Title:

Spatio-temporal patterns of cemetery use among Middle Holocene hunter-gatherers of Cis-Baikal, Eastern Siberia

Short Title: Patterns of cemetery use

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1. INTRODUCTION

Two papers in this special issue are dedicated to chronological developments among Middle Holocene hunter–gatherers (HG) of the Cis-Baikal region, Eastern Siberia (Fig. 1 and Fig. S1)[1]. Weber et al. (2020) examine chronological boundaries between a range of culture historical units of analysis (i.e., archaeological periods and mortuary traditions) as well as temporal patterns in past HG diets (i.e., the identification of dietary trends within various forager groups). This study, on the other hand, focuses on the spatio-temporal distribution of burial events *within* the region's mortuary traditions and cemeteries; in other words, on patterns of cemetery use. Both studies are based on the same body of biochemical results (radiocarbon dates and stable carbon and nitrogen isotope measurements associated with 560 individuals) and both examine these matters at scales varying from individual cemeteries through microregions to the entire Cis-Baikal. While both pieces rely to a large extent on the Bayesian analysis of radiocarbon dates, each employs different methods. Consequently, in assessment of the results, Weber et al. (2020) use mostly chronometric terminology and offer a range of parameters to define boundaries and durations of relevant culture historical units, while this study employs the language of relative chronology (e.g., older vs. younger, longer vs. shorter, etc.). Together, the two studies provide complementary insights about the processes of culture change and variation affecting these HG groups. Yet another paper in

[1] Cis-Baikal is an area of 200,000–250,000 km^2 (about the size, for example, of the United Kingdom) located immediately west of Lake Baikal between its northwest coast and roughly Ust'-Ilimsk on the Angara (Fig. 1).

this special issue integrates these findings with the rest of the available evidence into a synthetic narrative about the evolution of these HGs (Weber, 2020).

Perusal of the relevant literature on prehistoric HG cemeteries generates, for reasons given below, two impressions: (1) That, in general, they are not particularly amenable to studying patterns of use; and (2) That, while HG cemeteries do provide some insights about processes of culture change and variation between archaeological periods or cultures, they are a less useful source of information on culture change within such units. This paper challenges this state of affairs and demonstrates that much can, in fact, be learned about both subjects. Employing a novel approach, developed in part with the Baikal mortuary record in mind, the paper examines Middle Holocene HG cemeteries in the Cis-Baikal region and generates a host of new insights about the evolution of these groups. The method is based on radiocarbon-dating each available human interment to measure the timing of these burial events. Combining these radiocarbon dates with geographic location data (longitude and latitude) for all burials allows examination of their spatio-temporal distribution patterns at various scales of analysis, from individual cemeteries and the mortuary traditions documented within them, through microregions to the entire Cis-Baikal region.

That many elements of mortuary practices, including those of HG, are systematically linked to various aspects of socio-economic systems is a well-documented fact in the archaeological and anthropological literature (e.g., Beck, 1995; Binford, 1971; Carr, 1995; Chapman et al., 1981; Klaus et al., 2017; Rakita et al., 2005; Parker Pearson, 2000; Saxe, 1970; Tainter, 1978). Moreover, while such mortuary characteristics as grave architecture, grave goods and body treatment have played an important role in the development of relative dating techniques for archaeology and in addressing a variety of questions about past cultures (including matters of culture change and social differentiation), these applications have been essentially limited to farming, peasant, herding, and early state settings. Much less is known about the history and patterns of cemetery use or spatio-temporal variation in mortuary practices in past HG groups at the scale of individual cemeteries, microregions, regions or archaeological periods. A few factors account for this.

The general rarity and typically small size of prehistoric HG cemeteries during the Pleistocene and much of the Holocene have meant that the empirical data available for such units of analysis are rather scant. The slow pace of cultural change in most prehistoric HG groups has meant that changes in mortuary practices are expected to be subtle and, thus, not particularly amenable to detailed temporal studies in either chronometric or relative terms. Additionally, the small population size and density of most HG groups, and the resulting low frequency of deaths and mortuary events, have meant that a substantial amount of variation in HG mortuary practices seems to be attributable, at least implicitly, to stochastic processes rather than to culture change. Because of these limitations, most examinations of past HG mortuary practices have emphasized the functional approach paying considerably less attention to history. The analysis of the Yuzhnyi Olenii Ostrov cemetery in Karelia, northern Russia, by O'Shea and Zvelebil (1984), is a classic example of such an approach, though it is also a study that continues to stimulate much research including our own on Middle Holocene HGs in the Baikal region.

A few technical limitations of radiocarbon dating have also contributed to the current state of research on this matter. First, before the development of the AMS technique, direct dating of human skeletal remains required large samples, while indirect dating faced problems related to the availability of samples reliably associated with burial events, prohibiting large-scale applications. Second, the dates had large error terms not useful for building high-resolution chronologies. While the development of the AMS method has alleviated most difficulties related to the direct dating of human osteological remains, the problem of various reservoir effects has come into much sharper focus (Cook et al., 2001;

Keaveney and Reimer, 2012; Olsen et al., 2010; Philippsen and Heinemeier, 2013; Schulting et al., 2021; Wood et al., 2013).

Consequently, radiocarbon dating of prehistoric HG cemeteries has been rather limited in scope and primarily focused on confirming broad placement within a period, such as the Late Mesolithic cemeteries of Vedbæk in Denmark and Skateholm in southern Sweden (Albrethsen and Brinch Petersen, 1976; Larsson, 1988; Meiklejohn et al., 2009), or to overriding it, as for the Yuzhnyi Olenii Ostrov cemetery (Jacobs, 1995; Mamonova and Sulerzhitskii, 1989; Price and Jacobs, 1990). Interests in high-resolution chronology are also typically inhibited by a low number of radiocarbon dates. While Zvejnieki, a multi-component cemetery from northern Latvia with burials dating from the Mesolithic to the Iron Age, has seen somewhat more extensive dating, wider comparisons are restricted by the lack of similar cemeteries in the area (Eriksson et al., 2003; Mannermaa et al., 2007; Meadows et al., 2016, 2018; Zagorska, 1997).

Another factor limiting radiocarbon dating of past HG cemeteries is that, as with many other aspects of HG behaviour, changes in mortuary practice are assumed to take place mainly at period boundaries rather than within periods. Thus, instead of dating all burials, a representative sample is considered sufficient for general chronological assessment.

<Fig. 1. Map of Cis-Baikal…>

The research conducted on Middle Holocene HGs in the Cis-Baikal region of Eastern Siberia (Fig. 1) over the last 20–30 years by the Baikal Archaeology Project (BAP) has made a major contribution to addressing such limitations and developing new approaches (Zvelebil and Weber, 2013). Unlike most boreal regions world-wide, Cis-Baikal offers a wealth of HG mortuary data. Starting in the late 19th century, hundreds of HG cemeteries with around 1200 graves and close to 1500 burials have been documented (Weber and Bettinger, 2010: Table 3). The abundance of HG mortuary materials (i.e., grave architecture and inclusions, human skeletal remains, and details of spatial distribution at different scales of analysis) facilitates a range of empirical approaches rarely feasible elsewhere. In fact, it was exactly such materials that provided the basis for the first comprehensive synthesis of the region's Middle Holocene culture history (Okladnikov, 1950, 1955) and, while the archaeology of camp sites has seen much growth since Okladnikov's era, the cemeteries continue to generate new information to revise his synthesis and provide new insights about spatio-temporal variation in HG adaptive strategies.

Systematic large-scale radiocarbon dating of Cis-Baikal HG human skeletal remains has played a critical role in this research (Weber et al., 2016a, 2016b, 2020):

- It has rearranged the Okladnikov sequence of HG mortuary traditions and groups in the region (Table 1), rendering his synthesis effectively invalid (Mamonova and Sulerzhitskii, 1989; Weber, 1995, 2020);
- It has identified a millennium-long gap in the development of these traditions, during which Cis-Baikal HGs did not use formal cemeteries at all (contra Kuzmin, 2007);
- It has led to the discovery of a variable freshwater reservoir effect (FRE) in the Cis-Baikal aquatic ecosystem and, consequently, to the development of methods to correct this effect (Bronk Ramsey et al., 2014; Schulting et al., 2014, 2021);
- It has identified a discontinuity in the use of a large Early Neolithic cemetery otherwise invisible based on standard mortuary characteristics, thus hinting that similar discontinuities may exist in other cemeteries;
- It has demonstrated that at least some Early Neolithic cemeteries were not in use concurrently, suggesting that similar temporal offsets may characterize other cemeteries too;

- Combined with carbon and nitrogen stable isotope measurements associated with each radiocarbon-dated individual, it has provided new knowledge about spatio-temporal variation in dietary patterns in these groups; primary among these findings has been the discovery of a broad range of dietary trends, some involving increasing reliance on fish over time, others showing increasing reliance on game or seal, with other groups exhibiting dietary stability;
- It has further sharpened the definition of chronological boundaries between relevant culture historical periods and shown previously unknown microregional variation in the start and end of various mortuary traditions (Goriunova et al., 2020a, 2020b; Weber et al., 2020); and lastly
- All this has played an important role in the first attempt, since the Okladnikov synthesis, to develop a new model of the evolution of Cis-Baikal Middle Holocene HG groups (Weber, 2020).

<Table 1. Culture history…>

2. MATERIALS

Of the roughly 1240 archaeologically documented Middle Holocene burials in the Cis-Baikal region (Table 2), 560 (45%) from 65 cemeteries now have FRE-corrected radiocarbon dates[2] (Table 3, Supplement 1).

<Table 2. Spatio-temporal distribution of archaeologically...>

<Table 3. Numbers of Middle Holocene cemeteries...>

Even though this represents a substantial expansion (by 21%) of what was available at the time of the previous chronological analysis (256 dates, Weber et al., 2016a), the current dataset still shows several deficiencies that limit this examination.

<Table 4. Spatio-temporal distribution of radiocarbon dates...>

Although it was the Angara River valley (from Lake Baikal to Ust'-Ilimsk; Fig. 1) that provided the bulk of the mortuary data for the Okladnikov synthesis (1950, 1955), this microregional dataset retains a few gaps and biases (Tables 2 and 4). First, two cemeteries—Lokomotiv (EN) and Ust'-Ida I (EN, LN, and EBA)—account for 134 (75%) of the 175 radiocarbon dates available for this area. Of the five main mortuary traditions documented in the Angara valley, the small number of Khin burials probably represents the historical reality. The large number of Kitoi burials is likely an accurate reflection as well, despite the fact that the eponymous Kitoi cemetery, originally with about 34 documented burials (Okladnikov, 1974), is represented by a few dates only. The Isakovo tradition has a good number of dates but they mostly come from one cemetery (Ust'-Ida I, n = 36), the only 3 Serovo dates are from a cemetery with essentially no archaeological documentation (Kotin ostrov, an island on the Angara probably ~100 km downstream from Irkutsk[3]), and more than half of the dates available for the Glazkovo tradition are also from a single cemetery (Ust'-Ida I, n = 16). Obviously, the numbers of dated burials from these three mortuary traditions are not representative of the historical reality. The cemeteries of Galashikha, Ust'-Belaia, and Ust'-Ida I have been probably excavated in full but Lokomotiv has not, with only several areas in danger of destruction by contemporary construction projects subjected to rescue excavations.

[2] Radiocarbon dates available for 55 young children (younger than 5 y.) are excluded from analysis because their stable isotope measurements are expected to be affected by breastfeeding (Waters-Rist et al., 2011), which makes the matter of correcting their dates complicated (Schulting et al., 2014).
[3] Excavated by A.P. Okladnikov in 1955, the human skeletal remains are stored in the Museum of Anthropology and Ethnography, Russian Academy of Sciences, St. Petersburg.

Still, due to the large number of dated burials, the Lokomotiv sample is probably quite representative of its chronological structure. Sampling of older collections stored in Moscow and Irkutsk from along much of the Angara, currently in progress, will rectify some of these biases.

The SW Baikal microregion includes the coast of Kultuk Bay and the valley immediately west of it (Fig. 1). Since systematic archaeological research in this area started only recently, the mortuary record is limited to a single cemetery—Shamanka II, excavated in full between 1999 and 2019. Shamanka II provides our best body of information on many aspects of Kitoi mortuary practices and its chronological structure is well documented by 120 dated burials. The cemetery also has a smaller Glazkovo component with 15 burials, 9 of which have been dated; dating of a few burials excavated in 2019 is in progress. No Isakovo or Serovo graves are known so far in this microregion.

The Upper Lena South microregion (the first ~300 km of the Lena River valley from its source near Lake Baikal to Zhigalovo; henceforth Upper Lena) is where A.P. Okladnikov developed his archaeological interests by excavating a number of Neolithic and Bronze Age graves in the 1920s and 1930s. Unfortunately, little survives of the materials or documentation (Okladnikov, 1950, 1955, 1978). Although none of the cemeteries there seem to have been excavated in full and the overall number of dated burials is not particularly large (n = 82), the sample represents all relevant mortuary traditions relatively well or, at least, much better than on the Angara which has more than twice the number of dated burials. Verkholensk, excavated by P.P. Khoroshikh and A.P. Okladnikov from 1949 to 1951 (Okladnikov, 1978), clearly dominates the Serovo mortuary tradition while the Khin and Glazkovo units do not appear biased towards any one locality, although samples are rather small.

The Little Sea microregion— Ol'khon Island as well as a 150 km stretch along the west coast of Lake Baikal from the northern tip of Ol'khon Island to the mouth of the Bugul'deika River in the south (Fig. 1)—is perhaps the most representative sample in terms of mortuary traditions, cemetery size, and spatial distribution. Systematic archaeological work at mortuary sites started there in 1959 (Masson, 1992) and the tendency ever since has been to excavate cemeteries in full, aided by the frequent visibility of grave stone structures on the modern surface. Of the medium to large cemeteries, only two—Uliarba (Goriunova et al., 2004) and Shide (Gorbunova and Pshenitsyna, 1992)—are absent from the current dataset, although sampling and dating of Uliarba is in progress. Fieldwork at Mys-Uiuga (a small Khin cemetery) and Tuakhane IX (a medium size Glazkovo cemetery) also continues. Radiocarbon dating of Uliarba, Shide, and Tuakhane IX will increase the number of dated Glazkovo burials, which dominate the Little Sea sample already, and may identify more burials from the older mortuary traditions. Completion of dating Mys Uiuga will increase the number of dated Khin burials but not significantly. Overall, this work is unlikely to affect radically the relative numbers currently characterizing the spatio-temporal distribution of dated burials in this microregion.

<Table 5. Numbers of radiocarbon dates...>

Five cemeteries, all subject to ongoing bioarchaeological research by the BAP, are being analyzed here in more detail: EN Kitoi Lokomotiv (Angara), EN Kitoi Shamanka II (SW Baikal), LN Isakovo and EBA Glazkovo Ust'-Ida I (Angara), EBA Glazkovo Khuzhir-Nuge XIV (Little Sea), and EBA Glazkovo Kurma XIV (Little Sea) (Fig. 1). Relevant archaeological information for these cemeteries is summarized in Section 6 as an introduction to the assessment of chronological use patterns. All five cemeteries have dated burials belonging to a different mortuary component which are excluded from this examination due to the small sample size: Lokomotiv has 1 Khin burial, Shamanka II has 15 Glazkovo, Ust'-

Ida I has 1 Kitoi, and Khuzhir-Nuge XIV and Kurma XI have 1 and 2 Khin interments, respectively.

Chronology of the Khuzhir-Nuge XIV and Kurma XI cemeteries was examined prior to the discovery of the FRE, which impacted all radiocarbon dates on human skeletal remains and rendered most earlier findings invalid (Weber et al., 2005, 2008b; Weber, 2012). Lokomotiv and Shamanka II have been studied since the FRE discovery and the current analysis extends this research (Weber et al., 2016a, 2016b, 2020); chronology of Ust'-Ida I has been assessed only briefly, using radiocarbon dates not corrected for the FRE (Mamonova and Sulerzhitskii, 1989; Weber et al., 2006). Thus, this analysis is the first to examine the chronological structure of Ust'-Ida I, Khuzhir-Nuge XIV, and Kurma XI cemeteries with FRE-corrected dates.

3. APPROACH AND METHODS

The work completed to date suggests that many of the Middle Holocene HG cemeteries in Cis-Baikal had complicated and variable use histories (Weber et al., 2016a, 2016b, 2020). Consequently, while the main research focus so far has been on the definition of regional and microregional chronological boundaries between archaeological periods and mortuary traditions, the focus of this study is on the identification of spatio-temporal distribution patterns in burial events (graves and interments) *within* mortuary traditions, at varying geographic scales from individual cemeteries through microregions to the entire Cis-Baikal. In other words, the goal is to explore how the cemeteries were used relative to one another and how the relevant mortuary traditions developed in the main four microregions. Such tasks require an approach different from that applied previously.

Our ongoing chronological research on Cis-Baikal Middle Holocene mortuary materials employs Bayesian modelling of FRE-corrected ^{14}C dates in OxCal (Bronk Ramsey, 2014). The first two studies (Weber et al., 2016a; 2016b) used two models: one based on the assumption of a *Uniform* distribution of dated events within analyzed time intervals, the other assuming a *Trapezium* distribution (Lee and Bronk Ramsey, 2012) of dated events. The latest analysis of the expanded dataset employed only the *Trapezium* model, believed to be a more realistic representation of the chronological distribution of dated events within relatively large analytical units such as mortuary traditions, regions, and microregions (Weber et al., 2020). Although the results improve our understanding of the chronological boundaries and transitions between mortuary traditions and archaeological periods, they generate no insights about the historical distribution of dated events within them or within smaller units such as individual cemeteries.

In this study, the basic unit of analysis is the following string of information describing each examined individual (i.e., burial): Cemetery–ExcavationYear–Grave Number–BurialNumber–RadiocarbonDate–Error (Supplement 2). Each radiocarbon-dated burial is further assigned on typological grounds to one of the five main mortuary traditions (Khin, Kitoi, Isakovo, Serovo, and Glazkovo[4]) and placed into one of the four archaeological microregions (Angara, SW Baikal, Upper Lena, and Little Sea). Each string also includes the average cemetery longitude and latitude and can be further expanded by adding detailed grave locational data when available. Additional archaeological (e.g., body position, orientation, grave goods etc.) and bioarchaeological data (e.g., sex, age, health, and carbon and nitrogen stable isotope measurements) can also be included but are not, however, part of this examination (Supplement 1).

[4] In eight cases the published typological classification was overwritten based on the combination of new radiocarbon evidence and a re-evaluation of the archaeological context (Weber et al., 2020). More information regarding the typological criteria used to define these analytical units is provided in Weber et al. (2016a; 2020) and Weber (2020).

These data strings are analyzed using entirely novel techniques only recently developed in OxCal, some of them specifically for examination of the Baikal dataset. They include the "KDE_Model" (Kernel Density Estimate) function (Bronk Ramsey, 2017) and new visualizations, all described in more detail below. The current paper represents the first application of these methods on a large scale, both in terms of the number of dates analyzed as well as their spatio-temporal distribution.

3.1. OxCal Models

The analysis employs three OxCal models; examples of their code are provided in Supplement 2. The *basic* "KDE_Model" is employed to estimate the overall chronology and tempo of the use of 20 cemeteries with 5 or more radiocarbon-dated burials. The "KDE_Model" function allows the detection of any patterns in the distribution of the dated events (i.e., burials) within relevant analytical units. Its strength is that it provides our best estimate for the temporal distribution of the dated events at each cemetery, reducing the noise and spread of dates that come from the calibration process, while retaining as much of the underlying density of dates as possible (Bronk Ramsey, 2017).

The spatial kernel density estimation approach, also employing the "KDE_Model" function, allows a more detailed examination of internal spatio-temporal distributions within cemeteries with detailed grave location information. This facilitates a dynamic spatio-temporal simulation of the history of use of five cemeteries: Shamanka II and Lokomotiv (the Kitoi components), Ust'-Ida I (the Isakovo and Glazkovo components), and Khuzhir-Nuge XIV and Kurma XI (the Glazkovo components).

The remaining 45 cemeteries have fewer than 5 dates and so are not suitable for KDE modelling. These are analyzed using the "Sum" function, but with the addition of temporal uncertainty of 100 years (N(0,100)), which is sufficient to smooth out the structure from the calibration process but may slightly over-estimate the chronological spread of the dated burials and is effectively equivalent to a "KDE_Plot" function (Bronk Ramsey, 2017) with a predefined kernel size. This approach is consistently applied to these 45 cemeteries also because it is easily understood. With so few dated burials, the true spread of cemetery use may be larger than the spread of dated interments and, thus, this is as good an estimate as can be currently obtained.

Since many cemeteries are multi-component, with two or even three mortuary traditions (some separated from one another by a substantial amount of time), each group of dates is examined separately. Including all components in the same "KDE_Model", often dominated by one larger dataset, would bias the results for the smaller group(s). For example, at Sarminskii Mys, its three mortuary groups are analyzed separately: Khin (n = 2), Serovo (n = 13), and Glazkovo (n = 8) (Table 5).

Since the results from "KDE_Model" and "Sum" functions, as implemented here, are broadly comparable, their combined use allows the examination of relative chronology within and between cemeteries, microregions, and mortuary traditions. The entire dataset of 560 dates, sorted into 65 units of analysis from 46 localities (Table 5), was analyzed in a single OxCal file. However, to search for additional patterns, this dataset was further sorted in several other ways using criteria such as mortuary traditions, microregions, sectors or clusters within a cemetery, as well as their various combinations. These units of analysis were analyzed using the basic "KDE_Model" only.

3.2. Output analysis

Analysis of the results employs three methods: cemetery- or unit-specific plots, regional simulations, and cemetery-specific simulations, implemented in the following ways. First, summary graphs (supported by the basic "KDE_Model" and "Sum" functions) provide for a general assessment of the chronological position of a number of examined units relative to one another (e.g., Fig. 2).

Second, unit-specific plots (supported primarily by the basic “KDE_Model” function) facilitate more detailed assessment of the chronological structure of each unit separately including the frequency of burial events within them (e.g., Fig. S4). Time (“Modelled date BP”) is on the X-axis while the frequency of burials events (“Probability density”) is on the Y-axis: the higher the “Probability density”, the higher the frequency of burial events. For example, Little Sea Khin burials (Fig. S4: B) occurred very rarely (highest probability density ~0.02) over a very long period of time (~1500 years), while the Angara Kitoi burials (Fig. S4: D) occurred at a frequency an order of magnitude higher (highest probability density ~0.2) and over a much shorter time (~700 years)[5].

Third, the approach facilitates assessment of the spatio-temporal distribution of burial events at the Cis-Baikal regional level using dynamic plots of two-dimensional KDE-based contour maps of the dated burials based on their weighted probability for particular points in time (e.g., Fig. 7). This method is supported by the basic “KDE_Model” and “Sum” functions with average cemetery location information. The spatial distributions generated in this way are not geographically sensitive (for example they extend over Lake Baikal), and are not an attempt to model developments over time. Rather, their aim is to summarize the overall distribution of dated cemeteries and burial events across the region. Because the distribution is a kernel density (with contours set at linear probability increments), it will interpolate across the landscape, taking into account the sparsity of the data.

The cemetery-specific simulations, supported only by spatial kernel density estimation, generate dynamic maps showing the history of burial events for the five best documented sites. In the end, each such simulation produces a summary map with each burial color-coded for its calibrated and modelled radiocarbon age, which facilitates the search for spatio-temporal patterns in cemetery use (e.g., Fig. 13[6]). Not all dated burials are visible on the final map. This is because for graves with multiple interments, the marker for the burial with the youngest date covers those of the older ones. However, all burials, including those hidden underneath younger ones, are visible while the simulation is running. Two-dimensional KDE-based contour maps can also be used in this analysis. Simulations can be stopped at any time to generate graphic outputs and are well suited to investigating what is happening at different scales of analysis (regional, microregional, and cemetery) in particularly critical times such as onset, peak, change in tempo or end of burial activity.

The following discussion focuses on pattern recognition in the temporal distribution of burial events within the analyzed units, employing mainly relative terms such as younger vs. older, shorter vs. longer, earlier vs. later, etc. This helps to shift attention away from period boundaries and durations (the focus of previous studies), to other temporal aspects that are equally important for understanding the spatio-temporal variation in mortuary practices and, ultimately, in HG adaptive strategies in the region. More specific ages or intervals are given only when deemed useful. Furthermore, the OxCal functions used in this paper are not designed to generate such chronometric terms and inferring them via visual examination of the graphic outputs would only clutter the narrative with parameters that are both misleading

[5] In both, the “Sum” and “KDE_Model” unit-specific plots, the grey distribution provides our best estimate for the underlying frequency of burial events over time. The “KDE_Model” generates also specific frequency distribution estimate scenarios with the average of these shown with a solid blue line and the light blue band representing 1 standard deviation of uncertainly; these blue bands give an indication of the uncertainty in the frequency distribution estimate.

[6] Grave numbers are provided in accompanying cemetery maps (e.g., Fig. 12).

and methodologically incorrect[7]. The chronometric scale of each graph and map, the ranges of radiocarbon dates for each mortuary tradition, and the period boundaries in HPD estimates (the latter two provided in Table 1) are considered a sufficient temporal frame of reference for this examination, giving the reader an adequate sense of the tempo, duration, and chronological position of the various cultural developments examined in the paper. Weber et al. (2020) provides other relevant chronological terms for some of the units of analysis examined here. All terms, however, are generated using trapezium phase Bayesian-models, and thus are not directly comparable to ages from the graphs and maps presented in this paper, which use the KDE model (where possible) to look at changes in tempo of burial acitivity within and between various units of analysis.

The discussion also references dietary patterns among these HG groups identified in recent studies dedicated to this matter (Weber et al., 2016a, 2016b, 2020). The original radiocarbon, carbon and nitrogen isotope data are presented in Supplement 1, but the supporting statistical tests, graphs, and descriptions of trend structure are provided only in the referenced studies.

Lastly, for brevity, the discussion employs the abbreviations from Table 1 and their combinations to define relevant units of analysis. Also, many graphs presented in the paper have a more detailed equivalent included as supplementary material.[8]

4. DISCUSSION: RELATIVE CHRONOLOGY OF MORTUARY TRADITIONS

A concurrent analysis of the same data set using a different approach (Weber et al., 2020) has suggested that the histories of at least some Middle Holocene mortuary traditions in the Cis-Baikal region were not synchronous between the four microregions. As mentioned, assessment of this topic requires caution because some microregional datasets are affected by sampling biases. Many, however, are sufficiently representative for this analysis to proceed.

At the regional scale, mortuary traditions present in three or four microregions (i.e., Khin, Serovo, and Glazkovo) display chronological distributions that are broad relative to Kitoi and Isakovo, which are spatially restricted to one or two microregions (Fig. 2: A). At least in some cases, this seems to be a direct result of chronological offsets between microregions: the broader the geographic distribution of a mortuary tradition, the higher the chance of differences, effected by a combination of cultural and environmental factors, in the timing of its start and end between microregions (Fig. 2: B–E). Although some of these offsets are probably a product of sampling biases, some are very likely are historically real (c.f., Weber, 2020).

<Fig. 2. Chronology of mortuary traditions>

<Fig. 3. Chronology of the Middle Holocene cemeteries>

4.1. Khin Group and Kitoi mortuary tradition

The Khin Group of graves predates the Kitoi mortuary tradition and appears around the same time on the Angara, in the Little Sea, and on the Upper Lena, but is currently unknown in SW Baikal (Fig. 4 and Fig. S4). The ANG–KHI seems to have been relatively quickly replaced by Kitoi but a similar replacement is not seen in the Little Sea or on the Upper Lena. The histories of the LS–KHI and UL–KHI groups appear to be generally the same, with the

[7] In OxCal, a number of other functions are specifically designed to generate more specific chronological parameters (e.g., Sequence, Boundary, Start, Transition, End, Span, and Interval), all of which are used in studies dedicated to the chronometric chronology of the Middle Holocene Cis-Baikal HG cultures (Weber et al., 2016a; 2016b; 2020).

[8] Supplementary figures expand on the information provided in the figures included in the main body of the paper. Therefore, their numbering directly corresponds to the figures in the printed version of the paper. For example, supplementary Fig. S4 expands on Fig. 4.

former perhaps starting and ending a little later than the latter. These differences, however, are likely related to the current state of fieldwork, particularly on the Upper Lena.

<Fig. 4. Chronology of Khin>

The Khin Group is best represented in the Little Sea, where Goriunova et al. (2020a) have analyzed 26 such graves with 31 burials from 8 cemeteries[9]. The 16 dates available for these interments suggest that, as in the other two microregions, graves of the LS–KHI group appear several centuries before the start of Kitoi; however, its peak seems to parallel that of ANG–SWB–KIT (Fig. 4). The end of LS–KHI also seems coincident with the end of Kitoi, if Phase 2 of the Kitoi cemetery at Shamanka II on SW Baikal (which post-dates the end of LS–KHI by a few centuries) is excluded from consideration.

The Kitoi mortuary tradition provides our most robust dataset: it is confined to two microregions located in close proximity to each other (Angara and SW Baikal), and its chronology can be assessed based on a large number of radiocarbon dates (n = 225, Table 4). The relative temporal position of the ANG–KIT and SWB–KIT groups is essentially the same excepting the late Kitoi component at Shamanka II. This has no analogue on the Angara despite the sufficient number of dates (n = 105) for it to be visible had it existed (Fig. 4 and Fig. S4). The Kitoi dataset shows a few other patterns that are further discussed below.

4.2. Isakovo and Serovo mortuary traditions

The Isakovo and Serovo mortuary traditions come next, separated from the ANG–KIT and from the LS–KHI and UL–KHI by a millennium-long gap (Table 1, Fig. 5 and Fig. S5). Thus far, the consensus has been that the Isakovo tradition was restricted to the Angara valley, but this may not be the case. A recent reassessment of the Verkholensk cemetery on the Upper Lena revealed that one of its graves shows some Isakovo characteristics (Table 4; Weber et al., 2020; White et al., 2020). Regardless of this reassignment, the Isakovo distribution is still mainly on the Angara and the sample of radiocarbon dates is heavily biased towards the Ust'-Ida I cemetery. In contrast, Serovo is known from three microregions and the sample of ANG–SER radiocarbon dates is minimal (n = 3; Table 4).

Ever since the original Okladnikov (1950) Middle Holocene culture history of Cis-Baikal was revised based on radiocarbon evidence (Mamonova and Sulerzhitskii, 1989; Weber, 1995; Weber et al., 2002, 2006, 2016a), it has been generally accepted that the Isakovo and Serovo mortuary traditions were contemporaneous. However, the radiocarbon evidence presented in this paper suggests the presence of some subtle microregional differences (Fig. 5). First, the oldest Isakovo or Serovo burials seem to come not from the Angara but from the Upper Lena (n = 1) and the Little Sea (n = 2), respectively. It would be tempting to dismiss these three dates as measurement outliers, but a strong argument can be provided against doing so. First, they come from multi-component cemeteries: Verkholensk with four mortuary traditions represented (Khin[10], Isakovo, Serovo, and Glazkovo) and Ulan-Khada with three (Khin, Serovo, and Glazkovo), often separated from one another by a substantial amount of time. Second, in both areas, there are many other multi-component cemeteries with similar use histories (e.g., Sarminskii Mys, Shamanskii Mys, and Kurma XI in the Little Sea and Makrushino on the Upper Lena; Table 5). And third, these three early dates are consistent with one another and thus perhaps mark together the earliest horizon of

[9] The graves in the Little Sea microregion labelled in this paper the "Khin Group" are labelled differently by Goriunova et al. (2020a), who subdivide them into two groups: "Khotoruk" and "Kurma".

[10] Radiocarbon dating of Burial 1 from Grave 19 identified it as belonging to the Khin mortuary tradition. The date, however, is excluded from this analysis because it is for a young child (<5 y.) and thus has not been corrected for the freshwater reservoir effect (White at al., 2020).

the reappearance of formal burials in Cis-Baikal after the long discontinuity that began with the end of the Kitoi and Khin mortuary patterns.

<Fig. 5. Chronology of Isakovo and Serovo>

A few other tentative observations can be offered (Fig. 5). The ANG–ISA appears very short in duration, regardless of whether or not the one date from the eponymous Isakovo cemetery is included. More dates are needed to asses to what extent this applies to Ust'-Ida I only, or to the entire ANG–ISA tradition. Interestingly, the proportion of subadults (younger than 15 years) in Isakovo graves on the Angara is ~60% (Bazaliiskii, 2010) and even higher at Ust-Ida I alone (66%; Lieverse, 2010; Tiutrin and Bazaliiskii, 1996). For the other mortuary traditions in all four Cis-Baikal microregions the proportion of this age cohort is much lower, in many cases lacking entirely. This may mean that the ANG–ISA was a relatively short-lived phenomenon, its culture-historical importance in need of a dedicated analysis. Next, the ANG–ISA burials appear to be roughly coincident to most of the UL–SER and older than the LS–SER (disregarding the two old burials from Ulan-Khada). The ANG–SER seems younger than the ANG–ISA and all three Serovo units are roughly parallel to each other. However, the main part of the LS–SER distribution is substantially wider than the UL–SER and shifted towards the young end. Continued dating of these materials, particularly from the Angara, is necessary to test these observations.

4.3. Glazkovo mortuary tradition

Although the numbers of dates available for the Glazkovo mortuary tradition differ greatly between the microregions, the numbers of cemeteries represented on the Angara, in the Little Sea, and on the Upper Lena are about the same (Table 5). The balance between the latter compensates somewhat for its lack between the former. The SW Baikal, with only one Glazkovo cemetery and nine dated burials, is the exception limiting comparison with the other areas.

<Fig. 6. Chronology of Glazkovo>

The main chronological offsets between the four microregions regard the start of ANG–GLA (n = 27) and the end of UL—GLA (n = 39), which appear somewhat older and younger, respectively, than the LS–GLA (Fig. 6 and Fig. S6) with a much larger number of dated burials (n = 132) than the other two. Thus, continued dating of the LS–GLA is less likely to shift its boundaries in either direction. The SWB–GLA belongs to the second half of the entire Glazkovo chronological range and its modelled distribution is very similar to the ANG–ISA. Both could be very short-lived mortuary phenomena, the SWB–GLA perhaps shorter still. The SWB–GLA, the peak of LS–GLA, and the younger peak of the UL–GLA appear to be coterminous.

4.4. Results from the regional KDE simulation

The two-dimensional KDE-based contour map simulation is introduced here mainly to show its analytical potential once the dataset becomes more spatially and chronologically balanced. It visualizes results in a manner different from the other techniques and can reveal patterns that are not as readily detectible otherwise. The simulation shows well the following:

- The essentially coterminous appearance of LM Khin burials across Cis-Baikal and well before the start of the Kitoi mortuary tradition (Fig. 7: A);
- The "explosion" of EN Kitoi burials on the Angara and in SW Baikal rapidly replacing the Khin there, as well as the continuation of Khin burials in the Little Sea and on the Upper Lena (Fig. 7: B);

- The northward spread of Kitoi burials along the Angara soon after the end of Shamanka II Phase 1 (Fig. 7: C);
- The discontinuity between Shamanka II Phase 2 and all earlier Kitoi burial events (Fig. 7: B–D);
- The MN discontinuity in formal burials across Cis-Baikal (Fig. 7: E);
- The contemporaneity of LN Isakovo and Serovo interments on the Angara with those on the Upper Lena (Fig. 7: F);
- The much later development of the Little Sea Serovo relative to Isakovo and Serovo in the Angara valley and on the Upper Lena (Fig. 7: G).
- The high frequency of burials at Khuzhir-Nuge XIV dominating the second half of the EBA Glazkovo mortuary tradition in the Little Sea (Fig. 7: H). And,
- The continuation of Glazkovo burials, though at a low frequency, on the Upper Lena until much later than in the Little Sea (Fig. 7: I).

<Fig. 7. Spatial distribution of Middle Holocene burial events…>

5. DISCUSSION: RELATIVE CHRONOLOGY OF CEMETERY SIZE AND CEMETERY USE PATTERNS

While an examination of the frequency of burial events is possible only for large cemeteries, a chronological assessment of cemetery size works for all sites. Very small samples (n < 5) are included because many of them were probably just as they appear: small cemeteries or isolated graves as confirmed by negative results of extensive searches for other graves around them.

Cemeteries of the same mortuary tradition in all microregions display varied chronologies: some parallel one another, some overlapping, and some separated by up to a few centuries (Fig. 3. Their different relative chronological positions do not seem to be reflected in mortuary practices, including grave architecture, body treatment, or grave goods. The periods of use also vary substantially from very short (as little as a single generation) to very long (up to several centuries), in a fashion that does not always appear to be a direct function of cemetery size. Furthermore, the temporal distribution of burial events within individual cemeteries, or composite units of analysis, is also variable. The Kitoi cemeteries on the Angara and in SW Baikal and the Glazkovo ones in the Little Sea are the best prospects to explore this matter in more detail, but a few other units of analysis are useful too.

5.1. Khin Group and Kitoi mortuary traditions

Most cemeteries of the Khin Group seem to differ chronologically from one another, cumulatively spanning well over a millennium (Fig. 8). The Kitoi cemeteries of Lokomotiv (Angara) and Shamanka II Phase 1 (SW Baikal) are essentially coterminous, but Ust'-Belaia and Galashikha, both from the Angara, are younger and Shamanka II Phase 2 is younger still. The gap between Shamanka II Phase 1 and Phase 2 is obvious and the latter is the youngest relatively large Kitoi mortuary component documented thus far (Fig. 9 and Fig. S9).

<Fig. 8. Chronology of Khin cemeteries>

<Fig. 9. Chronology of Kitoi cemeteries>

Burials at Lokomotiv (n = 80) and Shamanka II Phase 1 (n = 103), by far the largest Kitoi samples, are skewed towards the first half of each cemetery's use (Fig. S9), an observation consistent with results of a different modelling of the same datasets, implying a rather quick start in the use of these two large cemeteries (Weber et al., 2016a, 2016b, 2020). This finding invites examination of the temporal distribution of the rest of the dated Kitoi burials from the Angara valley (n = 22). The eponymous Kitoi cemetery (n = 3) is excluded because these few dates derive from what was quite a large cemetery with 35 documented burials (Okladnikov, 1974) and many more probably destroyed through farming before and after its excavation in the 1880s. Excluding Lokomotiv, Kitoi burials from the Angara show a temporal distribution with two peaks: the small initial peak dates to about the time when Lokomotiv and Shamanka II start and grow rapidly, while the large late peak dates to the interval separating Shamanka II Phase 1 from Phase 2 (n = 17). The small Kitoi–KIT sample is consistent with the peaks at Lokomotiv and Shamanka II Phase 1. All this suggests that the first half of the Kitoi mortuary tradition was dominated by large cemeteries (Kitoi, Lokomotiv, and Shamanka II Phase 1), while small to medium cemeteries (Galashikha, Ust'-Belaia, and Shamanka II Phase 2) are typical of the second half. Very small cemeteries with only a few burials likely appeared sporadically in the Angara valley from start to end of Kitoi.

5.2. Isakovo and Serovo mortuary traditions

The Isakovo component at Ust'-Ida I (n = 36), the largest single-cemetery sample of either Isakovo or Serovo anywhere in Cis-Baikal, is much shorter in duration than any other LN unit with similar numbers of radiocarbon-dated burials (e.g., Verkholensk–SER, n = 32; UL–SER, n = 38; LS–SER = 26; Fig. S5). In the Little Sea, an area with the highest number of dated Serovo cemeteries (n = 8), most have different chronologies, thus creating the broadest, at least millennial, distribution of either of these two mortuary traditions anywhere within Cis-Baikal (Fig. 5). Budun IV (Fig. 3: C), a small Serovo cemetery with seven dated burials, shows a chronological structure that is similar to that seen at Galashikha–KIT (Fig. 9), Ust'-Ida I–ISA (Fig. S5: B), and Shamanka II–GLA and Kurma XI–GLA (Fig. S10: A, C), all probably used over very short intervals, from one generation to a few at the most. The fact that at Budun IV 4 radiocarbon dates from 1 grave with 7 burials can be RCombined (4167 ± 30 BP; χ^2 Test: df = 3, T = 1.9 (5% 7.8)) demonstrates this pattern and suggests that the grave was a single burial event.

5.3. Glazkovo mortuary tradition in the Little Sea and on the Upper Lena South

In the Little Sea, the Glazkovo mortuary tradition is represented by 10 cemeteries, of which 9 have 1 to 19 dated individuals and 1 (Khuzhir-Nuge XIV) has 72 (Table 5)[11]. It will suffice to take a closer look at just four cemeteries to show the complexity of Glazkovo burial activities in this area (Fig. 10: B and Fig. S10). Ulan-Khada (n = 13) has the widest temporal distribution (a millennium) by a significant margin and the oldest peak, Khadarta IV (n = 9) and Kurma XI (n = 19) have roughly coterminous peaks but the interval of the former (several centuries) is considerably longer than the interval of the latter (a few centuries), and Khuzhir-Nuge XIV shows the youngest peak and an interval that is about the same as that of the much smaller and older Khadarta IV.

<Fig. 10. Chronology of SWB–GLA and LS–GLA>

Such differences call for examination of LS–GLA mortuary activities in the same manner as for the ANG–KIT, by comparing Khuzhir-Nuge XIV with the rest of LS–GLA sample. Excluding Khuzhir-Nuge XIV, Glazkovo mortuary events appear to build up rather gradually to reach a peak that is older by a few centuries than that at Khuzhir-Nuge XIV (Fig. S10: E, F). Furthermore, the pattern of cemetery use for Khuzhir-Nuge XIV closely resembles in duration, but not in distribution, those for equally large Kitoi samples from Lokomotiv and Shamanka II: the two Kitoi distributions are skewed towards the start (Fig. S9: A, C), while the Khuzhir-Nuge XIV is basically normal (Fig. S10: E). Comparing further ANG–SWB–KIT (Fig. S9: D) with LS–GLA shows that the former is relatively short (a few centuries) and

[11] Dating of Uliarba, a cemetery with ~40 excavated Glazkovo graves (Goriunova et al., 2004), is in progress and will provide an additional sample of 20–25 dated burials.

skewed towards the start, mostly on the account of its two large cemeteries (Lokomotiv and Shamanka II Phase 1), while the latter is much longer (over a millennium) and skewed towards the end, even more so if Khuzhir-Nuge XIV is included (Fig. S10: F, G).

<Fig. 11. Chronology of ANG–GLA and UL–GLA>

On the Upper Lena, the Glazkovo tradition is represented by 9 rather small cemeteries; Obkhoi with 13 dated burials comprises the largest sample (Fig. 11: B and Fig. S11). The number of sites is about the same as on the Angara and in the Little Sea, and the number of dates (n = 39) is similar to the former (n = 27) but much lower than the latter (n = 132) (Table 5). Thus, observations are qualified by the unequal sample sizes. The UL–GLA dataset shows a bimodal distribution which could be dismissed on account of the small sample size if it were not for the ANG–GLA (Fig. S6: A) also showing two peaks, the younger of which coincides with the older peak on the Upper Lena (Fig. S11: F). The two UL–GLA peaks also have a geographic aspect: the older group includes the Obkhoi and Ust'-Ilga cemeteries, while the younger one centers on Verkholensk and a few sites around it (Fig. 1). Lastly, some small cemeteries such as Obkhoi, Ust'-Ilga, and Verkholensk appear to have been used over a much longer period (over a millennium) than cemeteries of similar size in the Little Sea area (e.g., Khadarta IV and Kurma XI) and even Khuzhir-Nuge XIV—the largest of all (Fig. 10: B).

6. DISCUSSION: FIVE LARGE CEMETERIES

Another goal of this study is to examine in detail the history of burial events at the five best documented Cis-Baikal Middle Holocene cemeteries: Lokomotiv, Shamanka II, Ust'-Ida I, Khuzhir-Nuge XIV, and Kurma XI.

6.1. Lokomotiv

Lokomotiv, located at the confluence of the Angara and Irkut rivers in the city of Irkutsk (Fig. 1), is believed to be the largest Kitoi cemetery (Bazaliiskii, 2010). The older excavations have been described by Okladnikov (1974), but these materials (26 graves with ~30 individuals) are no longer available for sampling. The collections excavated in the 1980s–1990s are available for research, however, they have not been fully published yet and are known only from a few review papers (e.g., Bazaliiskii, 2010; Bazaliiskiy and Savelyev, 2003). Although a large part of the cemetery remains unexcavated, the 59 graves excavated at the end of the 20th century form 7 spatial clusters ranging in size from as many as 25 graves in Cluster 2 to as few as 1 (Cluster 3) or 2 (Cluster 6; Fig. 12). Many graves within these clusters are arranged into rows. Most graves contain single interments; however, double burials are not uncommon, and graves with as many as 8 deceased have been recorded too. The 103 individuals identified in these graves range in age from 0.5–2 years up to 50+ years old (Lieverse, 2010; see Table 6 for demographic summary). Biochemical results (i.e., radiocarbon dates and carbon and nitrogen stable isotope measurements) for 80 individuals older than 5 years have been further examined for spatio-temporal dietary variation, which revealed the presence of dietary trends among burials from a few spatial clusters (Weber et al., 2020).

<Table 6. Demographic summary>

<Fig. 12 Lokomotiv map>

Excluding the two small Clusters 3 and 6 from further assessment, the first graves appear to belong to Cluster 1 (Lokomotiv-Raisovet), followed quickly by a few interments in Cluster 4 and then in Cluster 7 (Fig. 13 and Fig. S13). Overall, Cluster 1 with 15 graves (all scattered) and 16 analyzed burials, is the oldest cluster and the individuals interred there do not display a dietary trend even though the group had enough time for a trend to develop and be visible in the biochemical data. Cluster 7, with 5 graves (3 forming a row and 2 scattered) and 8 analyzed burials, was also established rather early but appears to have been quickly abandoned. No dietary trend is visible among its burials either, but this is less surprising because of the cluster's short duration. Lokomotiv's main dietary trend (an increased reliance on local fish) appears to be driven by burials from Clusters 2 (n = 41), 4 (n = 7) and 5 (n = 5). Most graves in these three clusters were arranged into rows and, together, they date to the latter two-thirds of the cemetery use; during the first-third scattered graves were more common.

<Fig. 13. Chronology of Lokomotiv: KDE modelling>

6.2. Shamanka II

Shamanka II, located in the SW corner of Lake Baikal (Fig. 1), is the only Kitoi cemetery believed to be excavated in full. The cemetery is situated on a narrow peninsula running E–W. Fieldwork conducted by the BAP revealed 99 Kitoi graves with 156 interments, of which 120 are part of this analysis[12]. The EN graves form two obvious spatial groups: the North and South Sectors (Fig. 14). The North Sector can further be divided into the Northwest and Southeast Clusters which are separated from one another by a narrow gap, a product of outcropping bedrock that made grave building difficult in this area. Within these three main spatial units, many graves are arranged into rows. Most graves contain single interments but many have two or more (up to 5) burials, generating a collection ranging in age from under 1 year up to 50+ years old (BAP data summarized in Table 6). Analysis of biochemical data associated with 120 individuals over the age of 5 years (Table 5) demonstrated two phases of cemetery use and the presence of a few dietary trends, the latter found in groups of individuals defined using spatial criteria (Weber et al., 2016b, 2020). While a monographic publication of the Kitoi materials is in the final stages of preparation, Bazaliiskii (2010) and Weber et al. (2016b) provide more information about the cemetery. The presence of two unambiguous phases of cemetery use within the same mortuary tradition (Weber et al., 2016b) makes Shamanka II unique on the regional scale. This, together with the two sectors, generates four main units of analysis. Interestingly, the phases show chronological structures that differ somewhat from one another.

<Fig. 14. Shamanka II map>

<Fig. 15. Chronology of Shamanka II–KIT: KDE modelling>

Phase 1

The first graves appeared roughly around the same time in both clusters of the North Sector and in the South Sector of the cemetery (Fig. 15). Some of these early graves seem to mark the start of a row, which then expanded in both directions, but some graves remained scattered until the end of the cemetery's use. Early growth of the cemetery occurred in all three spatial groups but late growth took place mostly within the SE Cluster: the area where most graves are arranged into rows, and burials (n = 51) show the main dietary trend (an increase in the consumption of local fish) documented for this cemetery (Weber et al., 2016b, 2020). This pattern suggests that the distinction between the NW and SE Clusters may not be as dependent on topographic criteria as it first appears. Likewise, the density and number of graves and burials (particularly within the SE Cluster) appear high enough to fill in the 15 m-wide-gap separating the North and South Sectors, indicating that the sectors were meant to be

[12] Three burials from two graves excavated in 2019 are not included here as their analysis is in progress.

spatially separate from one another from the time they were established and to remain so throughout the cemetery's use.

Phase 2

After a gap lasting a few centuries (Weber et al., 2016b, 2020), new burials were interred mainly in the South Sector and in the SE Cluster of the North Sector (Fig. 15)[13]. New burials were added at about the same frequency across these two spatial units, resulting in a more equitable spatial distribution of Phase 2 burials between the sectors relative to Phase 1, when the SE Cluster saw more burials (Fig. 15). Also, while some graves were scattered, others were integrated into rows established in Phase 1. In several cases, graves built during Phase 1 (e.g., Gr. 23, 26, 42, 50, and 59) were reopened and new burials were added. Moreover, there are no rows consisting entirely of Phase 2 graves. This suggests that the mortuary activities of Phase 2 followed the spatial patterns of cemetery use established in Phase 1, further implying a substantial degree of cultural continuity. Still, given the length of the gap between the two phases, the matter of real or perceived relationships between those interred in the original graves and those added to existing rows or graves, is an important one and merits dedicated examination. Moreover, the dietary trend of Phase 2 burials (n = 17) repeats exactly the main trend from Phase 1 that characterized row burials from the SE Cluster.

6.3. Ust'-Ida I

Ust'-Ida I, a cemetery located on the Angara some 250 km from Lake Baikal (Fig. 1), was excavated in full in the 1980–1990s. Unfortunately, the archaeological information provided in a few cursory reports is rather limited (Tiutrin and Bazaliiskii, 1996; Bazaliiskii 2010). The two main mortuary components consist of 33 LN Isakovo and 17 EBA Glazkovo graves, together yielding about 68 individuals[14]. Isakovo and Glazkovo graves are arranged into two spatial units: North and South Sectors separated from one another by a 30 m gap of somewhat lower ground along the Angara River (Fig. 16). Many of the graves form rows. Glazkovo Graves 19 and 45, located on the northern outskirts of the cemetery, are not considered part of the North Sector, which is represented in this study by 20 Isakovo and 5 Glazkovo burials. The South Sector is represented by 16 Isakovo and 9 Glazkovo burials. Most Isakovo graves are single interments but graves with two or three are not uncommon and one grave has five individuals. The Isakovo group is also quite variable in age (from 0.5–2 years to 50+ years old), while the Glazkovo sample consists essentially of adults only (Lieverse, 2010). Not counting the *in utero* individual, all graves in the Glazkovo component are single burials. Table 6 summarizes the demographic structure of all excavated LN and EBA skeletons examined by the BAP. Biochemical results for the Isakovo and Glazkovo individuals over the age of 5 years (Table 5) have demonstrated that the diet of the LN group changed over time while the diet of the EBA sample remained stable (Weber et al., 2020).

<Fig. 16. Ust'-Ida map>

The Isakovo mortuary component

The Isakovo component at Ust'-Ida I, as mentioned, was rather short in duration (from several generations to a few centuries at the most), though long enough to show

[13] Presently, there are no interments from the NW sector radiocarbon-dated to Phase 2. However, it is possible that some of the five young children (<5 y. old) from the NW Sector, whose dates have not been corrected for the FRE, belong to Phase 2; two other NW Sector individuals were not dated at all due to a lack of suitable skeletal remains. Overall, if any of these seven burials were interred during Phase 2, it would still not make many of them.

[14] These counts do not include several graves with minimal archaeological information rescued from the river bank.

chronological structure, had it existed. Indeed, although chronologically both sectors are generally similar to one another, there appear to be some differences between them (Fig. 17 and Fig. S17). The first Isakovo burials seem to have been interred in the North Sector, which shows three rather short pulses of burials. The South Sector started a little later, a few generations at the most, and shows two pulses. These pulses are likely not coincident with the three pulses of the North Sector, as suggested by the density plot for the entire UID-ISA sample, which shows a continuous distribution of burial events (Fig. S5: B). If these pulses were coterminous, it would be expected that the pattern visible in Fig. S17: A & B would be enhanced in Fig. S5: B, but it is not. The spatial arrangement of the cemetery is likely intentional, as each sector clearly had enough room to accommodate all graves and burials. Lastly, despite the very short span, the sample shows a dietary trend towards the increased use of local fish (Weber et al., 2020).

<Fig. 17. Chronology of Ust'-Ida I: KDE modelling>

The Glazkovo mortuary component

The Glazkovo burials at Ust'-Ida I span a millennium, much longer than the Isakovo component with twice as many dated burials, and surely long enough to show chronological structure, had it been present. Though the small sample size hinders their detection, some subtle differences between the sectors seem to have existed (Fig. 17 and Fig. S17). In general, while Glazkovo mortuary events appear to have started and ended around the same time in both sectors, the analysis suggests the presence of two phases, each several centuries long:

- Phase 1 with 4 burials: 2 in the North Sector and 1 in the South Sector. Grave 19, located far to the north of the North Sector, likely belongs to this phase too (Fig. S11: A, Fig. 17, and Fig. S17); and
- Phase 2 with 12 burials: 6 in both the North and South Sectors.

Regarding spatial organization, even though there was room further away from the Isakovo graves, most (but not all) Glazkovo graves were built rather close to them (Fig. 16). Their placement even suggests a deliberate effort to fit some Glazkovo graves within pre-existing rows of Isakovo graves.

In sum, the two sectors were clearly established to function as spatially separate areas of mortuary activities, for both the Isakovo and Glazkovo. These two mortuary traditions show similar spatial structure but rather different chronological, demographic, and dietary characteristics. The Isakovo component was no longer than several generations, with as many as five high-frequency pulses of burials, many children, and a dietary trend. The Glazkovo component, in contrast, was considerably longer, millennial in duration, with a lower frequency of burials involving mostly adults, and showing no dietary trend. These differences likely signify a substantial change in how the same space was used for burial by the peoples of the area. Why the isolated Glazkovo Graves 19 and 45 (of which No. 19 was certainly built early enough) did not attract additional interments, while the others built within the North and South Sectors did, is a question with no answer.

6.4. Khuzhir-Nuge XIV

Khuzhir-Nuge XIV, located in the Little Sea microregion (Fig. 1), has been completely excavated by the BAP (1997–2001) and its materials fully published (Weber et al., 2007, 2008a). With 78 graves and 87 burials (72 of which are included in this study), Khuzhir-Nuge XIV is the largest Glazkovo cemetery known to date in the entire Cis-Baikal. Most graves are single burials but several have two individuals and two graves have three[15]. Based on a

[15] One of the individuals in a grave with three individuals is *in utero* (Lieverse, 2007).

combination of archaeological criteria, McKenzie et al. (2008) identified three cemetery sectors at Khuzhir-Nuge XIV (Fig. 18); more detailed description of this structure is provided below. Excluding the one *in utero* individual, the cemetery population ranges in age from 2–4 years to 50+ years old (Table 6) (Lieverse, 2007). Examination of stable isotope results from the entire Little Sea microregion has revealed the existence of two dietary groups: Game-Fish-Seal (GFS) and Game-Fish (GF) (Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2016b, 2020). Based on the strontium isotope data, it has been suggested that the GFS diet is of local (Little Sea) origin, while the GF diet is non-local (Weber and Goriunova, 2013). While both diets are present at Khuzhir-Nuge XIV, biochemical results for individuals over the age of 5 years have revealed substantial spatio-temporal variation in their distribution across the cemetery, including the presence of dietary trends among some units of analysis (Weber et al., 2020).

Khuzhir-Nuge XIV is the only cemetery of the five analyzed here, and essentially of all documented Middle Holocene cemeteries in Cis-Baikal, where the spatial structure has been defined using mainly mortuary and demographic characteristics rather than gaps in the horizontal arrangement of graves (McKenzie et al., 2008). This is interesting on its own because the area of the Khuzhir-Nuge XIV cemetery is large enough for a spatial separation, such as at Shamanka II or Ust'-Ida I, yet the sectors are contiguous (Fig. 18). Additionally, within the three-sector structure, Weber and Goriunova (2013) have identified additional groups based on dietary criteria. In sum, the spatial organization can be described as follows:

- **West Sector**: Mostly scattered graves (excepting one row of three graves), intact graves with single burials only, mostly adults (with only two children, both from the row of graves), few and generally poor grave goods (no beads), and all individuals with the GFS diet.
- **Centre Sector**: Most graves arranged in rows (up to five graves per row), intact and disturbed graves, graves with single and multiple burials (up to three individuals per grave), adults and many children, grave goods more diverse and abundant than in the West (beads present in essentially all graves and a few copper or bronze objects), extensive use of fire inside graves, and individuals with GFS and GF diets defining two subsectors: one with mostly GF (Centre–West Subsector), and one with mostly GFS diet (Centre–East Subsector).
- **East Sector**: Only scattered graves, prominent grave stone structures, all graves disturbed, exclusively single-burial graves, mostly adults (two adolescents only and no children), more abundant and diverse grave goods than in the Centre including some rare objects (nephrite) and the prevalence of tools, only one copper or bronze object (no beads), a mix of individuals with GFS and GF diets forming three spatial groups: East–NW Cluster (GFS), East–NE Cluster (GF), and East–S Cluster (GF).

<Fig. 18. Khuzhir-Nuge XIV site map>

The cemetery shows a chronological structure (Fig. 19 and Fig. S20):

- **West Sector**: This is, apparently, where the cemetery was established and burial events continued, albeit at a very low frequency, until the end of its use; no dietary trend has been found in this group of burials;
- **East Sector**: The first "rich" burials were interred here a few centuries after the start of the cemetery, ~100 m away from the West Sector; graves continued to be built here until the end of the cemetery; East Sector people with the GF diet and individuals from the Centre Sector with the same diet (n = 21), separately or combined, show the same dietary trend (increasing consumption of Baikal seal);
- **Centre Sector**: Started soon after the beginning of the East Sector and grew with the highest frequency of burials of all three sectors, peaking soon after the peak of the

East Sector; the GFS individuals from its Centre–East Subsector (n = 22) show a dietary trend (increasing consumption of large and medium game and, perhaps, also plant foods) that is different from the one affecting its neighbors with the GF diet.

<Fig. 19. Chronology of Khuzhir-Nuge XIV: KDE modelling>

These patterns suggest that the chronological structure of the Centre and East Sectors be examined in more detail (Fig. 20 and Fig. S20). The Centre–West and Centre–East Subsectors were essentially coterminous with one another and with most of the West Sector, aside from its oldest burials.[16]

<Fig. 20. Chronological structure of Khuzhir-Nuge XIV>

The East–NW Cluster (GFS) and East–S Cluster (GF) are coterminous with one another and several generations older than the East–NE Cluster (GF). Thus, it is these two clusters that, together, mark the start of the East Sector. Moreover, the peaks of the East–NW and East–S Clusters predate the peaks of the West Sector and of both Centre subsectors, the Centre Sector being the area with the highest number and frequency of burial events at this cemetery. The East–NE Cluster is not only younger than the other two clusters in the East Sector but its chronological distribution mirrors that of the Centre–East Subsector and the bulk of the West Sector and Centre–West Subsector distributions.

This suggests that the Khuzhir-Nuge XIV cemetery started in the West Sector, in a manner similar to other Glazkovo cemeteries in Cis-Baikal (e.g., Khadarta IV and Ulan-Khada in the Little Sea, Obkhoi on the Upper Lena, and Ust'-Ida I on the Angara): as if intended to be a cemetery for the occasional interment of mainly adults, in this case with GFS diet, over a long period of several centuries. However, when a number of new graves with "rich" adult burials and GFS and GF diets appeared some time later, and at a considerable distance east of these early graves, the pattern of cemetery use seems to have changed. From this point forward, interments included individuals of variable age (including young children) with both diet types, mainly in graves arranged into rows and in the Centre Sector, and additionally showing a number of mortuary characteristics absent in the other two sectors. The two dietary trends identified at Khuzhir-Nuge XIV are accounted for mostly by Centre Sector individuals.

The Centre Sector seems to have bridged the horizontal gap between the West and East Sectors present during early cemetery use. Therefore, unlike the other cemeteries with separate spatial sectors (e.g., Shamanka II and Ust'-Ida I), by the end of its use, Khuzhir-Nuge XIV displayed spatial continuity. The group of individuals forming the East–NE Cluster, apparently, had little to do with the establishment of the Centre Sector of the cemetery. However, they may have played a role in, first, the fast growth and, then, the termination of Glazkovo burials at this cemetery, used over the disproportionately short span of a few centuries, relative to the large number of graves and burials. Also, if the hypothesis that all Khuzhir-Nuge XIV individuals with the GF diet and some showing the GFS diet were born outside the Little Sea is true (Weber and Goriunova, 2013), then, obviously, these non-locals played an important role in the history of this cemetery.

6.5. Kurma XI

Kurma XI, like Khuzhir-Nuge XIV, is also located in the Little Sea (only about 15 km farther northeast along the coast; Fig. 1), it also represents the Glazkovo mortuary tradition, has been fully excavated by the BAP (2002–2003) and published in a monograph (Weber et al., 2012).

[16] The oldest burial in the Centre–West Subsector (K14_1993.001; Supplement 1) probably belongs to the West Sector). This is suggested by its location very close to the boundary with the West Sectors, the GFS diet of the burial, and poor grave goods (Weber et al., 2008a; Weber and Goriunova, 2013).

However, Kurma XI is a much smaller cemetery (20 graves with 19 dated burials; Table 5), only one grave has two interments, the cemetery shows no overt spatial structure (except for two graves located higher upslope about 50 m away from the main group), it has no rows of graves, and has only adult burials (from 15–20 to 35–50 years old; see Table 6 for demographic summary) (Lieverse, 2012). Lastly, while both GFS and GF dietary groups are present, no patterns in their spatio-temporal distribution have been found (Weber et al., 2020). Kurma XI also differs from Khuzhir-Nuge XIV in a few mortuary characteristics, such as frequently relatively numerous grave good assemblages, which are more diverse and include many rare objects (e.g., nephrite adzes and rings, a bronze medallion, other bronze and copper objects, a silver ring, and harpoons and bone points, but no beads); more common grave disturbances; the absence of fire in graves; and more variable body position, including three individuals probably interred tightly flexed (Weber et al., 2012). In its general archaeological appearance, Kurma XI looks more like the East Sector at Khuzhir-Nuge XIV than the other two sectors. However, Kurma's chronological structure is quite different from both the East Sector specifically and Khuzhir-Nuge XIV as a whole (Fig. S10: C, E and Fig. S19: C, D).

<Fig. 21. Kurma XI map>

The cemetery, used for no more than a few centuries, seems to have started slowly with a burial at the bottom of the hill followed by the two tightly flexed burials up the slope. Next, perhaps, there was a short pause followed by a rapid increase in burials east and west of the first burial and, eventually, a relatively quick end to cemetery use. The burial of the "shaman" (Gr. 1, the first on the western end; Fig. 21 and Fig. 22) with a medallion designed in the manner characteristic of Siberian shamanistic rituals (Goriunova and Weber, 2003) belongs to the second half of the cemetery history and is unrelated to either its establishment or its termination.

<Fig. 22. Chronology of Kurma XI: KDE modelling>

Relative to the other Glazkovo cemeteries in the Little Sea microregion with better documented chronology (Fig. S10: B–E), Kurma XI seems to have had a much shorter lifespan. It also seems to have been a few generations older than Khadarta IV (about 2.5 km southwest of Kurma XI along the coast of the lake; Fig. 1) but younger than Ulan-Khada (about 35 km southwest in the Mukhor Bay), both of which have fewer burials, though all three have individuals showing the GFS diet. Kurma XI is older than Khuzhir-Nuge XIV by a few centuries, and older still than the East Sector specifically (Fig. S19: C, D), with which it shares mortuary characteristics. Moreover, Kurma XI shows an even shorter use interval relative to both Khuzhir-Nuge XIV as a whole and its East Sector. While both cemeteries started at a similarly slow pace, the rest of their histories were very different.

7. SUMMARY

The extensive program of radiocarbon dating Middle Holocene burials from Cis-Baikal and the use of novel methods of analysis have revealed many original insights about chronological aspects of the mortuary practices of these HG groups. The detail and breadth of the new findings goes substantially beyond what was available before, with some patterns wholly unexpected. As mentioned, thorough assessment of all these discoveries would go well beyond the space and scope limits of this paper, but some of these points are part of a more comprehensive examination of the evolutionary history of Cis-Baikal Middle Holocene HGs presented in a different paper of this special issue (Weber, 2020). Thus, this paper concludes with a descriptive summary of the main findings.

7.1. Relative chronology of mortuary traditions

Prior to this examination and the recent work on Shamanka II (Weber et al., 2016b), all cemeteries within a given mortuary tradition were assumed to be rather similar regarding relative chronology and spatial and chronological structure. Thus, little microregional variation was expected, with two minor exceptions worth noting.

First is Okladnikov's notion that the UL–SER, essentially limited at the time to the Verkholensk cemetery, was somewhat older than the ANG–SER (Okladnikov, 1978) and the second is Goriunova's proposition that the LS–SER was somewhat younger than the ANG–SER and UL–SER (Goriunova, 1997, 2002; Goriunova and Batrakova, 2005). Both ideas were put forward mostly based on the morphology of grave goods—not a particularly reliable dating tool for these materials—though the latter relied also on a few radiocarbon dates. Unsurprisingly, neither notion finds support in the current analysis. More radiocarbon evidence is needed, particularly from the Angara, to assess better the relative chronology of the Serovo microregional groups, their position relative to Isakovo and, consequently, the merits of both of these propositions. If confirmed, it would be necessary to investigate further their socio-economic underpinnings.

Returning to the matter at hand, the different microregional histories of the Khin Group—the earliest Middle Holocene formal interments in Cis-Baikal—are beyond doubt. Appearing around the same time everywhere, it was rapidly replaced on the Angara by the Kitoi mortuary and socio-economic pattern, while in the Little Sea and on the Upper Lena it continued parallel to the Kitoi. This makes the duration of the Khin mortuary group over a millennium.

The complicated, though much shorter (no more than several centuries), history of the Kitoi mortuary pattern is equally apparent, highlighted by the following points:

- Its rapid origins on the Angara and in SW Baikal around the same time;
- The change in the spatial organization of graves at Lokomotiv from mostly scattered to mostly arranged into rows;
- The northward geographic expansion along the Angara, where either small cemeteries or isolated burials became more prevalent soon after the end of Shamanka II–Phase 1;
- Phase 2 at Shamanka II representing a probable resurgence, albeit short-lived, of the Kitoi socio-economic pattern after it had ended on the Angara.

The new Kitoi cemetery discovered recently on the lower Irkut at Moty-Novaia Shamanka (Bazaliiskii et al., 2016) may introduce additional variation into the tradition's history, if only for the singular reason that it is the only Kitoi cemetery so far located not in SW Baikal or on the Angara but on one of its large left tributaries. However, the true socio-economic significance of this cemetery will be difficult to evaluate as it has been completely destroyed and little information is available. Still, radiocarbon dating, stable isotope analysis, DNA work, and osteological studies, all in progress on limited scale (e.g., Bourgeois, 2020), will provide some useful clues.

The MN break in the use of formal cemeteries appears to be present in all microregions (Fig. 2 and Fig. 3; Table 1) but its chronology varies between them (Weber et al., 2020: Table 3). In the Angara valley, continued dating of Isakovo and Serovo burials may move the LN lower boundary back in time, making the MN shorter than current estimates. On SW Baikal the break appears at least twice as long as elsewhere merely because Kitoi and Glazkovo are the only mortuary traditions presently documented there. Even a few Isakovo or Serovo dated burials would considerably change this picture. In the Little Sea the break in the use of formal cemeteries is shorter than on the Angara, mostly on account of the two very old burials from Ulan-Khada. A similar situation applies to the Upper Lena where the MN discontinuity shows the shortest duration: again, this is mostly on account of the one very early Isakovo burial from Verkholensk. A further caveat regards the FRE correction equation for this microregion, which is currently less robust than for the other areas and may change somewhat with ongoing work (Schulting et al., 2015, 2021).

Addressing the sampling biases regarding the dating of Isakovo and Serovo burials may make the end of the MN period just about the same everywhere. However, its duration will still vary between microregions because of how its lower boundary is defined. On the Angara and in SW Baikal it is defined by the end of Kitoi, while in the Little Sea and on the Upper Lena it is defined by the end of Khin, which have quite different histories.

Assessment of the history of the Isakovo and Serovo mortuary traditions is hindered the most by sampling biases. As of today:

- The earliest post-MN formal burials, either Isakovo or Serovo, appear around the same time on the Upper Lena and in the Little Sea.
- The ANG–ISA mortuary pattern seems to be of very short duration (a few centuries), perhaps even shorter than Kitoi.
- The ANG–ISA, UL–SER, and ANG–SER units are all concurrent to some extent but the bulk of the LS–SER is younger than the other two groups. And,
- The LS–SER appears to have had the longest history (millennial) of all these microregional groups.

Assessment of the history of the Glazkovo mortuary tradition is also somewhat hindered by sampling biases. Presently:

- With the exception of SW Baikal, the Glazkovo mortuary pattern shows more than a millennium-long history in all microregions.
- Glazkovo may have formed first on the Angara but similar developments soon followed in the Little Sea and on the Upper Lena, where it lasted a few centuries longer than in the Little Sea. And,
- Glazkovo's complicated history in the Little Sea is already well documented, as best exemplified by the use pattern of the Khuzhir-Nuge XIV cemetery. However, the radiocarbon evidence suggests that a similar situation may have existed on the Upper Lena and perhaps also on the Angara, that is if the bimodal distribution of dated burials is confirmed through future research.

7.2. Relative chronology of cemetery size and use patterns

Khin is the only mortuary group whose cemeteries in all microregions, while showing much variation in terms of their chronology and mortuary characteristics (Bazaliiskii, 2010; Weber et al., 2020; Weber 2020), show little variation in size and pattern of use: they are invariably small and used sporadically. Moreover, they include very few children. Cemeteries of all other mortuary traditions and in all microregions show significant variation in size, chronology and pattern of use, as well as demographic structure, with the number of children varying from none to more than half. These cemeteries also vary substantially in duration of use and in frequency of burials: from long intervals (several centuries) at low frequencies to short spans (a few generations) at much higher frequencies. In some cases, such as at Khuzhir-Nuge XIV (Glazkovo), the frequency of burial events changed considerably within the span of cemetery use. Within the same mortuary tradition and microregion, some cemeteries were used at about the same time, but many were not: only partially overlapping or not overlapping at all. These differences may reflect fluctuations in population size, as well as—perhaps more likely—changes in local and microregional distribution (cf. Weber, 2020). The disconnect also likely reflects socio-political concerns (e.g., those involved in making territorial statements and defining the in-group versus the out-group).

Analysis of the five best-documented cemeteries demonstrates that each was used in a unique pattern. Lokomotiv started with scattered graves and rows were introduced only later, while at Shamanka II, both formations were used from the start. The discontinuity between Shamanka II–Phase 1 and the rest of Angara, on the one hand, and Shamanka II–Phase 2, on the other, as well as how the Kitoi burials of Phase 2 were integrated with those from Phase 1 at Shamanka II are indeed intriguing. The cemeteries of Ust'-Ida I and Khuzhir-Nuge XIV are equally insightful but each for different reasons. Ust'-Ida I is noteworthy due to its spatial organization and changes in the use pattern from Isakovo to Glazkovo. The Ust'-Ida I–ISA stands out because of the very high number of children, perhaps as many as five pulses of burials, and the presence of a dietary trend—both despite the cemetery's short span. All this creates a pattern very rare across the entire region.

Khuzhir-Nuge XIV is unique on account of its complex spatio-temporal structure and a rather dramatic change in use pattern within the same mortuary tradition (Glazkovo) in contrast, for example, to Ust'-Ida I where the change in use occurred from one mortuary tradition (Isakovo) to another (Glazkovo). The history of Khuzhir-Nuge XIV is so far without a regional analog and raises a host of questions. For example, What kind of broader socio-economic processes does this change relate to? Was the geographic scope of these processes limited to the Little Sea or wider?

When the chronological parameters of these five cemeteries are compared to others of the same mortuary traditions, additional dimensions of variation emerge. For example, the Kitoi cemeteries of Lokomotiv and Shamanka II are different from one another and both are different from Ust'-Belaia and Galashikha in several ways. Regarding the Glazkovo cemeteries, Khuzhir-Nuge XIV is different from Ulan-Khada, Khadarta IV and, essentially, all other Glazkovo cemeteries. Moreover, all three are different from Kurma XI and Shamanka II–GLA.

8. CONCLUSIONS

Documenting and understanding chronological and spatial aspects of variation in the mortuary activities of past groups, in addition to the more traditional attention paid to grave architecture and grave goods, body disposal, and demographic characteristics, is fundamental to understanding the socio-economic settings within which such cemeteries operated. How the demonstrated variation in spatial organization, patterns of use, frequency of burials, chronological parameters, and demographic structure in the cemetery were related to broader technological, economic, social, political, ideological, and demographic processes affecting Middle Holocene HGs in Cis-Baikal requires dedicated research.

The number of cemeteries and whether they were used concurrently, sequentially, or with some overlap, is singularly important for understanding how these groups functioned together as parts of a larger socio-economic entity and how they evolved over time. Obviously, cemeteries such as Khadarta IV cannot be viewed as representative of the demographic structure of the entire socio-economic unit(s) using it. Although there must have been other individuals—entire families—behind each person buried there, these individuals appear to represent the history of one relatively homogeneous socio-economic unit over several generations. This interpretation seems applicable to several other cemeteries of this kind; such cemeteries likely represent corporate units, the clearest examples of which may be seen in the EBA though their presence already in the EN Kitoi is likely.

Regarding the matter of demographic structure, while the cemeteries vary in this respect, it is clear that none (Ust'-Ida–ISA perhaps the only exception) have enough children to be demographically representative of the groups using them. Why some cemeteries have children and others do not is a good question. Interestingly, across all mortuary traditions and all microregions, the presence of child burials seems to be strongly associated with graves arranged into rows. For example, at Lokomotiv and Shamanka II (both Kitoi), Ust'-Ida I (Isakovo), and Khuzhir-Nuge XIV (Glazkovo), most children come from sectors or clusters where graves were organized into rows. At Kurma XI and Khadarta IV (both Glazkovo), there are no rows and only one child (Khadarta). Thus, as already observed by Okladnikov (1950, 1955), rows likely represent family units—however these might be defined. If so, this raises a few additional questions: Why are such family rows not equally expressed in all cemeteries and all spatial units within cemeteries? Why do family rows appear from the start at some cemeteries but only much later at others?

The most general lesson emerging from this examination is that each cemetery seems to tell a different story about the people using it and, perhaps, about their contribution to the functioning of the broader microregional or regional population (c.f., Weber, 2020). While this seems to apply to all mortuary traditions, it is presently best documented for a few Kitoi and Glazkovo cemeteries. For example, Lokomotiv (with the change in the pattern of use) and Shamanka II (with the two phases and the spatial integration of their graves and burials) provide, in many ways, quite different insights about the history of Kitoi communities. Likewise, such Glazkovo cemeteries as Khadarta IV (with its low frequency of mostly adult burials, long use interval and lack of overt spatial structure) give very different insights about past groups than cemeteries such as Khuzhir-Nuge XIV (with a variable and much higher frequency of burials, including children, a shorter span of use, and a complicated spatial structure). These insights, in turn, are different from the stories inherent to Kurma XI and Shamanka II–GLA.

As research on Cis-Baikal Middle Holocene HGs continues, a dataset of another 300–400 radiocarbon dates and stable isotope measurements is expected to be available in a few years, mostly on skeletons from older excavations (first and early second half of the 20th century). Additionally, about 400 individuals have now been sampled for a new round of DNA studies. New excavations planned in the Upper Lena microregion may produce a substantial sample of new human skeletal material to work with. Consequently, in a few years, a considerably larger body of data will be available to test the observations resulting from this study and to generate new insights, leading to an even better understanding of the history of these peoples.

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CAPTIONS

Figures

Figure 1. Map of Cis-Baikal with Middle Holocene hunter–gatherer cemeteries analyzed.

3	Ershi	89	Popovskii Lug 2	129	Shamanskii Mys
7	Glazkovo	91	Makarovo	132	Budun IV
8	Lokomotiv	95	Nikolskii Grot	138	Kurma XI
14	Kitoi	96	Verkholensk	141	Khuzhir-Nuge XIV
16	Galashikha	98	Obkhoi	142	Shamanka II
18	Shumilikha	99	Ust'-Iamnaia	147	Khankhoiskaia Guba I
19	Ust'-Belaia	101	Zapleskino	148	Khadarta IV
36	Ust'-Ida I	106	Ust'-Ilga	149	Borki
40	Gorodishche II	114	Khotoruk	152	Kaiskaia Gora
44	Pad' Khinskaia	115	Ulan Khada	154	Roshcha Zvezdochka
64	Rasputino	121	Shide I	156	Badai
72	Isakovo	122	Sarminskii Mys	158	Mys Uiuga
81	Manzurka	124	Kulgana	159	Khuzhir-Nuge IX
82	Ulus Khalskii	125	Khuzhir-Nuge VI	163	Shidinskii prichal I
84	Makrushino	126	Elga III	168	Kotin ostrov
85	Iushino I				

Figure 2. Chronology of Middle Holocene hunter–gatherer mortuary traditions in Cis-Baikal.

A. Cis-Baikal
B. Angara
C. SW Baikal
D. Little Sea
E. Upper Lena

Figure 3. Chronology of the Middle Holocene cemeteries in Cis-Baikal (cemeteries are arranged by mortuary tradition and then alphabetically by name).

A. Angara (n = 22)
B. SW Baikal (n = 2)
C. Little Sea (n = 24)
D. Upper Lena (n = 17)

Figure 4. Chronology of the Khin and Kitoi mortuary traditions in Cis-Baikal.

Figure 5. Chronology of the Isakovo and Serovo mortuary traditions in Cis-Baikal.

Figure 6. Chronology of the Glazkovo mortuary tradition in Cis-Baikal.

Figure 7. Spatial distribution of Middle Holocene burial events in the Cis-Baikal region at various times: Results from Kernel Density Estimate modeling.

A. 8500 cal BP: Coterminous appearance of the oldest Khin burials across Cis-Baikal.
B. 7500 cal BP: "Explosion" of Kitoi burials on the Angara and SW Baikal and continuation of Khin burials on the Upper Lena and in the Little Sea.

C. 7000 cal BP: Northward spread of Kitoi burials along the Angara after the end of Shamanka II Phase 1.
D. 6800 cal BP: Late Kitoi, Shamanka II Phase 2.
E. 6500 cal BP: Middle Neolithic discontinuity in formal burial activities across the entire Cis-Baikal.
F. 5400 cal BP: Contemporaneous appearance of Isakovo and Serovo burial events on the Angara and Upper Lena.
G. 4800 cal BP: Much later development of the Little Sea Serovo.
H. 3820 BP: High frequency of Glazkovo burial events at Khuzhir-Nuge XIV in the Little Sea.
I. 3520 BP: Continuation of Glazkovo burial events on the Upper Lena until much later than in the Little Sea.

Figure 8. Chronology of Khin cemeteries in Cis-Baikal (cemeteries are arranged by alphabetically by name).

A. Angara (n = 3)
B. Little Sea (n = 8)
C. Upper Lena (n = 4)

Figure 9. Chronology of Kitoi cemeteries on the Angara and SW Baikal (cemeteries are arranged alphabetically by name).

Figure 10. Chronology of Glazkovo cemeteries in SW Baikal and the Little Sea (cemeteries are arranged alphabetically by name).

A. SW Baikal (n = 1)
B. Little Sea (n = 10)

Figure 11. Chronology of Glazkovo cemeteries on the Angara and Upper Lena (cemeteries are arranged alphabetically by name).

A. Angara (n = 7)
B. Upper Lena (n = 9)

Figure 12. Lokomotiv site map (LOK = Lokomotiv, LOR = Lokomotiv-Raisovet).

Figure 13. Chronology of the Kitoi Lokomotiv (Angara) and Shamanka II (SW Baikal) cemeteries.

A. Results from Kernel Density Estimate modeling for Lokomotiv
B. Summary plots (by sectors and clusters) for Lokomotiv and Shamanka II

Figure 14. Shamanka II site map.

Figure 15. Chronology of the Kitoi Shamanka II cemetery on SW Baikal: Results from Kernel Density Estimate modeling. See Figs. 13 and S13 for summary and density plots and for comparison with Lokomotiv.

Figure 16. Ust'-Ida I site map (placement of grave numbers indicates orientation of the head, where established).

Figure 17. Chronology of the Isakovo and Glazkovo cemetery at Ust'-Ida I on the Angara.

A. Results from Kernel Density Estimate modeling for the Isakovo and Glazkovo components together
B. Summary plots for the Isakovo and Glazkovo components (by sector)

Figure 18. Site map of the Glazkovo cemetery at Khuzhir-Nuge XIV in the Little Sea.

Figure 19. Chronology of the Glazkovo cemetery at Khuzhir-Nuge XIV in the Little Sea (results for Kurma XI are included for comparison).

A. Results from Kernel Density Estimate modeling for Khuzhir-Nuge XIV
B. Summary plots for Khuzhir-Nuge XIV (by sector) and Kurma XI

Figure 20. Chronological structure of the Glazkovo cemetery at Khuzhir-Nuge XIV in the Little Sea (by sector, sub-sector, and cluster).

Figure 21. Kurma XI site map.

Figure 22. Chronology of the Glazkovo cemetery at Kurma XI in the Little Sea: Results from Kernel Density Estimate modeling. See Figs. 19, S19, and S20 for summary and density plots and for comparison with Khuzhir-Nuge XIV.

Tables

Table 1. Culture history of Middle Holocene hunter–gatherer mortuary traditions and groups in Cis-Baikal.

Table 2. Spatio-temporal distribution of archaeologically documented Middle Holocene human burials in Cis-Baikal.

Table 3. Numbers of Middle Holocene cemeteries of each mortuary tradition in Cis-Baikal dated by radiocarbon analyzed in the paper.

Table 4. Spatio-temporal distribution of radiocarbon dates for Middle Holocene human burials in Cis-Baikal analyzed in the paper.

Table 5. Numbers of radiocarbon dates available for the Middle Holocene cemeteries in Cis-Baikal and OxCal functions used in the analysis.

Table 6. Summary of demographic structure for the main five cemeteries analyzed in the paper.

Multimedia components (supplements)

MMC#1 Supplement 1. Dataset of Middle Holocene hunter–gatherer burials dated by radiocarbon analyzed in the paper. Records are sorted by microregion, cemetery name, Master ID. Explanation of SEX codes: F–female, FP–probable female, M–male, MP–probable male; U–undetermined.

MMC#2 Supplement 2. Examples of OxCal codes used in the analysis.

MMC#3 Supplement 3. Complete OxCal code for Model B (Expanded "KDE_Model") with cemetery and grave geographic location data and some additional (optional) information.

MMC#4 Supplement 4. Results from Model B: expanded "KDE_Model".

MMC#5 Figure S1. Map of Cis-Baikal with Middle Holocene hunter–gatherer cemeteries analyzed. Created by Christian Leipe using elevation data from SRTM Global 30 Arc-Second Elevation (GTOPO30) dataset developed by the U.S. Geological Survey. Waterbodies and international boundaries were derived from the Natural Earth map dataset (http://www.naturalearthdata.com/).

MMC#6 Figure S4. Detailed chronology of the Khin and Kitoi mortuary traditions in Cis-Baikal.

A. Khin in the Angara valley
B. Khin in the Little Sea
C. Khin on the Upper Lena

D. Kitoi in the Angara valley
E. Kitoi in SW Baikal

MMC#7 Figure S5. Detailed chronology of the Isakovo and Serovo mortuary traditions in Cis-Baikal.

A. Isakovo in the Angara valley
B. Ust'-Ida I Isakovo in the Angara valley
C. Serovo in the Angara valley
D. Isakovo and Serovo in the Angara valley
E. Serovo in the Little Sea
F. Isakovo on the Upper Lena
G. Serovo on the Upper Lena
H. Verkholensk Serovo on the Upper Lena

MMC#8 Figure S6. Detailed chronology of the Glazkovo mortuary tradition in Cis-Baikal.

A. Glazkovo in the Angara valley
B. Glazkovo on SW Baikal
C. Glazkovo in the Little Sea
D. Glazkovo on the Upper Lena

MMC#9 Figure S9. Detailed chronology of Kitoi cemeteries on the Angara and SW Baikal.

A. Lokomotiv
B. Angara excluding Lokomotiv and Kitoi
C. Shamanka II Phase 1 & 2
D. All Kitoi (Angara & SW Baikal)

MMC#10 Figure S10. Detailed chronology of Glazkovo cemeteries in SW Baikal and in the Little Sea.

A. Shamanka II
B. Ulan-Khada
C. Kurma XI
D. Khadarta IV
E. Khuzhir-Nuge XIV
F. Little Sea excluding Khuzhir-Nuge XIV
G. Little Sea including Khuzhir-Nuge XIV

MMC#11 Figure S11. Chronology of Glazkovo cemeteries on the Angara and Upper Lena.

A. Ust'-Ida I
B. Ust'-Ilga
C. Obkhoi
D. Verkholensk
E. Verkholensk area
F. All Upper Lena Glazkovo

MMC#12 Figure S13. Detailed chronology of the Kitoi Lokomotiv (Angara) and Shamanka II (SW Baikal) cemeteries.

A. Cluster 1 (Raisovet)
B. Cluster 2
C. Cluster 4
D. Cluster 5
E. Cluster 7

F. Shamanka II, North Sector
G. Shamanka II, South Sector

MMC#13 Figure S17. Detailed chronology of the Isakovo and Glazkovo cemetery at Ust'-Ida I on the Angara: Results from Kernel Density Estimate modeling.

A. Isakovo North Sector
B. Isakovo South Sector
C. Glazkovo North Sector
D. Glazkovo South Sector

MMC#14 Figure S19. Detailed chronology of the Glazkovo cemetery at Khuzhir-Nuge XIV in the Little Sea (results for Kurma XI are included for comparison).

A. Khuzhir-Nuge XIV, West Sector
B. Khuzhir-Nuge XIV, Centre Sector
C. Khuzhir-Nuge XIV, East Sector
D. Kurma XI

MMC#15 Figure S20. Detailed chronological structure of the Glazkovo cemetery at Khuzhir-Nuge XIV in the Little Sea.

A. West Sector
B. Centre-West Subsector
C. Center-East Subsector
D. East–NW Cluster
E. East–NE Cluster
F. East–S Cluster

Figure 1

Figure 1

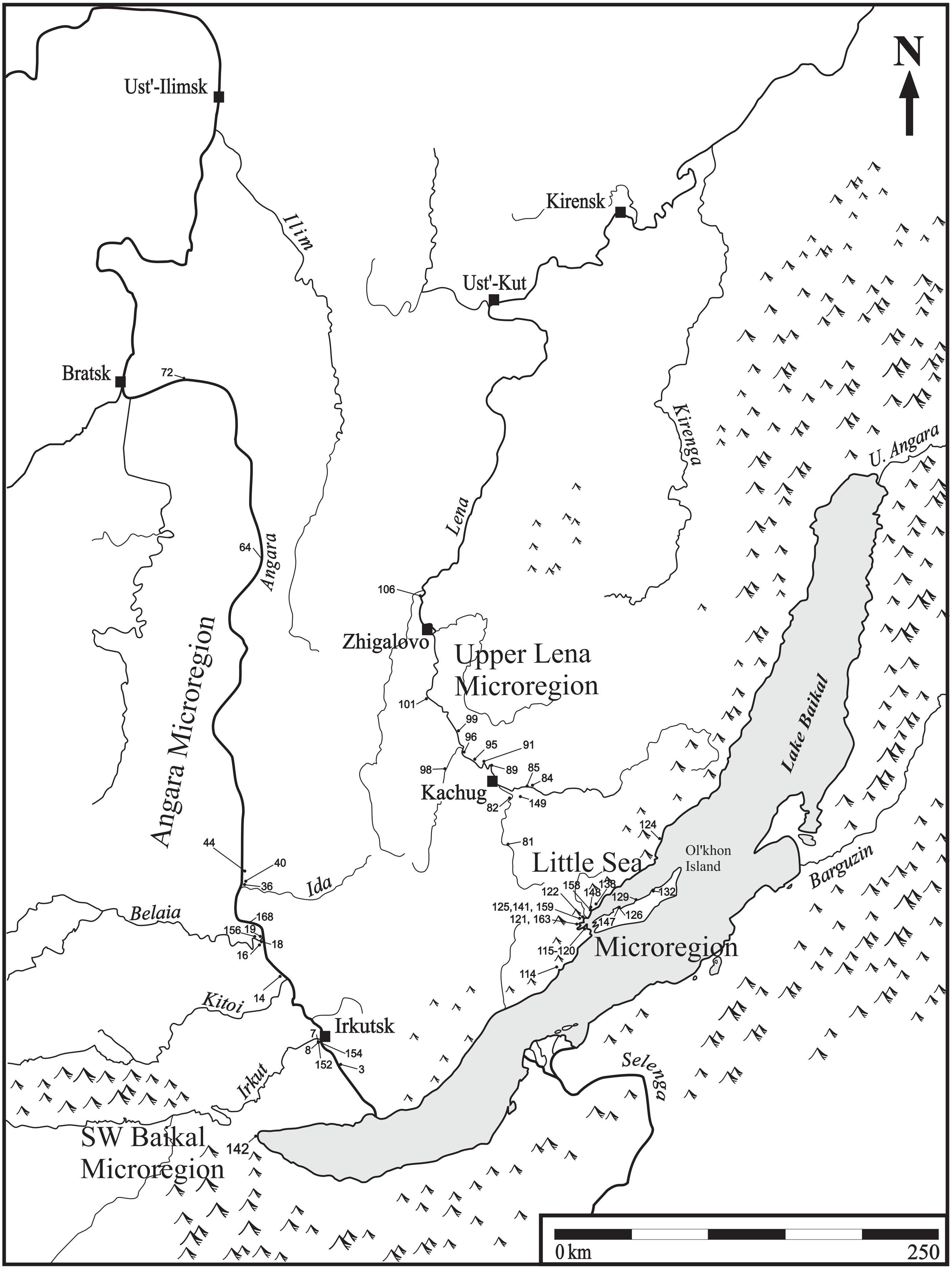
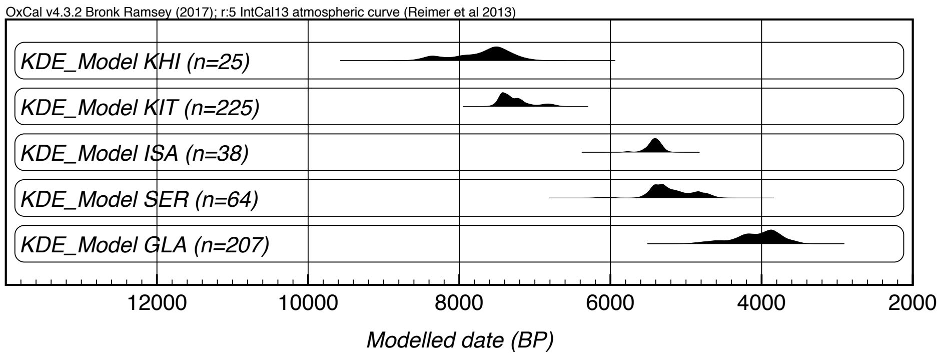


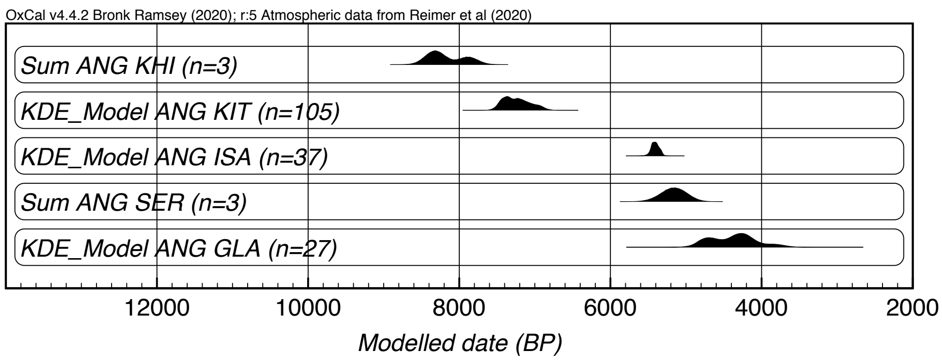
Figure 2

Figure 2

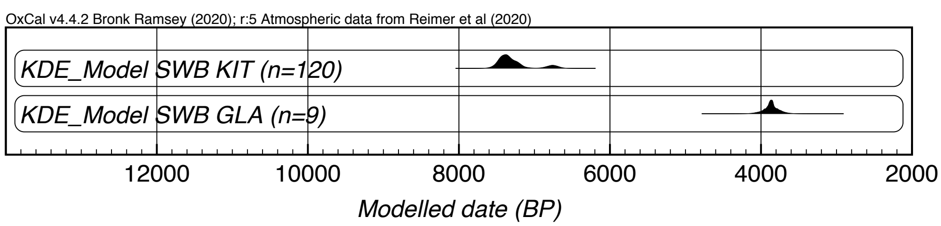
A. Cis-Baikal



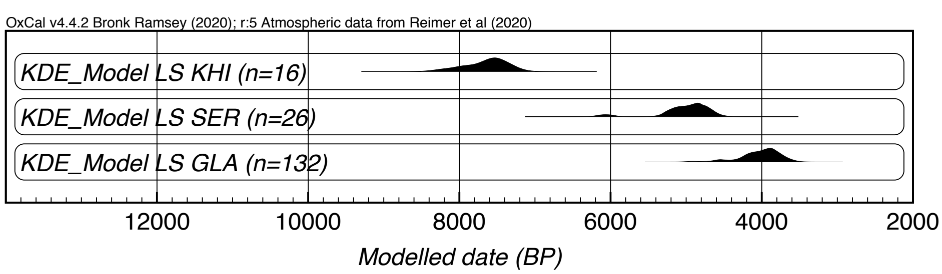
B. Angara



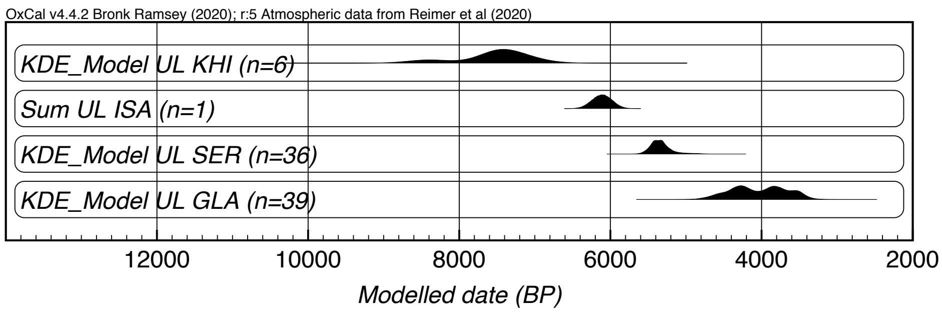
C. SW Baikal



D. Little Sea



E. Upper Lena

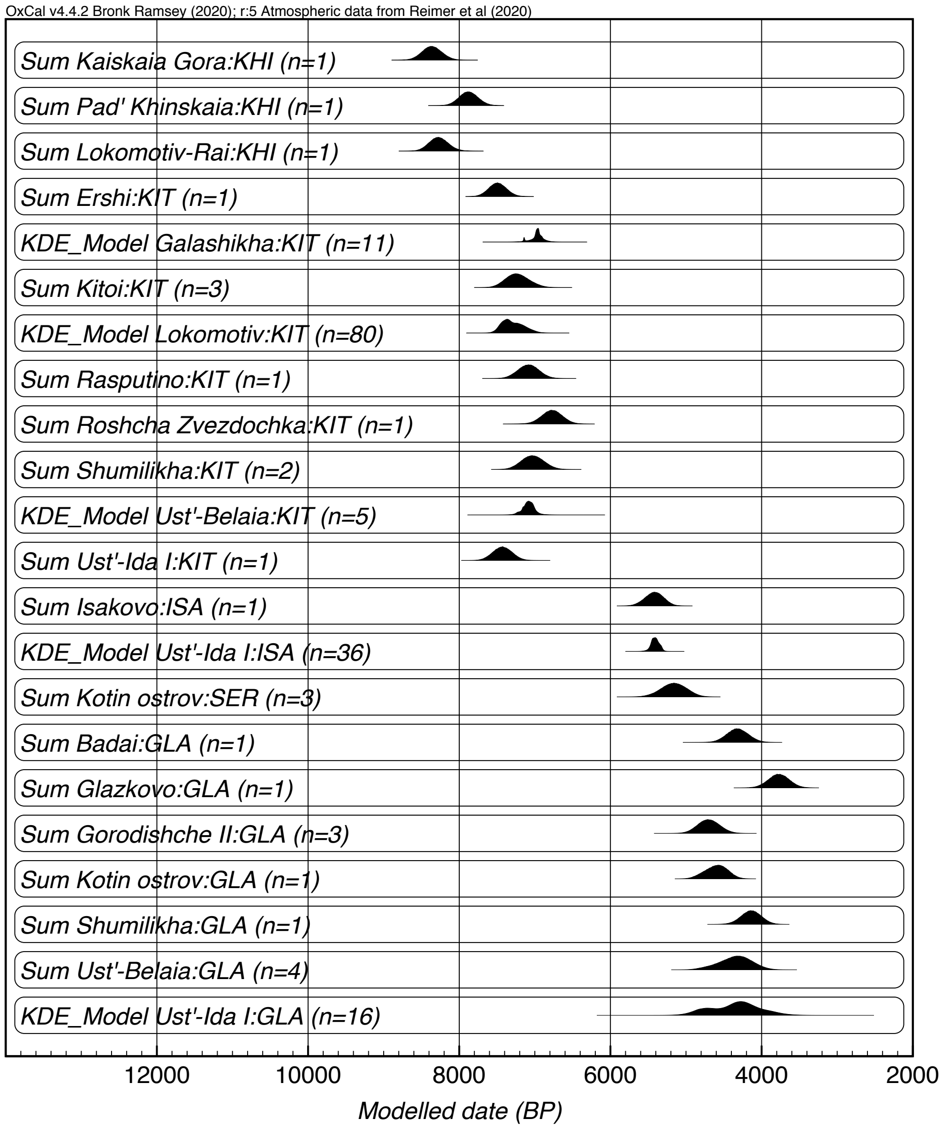


OxCal v4.4.2 Bronk Ramsey (2020); r:5 Atmospheric data from Reimer et al (2020)
KDE_Model UL KHI (n=6)
Sum UL ISA (n=1)
KDE_Model UL SER (n=36)
KDE_Model UL GLA (n=39)
12000
10000
8000
6000
4000
2000
Modelled date (BP)

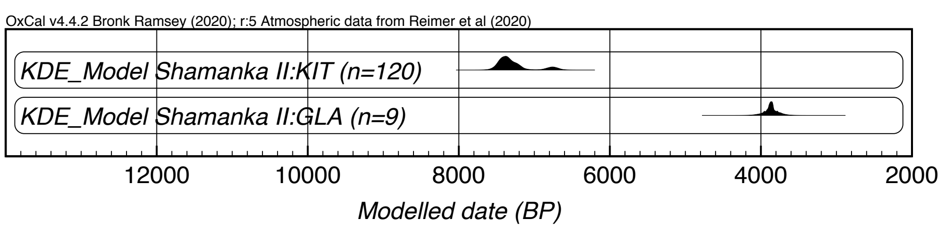
Figure 3

Figure 3

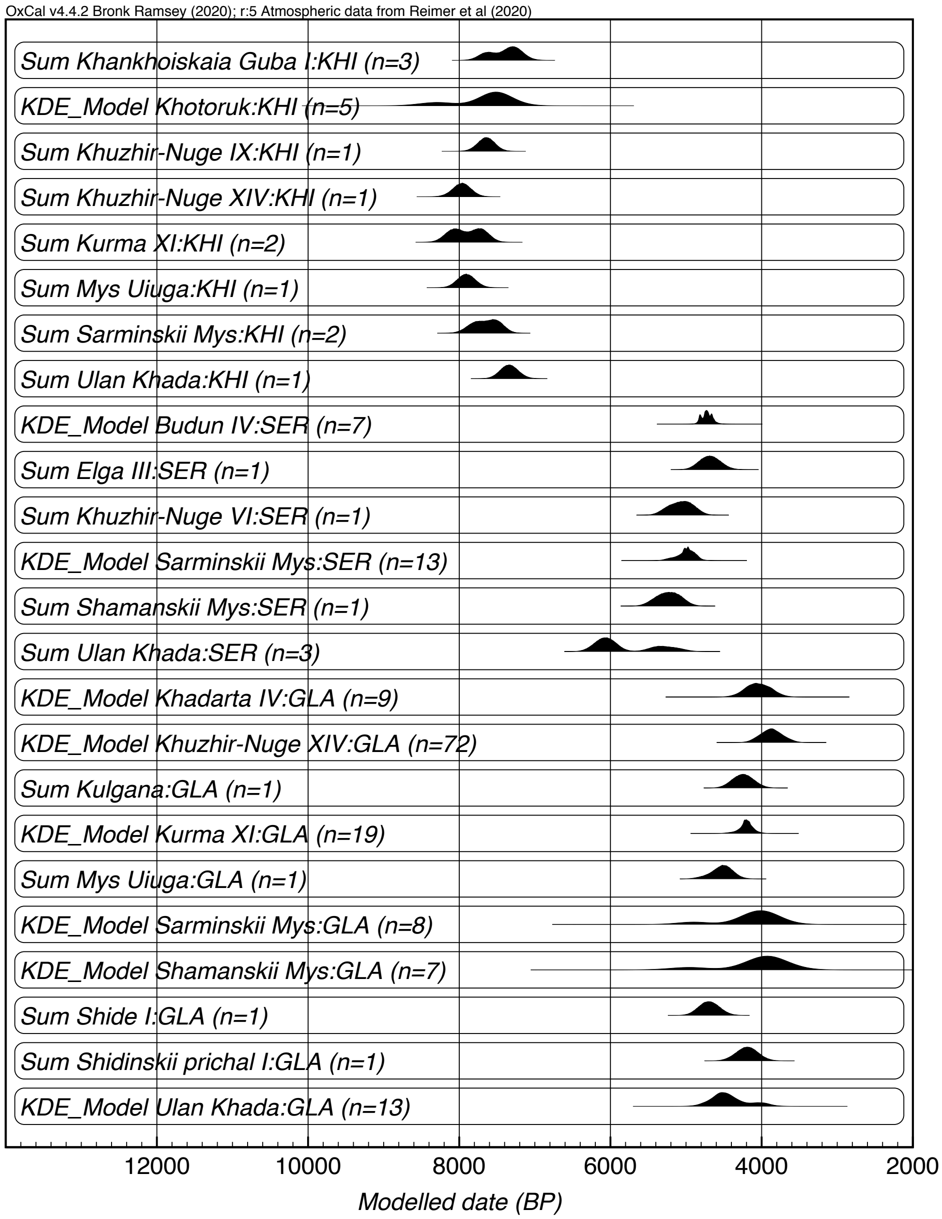
A. Angara (n = 22)



B. SW Baikal (n = 2)



C. Little Sea (n = 24)



D. Upper Lena (n = 17)

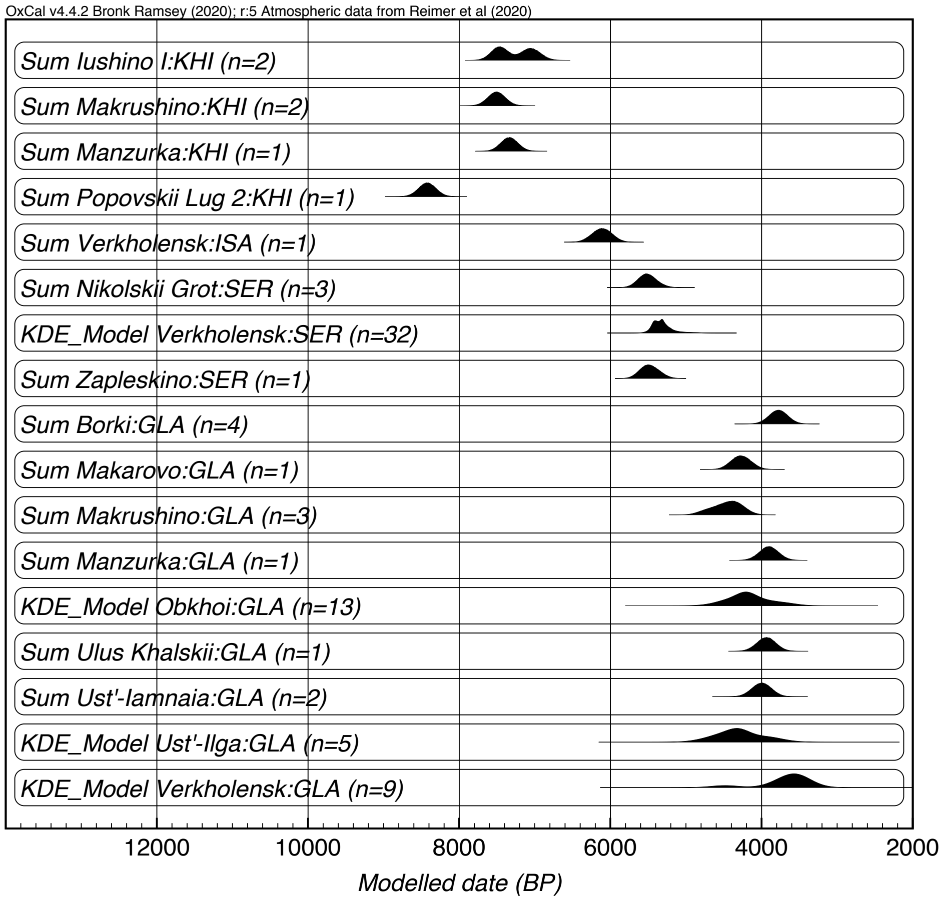


Figure 4

Figure 4

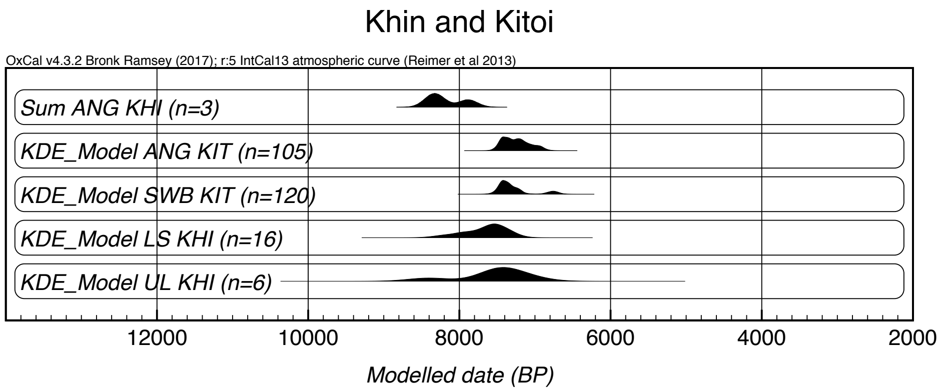


Figure 5

Figure 5

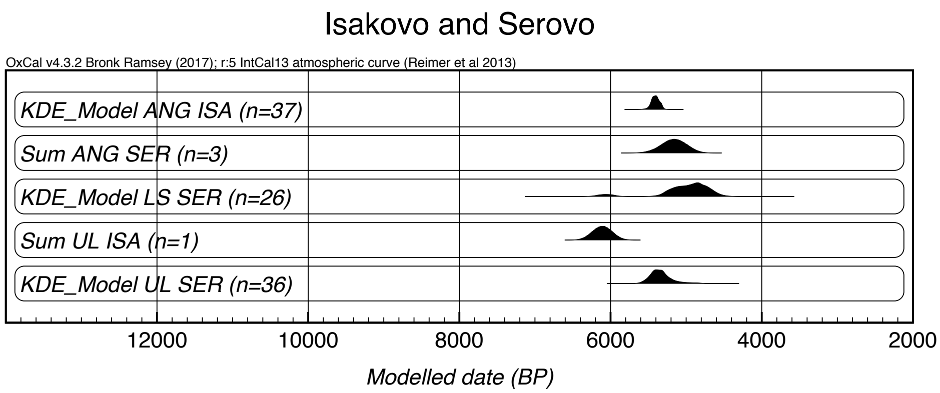


Figure 6

Figure 6

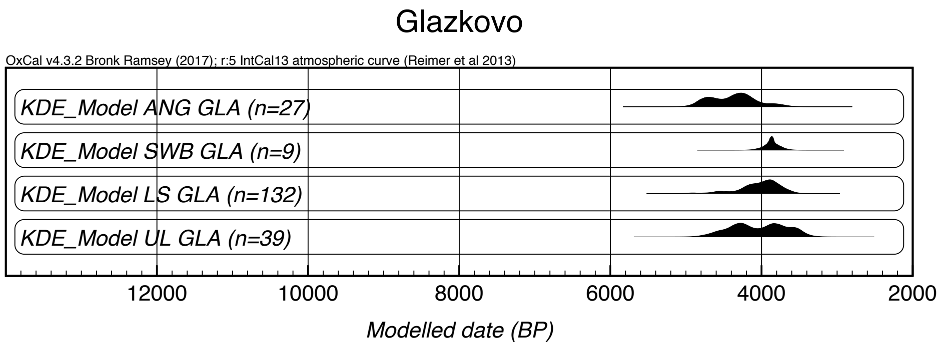
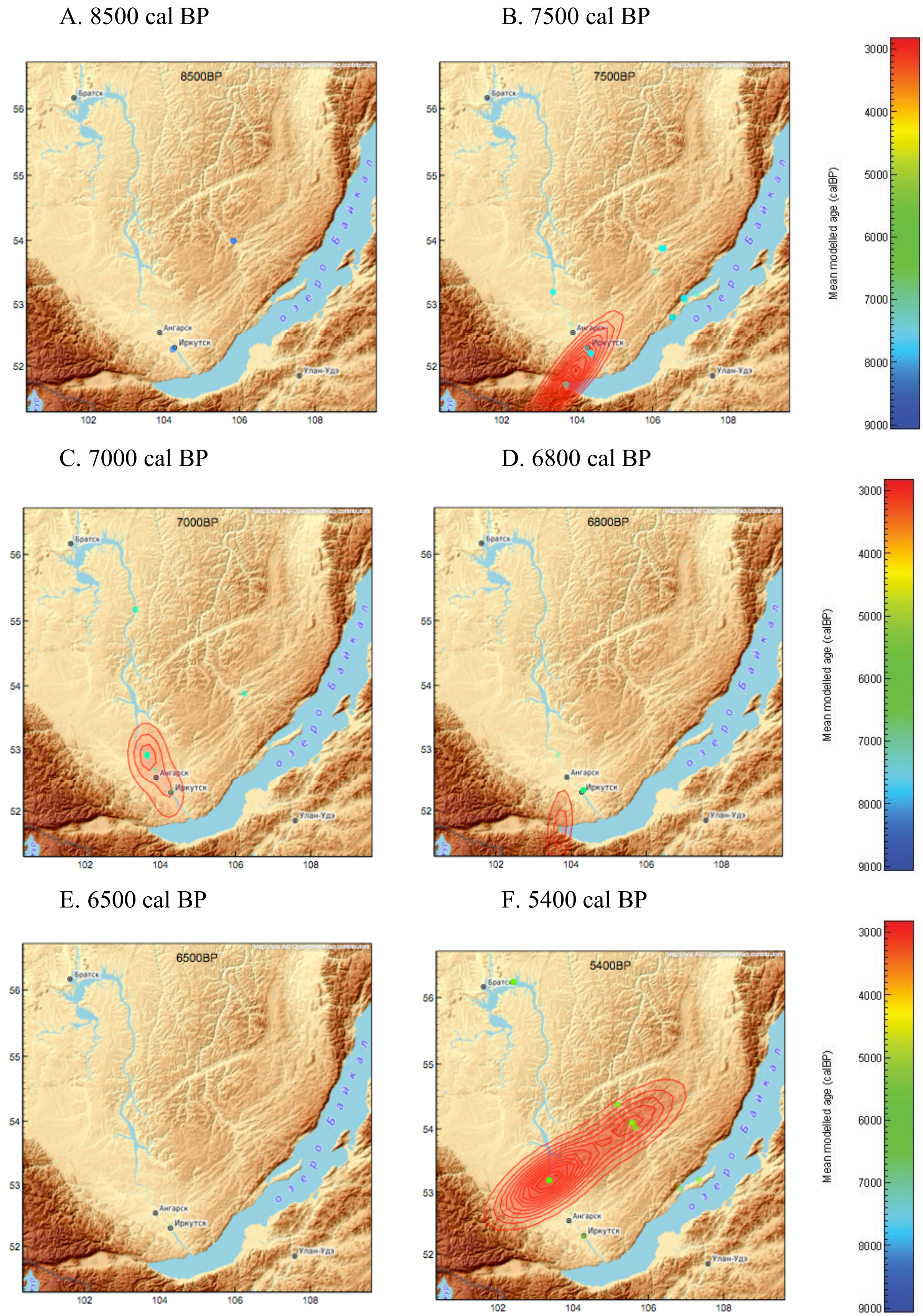


Figure 7

Figure 7



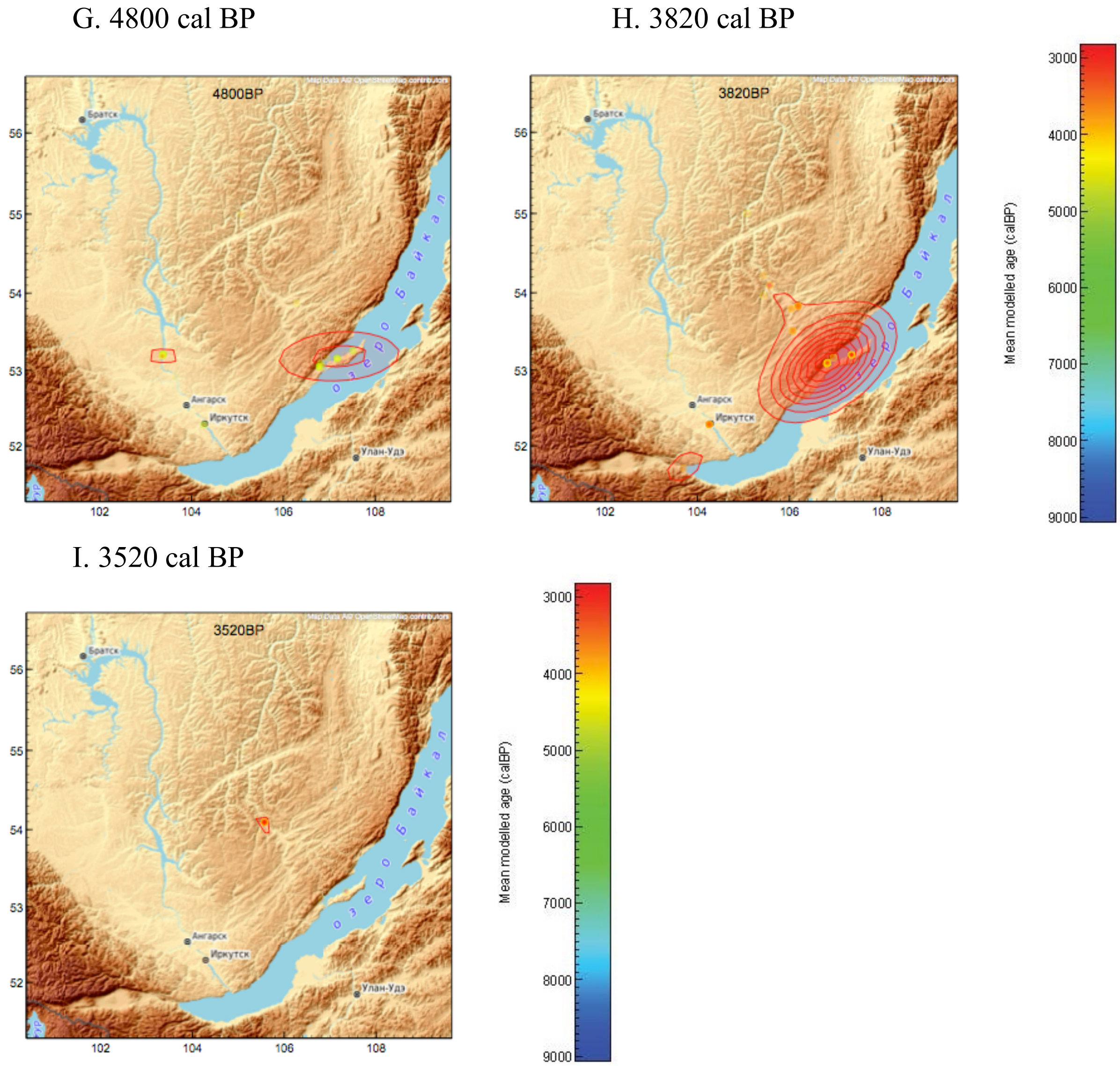
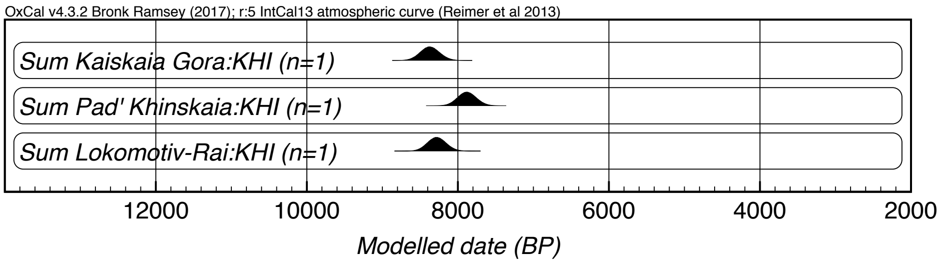

G. 4800 cal BP
4800BP
H. 3820 cal BP
3820BP
I. 3520 cal BP
3520BP
Братск
Ангарск
Иркутск
Улан-Удэ
озеро Байкал
56
55
54
53
52
102
104
106
108
Mean modelled age (calBP)
3000
4000
5000
6000
7000
8000
9000

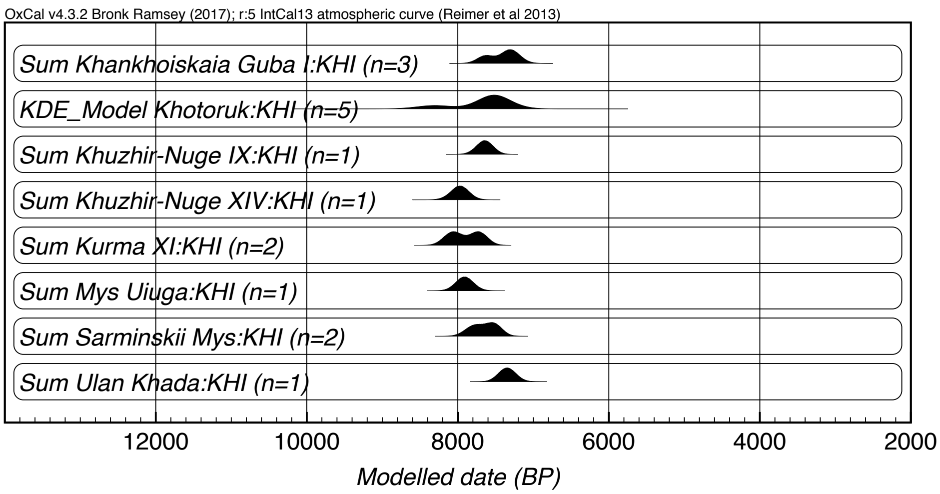
Figure 8

Figure 8

A. Angara (n = 3)



B. Little Sea (n = 8)



C. Upper Lena (n = 4)

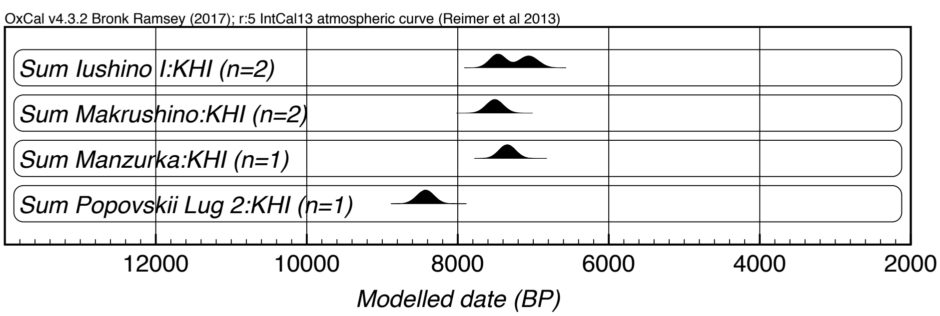


Figure 9

Figure 9

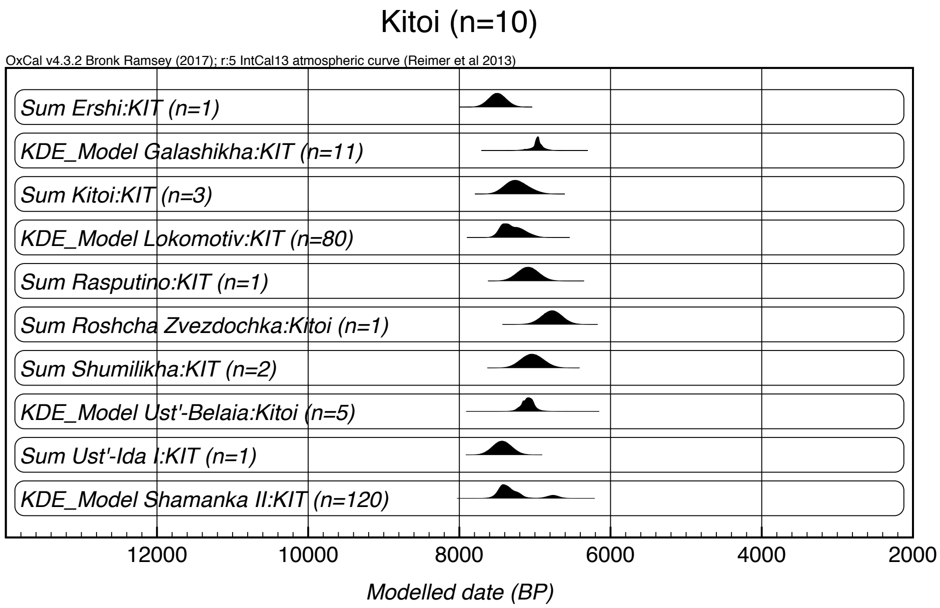
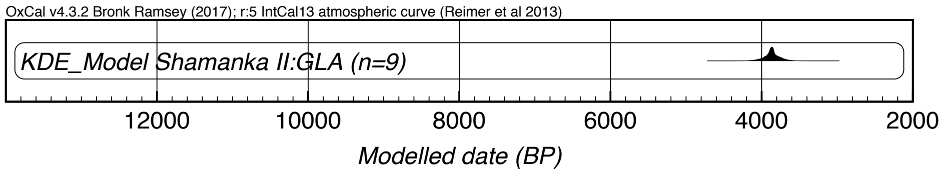


Figure 10

Figure 10

A. SW Baikal (n=1)



B. Little Sea (n=10)

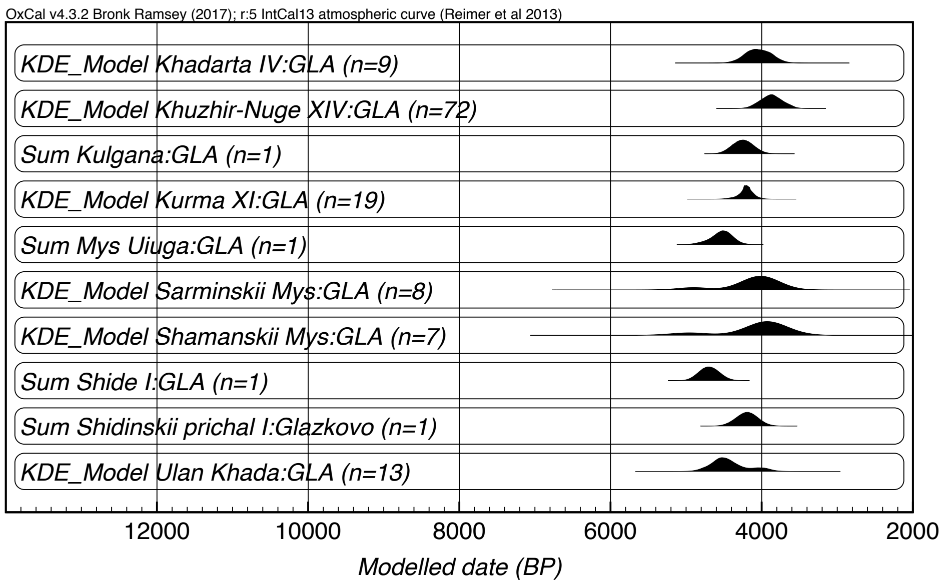
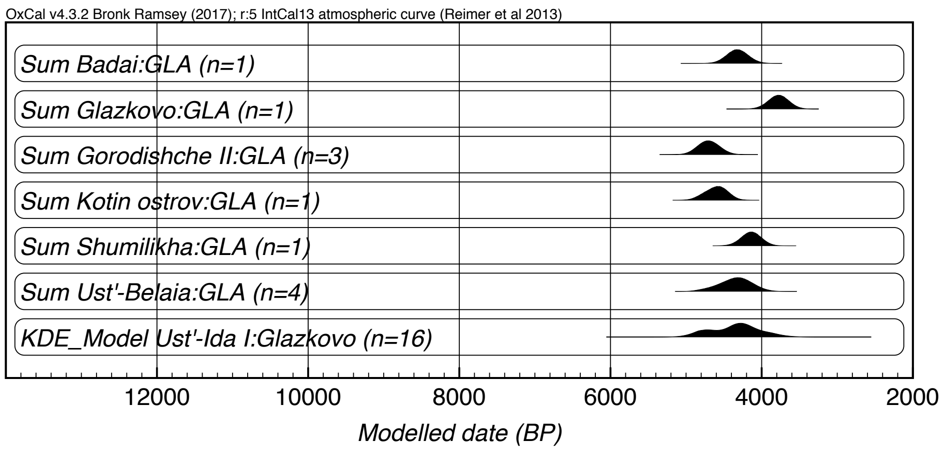


Figure 11

Figure 11

A. Angara (n=7)



B. Upper Lena (n=9)

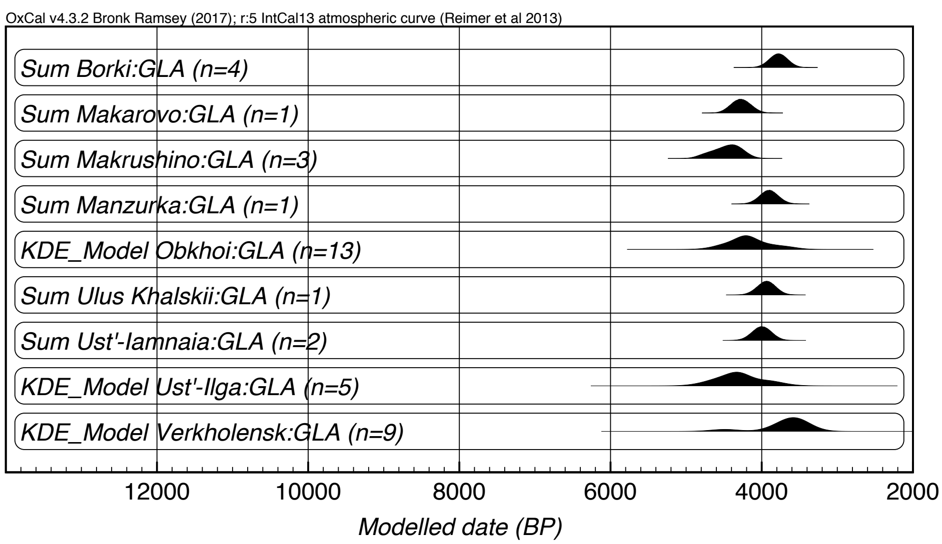
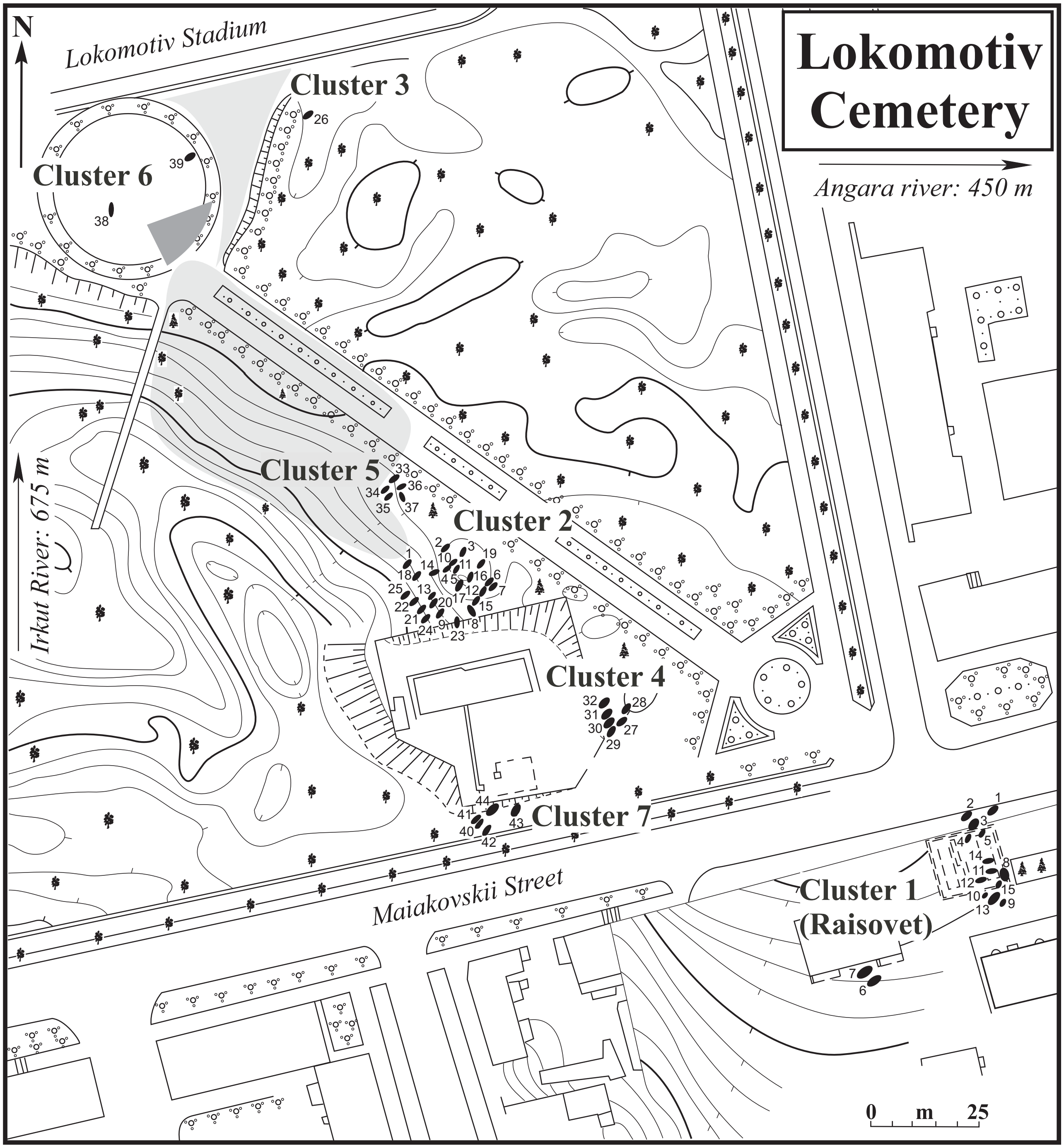


Figure 12



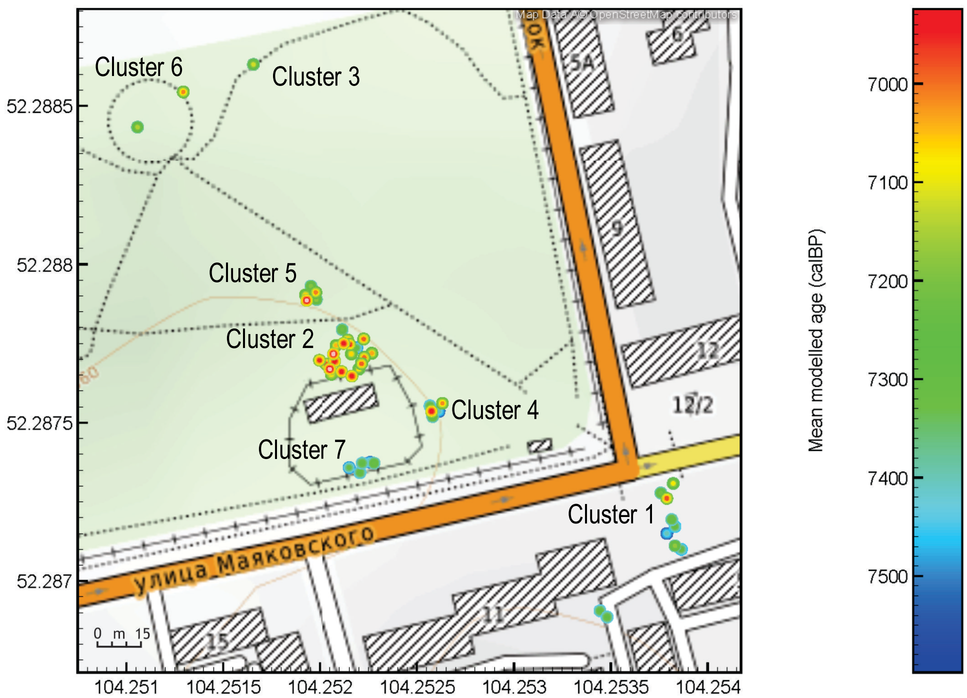
Early Neolithic Kitoi grave
Early Bronze Age Glazkovo grave
Unexcavated area (> 50 graves)
Gerasimov's 1928 excavation (5 graves)

Cluster 1: LOR Nos. 1–15
Cluster 2: LOK Nos. 1–25
Cluster 3: LOK Nos. 26
Cluster 4: LOK Nos. 27–32
Cluster 5: LOK Nos. 33–37
Cluster 6: LOK Nos. 38–39
Cluster 7: LOK Nos. 40–44

Figure 13

Figure 13

A. Results from Kernel Density Estimate modeling for Lokomotiv.



B. Summary plots (by sectors and clusters) for Lokomotiv and Shamanka II

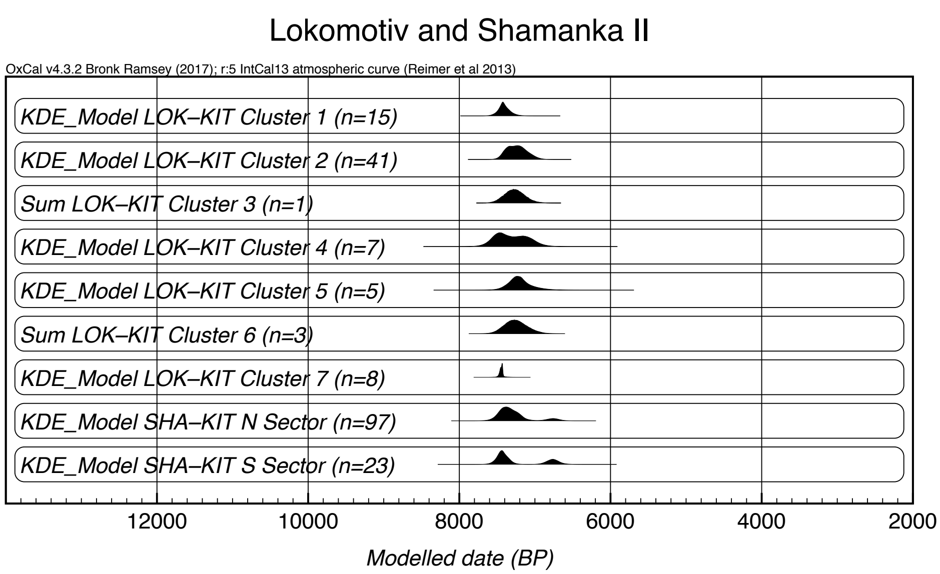


Figure 14

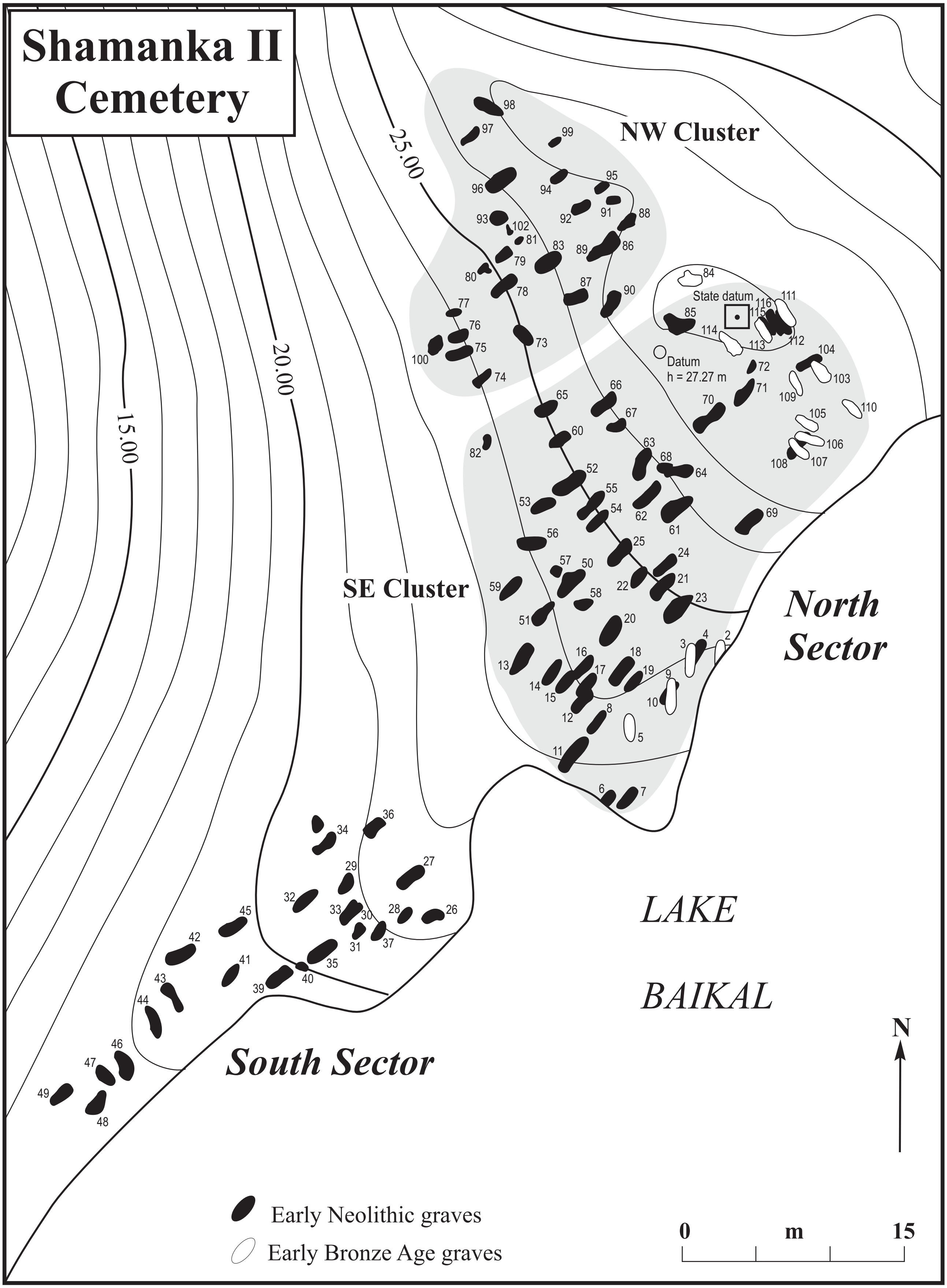

Shamanka II Cemetery
NW Cluster
SE Cluster
North Sector
South Sector
LAKE BAIKAL
State datum
Datum
h = 27.27 m
25.00
20.00
15.00
N
Early Neolithic graves
Early Bronze Age graves
0 m 15

Figure 15

Figure 15

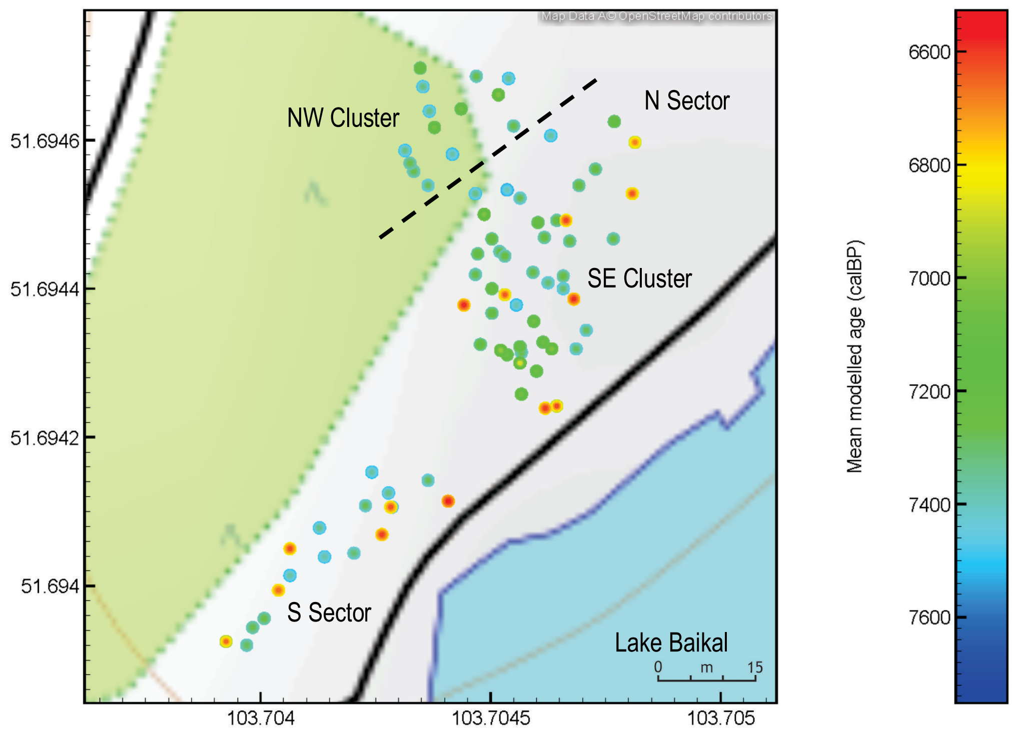


Figure 16

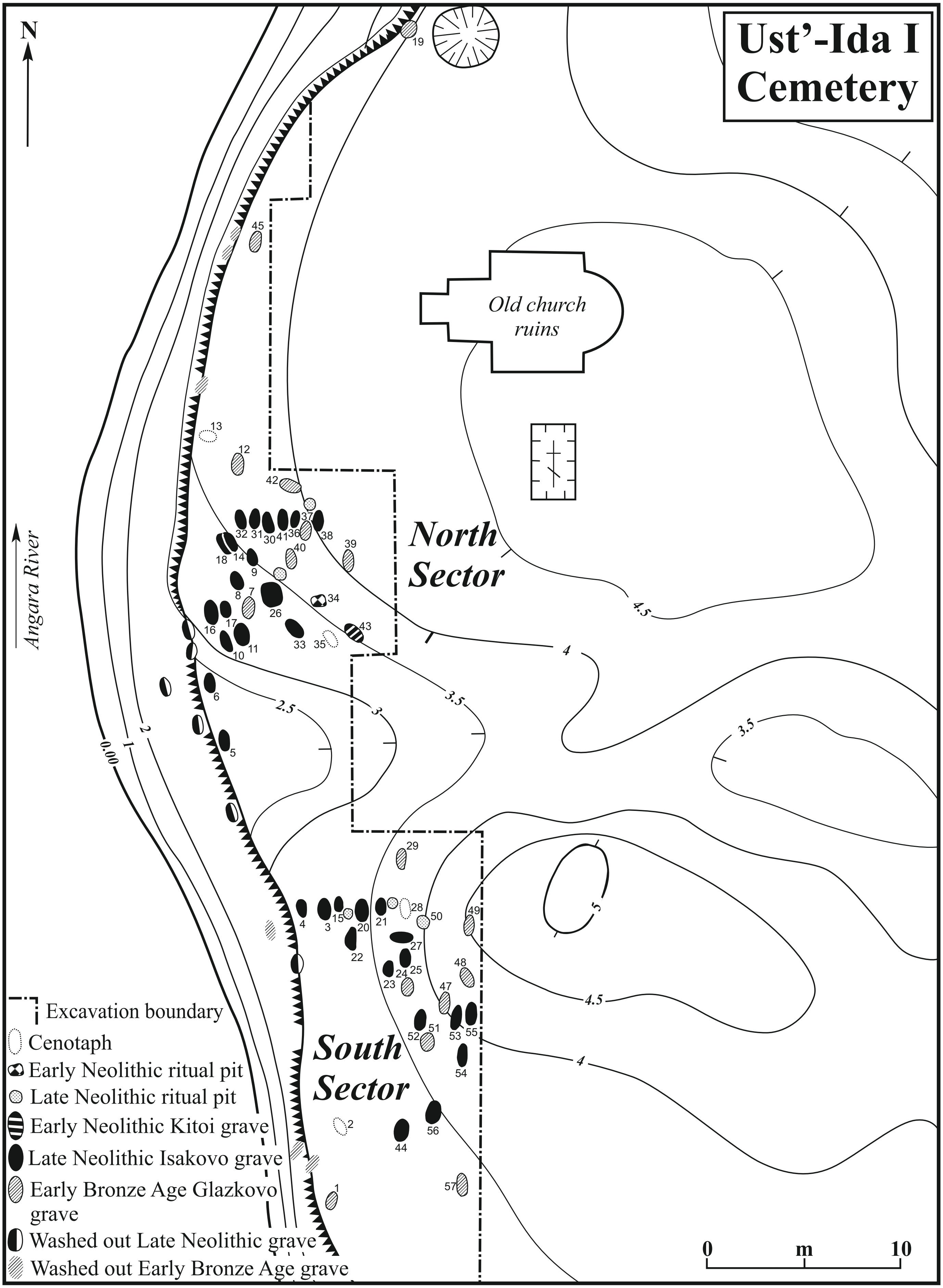
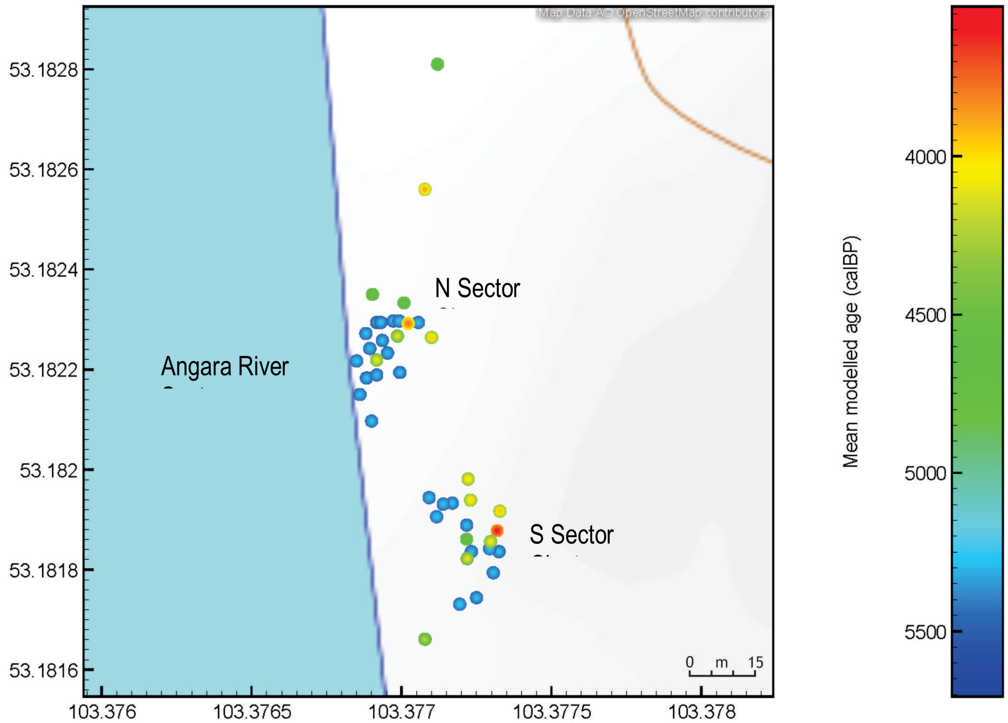

Ust'-Ida I Cemetery
N
Old church ruins
North Sector
South Sector
Angara River
0.00
1
2
2.5
3
3.5
4
4.5
5
0 m 10
Excavation boundary
Cenotaph
Early Neolithic ritual pit
Late Neolithic ritual pit
Early Neolithic Kitoi grave
Late Neolithic Isakovo grave
Early Bronze Age Glazkovo grave
Washed out Late Neolithic grave
Washed out Early Bronze Age grave

Figure 17

Figure 17

A. Results from Kernel Density Estimate modeling for the Isakovo and Glazkovo components together



B. Summary plots for the Isakovo and Glazkovo components(by sector)

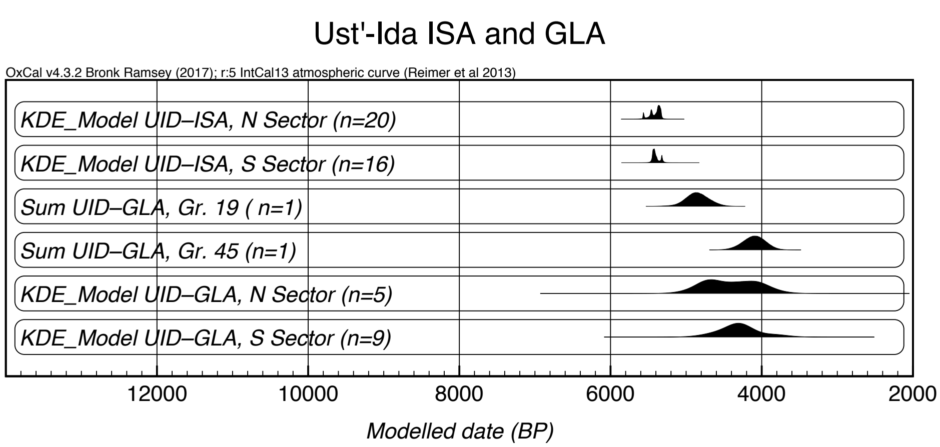


Figure 18

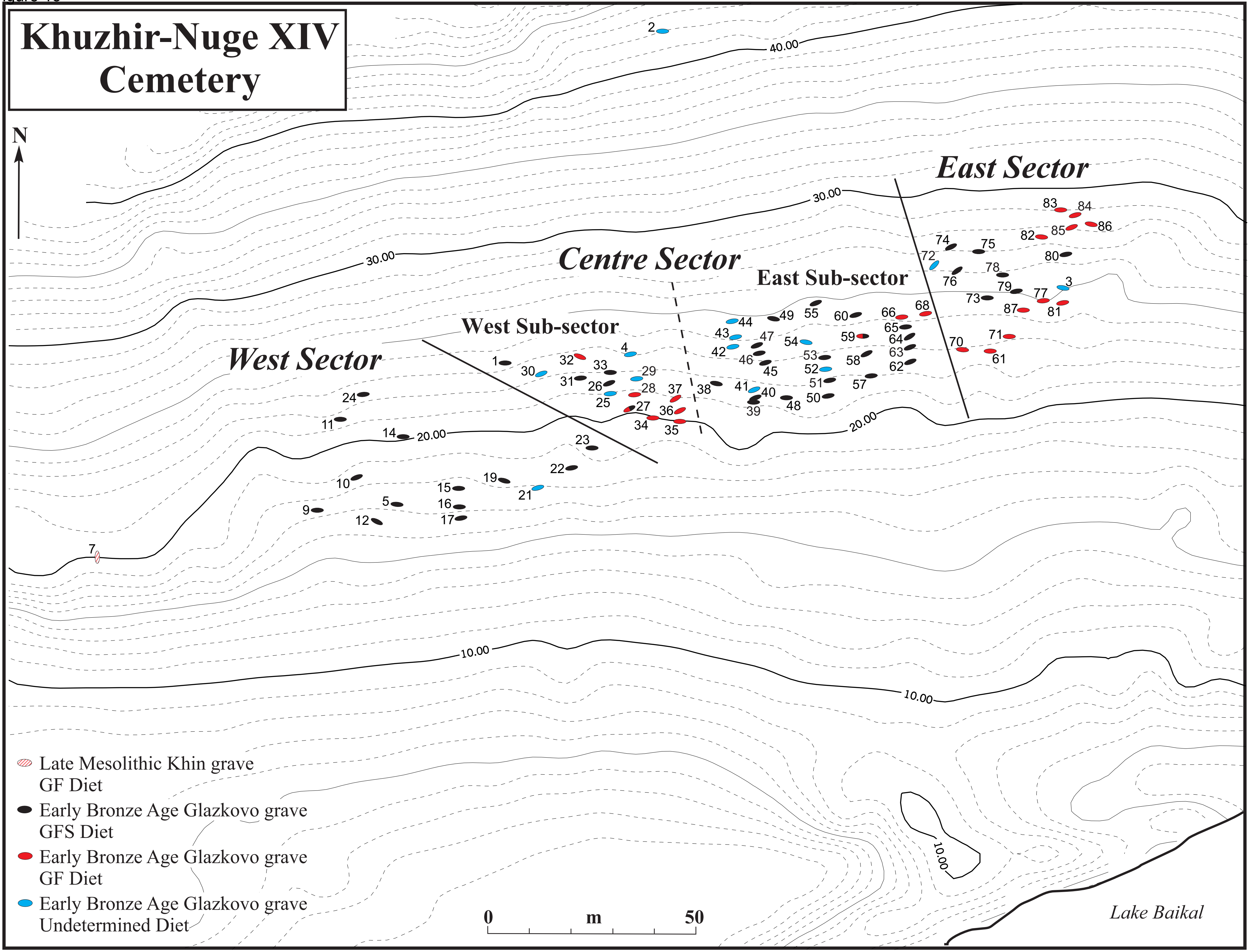
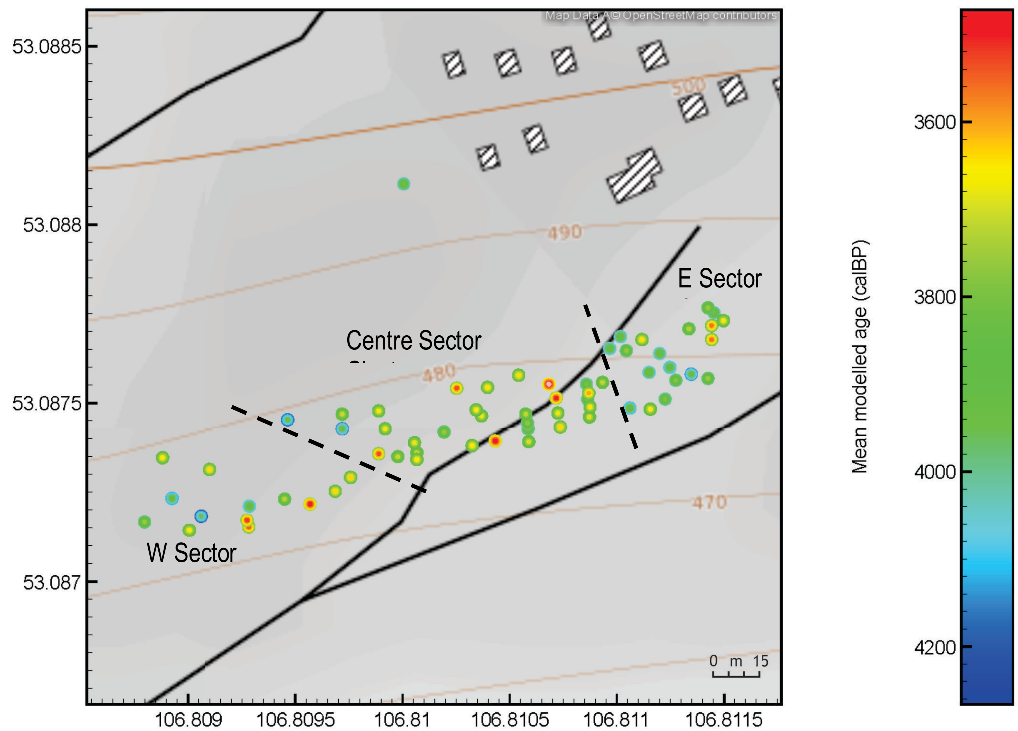

Khuzhir-Nuge XIV Cemetery
N
East Sector
Centre Sector
East Sub-sector
West Sub-sector
West Sector
40.00
30.00
20.00
10.00
Late Mesolithic Khin grave GF Diet
Early Bronze Age Glazkovo grave GFS Diet
Early Bronze Age Glazkovo grave GF Diet
Early Bronze Age Glazkovo grave Undetermined Diet
0 m 50
Lake Baikal

Figure 19

Figure 19

A. Results from Kernel Density Estimate modeling for Khuzhir-Nuge XIV



B. Summary plots for Khuzhir-Nuge XIV (by sector) and Kurma XI

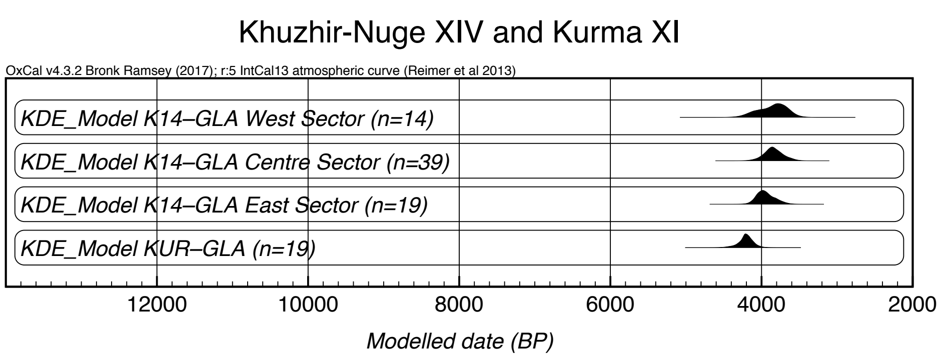


Figure 20

Figure 20

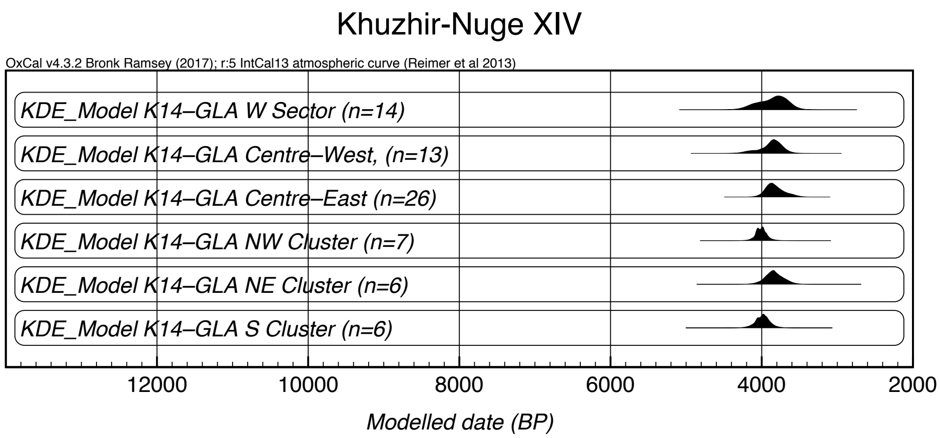
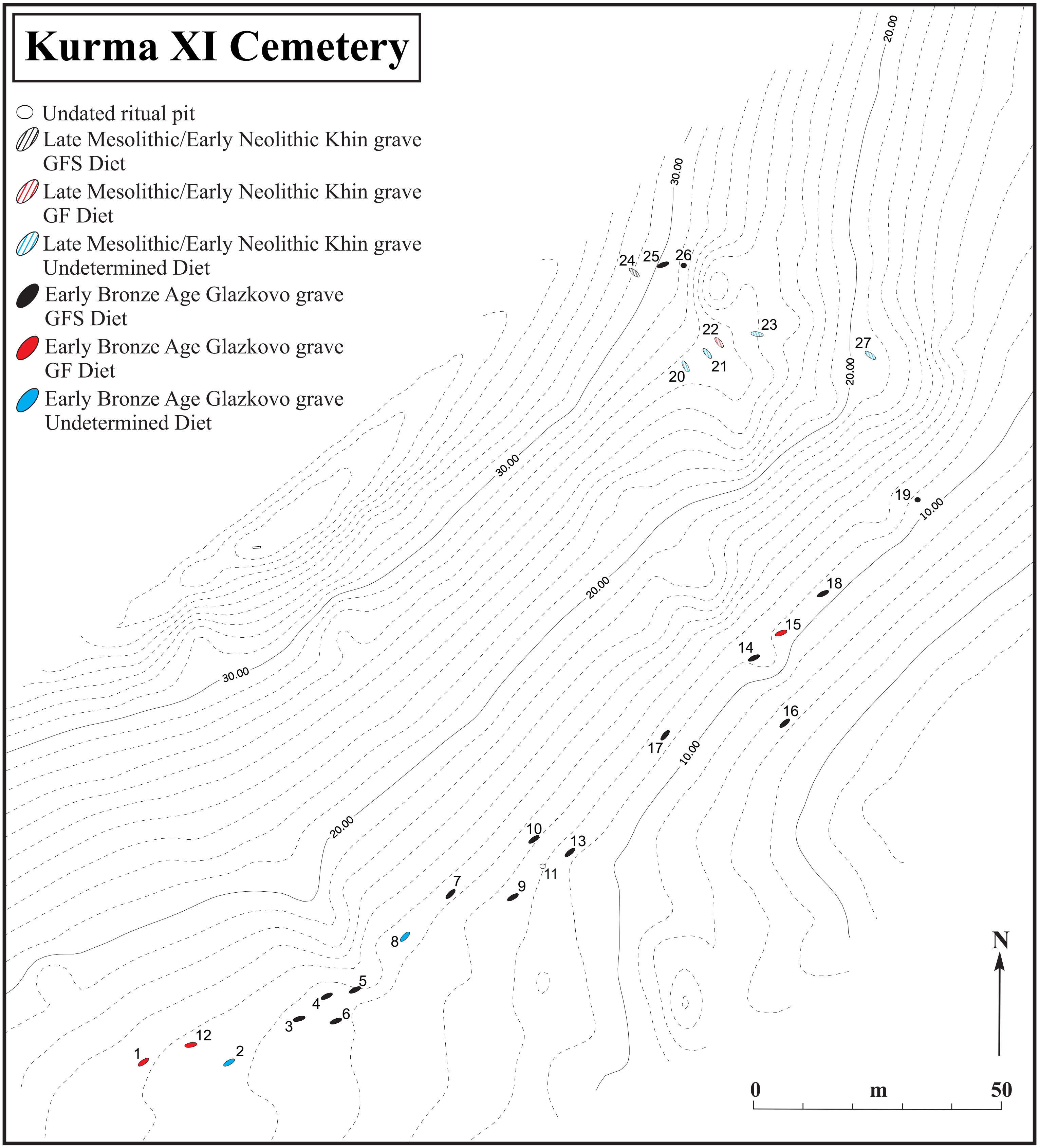


Figure 21



Kurma XI Cemetery
Undated ritual pit
Late Mesolithic/Early Neolithic Khin grave GFS Diet
Late Mesolithic/Early Neolithic Khin grave GF Diet
Late Mesolithic/Early Neolithic Khin grave Undetermined Diet
Early Bronze Age Glazkovo grave GFS Diet
Early Bronze Age Glazkovo grave GF Diet
Early Bronze Age Glazkovo grave Undetermined Diet
30.00
20.00
10.00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
N
0
m
50

Figure 22

Figure 22