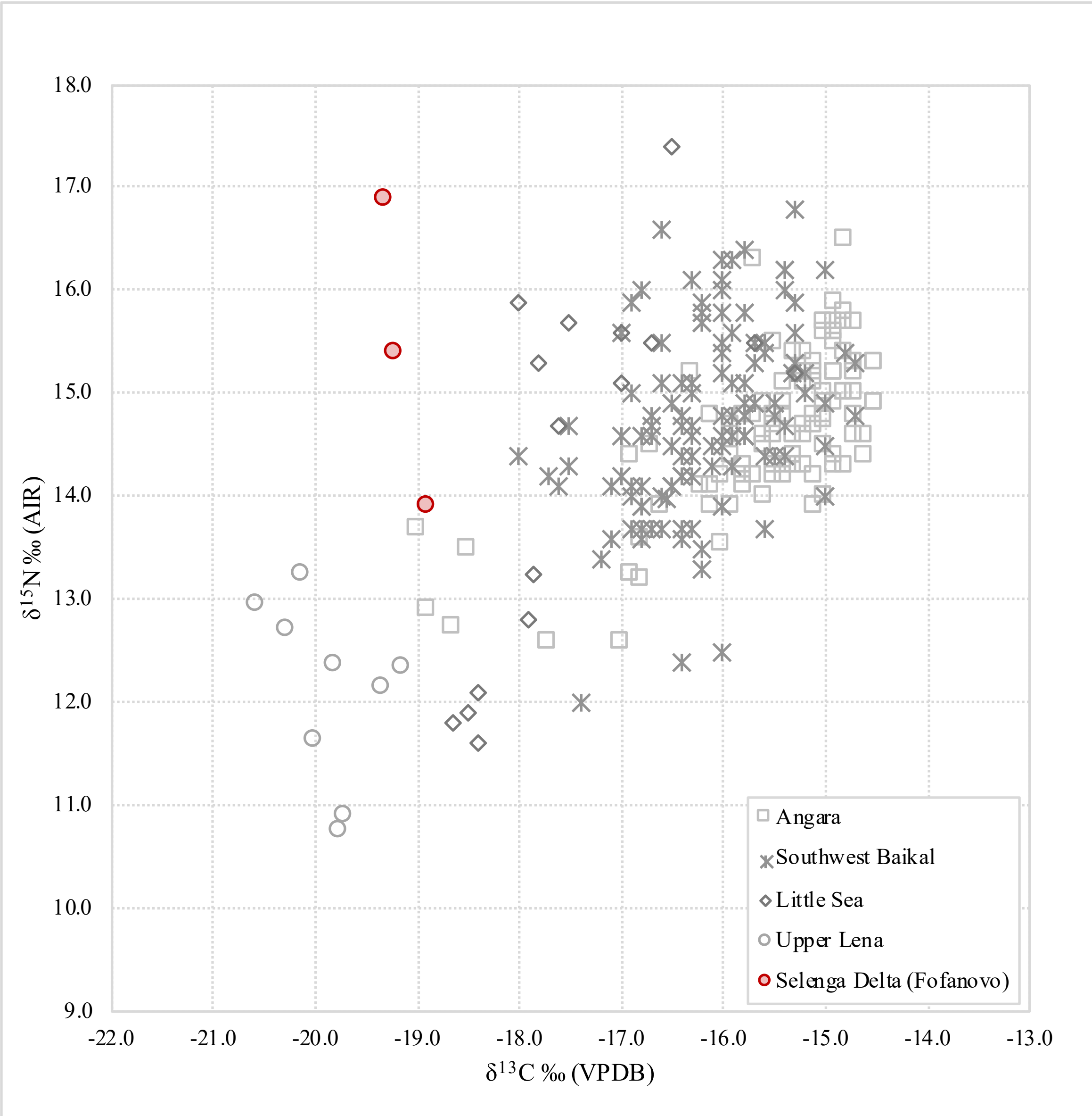


Figure 7: LN individuals (age ≥ 5) from the Baikal region in the current BAP/BHAP database.

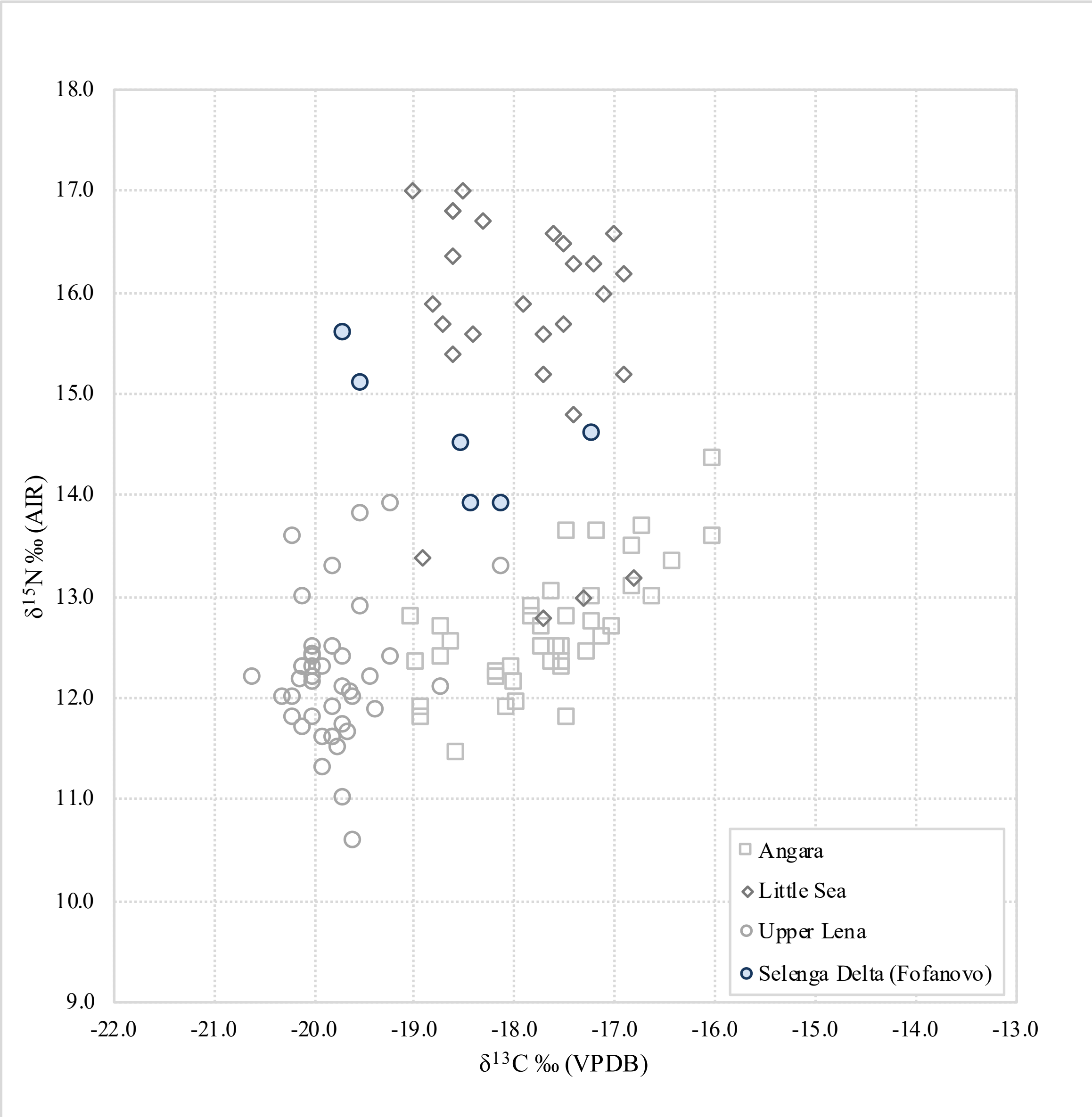
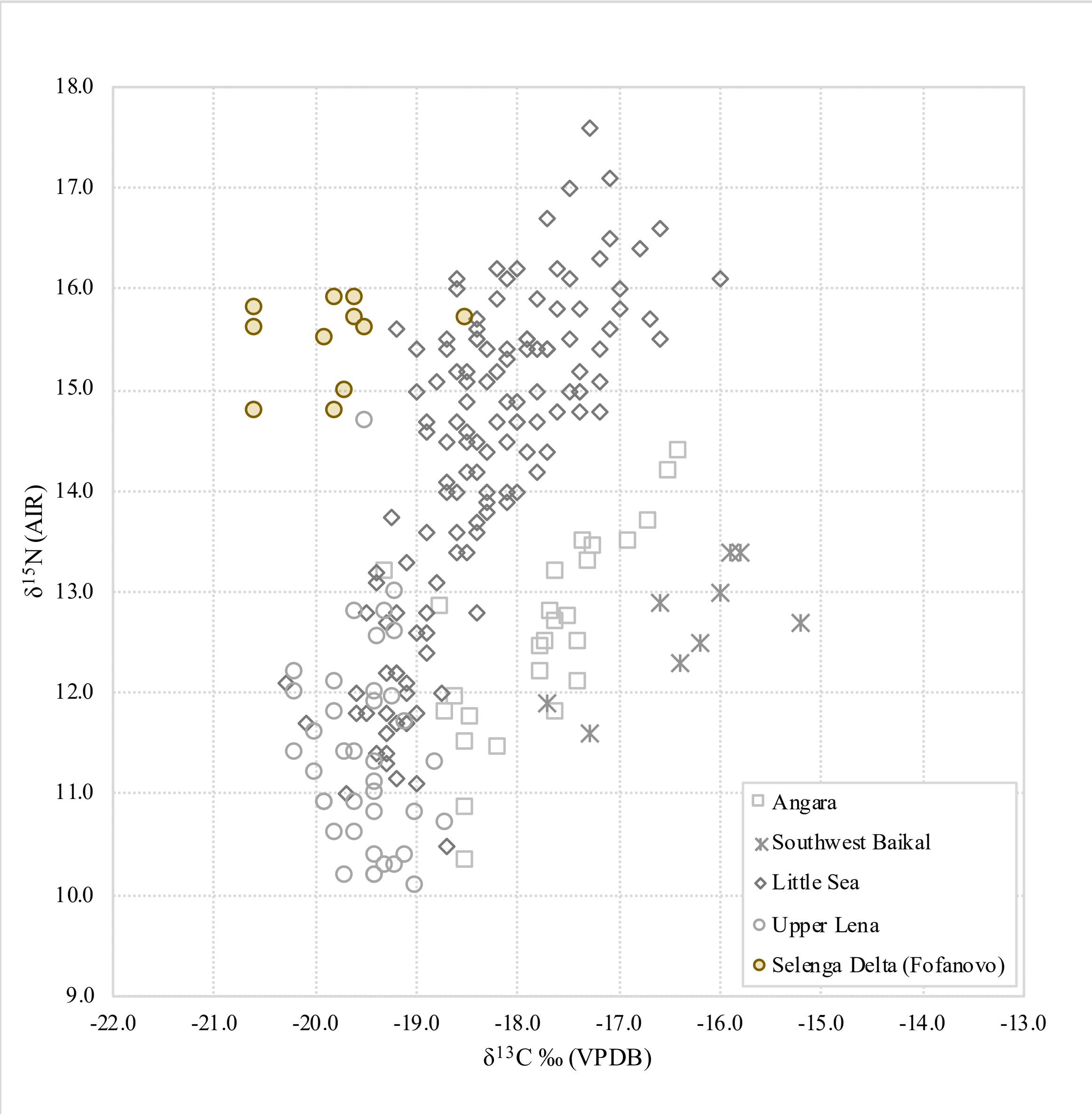


Figure 8: EBA individuals (age ≥ 5) from the Baikal region in the current BAP/BHAP database.



There are too few sexed individuals for each chronological unit in the dataset to test formally for possible isotopic differences between the sexes. There appears to be no obvious difference between females and males, which is consistent with previous findings from Cis-Baikal (Weber et al., 2016a; though see White et al., 2020). The single older child's $\delta^{15}N$ value of 15.6‰ is 1‰ higher than the LN adult average. Whether this represents a residual nursing effect is unclear given that this child is 5–7 years old, well past the expected weaning age for Cis-Baikal's hunter-gatherers (Waters-Rist et al. 2011). Alternatively, it may reflect physiological stress (Beaumont and Montgomery, 2016; Fuller et al., 2005; Mekota et al., 2006), or simply be part of the normal range of variability for this group. More data on non-adults will be required evaluate this issue further.

The three LM individuals are relatively depleted in ^{13}C, all within 1‰ of each other. Yet, the LM $\delta^{15}N$ values are more dispersed than the LN and EBA individuals. The only male LM individual has the highest $\delta^{15}N$ value, 16.9‰, of all the Fofanovo individuals analysed. The other two LM individuals are female. There is no overlap between the range of the Fofanovo LM values and the LM–EN values from Cis-Baikal's micro-regions (Figure 6). Unfortunately, until further analysis is undertaken, there is little more that can be said.

The LN and EBA results from Fofanovo form two overlapping but distinct clusters (Mann-Whitney U test, n = 17; $\delta^{13}C$ $p = 0.01$; $\delta^{15}N$ $p = 0.01$). In addition, $\delta^{13}C$ values are positively correlated with mean dates cal BP, becoming more negative over time (n = 17, $p = 0.00$, $r = 0.73$). The $\delta^{15}N$ values increase in the EBA compared to the LN, but are not significantly correlated with mean cal BP radiocarbon dates.

The isotopic distinction between the LN and EBA is possibly driven by a greater reliance on aquatic foods from the lake's shallows or lagoons in the LN and a greater reliance on the Selenga— perhaps including more intensive procurement of omul' and sturgeon — in the EBA. When plotted with LN humans from Cis-Baikal (Figure 7), Fofanovo falls almost in between 'Game-Fish' (GF) and 'Game-Fish-Seal' (GFS) diets in the Little Sea (Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2011). Although an isotopic baseline for the littoral waters near the entrance of the Selenga into Lake Baikal is currently unknown, if the shallows of the Little Sea and those near the Selenga delta are similar isotopically and as such can be used as a proxy, then the elevated ^{13}C values from the Fofanovo LN could indicate a significant reliance on littoral fish from Lake Baikal's coastal waters, ca. 45 km downriver. This would imply considerable – perhaps seasonal – mobility for the LN communities using Fofanovo for burial.

Compared to the LN, the EBA individuals are more tightly clustered, temporally and isotopically, being more depleted in ^{13}C and elevated in ^{15}N. The earliest EBA adult female, FOF_1936.009, is an outlier in carbon, and falls closer to the range of the Little Sea micro-region (Figure 8). Given the depleted carbon signature of the Selenga River's fishes, the pelagic omul' and sturgeon, and Lake Baikal's seal, it is likely that some combination of these contributed more to the diet during the EBA. Autumn and spring runs of spawning omul' and sturgeon respectively would likely be the most productive and, hence, attractive resource on the Selenga. If so, full use of these time-limited resources would have entailed considerable processing (drying and smoking) costs and more centralised storage facilities (perhaps facilitated by freezing once winter arrived). Sturgeon have received far less attention in the resource management literature for Lake Baikal, since stocks were over-exploited historically to the extent that, unlike the omul', the fishery is no longer viable. Very likely it would have been far more productive in the past and especially attractive given the large size of sturgeon. Parallels might be drawn with the suggested importance of the sturgeon fishery to Mesolithic communities along the Iron Gates of the Danube (Bartosiewicz et al., 2008).

The potential role of the Baikal seal – slightly ^{13}C-depleted but considerably ^{15}N-enriched relative to terrestrial fauna – may be another significant resource during the EBA. Seals congregate around the mouth of the Selenga River during the autumn, as the lake is slower to freeze over near the delta (T. Nomokonova and R. Losey, personal communication). Moreover, seals have been reported to enter the Selenga itself in pursuit of prey (Pastukhov, 1993; Petrov, 1997).

Exactly what circumstances might have led to a greater reliance on the lower Selenga River's resources during the EBA and indeed whether the dietary difference between the two periods remains robust will be explored further in future studies. Nevertheless, at this point it is possible to posit several scenarios. One possibility is that the foraging range or seasonal round changed within the group that was using the Fofanovo cemetery. Alternatively or concurrently, a change in foraging strategy might have occurred. Changes in the isotopic baseline (e.g., resulting from environmental changes) are also possible, but in the absence of relevant terrestrial faunal data for Trans-Baikal this cannot be assessed; however, given the size of the human isotopic shifts it appears the least likely of the alternatives.

Analysis of the nearby Burdukovo site's sediments along the Selenga River indicated a prolonged period of fluctuation in the water level of the river (ca. 7.7 – 3.8 ka BP) during a drier period in the region, which would likely have influenced more than just the area of the site as the Selenga lower watershed's levels are directly tied into the upper watershed extending into the northern part of the Mongolian Plateau (White et al., 2013:78). This does not suggest a drastic change in the productivity of the lower Selenga River between the LN and EBA. Nevertheless, it is possible that social and/or economic changes in the local communities would have encouraged a more risk-averse foraging strategy during a time of more variable resource productivity that emphasised 'front-loaded' resource acquirement and storage of time-sensitive spawning runs and seal aggregation (Bettinger, 1999a,b, 2009; Winterhalder et al., 1999; Testart, 1982). The diverse resources of the lower Selenga River could have then provided the incentive for a degree of settlement permanence during the EBA, with privileged access supported by the presence of the deceased in nearby cemeteries, demonstrating the group's ancestral rights (Charles and Buikstra, 1983; Elder, 2010; Goldstein, 1981; Saxe, 1970). The EBA mortuary traditions in the Baikal region have long been noted to be more uniform throughout the different micro-regions and evidence of extensive exchange networks has also been emphasised (see discussion in Section 2.2. and cf. Shepard et al., 2016); how this might also be related to potentially more concentrated resource management in Trans-Baikal will be well worth further study.

While links, including the exchange of individuals as marriage partners, with other micro-regions are certainly possible, their elucidation will require additional research. One observation that can already be made, however, is that the Lower Selenga's resources are unlikely to have been of importance to individuals from the large EN and EBA cemetery at Shamanka II, some 220 km to the west. The Selenga had been proposed as one possibility in the absence of any comparably ^{13}C-depleted and ^{15}N-depleted values in Cis-Baikal, but this now seems unlikely (Figures 6 and 8; Weber et al., 2016b: 249–251).

8. Conclusions

The initial radiocarbon and stable isotope results reported here from the multiperiod cemetery at Fofanovo confirm the lower Selenga's status as an isotopically distinct micro-region, the first to be isotopically examined in the vast Trans-Baikal region.

The radiocarbon results suggest the appearance of formal cemeteries in Trans-Baikal predating the Kitoi tradition of Cis-Baikal. In addition there is a substantial and previously unrecognised LN component at Fofanovo that possibly begins as early as in Cis-Baikal. The EBA component of the Fofanovo cemetery is present as expected and thus far appears to be contemporaneous with that in Cis-Baikal. Lastly, Fofanovo may be the only large Middle Holocene hunter–gatherer cemetery in the entire Baikal region, i.e. in Cis- and Trans-Baikal, analysed so far with all four archaeological periods (LM, EN, LN, EBA) represented in mortuary assemblages, while still showing the MN break in the use of formal cemeteries. If confirmed, this implies that conditions that resulted in the well-documented discontinuity in use of formal hunter–gatherer cemeteries on the Cis-Baikal side of lake, existed also on the Trans-Baikal side or at least in the areas closer to the lake (Weber, 2020).

The stable $\delta^{13}C$ and $\delta^{15}N$ isotopic results from Fofanovo demonstrate a distinct isotopic signature for individuals along the Selenga, thereby constituting a new micro-region. In addition, a dietary difference between the LN and EBA individuals was identified, possibly resulting from a shift from greater reliance on aquatic resources from Lake Baikal shallows to reliance on the aquatic resources of the lower Selenga river. EBA utilisation of the Selenga's resources might have focused on seasonally-restricted spawning runs and seal aggregation.

Further research will target archaeological fish and mammal faunal bone from the newly-defined lower Selenga micro-region. Additionally, the development of a FRE correction for the Selenga River delta will be prioritized as it is currently difficult to make robust statements about the chronology until the radiocarbon dates have been adjusted accordingly. Further sampling of individuals from the Fofanovo cemetery is a priority as well so as to test whether the patterns found in this preliminary study are sustained, and to further explore dietary variability at the site. We have only begun to analyse the Fofanovo cemetery complex, but it is already clear that it has great potential to increase our understanding of long-term hunter-gatherer adaptations around Lake Baikal, complementing the considerable amount of research available for Cis-Baikal. Additionally, analysis of sites along the Selenga River invites investigation of how they and Cis-Baikal are related to cultures further up the river on the Mongolian Plateau. Our preliminary results have raised as many new questions as have been answered, and no doubt this will continue as new analyses are undertaken.

Acknowledgments
The authors would like to thank the RLAHA staff for their help with sample preparation and analysis and the "10,000 Years Institute" for permission to cite Selenga isotopic data on modern fish from the unpublished report by Sampson et al. (2002). This project was supported by the Baikal-Hokkaido Archaeology Project (Social Sciences and Humanities Research Council of Canada Major Collaborative Research Initiative grant No. 412-2011-1001, Partnership Grant No. 895-2018-1004, and the University of Alberta Killam Cornerstone Grant), the University of Oxford Clarendon Fund, and the Government of the Russian Federation, grant № 075-15-2019-866 ("Baikal Siberia in the Stone Age: At the crossroads of the worlds").

References

Ambrose, S.H., 1990. Preparation and characterization of bone and tooth collagen for isotopic analysis, Journal of Archaeological Science 17, 431–451.

Ambrose, S.H., Norr, L., 1993. Experimental Evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate, in: Lambert, J.B., Grupe, G. (Eds.), Prehistoric Human Bone: Archaeology at the Molecular Level, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 1–37.

Bartosiewicz, L., Bonsall, C. and Sisu, V. 2008. Sturgeon fishing in the middle and lower Danube region. In: C. Bonsall, V. Boroneant and I. Radocanovic (eds.), *The Iron Gates in Prehistory: New Perspectives*: pp. 39-54. Oxford: Archaeopress, BAR International Series 1237.

Bazaliiskii, V.I., 2010. Mesolithic and Neolithic mortuary complexes in the Baikal region of Siberia. In: Weber, A.W., Katzenberg, M.A., Schurr, T. (Eds.), Prehistoric Hunter-Gatherers of the Baikal Region, Siberia: Bioarchaeological Studies of Past Lifeways. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, pp. 51–86.

Beaumont, J., Montgomery, J., 2016. The Great Irish Famine: Identifying Starvation in the Tissues of Victims Using Stable Isotope Analysis of Bone and Incremental Dentine Collagen, PLoS One 11, e0160065.

Bettinger, R.L., 1999a. From traveler to processor: regional trajectories of hunter–gatherer sedentism in the Inyo-Mono region, California, in: Billman, B.R., Feinman, G.M. (Eds.), Settlement Pattern Studies in the Americas: Fifty Years since Viru, Smithsonian Institution Press, Washington, DC, pp. 39–55.

Bettinger, R.L., 1999b. What happened in the medithermal, in: Beck, C. (Ed.), Models for the Millennium: Great Basin Anthropology Today, University of Utah Press, Salt Lake City, pp. 62–74.

Bettinger, R.L., 2009. Hunter–Gatherer Foraging: Five Simple Models, Eliot Werner Publications Inc., Clinton Corners, New York.

Bocherens, H., Drucker, D., 2003. Trophic level isotopic enrichments for carbon and nitrogen in collagen: case studies from recent and ancient terrestrial ecosystems, International Journal of Osteoarchaeology 13, 46–53.

Brock, F., Higham, T., Ditchfield, P., Ramsey, C.B., 2010. Current pretreatment methods for AMS radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU), Radiocarbon 52, 103–112.

Brock, F., Ramsey, C.B., Higham, T., 2007. Quality assurance of ultrafiltered bone dating, Radiocarbon 49, 187–192.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates, Radiocarbon 51, 337–360.

Bronk Ramsey, C. 2017. Methods for Summarizing Radiocarbon Datasets. Radiocarbon, 59(2), 1809–1833.

Bronk Ramsey, C., Schulting, R., Goriunova, O., Bazaliiskii, V., & Weber, A., 2014. Analyzing radiocarbon reservoir offsets through stable nitrogen isotopes and Bayesian modeling: A case study using paired human and faunal remains from the Cis-Baikal region, Siberia, Radiocarbon 56, 789–799.

Bronk Ramsey, C., Scott, E.M., Plicht, J.v.d., 2013. Calibration for archaeological and environmental terrestrial samples in the time range 25–60 ka cal BP, Radiocarbon 55, 2021–2027.

Charles, D.K. and Buikstra, J.E. 1983. Archaic mortuary sites in the central Mississippi drainage: distribution, structure, and behavioral implications. In: J.L. Phillips and J.A. Brown (eds.), *Archaic Hunters and Gatherers in the American Midwest*: pp. 117-145. New York: Academic Press.

Coplen, T.B., Brand, W.A., Gehre, M., Gröning, M., Meijer, H.J., Toman, B. and Verkouteren, R.M. 2006. New guidelines for δ13C measurements. Analytical Chemistry 78, 2439–2441.

.
de Barros Damgaard, P., Marchi, N., Rasmussen, S., Peyrot, M., Renaud, G., Korneliussen, T., Moreno-Mayar, J.V., Pedersen, M.W., Goldberg, A., Usmanova, E., Baimukhanov, N., Loman, V., Hedeager, L., Pedersen, A.G., Nielsen, K., Afanasiev, G., Akmatov, K., Aldashev, A., Alpaslan, A., Baimbetov, G., Bazaliiskii, V.I., Beisenov, A., Boldbaatar, B., Boldgiv, B., Dorzhu, C., Ellingvag, S., Erdenebaatar, D., Dajani, R., Dmitriev, E., Evdokimov, V., Frei, K.M., Gromov, A., Goryachev, A., Hakonarson, H., Hegay, T., Khachatryan, Z., Khaskhanov, R., Kitov, E., Kolbina, A., Kubatbek, T., Kukushkin, A., Kukushkin, I., Lau, N., Margaryan, A., Merkyte, I., Mertz, I.V., Mertz, V.K., Mijiddorj, E., Moiyesev, V., Mukhtarova, G., Nurmukhanbetov, B., Orozbekova, Z., Panyushkina, I., Pieta, K., Smrcka, V., Shevnina, I., Logvin, A., Sjogren, K.G., Stolcova, T., Taravella, A.M., Tashbaeva, K., Tkachev, A., Tulegenov, T., Voyakin, D., Yepiskoposyan, L., Undrakhbold, S., Varfolomeev, V., Weber, A., Wilson Sayres, M.A., Kradin, N., Allentoft, M.E., Orlando, L., Nielsen, R., Sikora, M., Heyer, E., Kristiansen, K., Willerslev, E., 2018a. 137 ancient human genomes from across the Eurasian steppes. Nature 557, 369–374.

de Barros Damgaard, P., Martiniano, R., Kamm, J., Moreno-Mayar, J.V., Kroonen, G., Peyrot, M., Barjamovic, G., Rasmussen, S., Zacho, C., Baimukhanov, N., Zaibert, V., Merz, V., Biddanda, A., Merz, I., Loman, V., Evdokimov, V., Usmanova, E., Hemphill, B., Seguin-Orlando, A., Yediay, F.E., Ullah, I., Sjogren, K.G., Iversen, K.H., Choin, J., de la Fuente, C., Ilardo, M., Schroeder, H., Moiseyev, V., Gromov, A., Polyakov, A., Omura, S., Senyurt, S.Y., Ahmad, H., McKenzie, C., Margaryan, A., Hameed, A., Samad, A., Gul, N., Khokhar, M.H., Goriunova, O.I., Bazaliiskii, V.I., Novembre, J., Weber, A.W., Orlando, L., Allentoft, M.E., Nielsen, R., Kristiansen, K., Sikora, M., Outram, A.K., Durbin, R., Willerslev, E., 2018b. The first horse herders and the impact of early Bronze Age steppe expansions into Asia. Science 360.

Dee, M., Bronk Ramsey, C., 2000. Refinement of graphite target production at ORAU, Nuclear Instruments and Methods in Physics Research B 172, 449–453.

DeNiro, M.J., 1985. Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction, Nature 317, 806–809.

DeNiro, M.J., Epstein, S., 1978. Influence of diet on the distribution of carbon isotopes in animals, Geochimica et Cosmochimica Acta 42, 495–506.

DeNiro, M.J., Epstein, S., 1981. Influence of diet on the distribution of nitrogen isotopes in animals, Geochimica et Cosmochimica Acta 45, 341–351.

Dufour, E., Bocherens, H., Mariotti, A., 1999. Palaeodietary Implications of Isotopic Variability in Eurasian Lacustrine Fish. Journal of Archaeological Science 26, 617–627.

Dulmaa, A., 1999. Fish and Fisheries in Mongolia, in: Petr, T. (Ed.), Fish and Fisheries at Higher Altitudes: Asia, Fisheries Technical Paper, Food and Agriculture Organization of the United Nations, Rome.

Elder, E. 2010. A Comparison of the Late Pleistocene and Early Holocene Burials of North Africa and Western Europe. Grim Investigations: Reaping the Dead. Oxford: Archaeopress, British Archaeological Reports, S2143.

Friedli, H., Lotscher, H., Oeschger, H., Siegenthaler, U., Stauffer, B., 1986. Ice core record of the 13C/12C radio of atmospheric CO2 in the past two centuries, Nature 324, 237–238.

Fuller, B.T., Fuller, J.L., Sage, N.E., Harris, D.A., O'Connell, T.C., Hedges, R.E., 2005. Nitrogen balance and δ15N: why you're not what you eat during nutritional stress, Rapid Commun Mass Spectrom 19, 2497–2506.

Gerasimov, M.M., Chernykh, E.N. 1975. Raskopki fofanovskogo mogil'nika v 1959 g. In: Mandel'shtam, A. M. (Ed.), Pervobytnaia arkheologiia Sibiri. Nauka, Leningrad, pp. 23–48. [In Russian]

Goldstein, L.G. 1981. One-dimensional archaeology and multi-dimensional people: spatial organisation and mortuary analysis. In: R. Chapman, I. Kinnes and K. Randsborg (eds.), The Archaeology of Death: pp. 53–69. Cambridge: Cambridge University Press.

Goriunova, O.I., Novikov, A.G., 2010. The Bronze Age in Cis-Baikal: A Review of Research and Future Prospects, in: Weber, A., Katzenberg, M., Schurr, T. (Eds.), Prehistoric Hunter-Gatherers of the Baikal Region, Siberia: Bioarchaeological Studies of Past Lifeways, University of Pennsylvania Museum of Archaeology and Anthropology, Pennsylvania, pp. 239–256.
Goriunova, O.I., Novikov, A.G., Turkin, G.V., Weber, A.W., 2020. Middle Holocene hunter–gatherer mortuary practices in the Little Sea micro-region on Lake Baikal, Part I: Early Neolithic. Archaeological Research in Asia. Submitted.
Goriunova, O.I., Novikov, A.G., Weber, A.W., 2020. Middle Holocene hunter–gatherer mortuary practices in the Little Sea micro-region on Lake Baikal, Part II: Late Neolithic. Archaeological Research in Asia. Submitted.
Hedges, R.E.M., Clement, J.G., Thomas, C.D.L., O'Connell, T.C., 2007. Collagen turnover in the adult femoral mid-shaft: modeled from anthropogenic radiocarbon tracer measurements, American Journal of Physical Anthropology 133, 808–816.
Hedges, R.E.M., Reynard, L.M., 2007. Nitrogen isotopes and the trophic level of humans in archaeology, Journal of Archaeological Science 34, 1240–1251.
Jarvis, A., Reuter, H.I., Nelson, A., Guevara, E., 2008. Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org).
Katzenberg, M.A., Bazaliiskii, V.I., Goriunova, O.I., Savel'ev, N.A., Weber, A.W., 2010. Diet reconstruction of prehistoric hunter-gatherers, in: Weber, A.W., Katzenberg, M.A., Schurr, T.G. (Eds.), Prehistoric Hunter-Gatherers of the Baikal Region, Siberia Bioarchaeological Studies of Past Life Ways, University of Pennsylvania Press, 176–191.
Katzenberg, M.A., McKenzie, H.G., Losey, R.J., Goriunova, O.I., Weber, A., 2012. Prehistoric dietary adaptations among hunter-fisher-gatherers from the Little Sea of Lake Baikal, Siberia, Russian Federation, Journal of Archaeological Science 39, 2612–2626.
Katzenberg, M.A., Weber, A.W., 1999. Stable isotope ecology and palaeodiet in the Lake Baikal region of Siberia, Journal of Archaeological Science 26, 651–659.
Kobe, F., Bezrukova, E.V., Leipe, C., Shchetnikov, A.A., Goslar, T., Wagner, M., Tarasov, P.E., 2020. Holocene vegetation and climate history in Baikal Siberia reconstructed from pollen records and its implications for archaeology. Archaeological Research in Asia 23, 100209.
Kozhov, M., 1950. Presnye vody Vostochnoi Sibiri (bassein Baikala, Angary, Vitima, verkhnego techenia Leny i Nizhnei Tunguski). (Fresh Waters of Eastern Siberia (Baikal, Angara, Vitim, Upper Lena and Lower Tunguska Basins) (In Russian), Irkustsk: Irkutskoe oblastnoe gosudarstvennoe izdatel’stvo. [In Russian]
Kozhov, M., 1963. Lake Baikal and its Life, Springer Science.
Kozhov.1972. Ocherki po baikalovedeniiu [Essays on Lake Baikal], Vostochno-Sibirskoe knizhnoe izdatel’stvo, Irkutsk. [in Russian]
Lbova, L.V., Zhambaltarova, E.D., Konev, V.P. 2008. Pogrebal’nye kompleksy neolita–rannego bronzovogo veka Zabaikal’ia. Russian Academy of Sciences, Siberian Branch, Novosibirsk. [In Russian]
Lee-Thorp, J.A. 2008. On isotopes and old bones. Archaeometry 50, 925–950.
Losey, R.J., Nomokonova, T., Goriunova, O.I., 2008. Fishing ancient Lake Baikal, Siberia: inferences from the reconstruction of harvested perch (Perca fluviatilis) size, Journal of Archaeological Science 35, 577-590.
Losey, R.J., Nomokonova, T., White, D., 2012. Fish and Fishing in Holocene Cis-Baikal, Siberia: A Review, The Journal of Island and Coastal Archaeology 7, 126–145.
Mamonova, N.N., Sulerzhitskii, L.D., 1989. Opyt datirovaniia po C14 pogrebenii Pribaikal’ia epokhi golotsena. Sovetskaia arkheologiia 1:19–32. [In Russian]
Matveyev, A.N., Samusenok, V.P., 2015. The fishes and fishery in Lake Baikal, Aquatic Ecosystem Health & Management 18, 134–148.

Mekota, A.M., Grupe, G., Ufer, S., Cuntz, U., 2006. Serial analysis of stable nitrogen and carbon isotopes in hair: monitoring starvation and recovery phases of patients suffering from anorexia nervosa, Rapid Commun Mass Spectrom 20, 1604-1610.

Michael, H.N., 1958. The Neolithic Age in Eastern Siberia, Transactions of the American Philosophical Society 48, 1–108.

Minagawa, M., Wada, E., 1984. Stepwise enrichment of 15N along food chains: Further evidence and the relation between δ^{15}N and animal age, Geochemica et Cosmochimica 48, 1135–1140.

Moussa, N.M., McKenzie, H.G., Bazaliiskii, V.I., Goriunova, O.I., Bamforth, F., Weber, A.W., 2020. Insights into Lake Baikal's Ancient Populations from genetic evidence at the Early Bronze Age Cemetery Kurma XI and the Early Neolithic Shamanka II. Archaeological Research in Asia. Submitted.

Movsesian, A.A., Bakholdina, V.Y., Pezhemsky, D.V., 2014. Biological diversity and population history of Middle Holocene hunter-gatherers from the Cis-Baikal region of Siberia. American Journal of Physical Anthropology 155:4, 559–570.

Nomokonova, T., Losey, R.J., Weber, A., Goriunova, O.g.I., Novikov, A.G., 2010. Late Holocene Subsistence Practices Among Cis-Baikal Pastoralists, Siberia: Zooarchaeological Insights from Sagan-Zaba II, Asian Perspectives 49, 157–179.

Nomokonova, T., Losey, R.J., Goriunova, O.g.I., Weber, A.W., 2013a. A freshwater old carbon offset in Lake Baikal, Siberia and problems with the radiocarbon dating of archaeological sediments: Evidence from the Sagan-Zaba II site, Quaternary International 290–291, 110–125.

Nomokonova, T., Losey, R.J., Iakunaeva, V.N., Emel'ianova, I.A., Baginova, E.A., Pastukhov, M.V., 2013b. People and Seals at Siberia's Lake Baikal, Journal of Ethnobiology 33, 259–280.

Nomokonova, T., Losey, R.J., Goriunova, O.I., Novikov, A.G., Weber, A.W., 2015. A 9,000 Year History of Seal Hunting on Lake Baikal, Siberia: The Zooarchaeology of Sagan-Zaba II, PLoS One 10, e0128314.

O'Connell, T.C., Kneale, C.J., Tasevska, N., Kuhnle, G.G., 2012. The diet-body offset in human nitrogen isotopic values: a controlled dietary study, American Journal of Physical Anthropology 149, 426–434.

Okladnikov, A.P. 1950 Neolit i bronzovyi vek Pribaikal'ia (chast' I i II). Materialy i issledovaniia po arkheologii SSSR, Vol. 18. Izdatel'stvo Akademii nauk SSSR, Moscow. [In Russian]

Okladnikov, A.P. 1955 Neolit i bronzovyi vek Pribaikal'ia (chast' III), Materialy i issledovaniia po arkheologii SSSR, Vol. 43. Izdatel'stvo Akademii nauk SSSR, Moscow. [In Russian]

Okladnikov, A.P. 1974. Neoliticheskie pamiatniki Angary (ot Shchukino do Bureti), Nauka, Novosibirsk. [In Russian]

Okladnikov, A.P. 1975 Neoliticheskie pamiatniki Srednei Angary (ot ust'ia r. Beloi do Ust'-Udy), Nauka, Novosibirsk. [In Russian]

Okladnikov, A.P. 1976 Neoliticheskie pamiatniki Nizhnei Angary (ot Serovo do Bratska). Nauka, Novosibirsk. [In Russian]

Okladnikov, A.P. 1978 Verkholenskii mogil'nik—pamiatnik drevnei kul'tury narodov Sibiri. Nauka, Novosibirsk. [In Russian]

Pastukhov, V. D. 1993. Nerpa Baikala. Nauka, Novosibirsk. [In Russian]

Petrov, E. A., Voronov, A. V. and Ivanov, M. K., 1997. Chislennost', raspredelenie priploda i promysel populyatsii baikal'skoy nerpy (Pusa sibirica). Zoologicheskii Zhurnal 76:7, 858–864. [In Russian]

Reimer, P.J., Bard, E., Bayliss, A., Beck, W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M., Plicht, J.v.d., 2013. IntCal 13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP, Radiocarbon 55, 1869–1887.

Robson, H., Andersen, S., Craig, O.E., Fischer, A., Glykou, A., Hartz, S., Lübke, H., Schmölcke, U. and Heron, C. 2012. Carbon and nitrogen isotope signals in eel bone collagen from Mesolithic and Neolithic sites in northern Europe. Journal of Archaeological Science 39, 2003–2011.

Sampson, J.R., Tarasova, E.A., Mamontova, E.M., Mamontov, A.A., Chandra, S., Kalmychkov, G.V., Toupitsyn, I.I., 2002. Polychlorinated Biphenyls and Mercury in Sediments and Aquatic Biota, Nearshore Juvenile Fish Communities and Aquatic Food Web Structure in the Lower Selenga River, Russia, 10,000 Years Institute, Washington, USA.

Saxe, A.A. 1970. Social Dimensions of Mortuary Practices. Unpubl. Ph.D., Dept. of Anthropology, University of Michigan.

Schoeninger, M.J., DeNiro, M.J., 1984. Nitrogen and carbon isotope composition in bone collage from marine and terrestrial animals, Geochemica et Cosmochimica 48.

Schulting, R., Bronk Ramsey, C., Bazaliiskii, V.I., Goriunova, O.I., Weber, A., 2014. Freshwater reservoir offsets investigated through paired human-faunal ^{14}C dating and stable carbon and nitrogen isotope analysis at Lake Baikal, Siberia, Radiocarbon 56, 991–1008.

Schulting, R., Bronk Ramsey, C., Bazaliiskii, V., Weber, A., 2015. Highly Variable Freshwater Reservoir Offsets Found along the Upper Lena Watershed, Cis-Baikal, Southeast Siberia, Radiocarbon 57, 581-593.

Schulting, R., Bronk Ramsey, C., Scharlotta, I., Richards, M., Weber, A.W., 2020. Freshwater reservoir effects in Cis-Baikal: an overview. Archaeological Research in Asia. Submitted.

Shepard, B.A., Goriunova, O.g.I., Novikov, A.G., Tiutrin, A.A., Weber, A.W., 2016. Macro-regional interconnections among ancient hunter-gatherers of the Cis-Baikal, Eastern Siberia (Russia), Quaternary International 419, 140–158.

Testart, A., 1982. The significance of food storage among hunter-gatherers: residence poatterns, population densities, and social inequalities, Current Anthropology 23, 523–537.

Tieszen, L.L., Boutton, T.W., Tesdahl, K.G., Slade, N.A., 1983. Fractionation and turnover of stable carbon isotopes in animal tissues: Implications for $\delta^{13}C$ analysis of diet, Oecologia 57, 32–37.

Tieszen, L.L., Fagre, T., 1993. Effect of diet quality and composition on the isotopic composition of respiratory CO2, bone collagen, bioapatite, and soft tissues, in: Lambert, J.B., Grupe, G. (Eds.), Prehistoric Human Bone: Archaeology at the Molecular Level, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 121–155.

van Klinken, G.J., 1999. Bone collagen quality indicators for palaeodietary and radiocarbon measurements, Journal of Archaeological Science 26, 687–695.

Waters-Rist, A.L., Bazaliiskii, V.I., Weber, A.W., Katzenberg, M.A., 2011. Infant and child diet in Neolithic hunter-fisher-gatherers from Cis-Baikal, Siberia: intra-long bone stable nitrogen and carbon isotope ratios, American Journal of Physical Anthropology 146, 225–241.

Waters-Rist, A.L., Bazaliiskii, V.I., Goriunova, O.I., Weber, A.W., Katzenberg, M.A., 2016. Evaluating the biological discontinuity hypothesis of Cis -Baikal Early versus Late Neolithic-Early Bronze Age populations using dental non-metric traits, Quaternary International 405, 122–133.

Weber, A., 1995. The Neolithic and Early Bronze Age of the Lake Baikal region: A review of ecent research, Journal of World Prehistory 9, 99–165.

Weber, A.W., 2003. Biogeographic profile of the Lake Baikal region, Siberia, in: Weber, A., McKenzie, H. (Eds.), Prehistoric Foragers of the Cis-Baikal, Siberia: Proceedings of the First Conference of the Baikal Archaeology Project, Canadian Circumpolar Institute Press.

Weber, A.W., 2020. Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Combined impacts of the boreal forest, bow-and-arrow, and fishing. Archaeological Research in Asia. Submitted.

Weber, A.W., Bettinger, R., 2010. Middle Holocene hunter-gatherers of Cis-Baikal, Siberia: An overview for the new century, Journal of Anthropological Archaeology 29, 491–506.

Weber, A.W., Beukens, R., Bazaliiskii, V.I., Goriunova, O.I., Savel'ev, N.A. 2006. Radiocarbon dates from Neolithic and Bronze Age hunter–gatherer cemeteries in the Cis-Baikal region of Siberia. Radiocarbon 48 (3), 1–40.

Weber, A.W., Bronk Ramsey, C., Schulting, R.J., Bazaliiskii, V.I., Goriunova, O.I., 2020. Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Chronology and dietary trends. Archaeological Research in Asia. Submitted.

Weber, A.W., Goriunova, O.I., 2013. Hunter–gatherer migrations, mobility and social relations: A case study from the Early Bronze Age Baikal region, Siberia, Journal of Anthropological Archaeology 32, 330–346.

Weber, A.W., Link, D.W., Goriunova, O.I., Konopatskii, A.K., 1998. Patterns of prehistoric procurement of seal at Lake Baikal: A zooarchaeological contribution to the study of past foraging economies in Siberia, Journal of Archaeological Science 25, 215–227.

Weber, A.W., Link, D.W., Katzenberg, M.A., 2002. Hunter-gatherer culture change and continuity in the Middle Holocene of the Cis-Baikal, Siberia, Journal of Anthropological Archaeology 21, 230–299.

Weber, A.W., Schulting, R.J., Bronk Ramsey, C., Bazaliiskii, V.I., Goriunova, O.I., Berdnikova, N.i.E., 2016a. Chronology of middle Holocene hunter–gatherers in the Cis-Baikal region of Siberia: Corrections based on examination of the freshwater reservoir effect, Quaternary International 419, 74–98.

Weber, A.W., Schulting, R.J., Ramsey, C.B., Bazaliiskii, V.I., 2016b. Biogeochemical data from the Shamanka II Early Neolithic cemetery on southwest Baikal: Chronological and dietary patterns, Quaternary International 405, 233–254.

Weber, A.W., White, D., Bazaliiskii, V.I., Goriunova, O.I., Savel'ev, N.A., Anne Katzenberg, M., 2011. Hunter–gatherer foraging ranges, migrations, and travel in the middle Holocene Baikal region of Siberia: Insights from carbon and nitrogen stable isotope signatures, Journal of Anthropological Archaeology 30, 523–548.

White, D., Preece, R.C., Shchetnikov, A.A., Dlussky, K.G., 2013. Late Glacial and Holocene environmental change reconstructed from floodplain and aeolian sediments near Burdukovo, lower Selenga River Valley (Lake Baikal region), Siberia, Quaternary International 290–291, 68–81.

White JA, Schulting R, Lythe A., Hommel P, Ramsey CB, Moiseyev V, Khartanovich V, Weber AW. 2020. Integrated stable isotopic and radiocarbon analyses of Neolithic and Bronze Age hunter-gatherers from the Little Sea and Upper Lena micro-regions, Cis-Baikal, Siberia, Journal of Archaeological Science 119, 105161.

Winterhalder, B., Lu, F., Tucker, B., 1999. Risk-senstive adaptive tactics: Models and evidence from subsistence studies in biology and anthropology, Journal of Archaeological Research 7, 301–348.

Yoshii, K., 1999. Stable isotope analysis of benthic organisms in Lake Baikal, Hydrobiologia 411, 145–159.

Yoshii, K., Melnik N.G., Timoshkin O.A., Bondarneko, N.A., Anoshko P.N., Yoshioka, T., Wada, E., 1999. Stable isotope analyses of the pelagic food web in Lake Baikal, Limnol. Oceanogr. 44, 502–511.

Declaration of interests

The authors have no known competing interests or relationships which might influence the research presented in this paper.

Author credit

J. Alyssa White: Investigation, formal analysis, visualisation, writing

Rick J. Schulting: Conceptualisation, investigation, formal analysis, writing, supervision

Peter Hommel: Visualisation, writing

Vyacheslav Moiseyev: Resources

Valeri Khartanovich: Resources

Christopher Bronk Ramsey: Conceptualisation, resources

Andrzej W. Weber: Conceptualisation, investigation, formal analysis, writing, supervision, project administration, funding acquisition

Supplement to

Turning Eastward: New Radiocarbon and Stable Isotopic Data for Middle Holocene Hunter-Gatherers from Fofanovo, Trans-Baikal, Siberia

J. Alyssa White[a]
Corresponding Author
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: julia.white@arch.ox.ac.uk

Rick J. Schulting[a]
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: rick.schulting@arch.ox.ac.uk

Peter Hommel[b]
[b] Department of Archaeology, Classics, University of Liverpool, 12-14 Abercromby Sq, Liverpool, L69 7WZ, UK
Email: peter.hommel@liverpool.ox.ac.uk

Vyacheslav Moiseyev[c]
[c] Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences, Universitetskaia Nab. 3, St. Petersburg, 199034, Russia
Email: vmoiseyev@mail.ru

Valeri Khartanovich[c]
[c] Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences, Universitetskaia Nab. 3, St. Petersburg, 199034, Russia
Email: vkhartan@kunstkamera.ru

Christopher Bronk Ramsey[a]
[a] School of Archaeology, University of Oxford, Dyson Perrins Building, 1 South Parks Road, Oxford OX1 3TG
Email: christopher.ramsey@arch.ox.ac.uk

Andrzej W. Weber[d,e,f]
[d] Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada T6G 2E5
[e] Aix Marseille Univ, CNRS, Minist Culture & Com, LAMPEA, Aix-en-Provence, France
[f] Research Centre "Baikal Region", Irkutsk State University, Karl Marx Street 1, Irkutsk 664003, Russia
Email: aweber@ualberta.ca

S1. Fofanovo Cemetery: Additional Details

S1.1. Archaeological fieldwork

Fofanovo has been excavated on several occasions, though the findings of the early campaigns are poorly documented and/or published. The site was discovered in 1926 by A.P. Okladnikov, who collected surface material from "Punkt I" (Lbova et al., 2008, Fig. 5). The first excavations were conducted by M.M. Gerasimov in 1931 and 1934–36. The goal of Gerasimov's fieldwork appears to have been the collection of surface material from the graves probably eroding from the slopes of "Punkt II". This fieldwork remains undocumented, the collected materials have never been published, and it is unclear how many graves were represented. However, 10 graves retained enough integrity to be assigned numbers (Nos. 1–10) by Gerasimov (Gerasimov and Chernykh, 1975: 23). The human remains from these graves are stored in Kunstkamera, St. Petersburg, from which seven individuals were sampled for this study.

In 1948 and 1950, Okladnikov returned to Fofanovo to work in "Punkt II". The results of these excavations have not been published; however, Lbova et al. (2008: 224–235) transcribed Okladnikov's field notes and summarized the mortuary data in a table (Lbova et al., 2008: Table 5). Although some ambiguity remains with regard to how many graves were excavated in these two campaigns, the consensus appears to be that Okladnikov uncovered a total of 39 graves: 19 in 1948 (Figure S1) and 20 in 1950 (Figure S2; Gerasimov and Chernykh, 1975: 23; Lbova et al., 2008: 29). Human skeletal remains from these excavations are also stored in Kunstkamera, from which 13 individuals were sampled for this study: five from 1948 and eight from the 1950 excavations.

Figure S1: Schematic plan of Okladnikov's 1948 excavations reconstructed from his notes in Lbova et al. (2008: 31, Figure 6) and adapted by PH. Period assignments shown are as determined in this study.

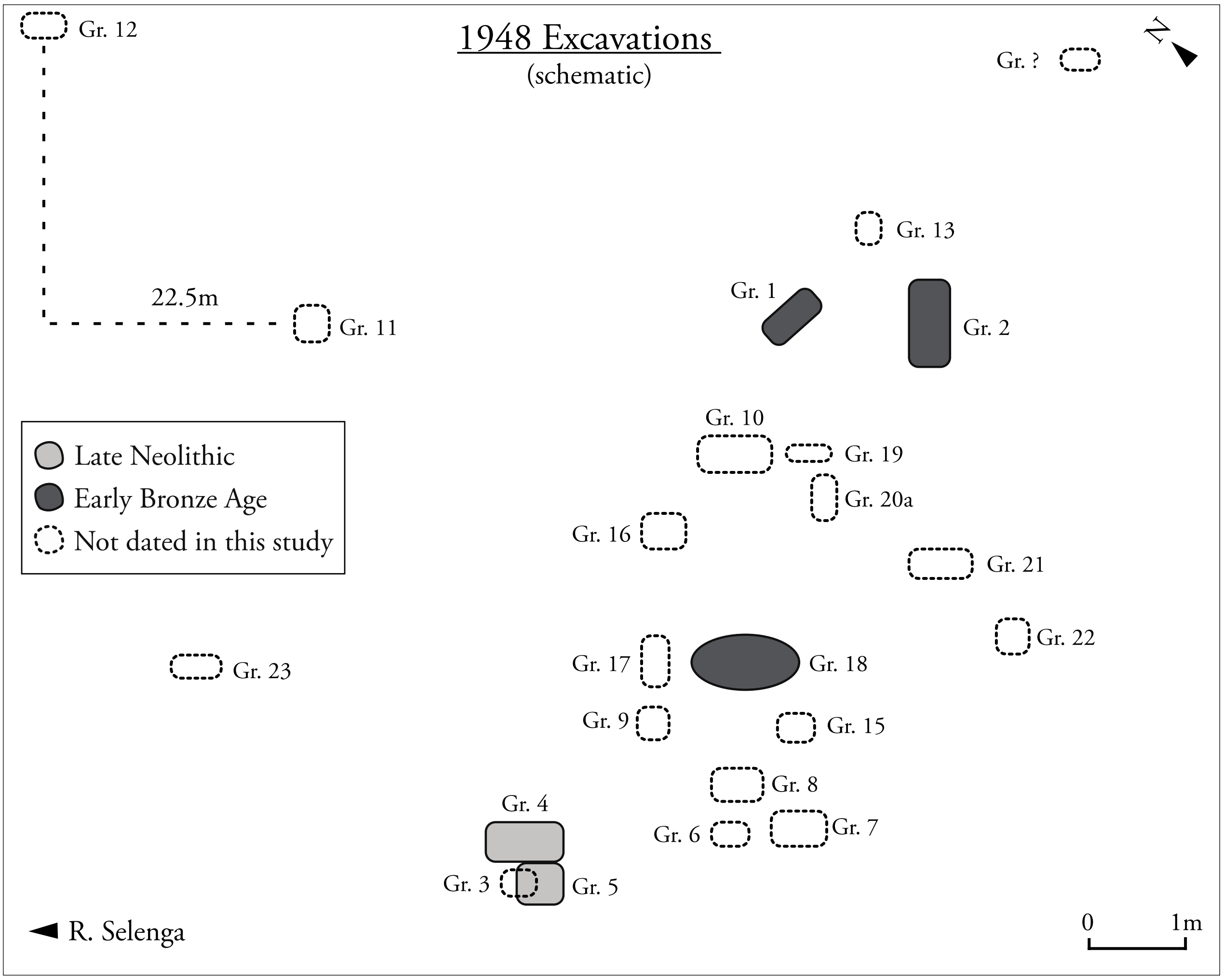
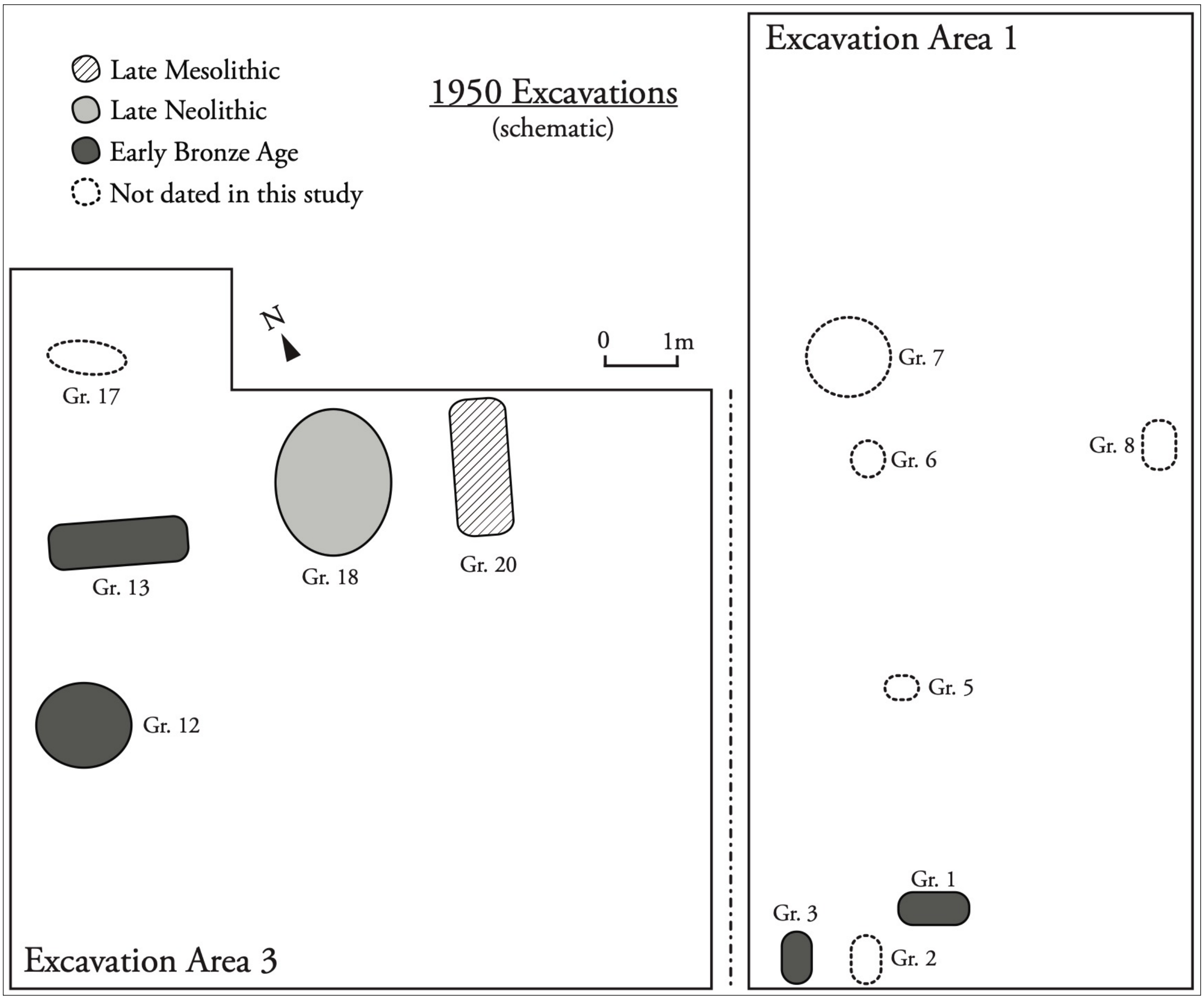


Figure S2: Schematic plan of Okladnikov's 1950 excavations reconstructed from his notes in Lbova et al. (2008: 34–36, Figures 9 and 11) and adapted by PH. Period assignments shown are as determined in this study. The relation between the two excavation areas is unclear.



Gerasimov worked at Fofanovo again as part of M.P. Griaznov's 1959 "Expedition to Lake Baikal", a large archaeological operation organized in association with the construction of a dam on the Angara River in Irkutsk. The goal of the expedition was to protect archaeological sites potentially endangered by the expected rise of Lake Baikal's water level. Gerasimov excavated a total of 41 graves in "Punkt II", published in a short report by Gerasimov and Chernykh (1975; see also Lbova et al. 2008: 195–200). Roughly 30 years later, between 1987 and 1996, V.P. Konev undertook a few fieldwork campaigns and excavated 17 graves, 10 in "Punkt I" and 7 in "Punkt II" (Lbova et al., 2008). The skeletal materials from the 1959 to 1996 excavations were not sampled for this study.

A total of 107 graves was excavated and documented at Fofanovo between 1931 and 1996 (Table 5) – albeit with variable scholarly rigour – of which 97 have been summarized by Lbova et al. (2008: 189–203). In addition, it is likely that a number of graves have eroded away without any documentation. Fofanovo is the largest multi-component middle Holocene hunter–gatherer cemetery known thus far in Trans-Baikal, perhaps even exceeding in size the largest cemeteries from Cis-Baikal, such as Lokomotiv in Irkutsk on the Angara or Shamanka II in the southwest corner of Lake Baikal (Bazaliiskii, 2010). However, unlike Cis-Baikal's Middle-Holocene cemeteries, Fofanovo has so far received very little attention from western researchers.

Table S1: Details of the excavations conducted at Fofanovo (Gerasimov and Chernykh, 1975; Lbova et al., 2008) and the number of burials successfully analysed for radiocarbon dating and stable isotope analyses in this study.

Fieldwork director	Excavation years	Number of excavated graves	Cemetery area	Number of burials successfully analysed
Okladnikov	1926	?	Punkt I	
Gerasimov	1931, 1934–1936	10	Punkt II?	7
Okladnikov	1948	19	Punkt II	5
Okladnikov	1950	20	Punkt II	8
Gerasimov	1959	41	Punkt II	
Konev	1987–1989	10	Punkt I	
Konev	1996, 1996	7	Punkt II	
Total		**107**		**20**

S1.2. Typological chronology

Little is known about the material collected by Okladnikov in 1926 and again in 1948, and Gerasimov did not leave behind any typochronological assessment of the material he acquired through his fieldwork in 1931 and 1934–36. Neither did he comment on the 1930's excavations in a later article dedicated to his 1959 excavations (Gerasimov and Chernykh, 1975).

The graves excavated by Okladnikov in 1950 received only very brief typochronological evaluation in his field notes without much justification (Lbova et al., 2008: 235). He attributed Graves 1–11, 13, 16, and 20 to the EBA Glazkovo mortuary tradition, Grave 17 to Glazkovo or Late Bronze Age (LBA) Shivera mortuary traditions, and Grave 12 possibly to Kitoi. However, this last assignment was annotated with a "?" mark, apparently believing that in the absence of most Kitoi diagnostic characteristics, the presence of only red ochre warranted caution. Clearly, he had more doubts with regards to Grave 18 (with no grave goods) and Grave 19 (with beads only), as these were omitted from his classification.

Chronological position of the graves excavated by Gerasimov in 1959 was discussed in more detail in his later paper dedicated to this cemetery (Gerasimov and Chernykh, 1975). Based on stratigraphic evidence and typological criteria, three chronological groups were proposed:

- **Group 1:** Graves 1–7 (n=7), roughly synchronous with the Kitoi mortuary tradition on the Angara. Six graves contained single interments and one (Gr. 7) had seven, some of which were placed in the head-to-toe position. All graves had copious amounts of red ochre. Individuals were usually buried on their backs with legs tightly flexed in different ways. Five burials in Grave 7 had missing skulls in a fashion similar to that known from the large Kitoi cemetery of Lokomotiv on the Angara. Grave goods were not very numerous and included boar tusks and red deer canine pendants, musk-deer canines, marmot incisors, mother-of-pearl beads and blades, daggers with microblades and blades, and flakes.

- **<u>Group 2</u>:** Graves 8–36 (n=29), generally synchronous with the Glazkovo mortuary tradition on the Angara. In all graves with well-preserved skeletal remains, the burials were laid out in the extended supine position with heads pointing E, upstream on the Selenga River. The grave goods included a broad range of lithic objects (arrowheads of different shapes, scrapers, retouched flakes, large scrapers [скребла], knives on blade-flakes, spears or spear-shaped knives, drills and perforators, flakes and micro-flakes, pestles, flakers, sinkers and others), bone or antler objects (harpoons, daggers, perforators and points, needles and needle boxes, fishhooks, arrowheads, spoons, and others), bone or antler ornaments (red deer teeth, boar tusks, and pendants), animal bones, fragments of clay pots with rounded, pointed or flat bottoms all with different kinds of surface decoration, and some bronze objects (knives, needles, an awl, and a fishhook).
- **<u>Group 3</u>:** Graves 37–41 (n=5), dating to the Iron Age Stone Cist Culture (культура плиточных могил), and hence outside the scope of this study.

At the time of Gerasimov and Chernykh's (1975) chronological assessment, Kitoi was generally believed to date to the Late Neolithic (LN), thus directly preceding Glazkovo (Okladnikov, 1950; 1955). Nevertheless, Gerasimov doubted a Kitoi–Glazkovo continuity, as the substantial stratigraphic separation between the levels from which Group 1 and Group 2 graves were excavated suggested a major temporal gap between them. This view was consistent with his critique, based on the human craniological data, of the Kitoi's chronological position in the Okladnikov model of Cis-Baikal Middle Holocene culture history expressed by Gerasimov previously (1955).

Lastly, the 17 graves excavated by Konev clearly associate with Gerasimov and Chernykh's (1975) Group 1. Due to the similarities with the Kitoi mortuary tradition displayed by Group 1, it is now assigned a much older chronological position (i.e., Early Neolithic) than assumed by Okladnikov and others (Weber 1995), as has been confirmed by the extensive program of radiocarbon dating which started in the late 1980's in Russia (Mamonova and Sulerzhitskii, 1989) and continued in the West from the late 1990's (Weber et al., 2006; Weber et al., 2016a; Weber et al., 2020).

S2. A Note on Comparing Radiocarbon Dates

It must be kept in mind that neither the AMS radiocarbon dates from Weber et al. (2020) nor the Mamonova and Sulerzhitskii (1989) radiocarbon dates are directly and fully comparable with the new Fofanovo dates. While the utility of the 1989 Russian dates is limited by the problems mentioned previously (see Section 3.1), the issues related to comparison with the large set of Cis-Baikal AMS dates are more nuanced. Although all the new dates from Fofanovo and Cis-Baikal datasets have been corrected for an old carbon effect, the subsequent processing of the corrected dates was different. After correction, Cis-Baikal dates were subjected to Bayesian modelling using two different distributions—trapezoidal and uniform—generating two sets of calibrated dates BP (Weber et al., 2016a; 2016b), neither of which are available for the new Fofanovo dates, which were only corrected and then calibrated without being modelled, as this would be premature given the small number of dates for each period (cf. Figure 5). Therefore, the new, corrected Fofanovo dates can only be directly compared with the corrected Cis-Baikal dates and the mean calibrated dates BP. Thus, placing the Fofanovo dates within the periods defined by the Bayesian analysis for Cis-Baikal requires caution. While the difference between unmodeled and modelled mean calibrated dates BP in the middle of each distribution (i.e., period) is usually negligible, the difference between the two can be as high as 200 years at the tails. Additionally, the difference tends to be larger for the dates produced by the uniform distribution model. To keep the matter simple, the current study references only the mean calibrated dates BP (cf. Table 9) for Fofanovo and the Cis-Baikal cemeteries (Weber et al., 2020). This has no effect on the present analysis, which is the first publication of what is expected to be a comprehensive examination of all Fofanovo materials still available for research. Once available, a larger dataset of Fofanovo radiocarbon dates will be modelled employing the same approach as for the Cis-Baikal datasets.

S3. Supplement References

Gerasimov MM. 1955. Vosstanovlenie litsa po cherepu: Sovremennyi i iskopaemyi chelovek. Trudy Instituta etnografii im. N.N. Miklukho-Maklaia. Volume 28. Moscow: Nauka. [In Russian]

Gerasimov, M.M., Chernykh, E.N. 1975. Raskopki fofanovskogo mogil'nika v 1959 g. In: Mandel'shtam, A. M. (Ed.), Pervobytnaia arkheologiia Sibiri. Nauka, Leningrad, pp. 23–48. [In Russian]

Lbova, L.V., Zhambaltarova, E.D., Konev, V.P. 2008. Pogrebal'nye kompleksy neolita–rannego bronzovogo veka Zabaikal'ia. Russian Academy of Sciences, Siberian Branch, Novosibirsk. [In Russian]

Mamonova, N.N., Sulerzhitskii, L.D., 1989. Opyt datirovaniia po C14 pogrebenii Pribaikal'ia epokhi golotsena. Sovetskaia arkheologiia 1:19–32. [In Russian]

Okladnikov, A.P. 1950 Neolit i bronzovyi vek Pribaikal'ia (chast' I i II). Materialy i issledovaniia po arkheologii SSSR, Vol. 18. Izdatel'stvo Akademii nauk SSSR, Moscow. [In Russian]

Okladnikov, A.P. 1955 Neolit i bronzovyi vek Pribaikal'ia (chast' III), Materialy i issledovaniia po arkheologii SSSR, Vol. 43. Izdatel'stvo Akademii nauk SSSR, Moscow. [In Russian]

Weber, A.W., Beukens, R., Bazaliiskii, V.I., Goriunova, O.I., Savel'ev, N.A. 2006. Radiocarbon dates from Neolithic and Bronze Age hunter–gatherer cemeteries in the Cis-Baikal region of Siberia. Radiocarbon 48 (3), 1–40.

Weber, A.W., Bronk Ramsey, C., Schulting, R.J., Bazaliiskii, V.I., Goriunova, O.I., 2020. Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Chronology and dietary trends. Archaeological Research in Asia. Submitted.

Weber, A.W., Schulting, R.J., Bronk Ramsey, C., Bazaliiskii, V.I., Goriunova, O.I., Berdnikova, N.i.E., 2016a. Chronology of middle Holocene hunter–gatherers in the Cis-Baikal region of Siberia: Corrections based on examination of the freshwater reservoir effect, Quaternary International 419, 74–98.

Weber, A.W., Schulting, R.J., Ramsey, C.B., Bazaliiskii, V.I., 2016b. Biogeochemical data from the Shamanka II Early Neolithic cemetery on southwest Baikal: Chronological and dietary patterns, Quaternary International 405, 233–254.