

Carbon of the Kolyma Lowland permafrost under recent change of climate

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ABSTRACT

Permafrost of the vast Siberian Coastal Plains is a potentially important source of carbon during warming periods. This lowland is underlined by continuous permafrost and the most ancient ground ice formation of Eurasia. The overwhelming majority of the modern landscape of this region contains icy loess-like loam sediments with thick polygonal ice wedges. The ice wedge landscapes are usually called “Yedoma” or “Ice Complex”. Compared to other Arctic regions, Yedoma has a higher ice and total organic carbon content. A boundary between active and older Yedoma layers called a transitional layer was generated by the climatic optimum of the Holocene. This layer (0.1 – 2.0m thickness) has the highest excess ice content. The current climate warming is increasing active layer thickness and thermokarst and thermo-abrasion, leading to the involvement of buried terrestrial carbon into the contemporary biogeochemical cycle. Here we present results of our study of carbon content and fluxes in different types and layers of permafrost of the Kolyma Lowland as they relate to recent climate change.

STUDY AREA

THE KOLYMA LOWLAND

- Predominantly Continental Climate
- Annual Air Temperature – 8 - -13o C
- Mean Summer Air Temperature +8 - +15oC

- Mean Winter Air Temperature -35 - -27o C
- Annual Presipitation Total 190 – 300mm
- Summer Total Presipitation 1/2 of Annual

- The region is underlined by continuous permafrost

- Kolyma permafrost is the most ancient in Eurasia (since Pliocene Age)
- Maximum thickness of permanently frozen loose sediments of the lowland - 500 – 600m
- Average permafrost temperature -3 - -11oC

- Upland landscapes of the Kolyma Lowland are underlined by ice-rich loess-like loam sediments with thick ice wedges that called in Russia as **YEDOMA** or **ICE COMPLEX**



YEDOMA – rich-organic sediments and potential source of soluble carbon that may be leached into river systems and modern soil at permafrost thawing

KOLYMA LOWLAND PERMAFROST

TRANSITIONAL LAYER

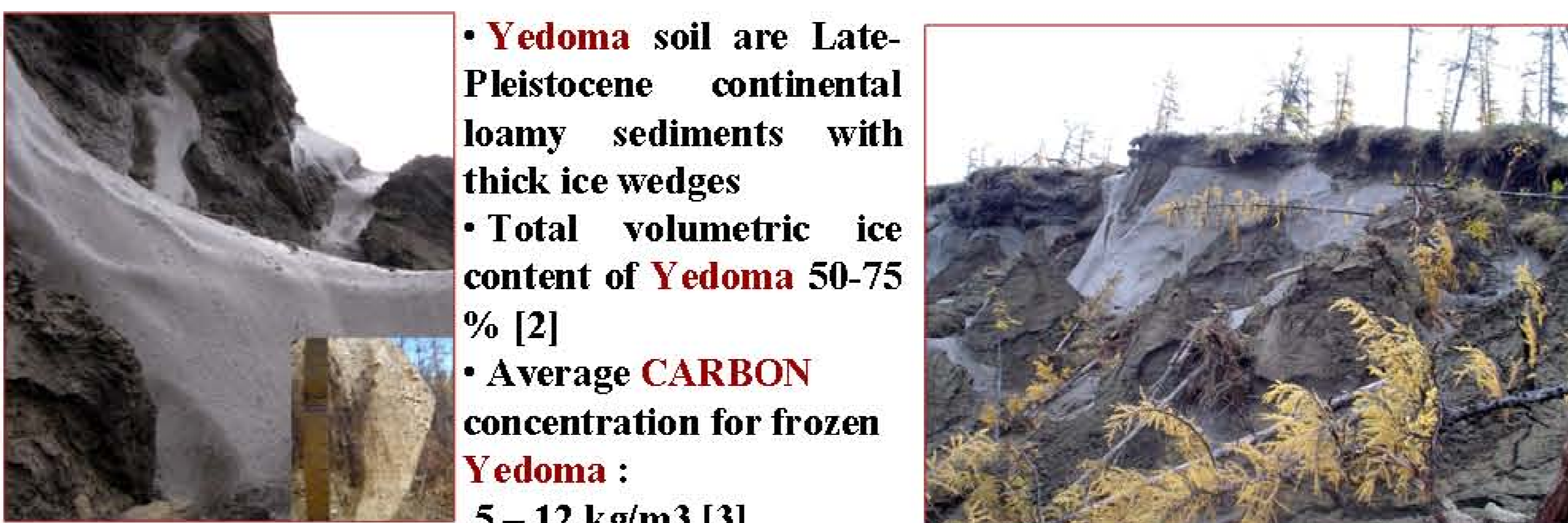


• This layer forms a boundary between the active layer and permanently frozen part of permafrost of **Yedoma**. The upper layer (0.1 – 2.0 m) of **Yedoma** was thawed during the climatic optimum of Holocene (9.6 – 6.3 thousand years ago for North-East Siberia). The consequent refreezing resulted in formation of the secondary frozen layer, called **Transitional Layer (TL)** [1]



• TL is characterized by very ice-rich cryogenic textures.
• Max volumetric water content > 90%
• Mean volumetric water content 55% (n=105)

YEDOMA



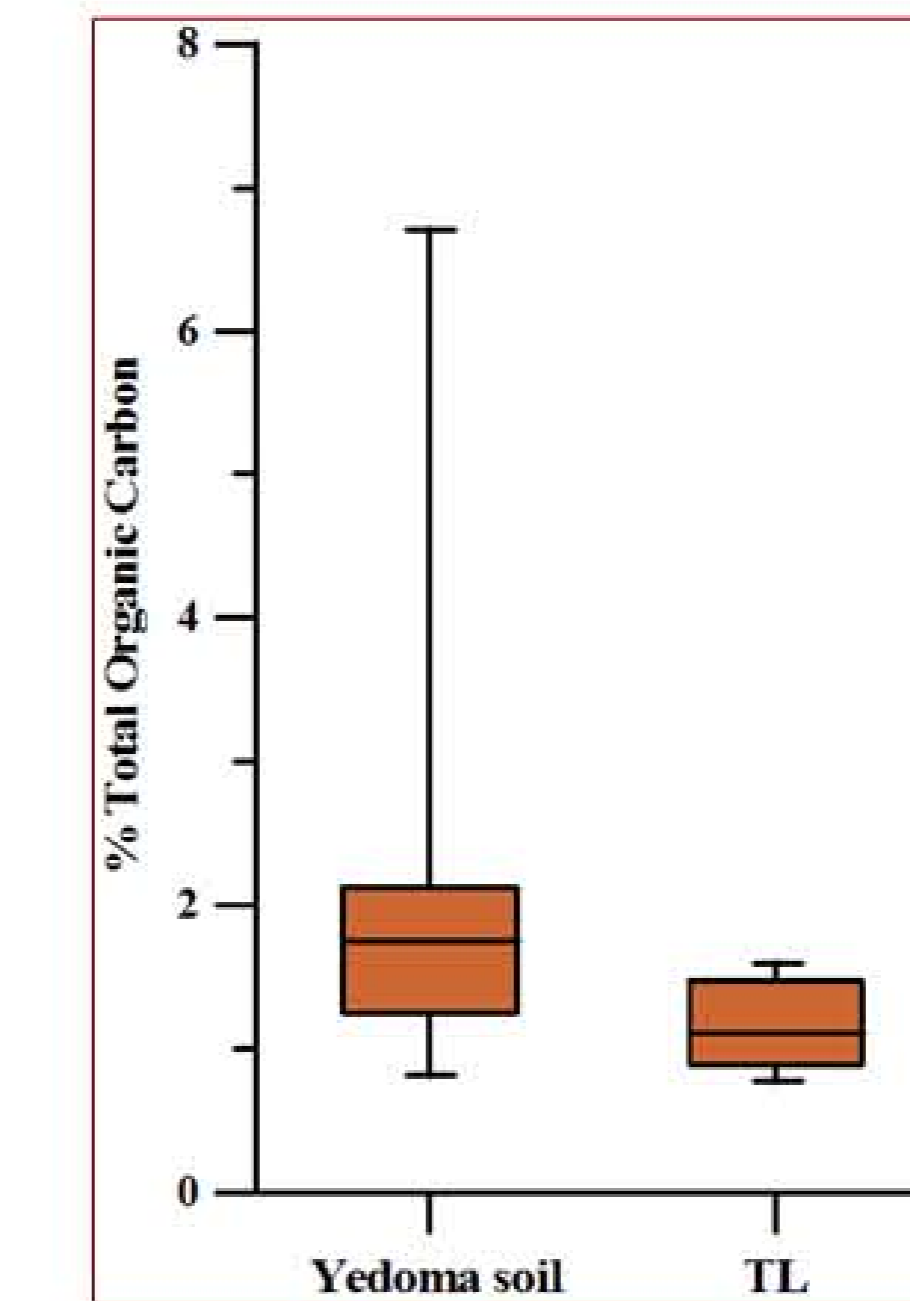
• **Yedoma** soil are Late-Pleistocene continental loamy sediments with thick ice wedges
• Total volumetric ice content of **Yedoma** 50-75% [2]
• Average **CARBON** concentration for frozen **Yedoma** :
5 – 12 kg/m³ [3]
21 kg/m³ [4]



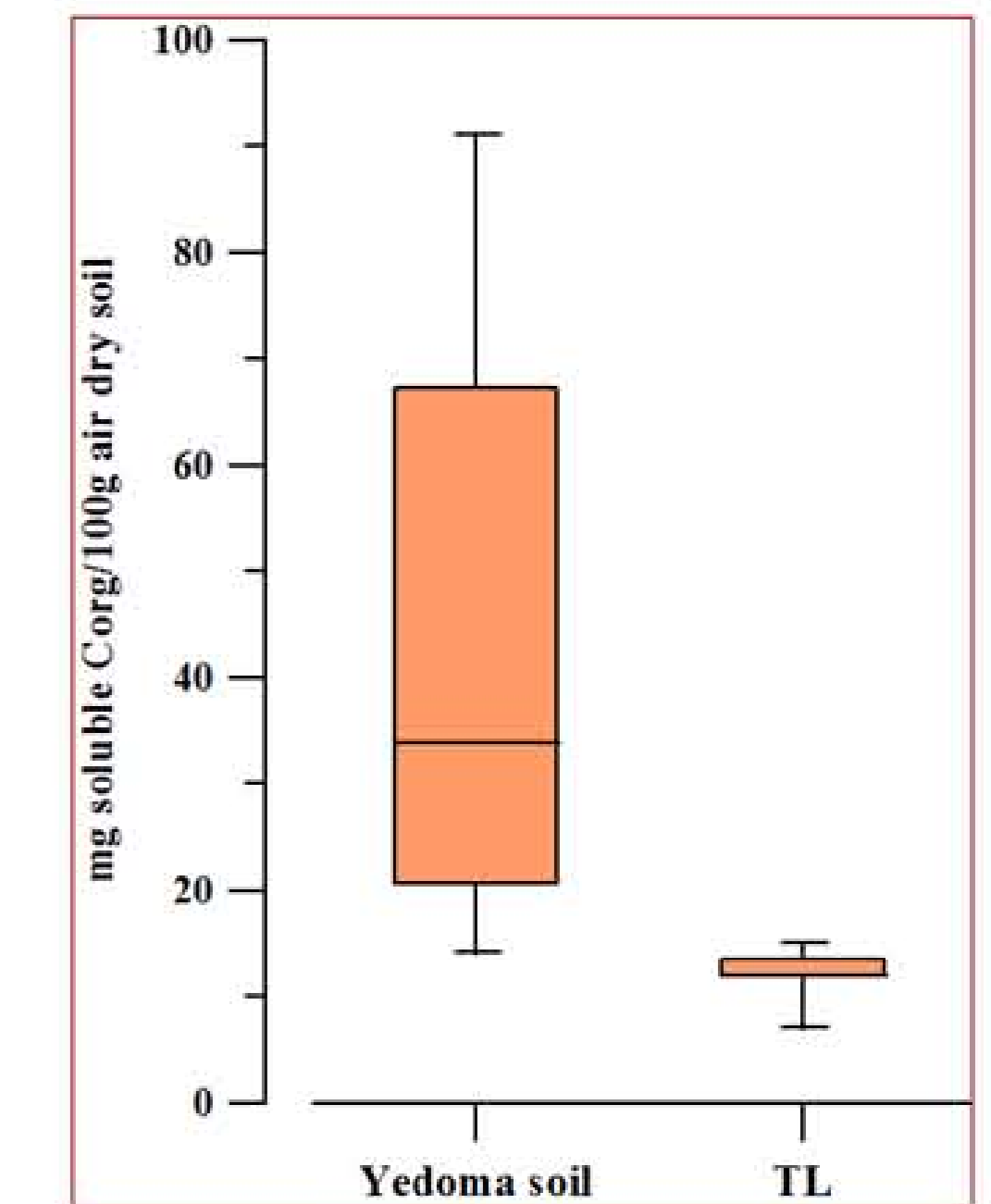
Yedoma organic matter are presented of frozen paleobiota remains including dissolved organic carbon (DOC)



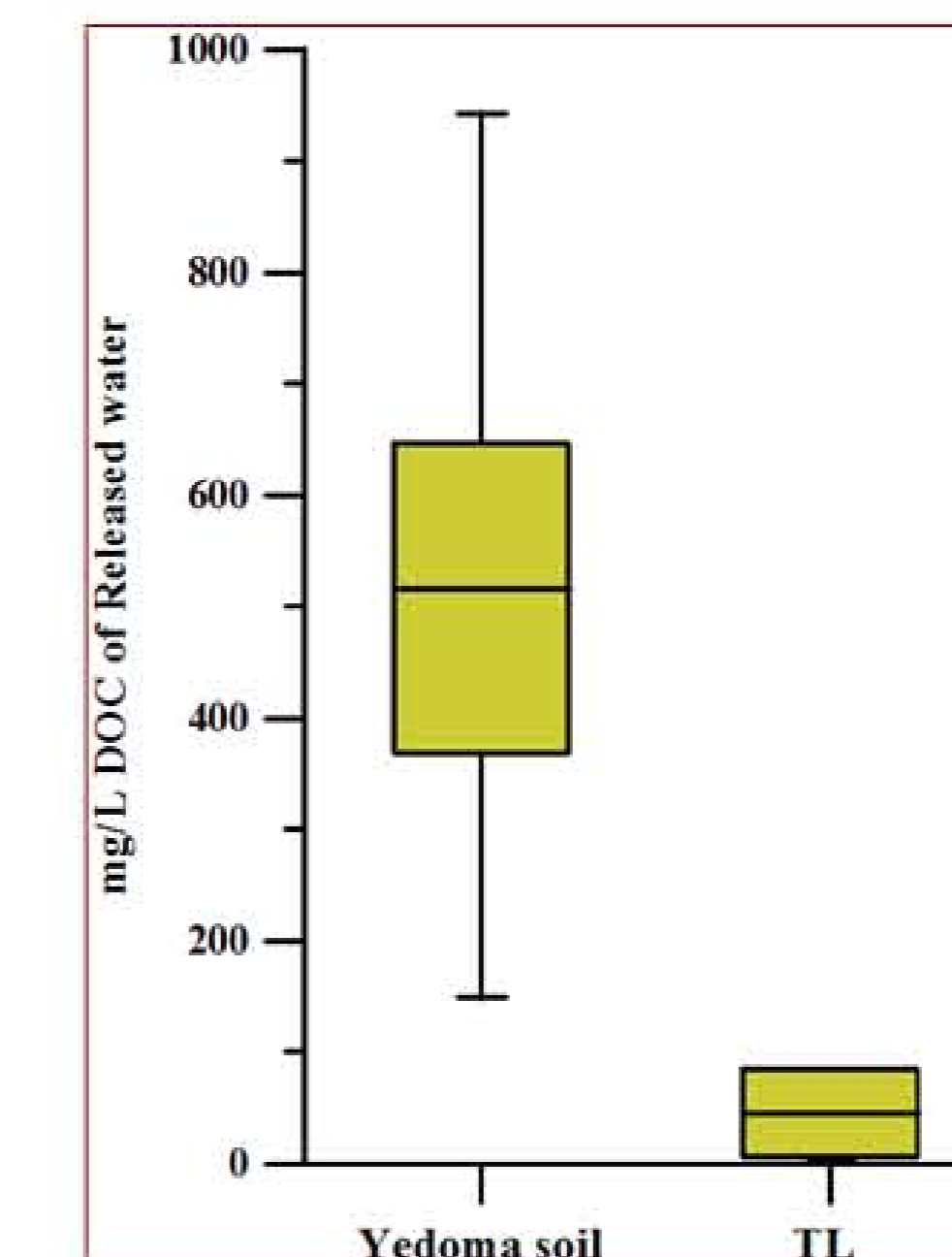
CARBON CONTENT IN DIFFERENT TYPES OF PERMAFROST



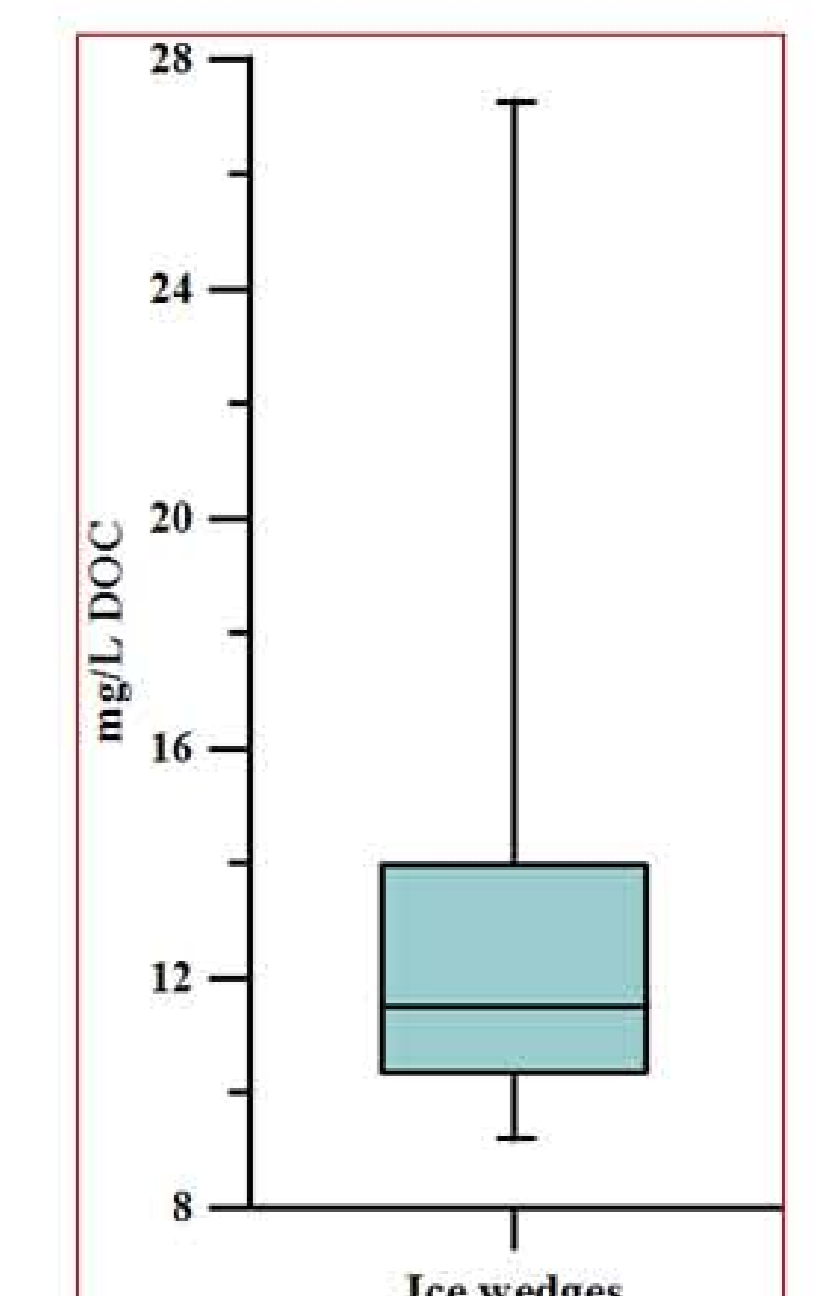
CONTENT OF TOTAL ORGANIC CARBON IN YEDOMA AND TRANSITIONAL LAYER



CONTENT OF SOLUBLE ORGANIC CARBON IN YEDOMA AND TRANSITIONAL LAYER



DOC CONCENTRATION IN RELEASED WATER FROM YEDOMA AND TRANSITIONAL LAYER



DOC CONCENTRATION IN MELTED WATER OF ICE WEDGES

AT MELTING ONE M³ OF PERMAFROST RELEASE ORGANIC CARBON:

- TRANSITIONAL LAYER**
- 9 kg total C org (on average)
 - 91g Soluble C org
 - 10 - 40g DOC of released water

- YEDOMA SOIL** (only loamy sediments)
- 15 – 18 kg total C org
 - 450g Soluble C org
 - 70 - 450g DOC of released water

ICE WEDGES release about 15 g of DOC (1 m³ of ice)

- Recent observations indicate degradation of ice-rich and carbon-rich permafrost of Kolyma Lowland as a result of arctic warming [6, 7]
- There is growing evidence that some early-Holocene and late-Pleistocene carbon is entering the contemporary biogeochemical cycle [8, 9]

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