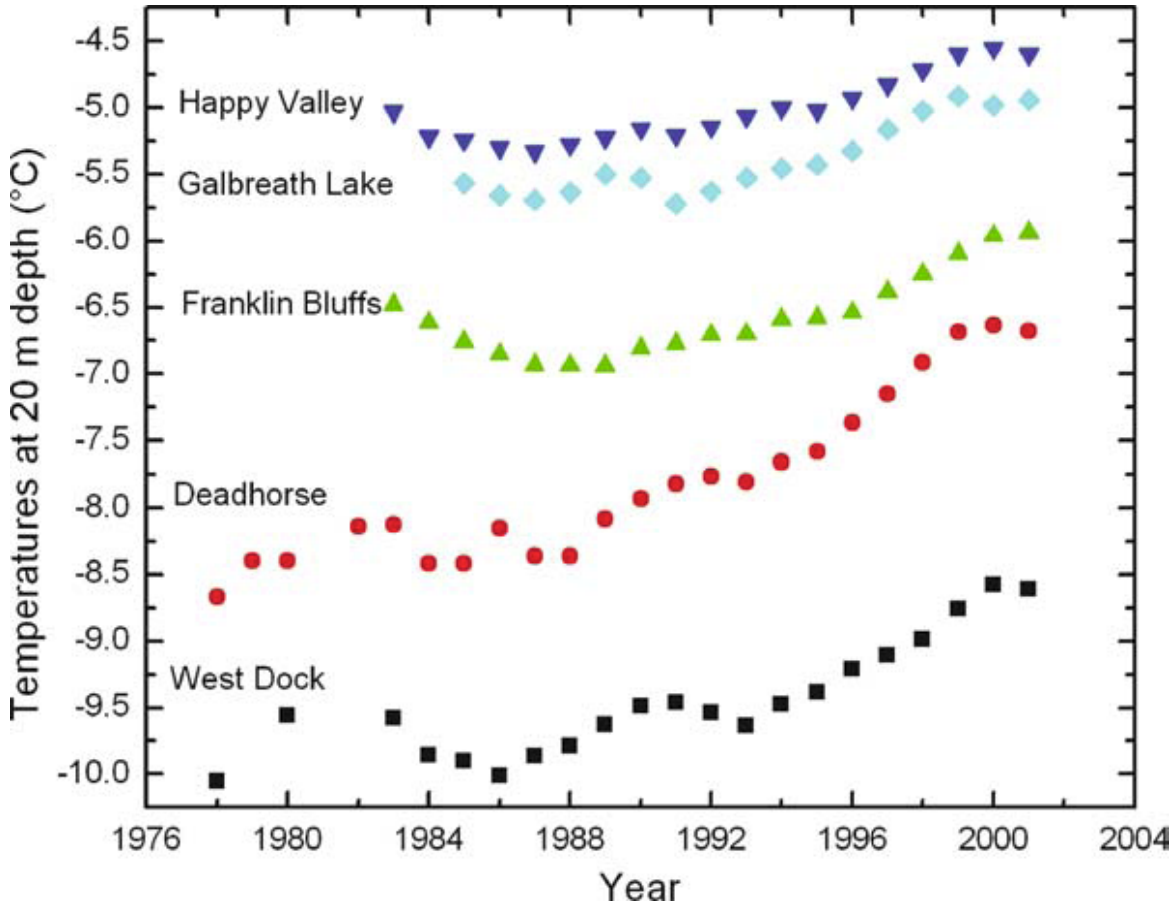
Permafrost Thawing at High Latitudes and its Affect on the Carbon Cycle

Jeff Chanton,
Department of Earth, Ocean and Atmospheric Science,
Florida State University



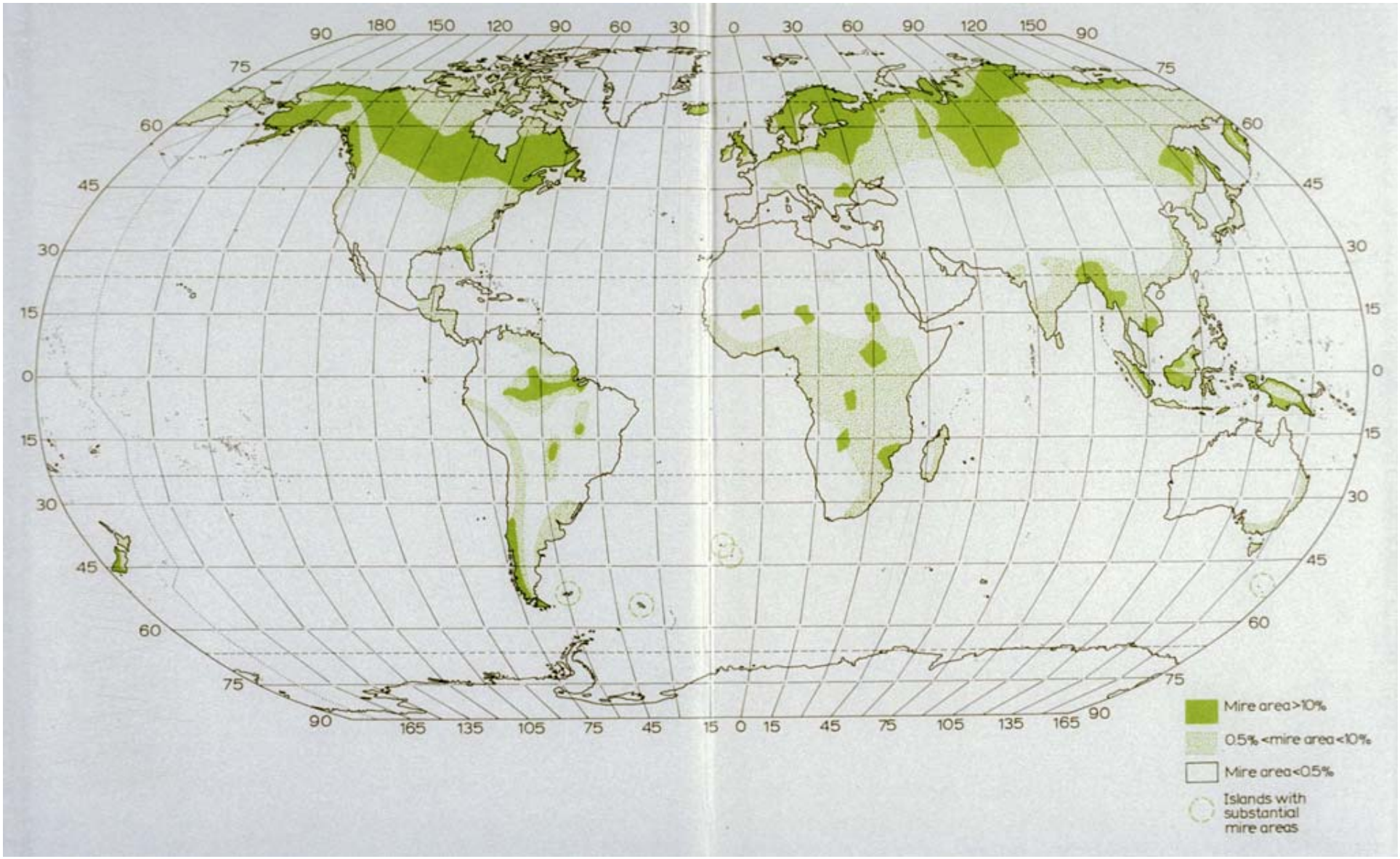
Temp increases at 20m depth in Alaskan permafrost soils

HINZMAN et al, 2005, Climate Change, 72: 251–298

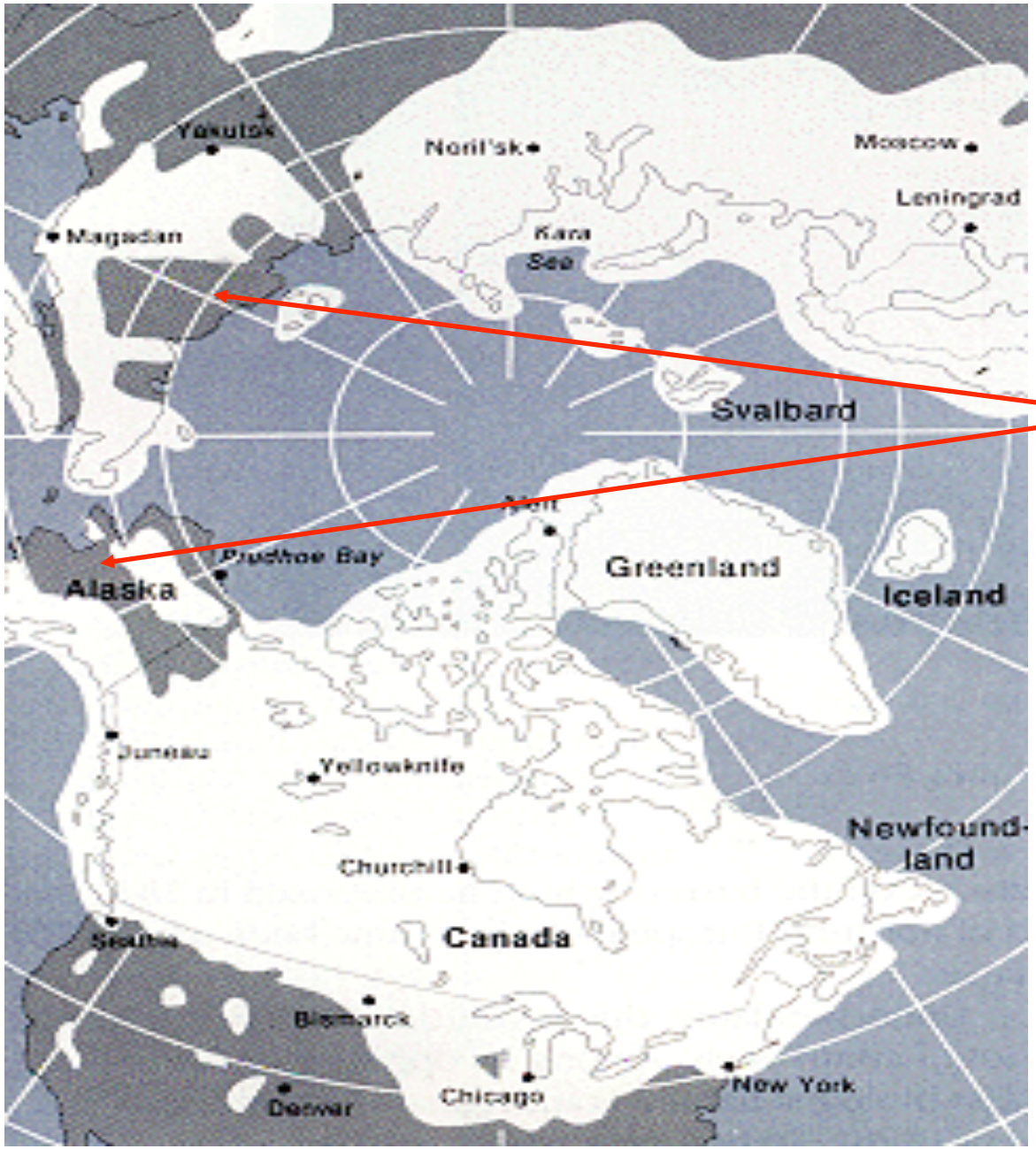
Schuur et al. 2008 Bioscience 58, estimate

- 1672 gigatons of C in permafrost worldwide of which 277 gigatons is in peatlands
- 455 gigatons of C in boreal and sub-arctic peatlands (Gorham, 1991, Ec. App. 1, 182.)


Pacific Ocean
Okhostk Sea
Bering Sea
Alaska (United States)
Anadyr
Chukchi Sea
Barrow
East Siberian Sea
Beaufort Sea
NEW SIBERIAN ISLANDS (RUSSIA)
CANADA
BANKS ISLAND
VICTORIA ISLAND
Laptev Sea
RUSSIAN FEDERATION
Arctic
SEVERNAYA ZEMLYA (RUSSIA)
TAIMYR PENINSULA
NORTH POLE
ELLESMERE ISLAND
Hudson Bay
Ocean
Dickson
Kara Sea
Thule
BAFFIN ISLAND
Baffin Bay
NOVAYA ZEMLYA (RUSSIA)
LABRADOR
GREENLAND
SVALBARD (NORWAY)
Barents Sea
Murmansk
Norwegian Sea
KOLA PENINSULA
FINLAND
NORWAY
ISLANDE
SWEDEN
Atlantic Ocean
North Sea
Permafrost
Isolated
Sporadic
Discontinuous
Continuous
Source: International Permafrost Association
GRID Arendal
UNEP


Mire area>10%
0.5% <mire area<10%
Mire area<0.5%
Islands with substantial mire areas

The Pleistocene, last Glacial Maximum



No glaciers

Mammoth steppe ecosystem.

http://www.jamestown-ri.info/northern_appalachians.htm

Yedoma: Zimov, 2005, Science 308, 796.

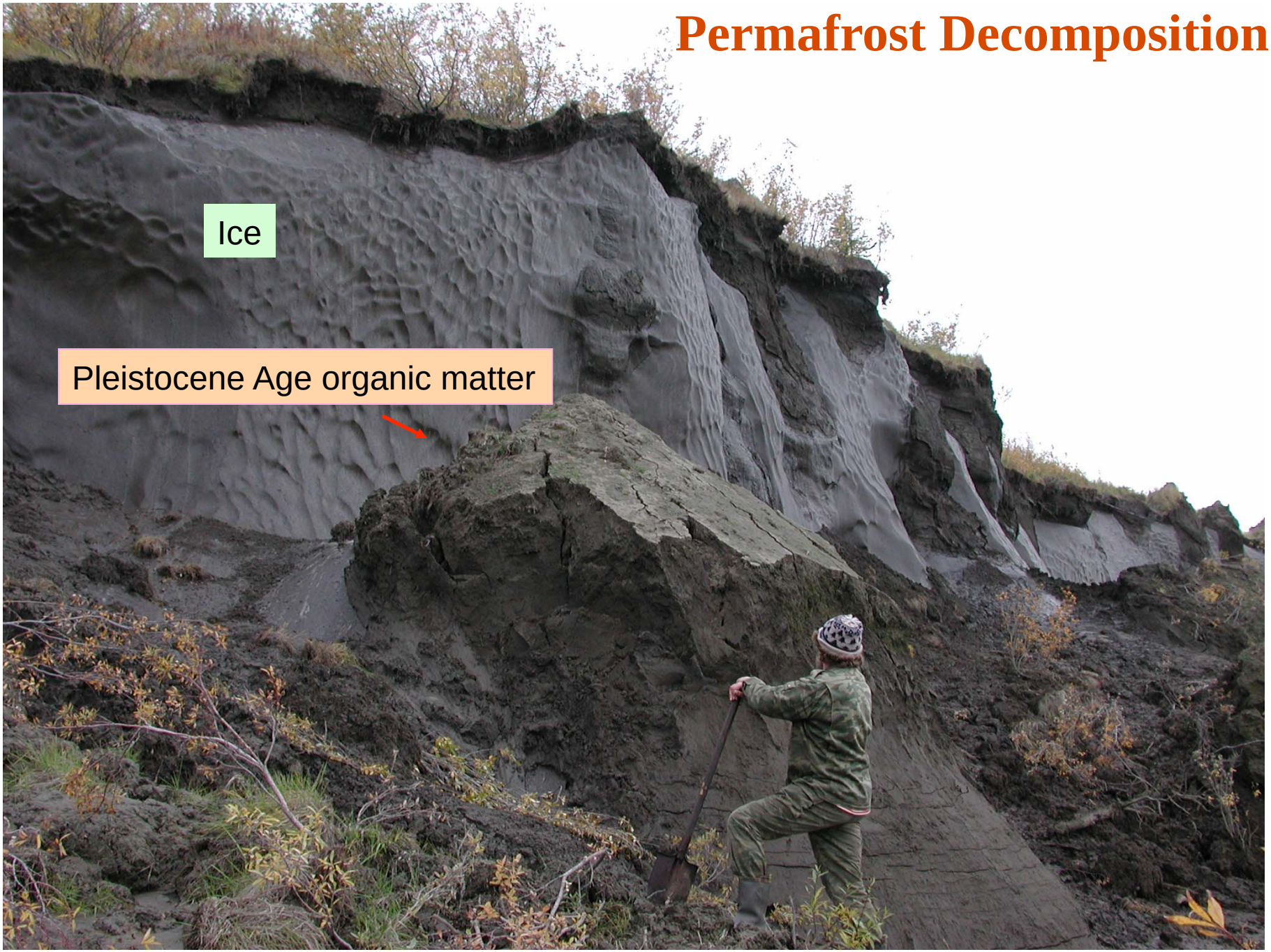
In the Pleistocene, NE Siberia remained relatively un-glaciated with vast dust-covered plains. Mammoth steppe ecosystem.

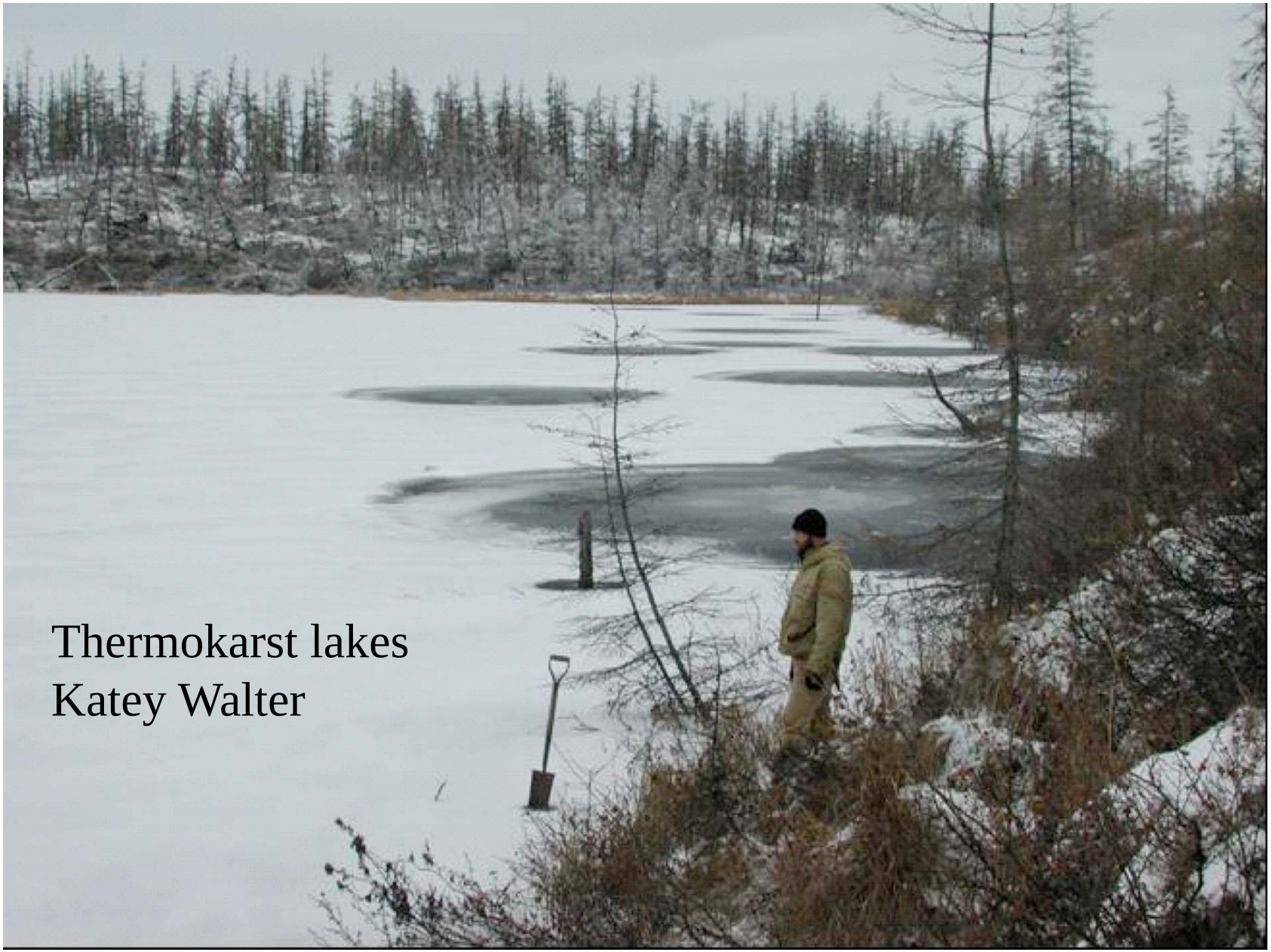
The ground froze, contracted, and cracked each winter. In spring, water penetrated and froze creating networks of ice wedges.

Over time, due to the accumulation of dust, river silt, and ice, Siberia became covered with a thick sedimentary mantle of frozen loess. These frozen sediments are filled with rootlets of grasses. LABILE!

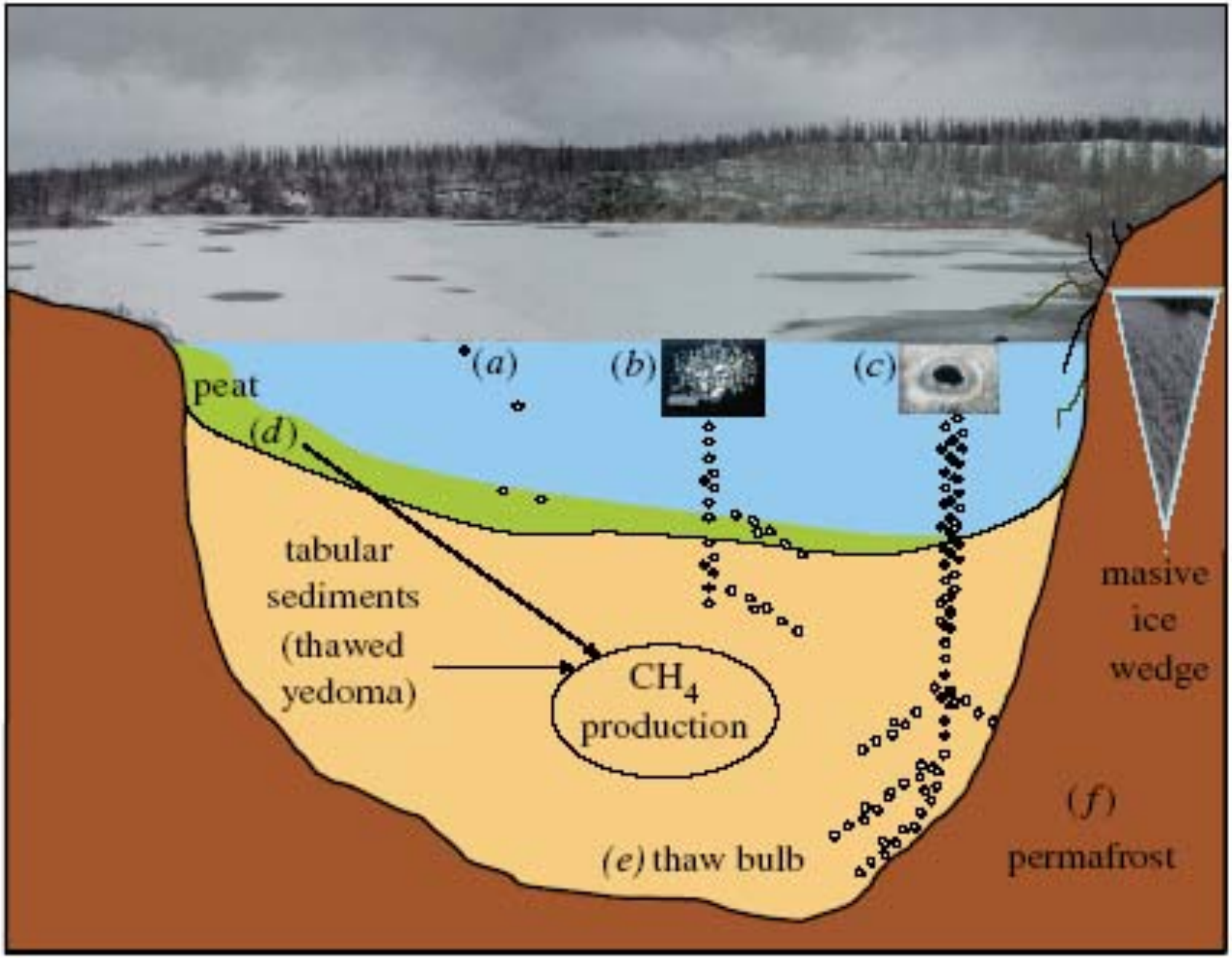

180°
90°E
80°
70°
60°
50°
40°
0
1000 km
0
500 miles
Ice sheet
Areas of permafrost at last glacial maximum
LGM coast
Extent of present-day permafrost
Areas of yedoma
Probable areas of yedoma
Areas of loess
Areas of loess, retransported loess and loess-related deposits

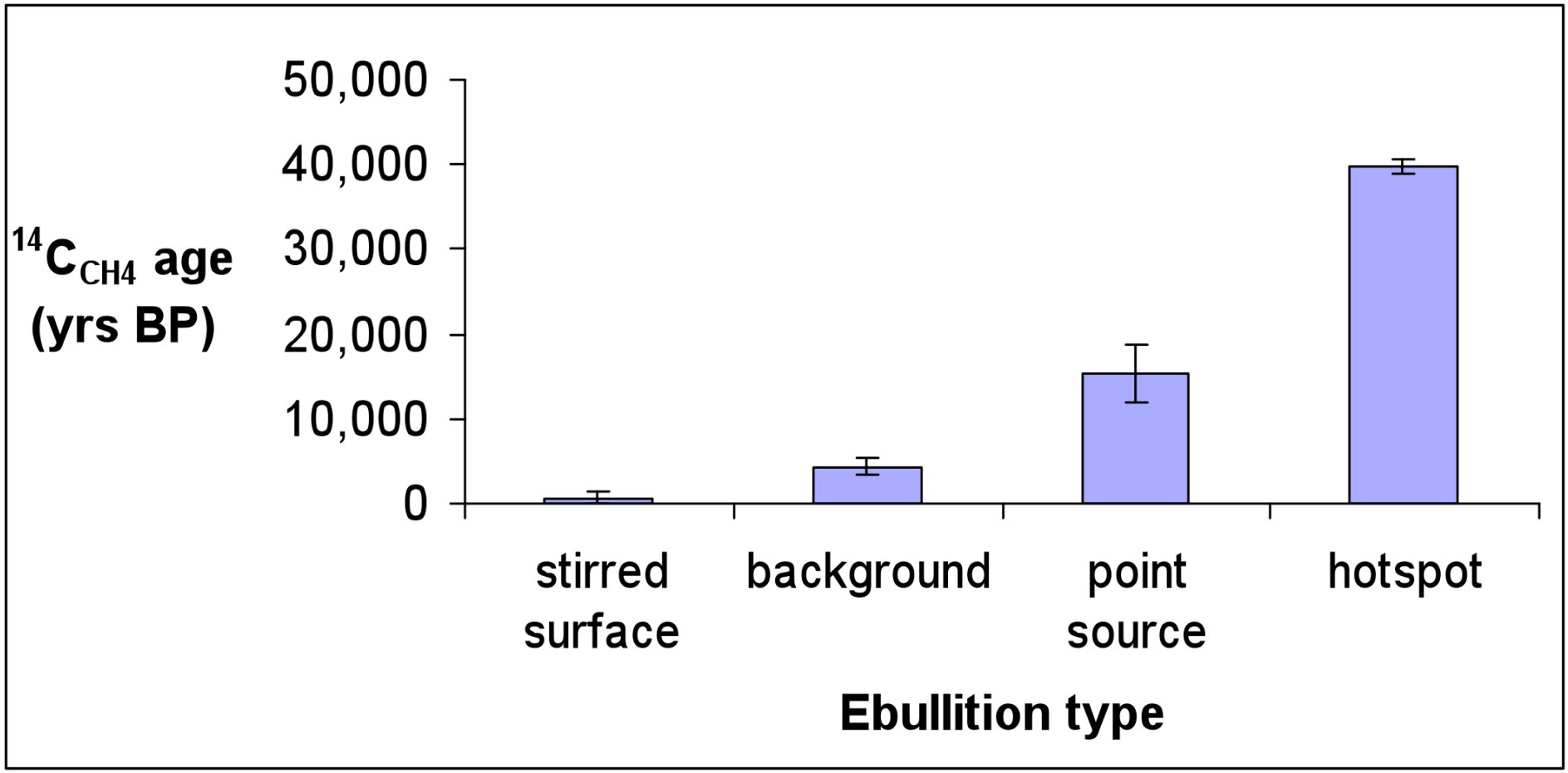
Permafrost Decomposition



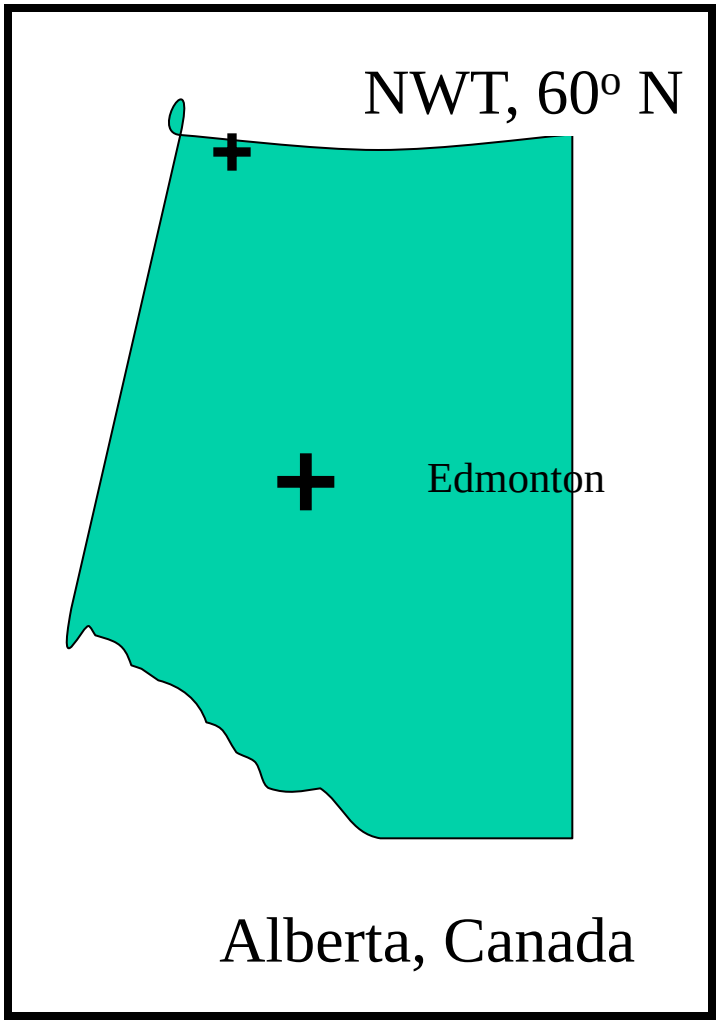


10-20 m drop in landscape, with ice thaw.


(a)
(b)
(c)
peat
(d)
tabular
sediments
(thawed
yedoma)
CH_4
production
masive
ice
wedge
(e) thaw bulb
(f)
permafrost


$^{14}C_{CH4}$ age (yrs BP)
50,000
40,000
30,000
20,000
10,000
0
stirred surface
background
point source
hotspot
Ebullition type

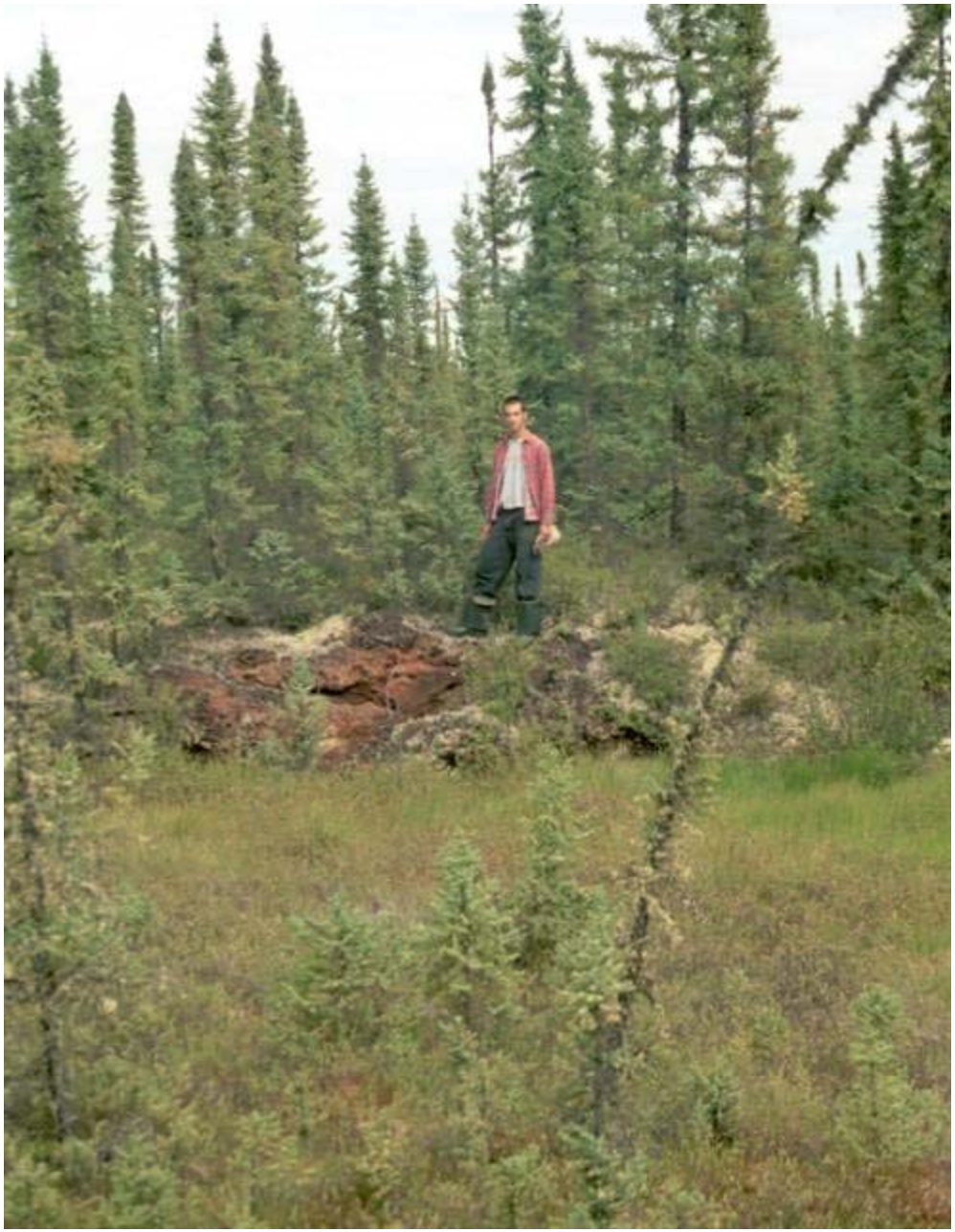
Field sites, 100 km N of High Level



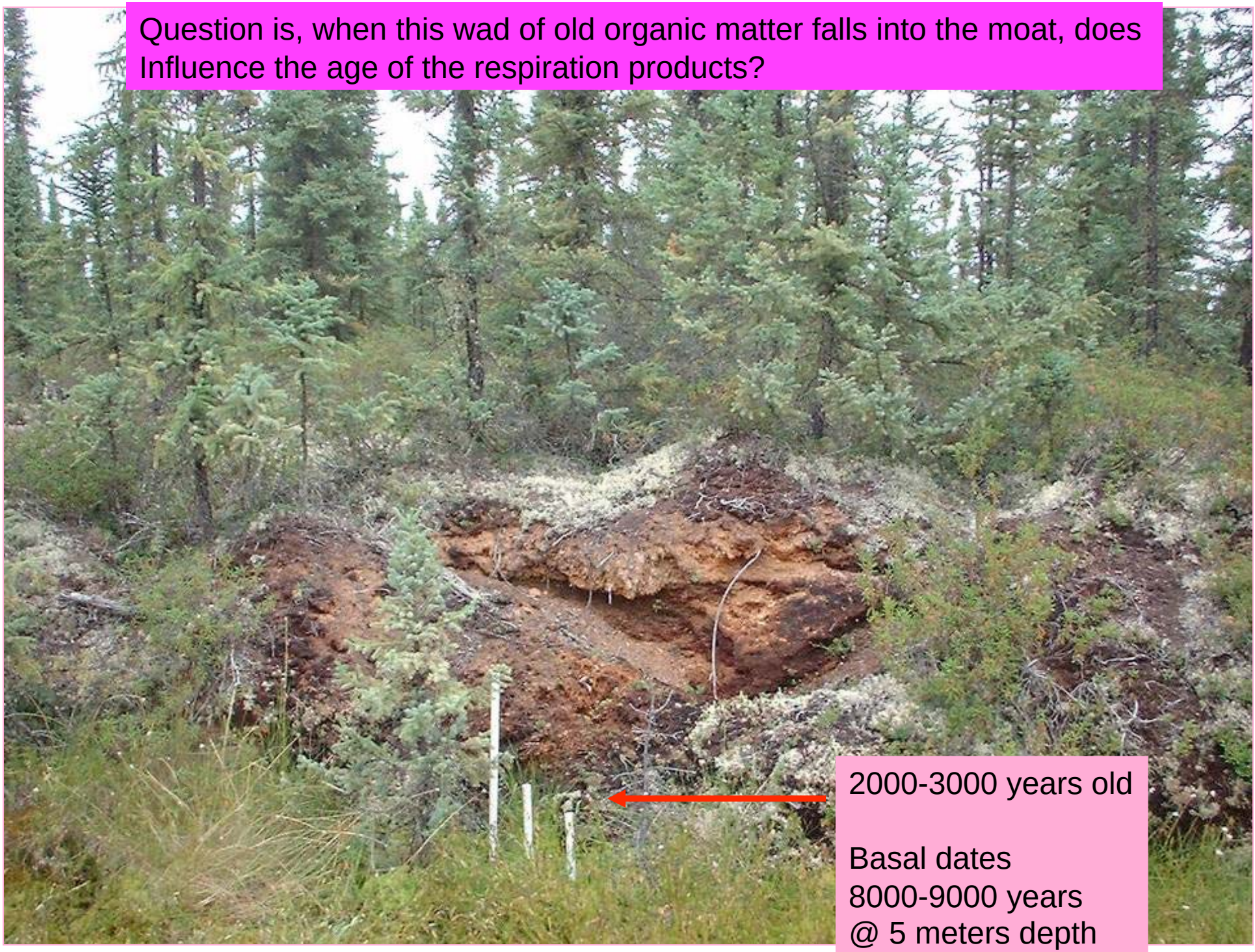
Peoples Republic of Canada

Collapse Scars with Moats in Discontinuous Permafrost Region

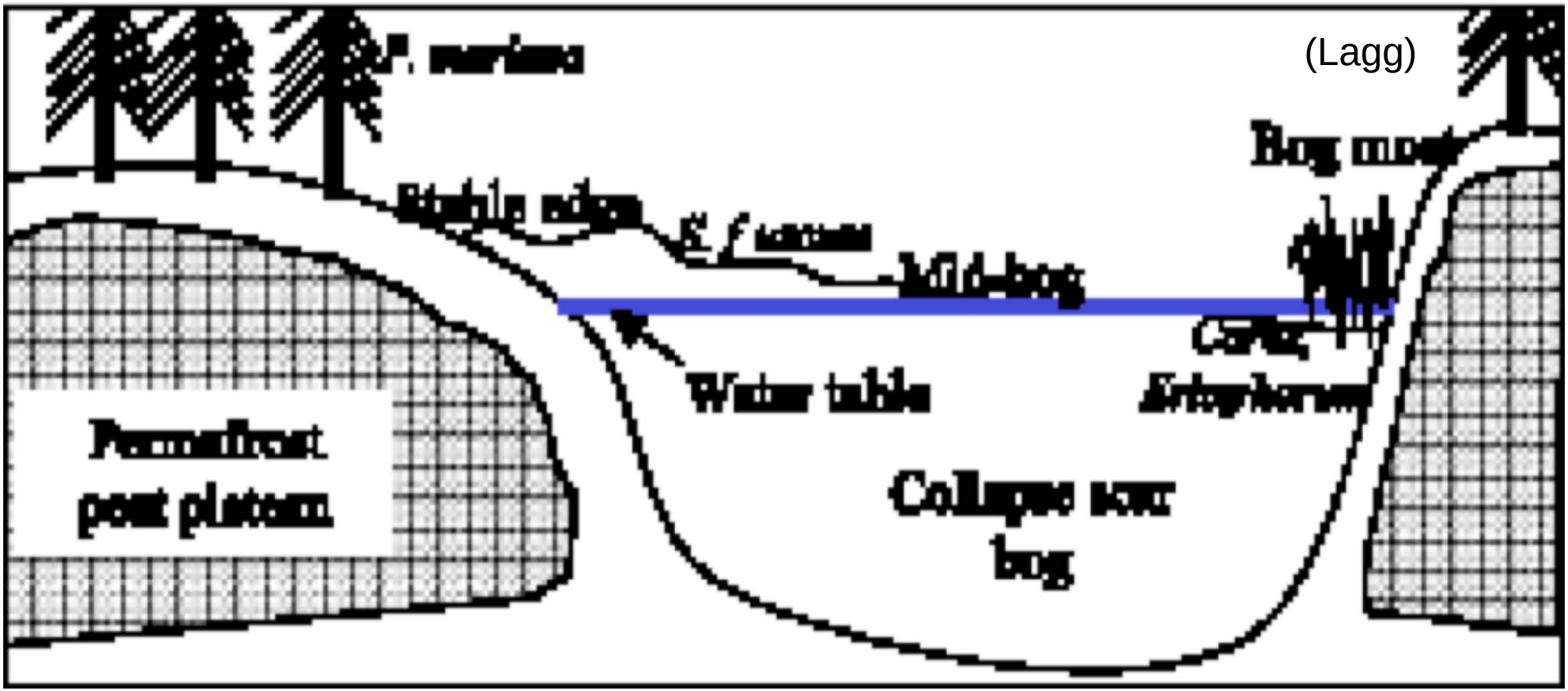
No ice wedges
Peat soil

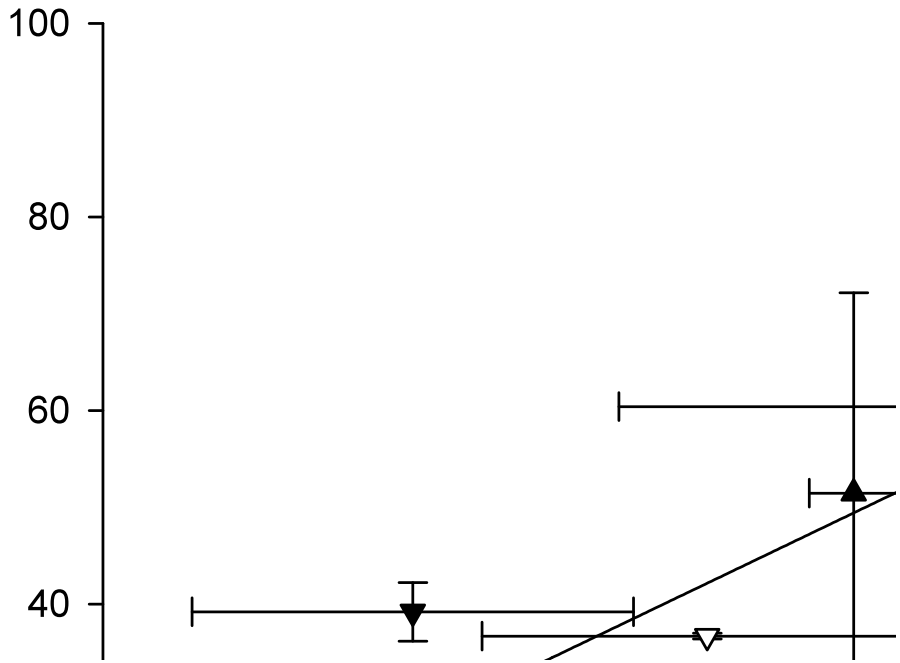


Relief upons subsidence
1 m 10 x LESS


Question is, when this wad of old organic matter falls into the moat, does Influence the age of the respiration products?
2000-3000 years old
Basal dates
8000-9000 years
@ 5 meters depth

Permafrost decomposition in Alberta

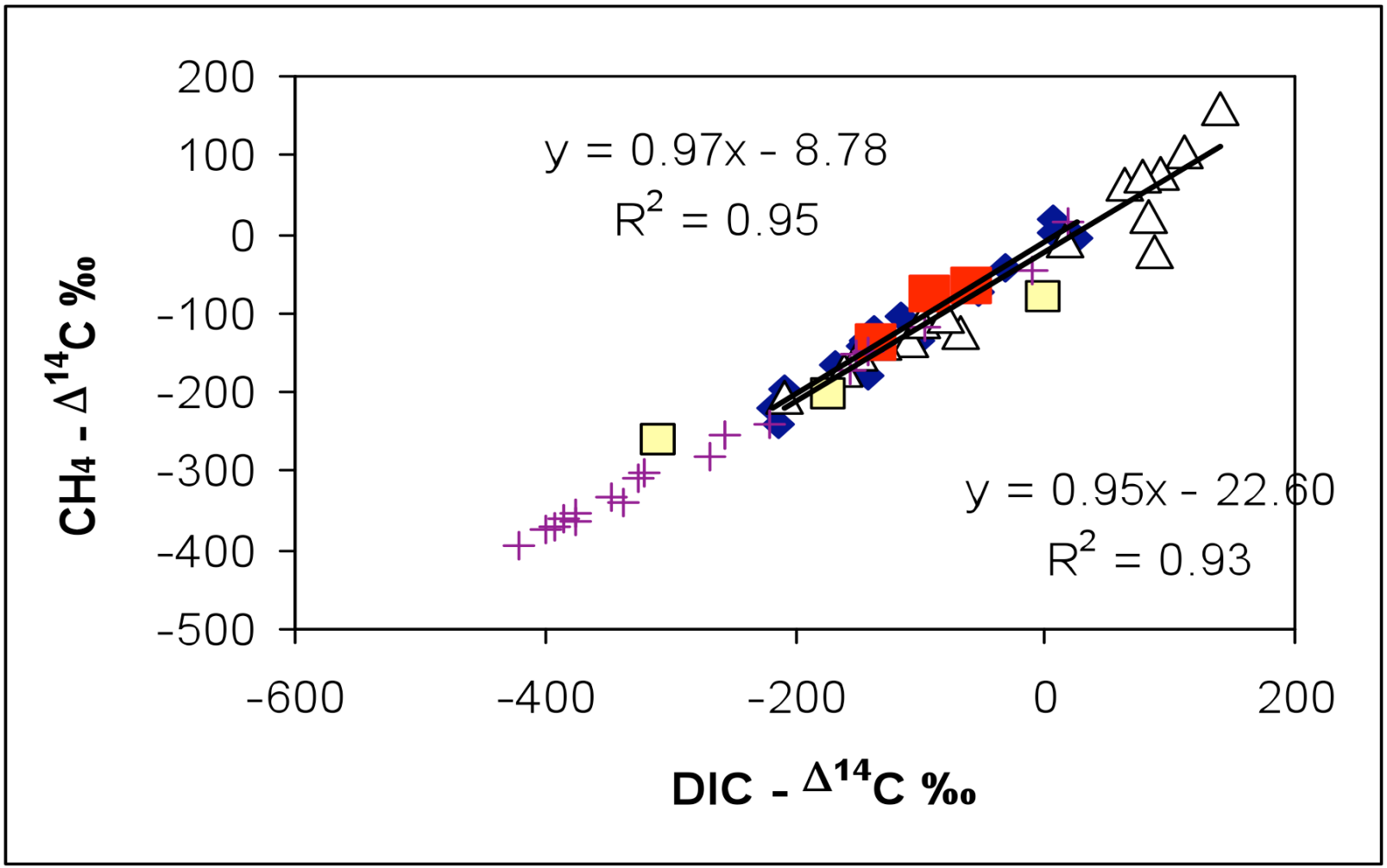


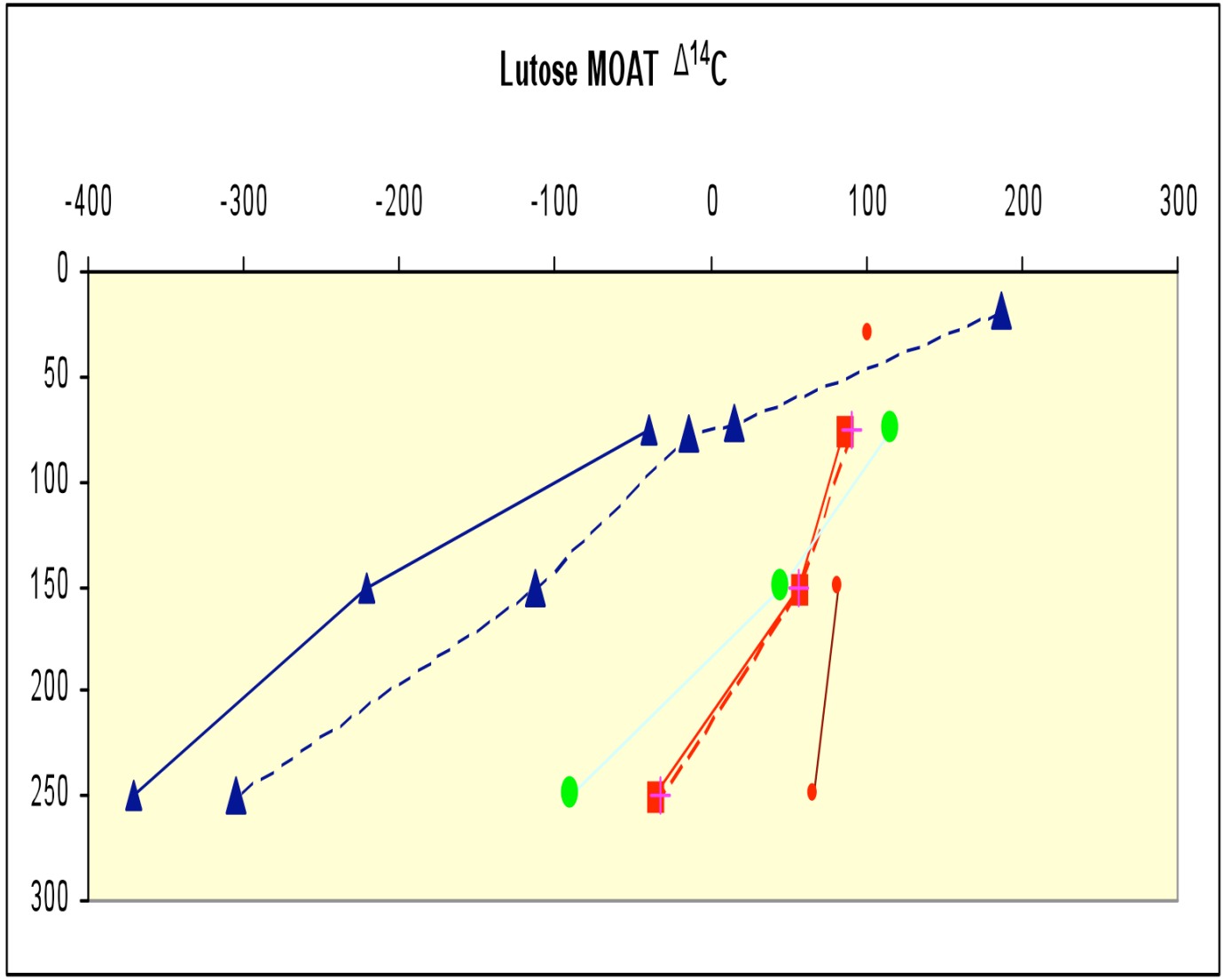


Moat edge

Stable edge

^{14}C in DIC and CH_4 are identical. Chanton et al. 2008 GBC





MOAT SITE

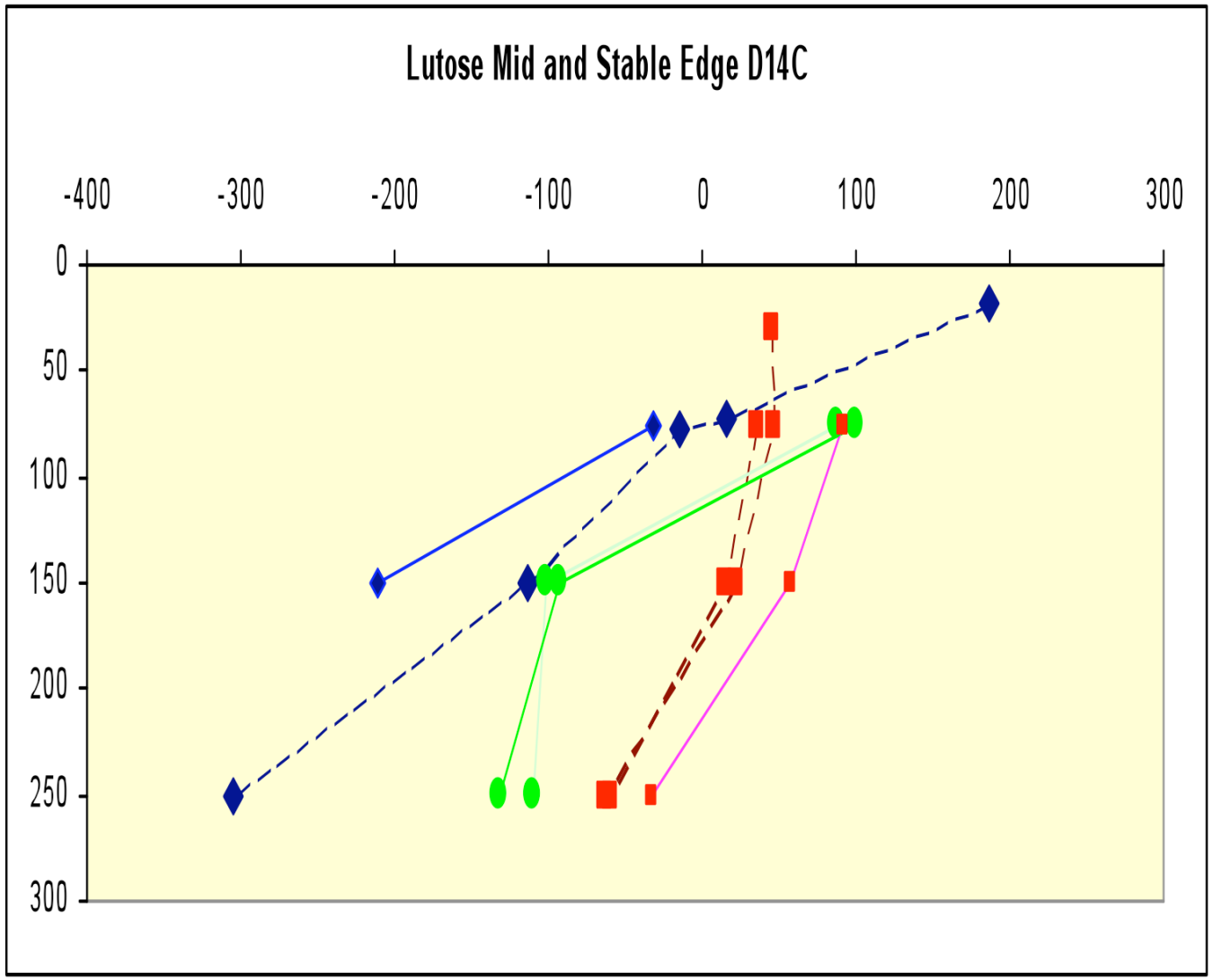
DIC = ΣCO_2

Peat

DOC

Is there Old Carbon in the respiration products of the MOAT??

Not observed, old carbon respiration overshadowed by respiration of surface Carbon



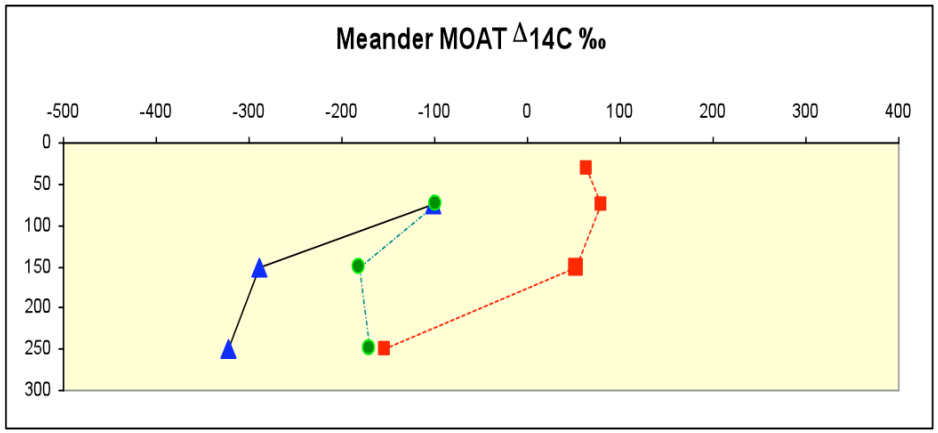
MID site & STABLE EDGE Combined

DIC = ΣCO_2

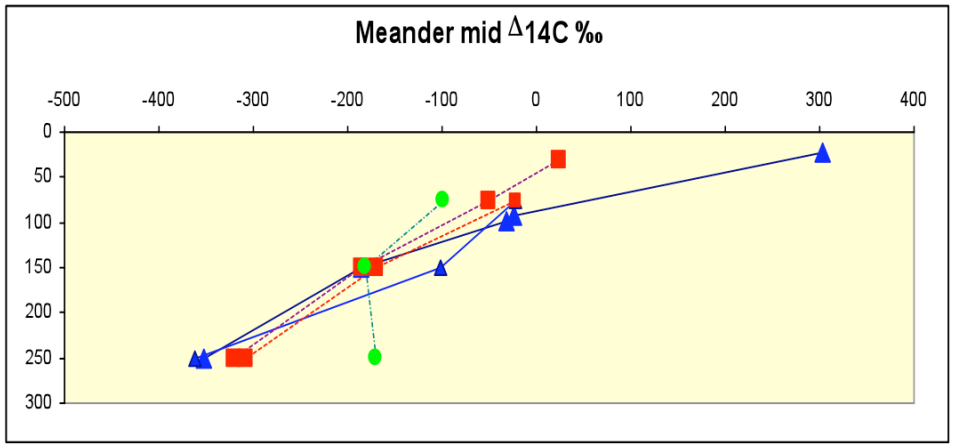
Peat

DOC

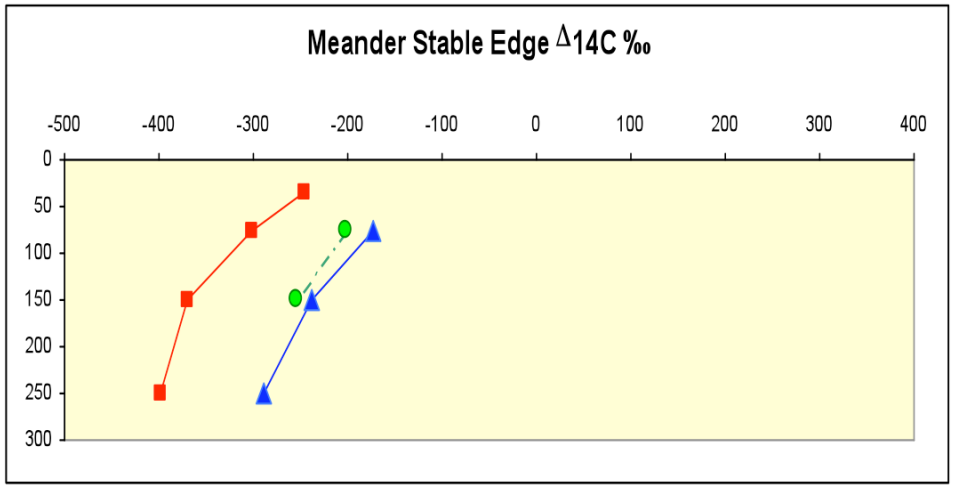
Respiration products shifted to older, but still dominated by surface production



MOAT



MID



DIC = ΣCO_2

Peat

DOC

Stable Edge

You saw earlier that primary production was the lowest at these sites, so surface production no longer masks the respiration of old carbon


Sweden
International boundary
National capital
Railroad
Road
0 50 100 Kilometers
0 50 100 Miles
Lambert Conformal Conic Projection, SP 47N/62N
NORWAY
SWEDEN
FINLAND
RUSSIA
DENMARK
ESTONIA
LATVIA
LITHUANIA
Norwegian Sea
North Sea
Baltic Sea
Gulf of Bothnia
Gulf of Finland
ALAND ISLANDS
Skagerrak
Kattegat
Gotland
Öland
Hiiumaa
Saaremaa
Arctic Circle
VESTERÅLEN
LOFOTEN
Oslo
Stockholm
Helsinki
Tallinn
Riga
Copenhagen
Bergen
Trondheim
Narvik
Kiruna
Luleå
Umeå
Sundsvall
Gävle
Uppsala
Göteborg
Malmö
Base 802435 (A04937) 2-96

In conclusion

- Permafrost Decomposition stimulates methane emission but in different ways.

- In Siberia, by decomposition of old OM.
- In Alberta, mostly by providing habitat for vascular plant colonization.
- In Sweden, we are just getting started.

Thank you for your attention