Isotopic Content of Ground Ice in the Lower Kolyma River Valley (Eastern Siberia)

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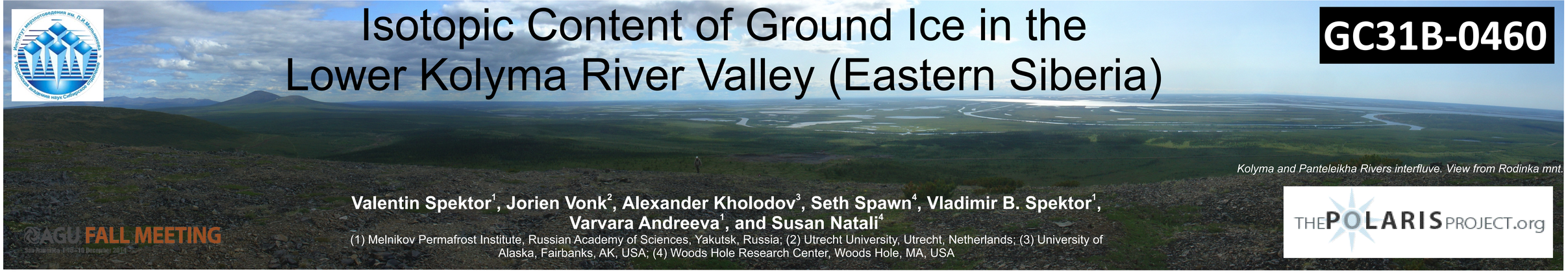

Kolyma and Panteleikha Rivers interfluve. View from Rodinka mnt.

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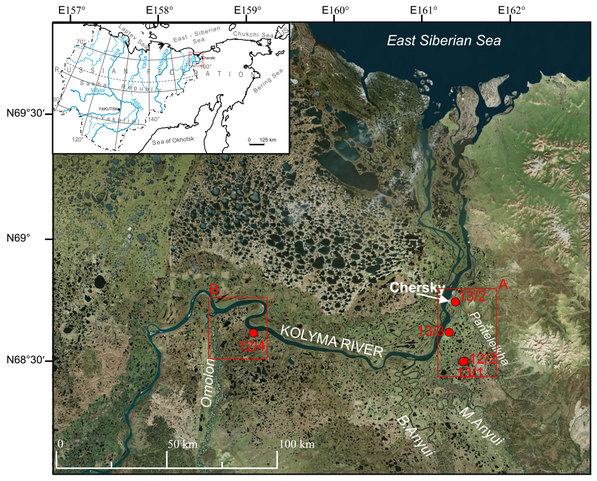
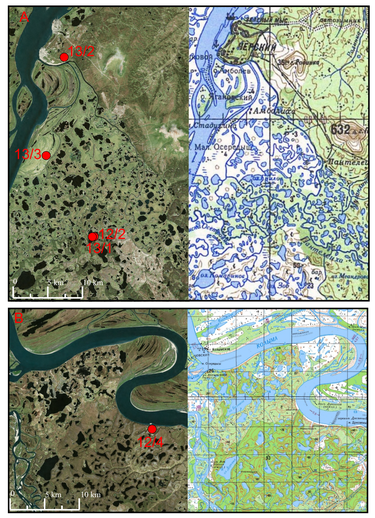


Locations of the boreholes 12/2, 13/1, 13/2, 13/3 and section 12/4 on the Kolyma River Lowland.



INTRODUCTION

This report deals with new results of isotopic investigations in ground ice of Quaternary sediments in the Lower Kolyma River Lowland.

Studies of stable isotopes of oxygen and deuterium permit reconstructing of palaeotemperature characteristics [Dansgaard, 1964; Ferronski&Polyakov, 2009], while the absolute ages of the enclosing sediments allow us to tell when the palaeoclimatic changes occured.

The previous main investigations of stable isotopes in this territory are described in [Vasil'chuk, 1992; Vasil'chuk et al., 2011; Arkhangelov et al., 1988; Mikhalev et al., 2006; Nikolaev&Mikhalev, 1999; etc.].

Field work was done between 2008 to 2013 as part of the POLARIS Project. We drilled 4 boreholes to the depths 15 to 22 m from the surface and studied sections in the Duvanny Yar exposure. Samples were collected from Late Pleistocene ice wedges, Holocene ice wedges, and segregation ice represented by ice-lense and basal cryostructure.

Analyses of oxygen (δ18O) and hydrogen (δD) stable isotopes were performed using a Picarro Isotopic Liquid Water Analyzer (Biogeosciences group, ETH-Zurich, Switzerland). Analyses of AMS 14C were performed in the AMS laboratory of the Woods Hole Oceanographic Institute (MA, USA).

At present, the studied territory is characterized by the following climatic parameters (for 2008-2013 period): annual mean air temperature is -9.1°C; the January mean air temperature is -31°C; the July mean air temperature is +12.8°C [http://rp5.ru/]; the mean winter temperature is -22.3°C [Vasil'chuk et al, 2001]. The ground temperatures in the boreholes (2-3 year periods of observations) at the depth of zero annual variations (15m) constitute approximately -5°C [TSP Project, and our observations].

ACKNOWLEDGEMENTS

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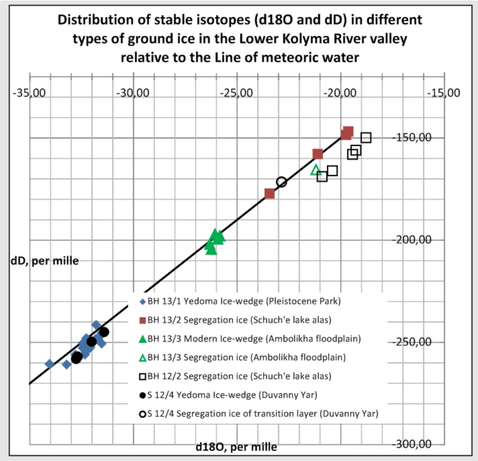
RESULTS



Late Pleistocene wedge ice (Ice complex) was recovered by the BH13/1 located on yedoma relics towering over the low thermokarst plain (N68°30.7' E161°29.6') and S12/4 in the Duvanny Yar exposure (N68°37.8' E159°08.6'). Isotopes δ18O and δD range from -31.413 to -34.05 and from -244.934 to -260.57, respectively.

Modern wedge ice was recovered by the BH13/3 located at the joint Kolyma and Panteleikha Rivers floodplain underlain by river-bed sediments (N68°36.8', E161°21'). Isotopes range from -25.83 to -26.32(δ18O) and from -197.09 to -204.47 (δD).

Oblique segregated ice layers adjacent to a modern ice wedge were recovered by the BH12/2 on the annually flooded thermokarst plain (N68°30.8' E161°30). Isotopes range from -18.778 to -20.897 (δ18O) and from -149.883 to -168.901 (δD). The δD contents are the lowest here, resulting possibly from mixed (ice wedging and segregation) mechanism of ice lenses formation.

Segregated ice was recovered by the BH13/2 on the Schuch'e lake alas (N68°44.77', E161°23.3') and S12/4 in the transition layer of the Duvanny Yar. Isotopes range from -19.63 to -23.43 (δ18O) and from -146.77 to -177.23 (δD).

The AMS 14C ages are presented on the topographic scheme and geological sketches, and mostly published here for the first time.

CONCLUSIONS

Preliminary results are as follows:

1) all samples are distributed near the line of meteoric water providing evidence for atmospheric origin of ground ice in the region;

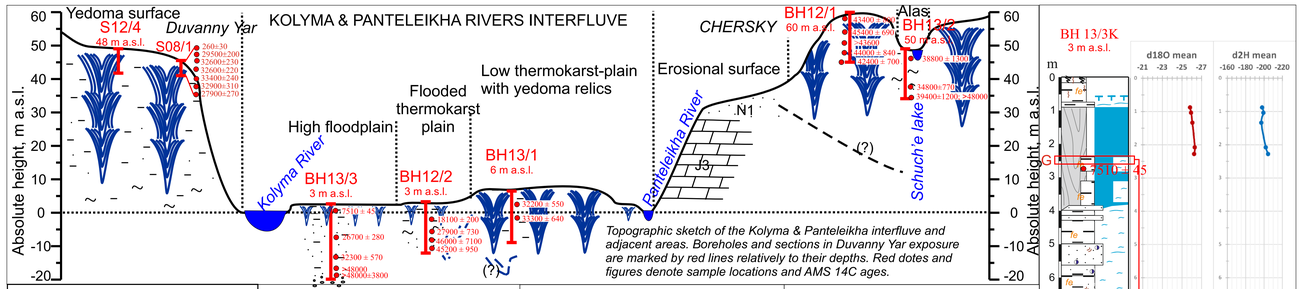
2) isotope distribution exhibits a clear distinction between Late Pleistocene wedge ice, modern wedge ice, segregated ice adjacent to a modern ice wedge, and segregated ice;

3) the excess shows evidence of far remoteness of the region from the sources of atmospheric moisture;

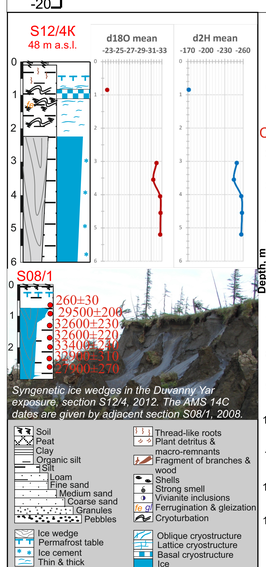
4) mean winter air temperatures reconstructed by δ18O [Dansgaard, 1964; Ferronski&Polyakov, 2009] constitute, on average, ca. -26°C for the Late Pleistocene wedge ice, -10°C for modern wedge ice, and, with certain reservation, -9° C for segregated ice.

Using the qualitative dependence [Vasil'chuk, 1992] figured out from statistics on modern ice wedges, the mean winter air temperatures for the time of Late Pleistocene ice wedges formation could be classified as "for very cold zones" when mean air temperatures were 6°C lower than modern ones, constituting ca. -28°C.

5) The obtained data show very good correlation with the data obtained by previous investigations.

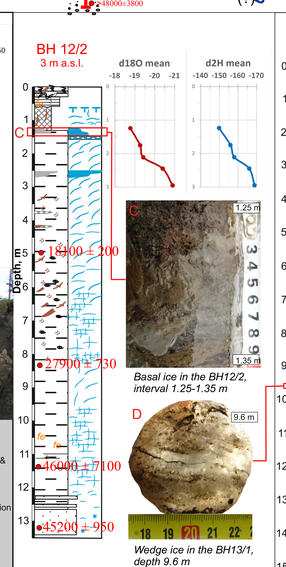


Topographic sketch of the Kolyma & Panteleikha interfluve and adjacent areas. Boreholes and sections in Duvanny Yar exposure are marked by red lines relatively to their depths. Red dotes and figures denote sample locations and AMS 14C ages.



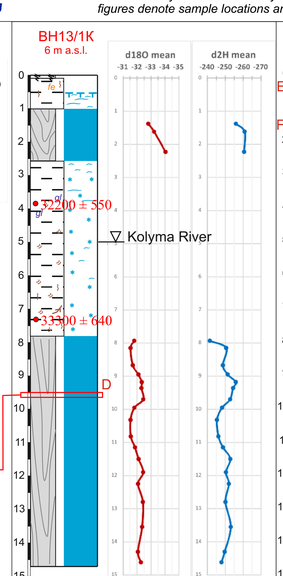
Syngenetic ice wedges in the Duvanny Yar exposure, section S12/4, 2012. The AMS 14C dates are given by adjacent section S08/1, 2008.

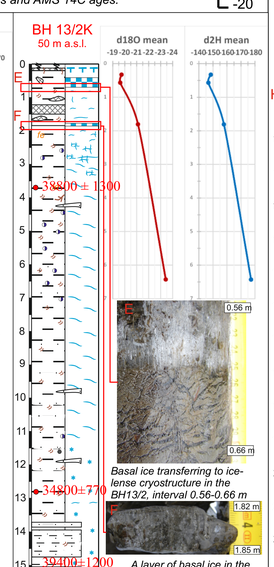
Soil
Peat
Clay
Organic silt
Silt
Loam
Fine sand
Medium sand
Coarse sand
Granules
Pebbles
Thread-like roots
Plant detritus & macro-remnants
Fragment of branches & wood
Shells
Strong smell
Vivianite inclusions
Ferrugination & gleization
Cryoturbation
Ice wedge
Permafrost table
Ice cement
Thin & thick lense-like cryostructure
Oblique cryostructure
Lattice cryostructure
Basal cryostructure
Ice
AMS 14C ages



Basal ice in the BH12/2, interval 1.25-1.35 m

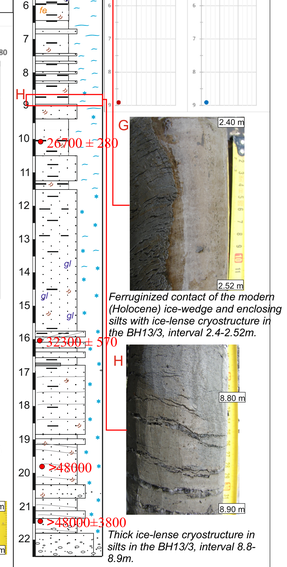
Wedge ice in the BH13/1, depth 9.6 m





Basal ice transferring to ice-lense cryostructure in the BH13/2, interval 0.56-0.66 m

A layer of basal ice in the BH13/2, interval 1.83-1.85 m



Ferruginized contact of the modern (Holocene) ice-wedge and enclosing silts with ice-lense cryostructure in the BH13/3, interval 2.4-2.52m.

Thick ice-lense cryostructure in silts in the BH13/3, interval 8.8-8.9m.