Late Pleistocene yedoma in south-western Yukon (Canada): a remnant of Eastern Beringia ?

Daniel Fortier[1, 2]
Jens Strauss[3]
Michel Sliger[1,2]
Fabrice Calmels[4]
Duane Froese[5]
Yuri Shur[3]

[1]*Geography Department, Université de Montréal, Montréal (QC), Canada, CP6128, H3C 3J7*
[2]*Center for Northern Studies, Université Laval, Québec (QC), Canada*
[3]*Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research, Potsdam, Germany*
[4]*Yukon Research Center, Whitehorse (YK), Canada*
[5]*Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, (AB), Canada*
[6]*Department of Civil Engineering, University of Alaska Fairbanks, Fairbanks (AK), USA*

Abstract

Yedoma deposits developed from the syngenetic accumulation and freezing of organic-rich and ice-rich sediments during the Late Pleistocene over vast portions of Siberia, Alaska and Yukon Territory. Cryostratigraphic investigations revealed the presence of a yedoma deposit in the Beaver Creek area of south-western Yukon. The Beaver Creek area was not glaciated during the last glacial advance and the cryostratigraphic record comprises Middle Wisconsinian up to Holocene deposits covering the Mirror Creek disintegration moraine. Reworking of glacial deposits by alluvial and solifluction processes and peat accumulation in the depression of the hummocky moraine likely occurred during the Middle Wisconsinian period and was followed during the Late Wisconsinian by the yedoma build-up. A major thaw event interrupted the syngenetic permafrost aggradation which eventually resumed as attested by the upward growth of ice wedges.

Keywords: Yedoma; Cryostratigraphy; Syngenetic Permafrost; Carbon Stock; Ice Wedge; Late Pleistocene

Introduction

During the Late Pleistocene extensive portions of Siberia, Alaska and the Yukon Territory remained largely unglaciated (Elias and Brigham-Grette, 2013). These areas were covered by yedoma deposits which developed from the syngenetic accumulation and freezing of organic-rich and ice-rich fine-grained sediments and growth of ice wedges. Strauss *et al.* (2013, 2017) estimated that yedoma deposits cover approximately 625 000 km² of the Northern hemisphere accounting for about 398 gigatonnes (Gt) of organic carbon (including taberal and Holocene strata). However, this estimate didn't take into account the yedoma deposits from south-western Yukon, Canada.

Last glacial maximum in North-West Canada

During the McConnell glaciation (last glacial maximum) the Cordilleran Ice Sheet covered most of north-western America and merged with the Laurentide Ice Sheet up to southwestern North-West Territories although some areas of North-Western Canada remained ice-free (Jackson *et al.*, 1991; Dyke 2004). Cryostratigraphic investigations in the Beaver Creek area, South-western Yukon, revealed the presence of yedoma deposit with ice-rich cryofacies and syngenetic ice wedges down to 10 m below the surface (Fig.1). The Beaver Creek area was not glaciated during the last glacial advance (Vermaire & Cwynar 2010).

Study site

The Beaver Creek area is located in the Wellesley basin, north of the Kluane range (Fig.2). The Wellesley basin rests at the base of the St-Elias Mountains, where a glacial lobe has spread as a piedmont glacier complex more than once during the Pleistocene (Fig.2) (Jackson *et al.* 1991).

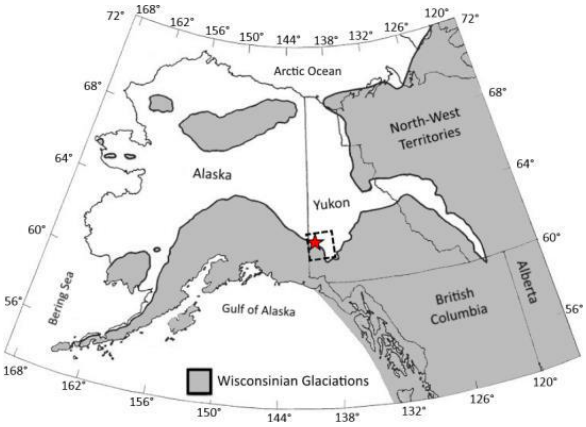

Figure 1. Localisation of the study site in relation to Eastern Beringia (unglaciated white area). The dashed square outlines the contour of Figure 2 and the red star locates the study site (figure modified from Sliger et al. 2015).

This site was glaciated during the Mirror Creek glaciation (Early Wisconsinian) but remained ice-free during the Late Wisconsinian McConnell glaciation (Fig.2)

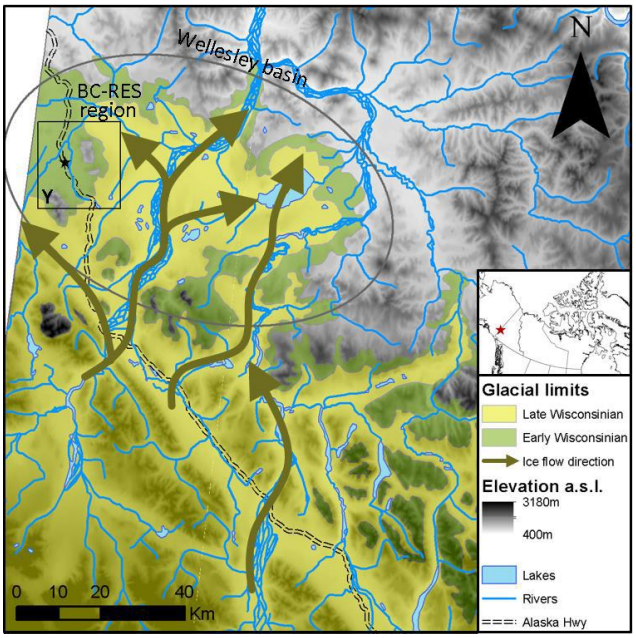

Figure 2. Glacial limits during the Wisconsinian and general ice flow direction. Star: study site location (figure modified from Sliger et al. 2015).

The Mirror Creek deglaciation left an extensive hummocky disintegration moraine deposits (Sliger *et al.* 2015). Reworking of glacial deposits by alluvial and solifluction processes and peat accumulation in the depression of the hummocky moraine likely began during the Middle Wisconsinian period and was followed during the Late Wisconsinian by the yedoma build-up. A major thaw event interrupted the syngenetic aggradation of the permafrost which later resumed as illustrated by the upward growth of the ice wedges. During the Holocene, the aeolian sedimentation and ice wedge growth decreased significantly and peat accumulation promoted the development of a carbon/ice -rich layer (*intermediate layer*).

Acknowledgments

This research was supported by Natural Sciences and Engineering Research Council of Canada, Transport Canada, and Yukon Highways and Public Works.

References

Dyke, A. S. 2004. An outline of North American Deglaciation with emphasis on central and northern Canada, *in* Ehlers, J. & Gibbard, P.L. (eds), *Quaternary Glaciations-Extent and Chronology*. Amsterdam: Elsevier, 373-424.

Elias, S.A., Brigham-Grette, J., 2013. Late Pleistocene Glacial Events in Beringia. In: Elias, S.T. (ed.), *Encyclopedia of Quaternary Science*. Amsterdam: Elsevier, 1057–1066.

Jackson, L.E. *et al.*, 1991. The Last Cordilleran Ice Sheet in Southern Yukon Territory. *Géographie physique et Quaternaire, 45*: 341-354.

Sliger, M. *et al.* 2017. Incidence of Late Pleistocene-Holocene Climate on the Concurrent Landscape and Permafrost Development of the Beaver Creek Region, Southwestern Yukon, Canada. *Proceedings of the Seventh Canadian Permafrost Conference & 68th Canadian Geotechnical Conference*, Quebec City, Canada, September 20th-23rd.

Strauss, J. *et al.*, 2017. Deep yedoma permafrost: a synthesis of depositional characteristics and carbon vulnerability. *Earth Science Reviews* 72: 75-86.

Strauss, J. *et al.*, 2013. The deep permafrost carbon pool of the Yedoma region in Siberia and Alaska. *Geophysical Research Letter* 40: 6165–6170.

Vermaire, J.C. & Cwynar. L.C., 2010. A revised late-Quaternary vegetation history of the unglaciated southwestern Yukon Territory, Canada, from Antifreeze and Eikland ponds, *Canadian Journal of Earth Sciences* 47: 75-88