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Regional chronostratigraphical correlation table for the last 270,000 years

North Atlantic – Greenland – West, North, Central, Eastern Europe, Russia – Siberia v. 2012b

INQUA 1928
International Union for Quaternary Research (INQUA), Stratigraphy and Chronology Commission (SACCOM).
http://www.inqua.tcd.ie/

International Union of Geological Sciences (IUGS), International Commission on Stratigraphy (ICS), Subcommission on Quaternary Stratigraphy (SQS).
http://www.stratigraphy.org/
IUGS

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http://www.quaternary.stratigraphy.org.uk

http://www.stratigraphy.org

Introduction

This poster presents a regional chronostratigraphical correlation chart for mid and high latitude Europe, north of the Mediterranean Sea. The chart spans the last 10% of Quaternary time, the critical youngest interval, that bears strongly on our environment today, and spans the two last glacial-interglacial cycles. For this period, records and associated chronostratigraphical division schemes are available based on a variety of sedimentary records, from many adjacent palaeoenvironments. For historical and geological reasons, a series of regional division schemes are in use. The chart shows how robust these divisions have become despite being defined on records of different types.

The chart is presented with columns listing stage names alternating with those that graphically display selected sedimentary sequences. In this way the chart shows the variety of Quaternary sedimentary records that underpin the diversity of division schemes in the various countries of Europe. The schemes are ordered from global to regional, from Atlantic to continental, from west to east, from glaciated to periglacial areas. With the chart the aim was (i) to review the progress that has been made in chronostratigraphical correlation, through the integration of numerical dating and stratigraphical correlation techniques and (ii) to highlight the overprinting of preservation on the resolution obtained for last cycle compared to deposits from the next-older and much-older cycles. The latter is a point often made when contrasting the Holocene with the rest of the Quaternary. Here it is highlighted for the last completed interglacial-glacial cycle, that is the Late Pleistocene, versus the penultimate cycle that is the last of the Middle Pleistocene.

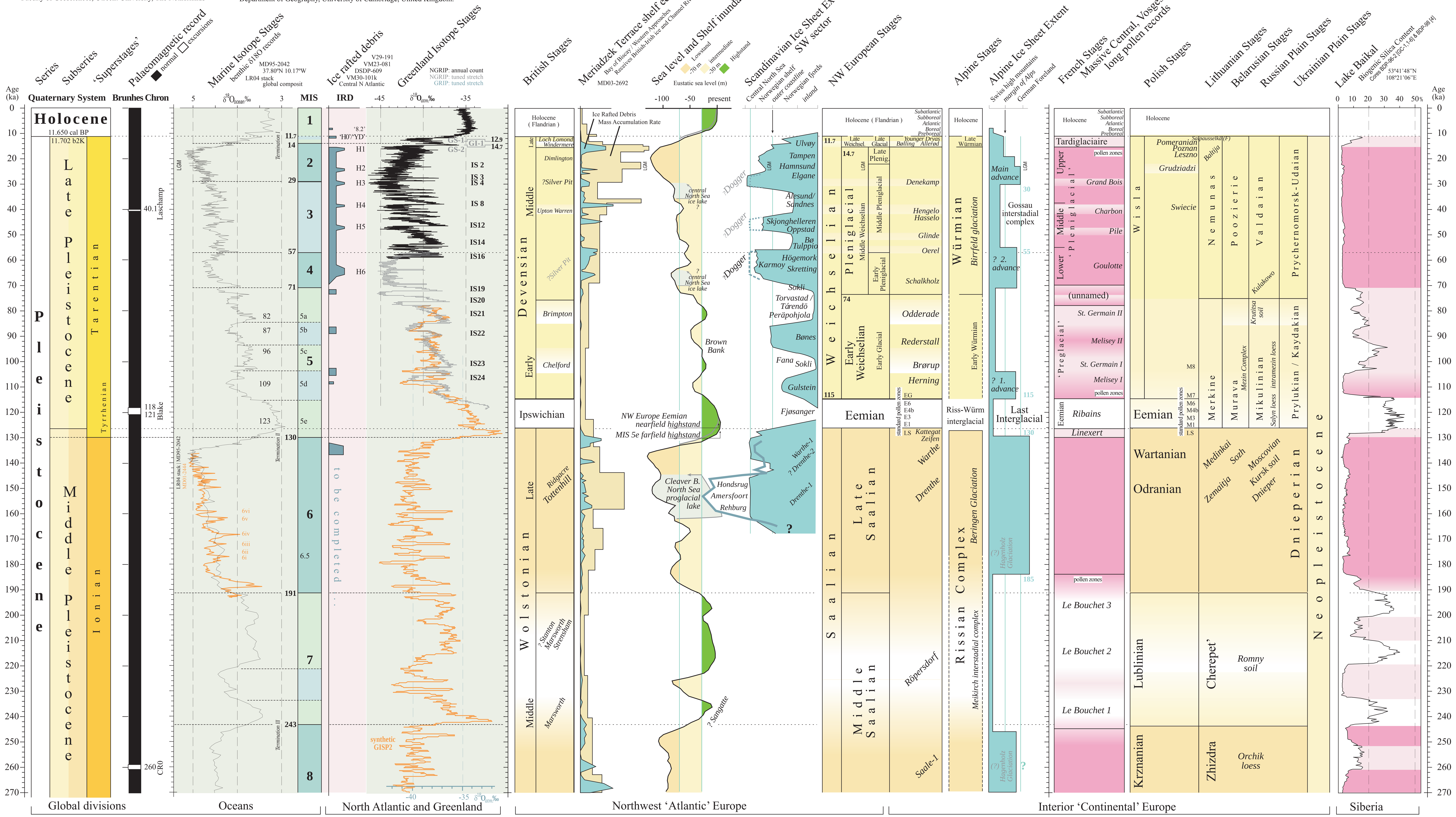
Our reasons to produce this chart

Europe has a long tradition of applying regional chronostratigraphical correlations in studies of its diverse Quaternary geological record. It has an almost equally long history of revision of schemes and their periodic replacement. Such revisions were required from time to time because of progress made in the understanding of the geological record, in the level of international compatability that necessitated the integration of national geology. It has also been driven by the introduction of new techniques, to test and improve the chronology of the correlations. In this paper the authors present a chart showing names in use in the various fields of Quaternary Geology in the region, displayed on a common time-axis spanning the last 270,000 years.

To address important open questions in Quaternary science – these include for example, natural climate and sea-level change in the past versus the present, the global impact of humans in the Holocene versus natural situations in past interglacials, routing of runoff and supply of sediment from upland and lowland to seas and oceans, the origin of ice ages, biogeographical evolution and faunal extinctions, and the origin of humans – a major trend has been to launch global and continental scale studies. This demands the integration of information from different sources for a large area (both in reconstruction and in modelling studies, either as input or validation). When such studies deal with the Holocene and the end of the Last Glacial (youngest 30 ka), several dating techniques (e.g. 14C, Optically Stimulated Luminescence) can be applied, allowing datasets to be equated based on numerical ages. When one changes to consider past interglacials and glacials in such studies, however, opportunities for independent age control immediately become more limited and relative dating, age-modelling and correlation techniques become more important. Pleistocene geological field evidence, especially that collected on land, is typically of very local observational nature (a core, an outcrop, a local map) and usually presented in a regional, rather than continental or global context. In Europe in particular, because of the long research tradition, the many countries each with their own languages, and the sheer quantity of research output, it is difficult to acquire an overview and to keep it up to date, especially as insights inevitably will continue developing.

By introducing this chart, the authors hope to provide an entry point for workers who want to search literature and use data across disciplines and national boundaries. Considerable progress has been made in chronostratigraphical correlation in the last decades through the integration of numerical dating, age-modelling and stratigraphical-correlation techniques, to such a degree that pan-european correlation, such as on that presented here, can be attempted. From this starting point, it is intended to revise the chart periodically as necessary using the website http://www.quaternary.stratigraphy.co.uk/ to distribute updates, as has been already established for the Gibbard & Cohen (2008) 'Global chronostratigraphical correlation chart for the last 2.7 Million years' (Gibbard et al. 2005; Cohen & Gibbard, 2011; 2012). We intend to show the diversity of schemes in use in Europe north of the Mediterranean, together with some from deep marine environments, those from vegetated terrestrial environments, and others concerning glaciation phenomena. Part of the columns display curve data that are measurements from increasing depth down core sequences. These are plotted on a time axis following depth-to-age conversions that are subject on occasion to change, an issue pragmatically dealt with when creating this chart, documented in some detail in this paper. The colour scheme adopted is retained from that used for the 2.7 Ma global chart. This has been done to ensure maximum compatibility for this 10x enlarged version, the aim being to create a family of charts. The chart is of necessity restricted to Europe north of the Mediterranean because this is the region with which the authors are most familiar. Moreover, there is a limit to the amount of information that can be portrayed on a single chart for practical graphical reasons. It is hoped that the work will spawn further initiatives to produce charts for other regions. Here the chart is focused on the Pleistocene part (95%) of the last 270,000 years and left the youngest Holocene interval (5%) empty of detail – again for practical graphical reasons. A future chart spanning only the last 27,000 years of the latest Quaternary could present the stratigraphical detail and diversity of this very youngest part of time, once again a 10x exaggeration.

Sequences from the last glacial cycle can be thought of as still in the process of being preserved, i.e. in some senses as being overpreserved in comparison to those from the next-older and much-older cycles. The chart highlights the resolution difference in the terrestrial schemes for the last glacial cycle (i.e. Late Pleistocene) compared to the penultimate cycle and highlights the amount of time occupied by situations that are very much intermediate between temperate 'interglacial' and very cold 'glacial maximum' conditions. It demonstrates that the record of the last 270 ka is more than 'two glacial maxima plus the Holocene', but it comprises an additional 200 ka of 'normal' conditions, throughout which landscape processes continued to operate.



Treatment of information and division in columns

Full documentation of the various records selected from the regional literature is work in progress. The poster at this stage only presents the short references for the data in the various columns.

Age-models for ice core and marine oxygen isotope data
The chart shows composite records for global marine and Greenland ice oxygen isotope variations and sea-level variation, single location marine and lake records, and schematic compilations of ice-cap marginal positions, together with the stratigraphic division columns. All this information is displayed on a common time axis in the graphics. The horizontal axes for the plots are displayed as in the original publications, however, for some of the datasets the ages attributed to excursions have been modified, and they therefore differ from the original age-depth models. Details of the age-depth model in the source publications were consulted. Typically, these age-depth models before 30,000 years ago are interpolations between tie-point marked changes in the measured signals, which were assigned target ages, for the Late Pleistocene based either on tele-correlations to the Greenland ice-core layer count age-depth curvers (to 60 ka), to ice-accumulation modelled age–depth curves. For Greenland these stretch to ca. 100 ka (NGRIP), for Antarctica to ca. 820 ka (EPICA Dome C). Thanks to the survival of the Greenland ice sheet and related opportunities for age control, for the Late Pleistocene the age of δ18O events within the Late Pleistocene marine isotope stage (e.g. those known as Dansgaard-Oeschger (D-O) oscillations) are now fairly accurately known. Conservatively, the dating accuracy is approaching 10^2 years in MIS 3 and 2 and is around 10^3 years in MIS 5 and 4 (although the MIS 5e record near the base of the Greenland ice core appears too disturbed to pin-point its beginning).

For assessing age in the older record, one typically relies on correlating to Milankovich forcing-age-tuned marine isotope records, or of the stacked global signal thereof. The Lisiecki & Raymo(2005) benthic oxygen isotope stacked record and age-model, dubbed LRO4, currently functions as the target-age reference at the resolution of whole glacial-interglacial cycles. In the LR04 stack, the interval MIS-5-6-7-8 is covered by 43 globally distributed ocean cores, including DSDP 607; ODP 980 and ODP 982, closest to the European continent (sources in Lisiecki & Raymo, 2005: their figure 1). For the Late Pleistocene part (22-135 ka), the LR04 stack was aligned to the age model for core MD95-2042, from off Portugal (Shackleton et al. 2000), on which additional age modelling has taken place by Shackleton et al. (2004). Beyond 135 ka, the age-model of the stack is constructed through iterations that at the one hand aims to optimally align and tune the observed milkanovich and sub-milankovich oscillations in the various records (when applied to a stacked record, after initial graphic wiggle matching), while at the other hand staying as close as possible to a linear sedimentation rate over the full distance between the best matched tie-points, such as the terminations of glacials. This is discussed extensively in Lisiecki & Raymo (2005). The age assigned to Termination II (130 ka; based on U-Th dating of coral terraces, Bard et al., 1990; Stein et al., 1993) is an important prior in this exercise. Whereas the youngest part has a 1000-year binned resolution, and the accuracy of ages assigned to the δ18O events that it shows within Middle Pleistocene cycles is between 10^4 and 2·10^3 yr. A planktonic δ18O record from off Portugal (Margari et al. 2010) illustrate the resolution difference of the LR04 Plio-Pleistocene global stack and that reached for the penultimate cycle in individual ocean cores at suitable locations. An alternative age-correlation target has recently become available. Barker et al. (2011) have explored the sub-milankovich residual cross-correlation between the Greenland and Antarctic ice records where they overlap in the Late Pleistocene, and used this to calculate a high-resolution synthetic Greenland ice record for Middle Pleistocene time. In older studies, different tie ages were originally chosen, and in these cases the curves plot out of phase on the vertical time axis if no correction is applied. A pragmatic approach was adopted here to retune the older age-models and correct this artificial problem. For the chart the original age-depth model was taken as the starting point, assigned the new target-ages to recognisable shifts in the measurements, and than linearly interpolated new ages for the measurements between, effectively tuning each curve to that of the LR04 stack.

Global and regional chronostratigraphic divisions for Atlantic and Continental Europe
The global divisions comprise chronostratigraphical Series, Subseries and 'superstages' of the portion of the Quaternary System depicted (from Gibbard & Cohen, 2008). The formal positioning of the base of the Late Pleistocene Subseries is awaiting the definition of a Global Stratigraphic Section and Point (GSSP), which may be either in the Mediterranean (base Late Pleistocene = base Tarentian Stage) or in NW Europe (base Late Pleistocene = base Eemian Stage). In the current chart the latter has been selected because it most clearly illustrates that two options are currently under consideration (Litt & Gibbard 2008).

The Northwest 'Atlantic' Europe part of the chart alternates division schemes of named intervals for Britain (e.g. Mitchell et al 1973; Bowen 1999) and the NW Europe (e.g. Zagwijn, 1996; Mangerud, 1994) with graphic records linking glaciated Scandinavia, via the North Sea Basin, to the marine record off the shelves of the English Channel (Meriadzek Terrace). The last glacial (Weichselian, Devensian) in the chart begins 115 ka and ends 11.7 ka (B2K). The last interglacial in the global record begins at 130 ka. The palynologically defined onset of the regional equivalent Eemian/Ipswichian Stage in this chart appears a few millennia later (comparable to the onset of the Holocene versus the onset of MIS 1). The section of the chart on Interior 'Continental' Europe contains the classic division of the Alpine glaciation into a younger Würm(ian) and a next-youngest Riss(ian) period, to the usage derived from Penck & Brückner (1911). A recently compiled the Alpine stratigraphy was adopted for this chart (Preusser et al., 2011). Long palynological records have been obtained from Maar lake sequences from sites in central and eastern France. The sequence for Poland, Belarus, Lithuania, Russia and the Ukraine integrates phases of glaciation, loess deposition and soil formation. The Lake Baikal record from Siberia is displayed as an extreme continental record, and a fututre tiepoint between the Russian-Siberian continental stratrigraphy and that of China and SE Asia.

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WORK IN PROGRESS

Selected references

Late Pleistocene:
Shackleton et al., 2000; 2004

Middle Pleistocene
Lisiecki & Raymo, 2005
MIS 6 Margari et al., 2010

Heinrich events:
McManus et al., 1994

MIS stage boundary ages, MIS substage midpoints:
cf. Lisiecki & Raymo, 2005

Greenland Ice cores:
Anderson et al., 2006;
Svenson et al., 2006;
NGRIP dating group, 2008.
NGRIP members, 2004 (further tuned)
Barker et al. 2011 (synthetic GISP2 record, modelled on Epica Dome-C Antarctic millenial variabilty)

Meriadzek platform:
Toucanne et al. 2009
Sea level rise:
Waelbroeck et al. 2002

Late Pleistocene glaciations:
Scandinavia: Mangerud, 2004; modified
North Sea: Hijma et al., 2012
Alps: Preusser et al., 2011

Middle Pleistocene glaciations:
North Sea, Netherlands: Busschers et al., 2008
N Germany: Ehlers (2004)
Swiss Alps (N): Preusser et al., 2011

France:
Beaulieu, 1984; 1992
Pons et al., 1992
Beaulieu & Reille, 1992
Reille & Beaulieu, 1995

Poland:
Marks 2011
Poland, Lithuania, Belarus:
Ber, 2006
Russia:
Molodkov & Bolikhovskaya 2010
Ukraine:
Gozhik et al., 2001

Lake Baikal:
Prokopenko et al., 2006

This poster version was produced for GSA meeting, Charlotte 4-7 November 2012