The recession of the Laurentide Ice Sheet in southeast Northwest Territories during the Pleistocene-Holocene transition

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Rationale:

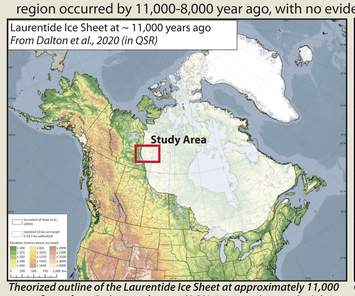
- The timing and pace of climatically-driven Laurentide Ice Sheet retreat along the northwestern margin during the Pleistocene-Holocene transition remains poorly constrained by spatially sparse minimum-limiting radiocarbon ages.
- Constraining the spatial and temporal pattern of retreat of the NW sector of the Laurentide Ice Sheet during the Pleistocene-Holocene transition will provide constrains on meltwater production, the evolution of Glacial Lake McConnell, as well as the potential to inform models of current high-latitude ice sheets in a warming climate.

Objectives:

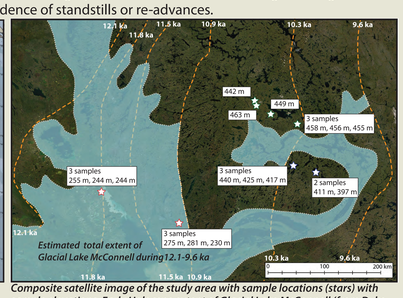
- Determine the timing and pattern of regonal Laurentide Ice Sheetdeglaciaiton using newly obtained cosmogenic exposure ages.
- Contrain the evolution of Glacial Lake McConnell using cosmogenic exposure ages from topographic highs within the Great Slave Basin.
- Investigate the pace of ice margin recession new and existing chronology.

Introduction:

Minimum-limiting radiocarbon ages indicate that the Laurentide Ice Sheet receded from west to east across the present-day Great Slave Lake basin from ~12,000 to 10,000 years ago, though chronologic control is spatially limited (Dalton et al., 2020 in QSR). A glacially impounded proglacial lake, Glacial Lake McConnell, followed the retreating ice margin with the Great Slave Basin, filling the basin up to a maximum elevation of ~320 m asl (Great Slave Lake currently lies at ~ 156 m asl), though little chronology exists to constrain when various lake levels were achieved (Smith, 1994 in QSR). Northwest of the Great Slave Basin, retreat of a roughly north-south oriented ice margin through the region occurred by 11,000-8,000 year ago, with no evidence of standstills or re-advances.



Theorized outline of the Laurentide Ice Sheet at approximately 11,000 years, figure from Dalton et al., 2020 (QSR). Note, major proglacial lakes not shown on the figure.



Composite satellite image of the study area with sample locations (stars) with sample elevations, Early Holocene extent of Glacial Lake McConnell (from Dyke, 2004), ice margins from Dalton et al., 2020 (QSR).

^{10}Be Cosmogenic Exposure Ages:

Sample ID	Transect	Latitude	Longitude	Elvevation (m)	Sample Type	Boulder Height (m)	Age	Error
NGO-SK-10	Northern	64.57	-111.53	440	Boulder	2	10,300	400
NGO-SK-11	Northern	64.52	-111.50	460	Boulder	1	12,300	300
NGO-SK-9	Northern	64.45	-110.90	450	Boulder	1.5	11,200	400
NGO-SK-8	Northern	64.36	-109.96	460	Boulder	1.5	10,500	300
NGO-SK-6	Northern	64.32	-109.89	460	Boulder	2	11,400	300
KC-17-002	Middle	63.71	-109.82	420	Boulder	0.8	23,600	400
KC-17-004	Middle	63.71	-109.84	440	Boulder	1.8	12,800	200
KC-17-005	Middle	63.70	-109.85	430	Boulder	2.3	8,800	200
KC-17-013	Middle	63.66	-109.01	410	Boulder	1.1	14,800	200
KC-17-015	Middle	63.65	-109.03	400	Boulder	0.7	11,000	200
17-RH-004	Southern	62.73	-116.11	240	Boulder	0.7	11,300	300
17-WT-004	Southern	62.52	-113.36	230	Boulder	1	9,300	100
17-WT-001	Southern	62.52	-113.36	280	Bedrock	n/a	11,900	300

Ages calculated using the Arctic production rate (Young et al., 2013 in JQS) and LSDn scaling Borchers et al., 2015 in Quaternary Geochronology), no corrections made for erosion, snow cover, or isostatic uplift.

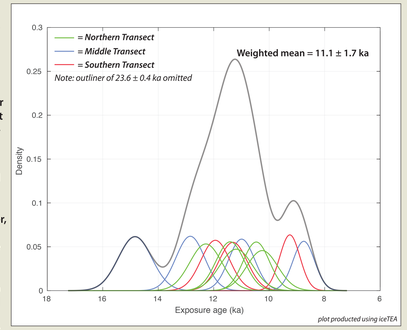
Notes on calculations:

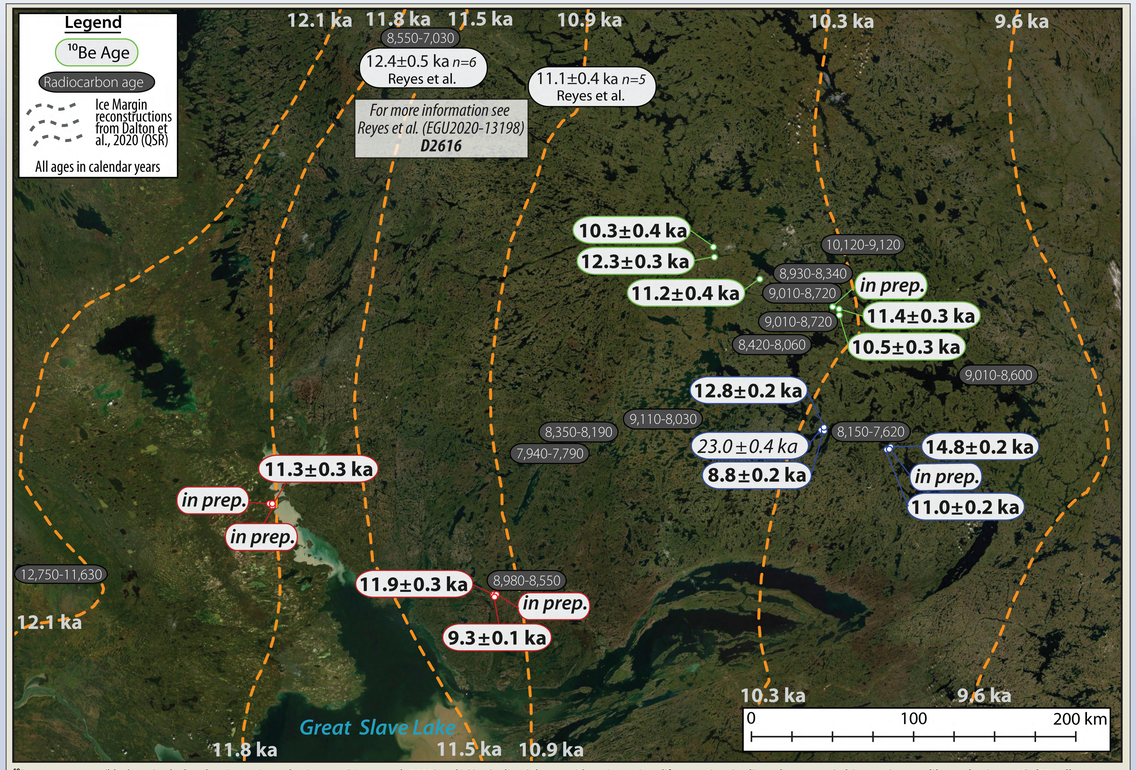
No correction is made to our ages for snow cover on these ages, as the boulders and single bedrock surface are elevated above the surrounding terrain, and thus believed to be wind-swept during winter months.

No correction is made to our ages for erosion, as erosion rates are quite low for this part of the Arctic, and thus the effect on the age would be negligible for Holocene exposure.

No correction is made to our ages for post-glacial isostatic uplift, which would likely be 80-90 meters since the Pleistocene-Holocene transition (estimate from ICE-6G model, Dick Peltier, University of Toronto). A correction for this change elevation over the Holocene would result in apparent exposure ages that would be older by ~5-15%. We choose not to make this correction as an appropriate atmospheric model needed to assess the change in attenuation of secondary cosmic ray flux resulting from this isostatic rebound is not available.

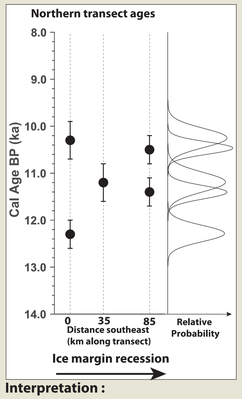
Kernal Density Plot for all ^{10}Be ages

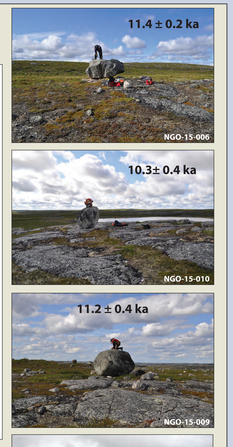




^{10}Be exposure ages (black text) calculated useing Artic production rate (Young et al., 2013) and LSDn Scaling Scheme, with no isostatic uplift correction. Radiocarbon ages (white text) are calibrated using IntCal13, all ages are complield in Dalton et al., 2020 (QSR), as are the theorized ice margin positions. All ages are in calendar years before present.

Northern Transect (Lac de Gras area)

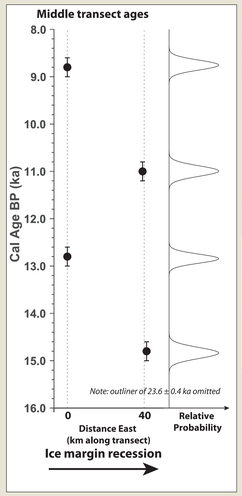


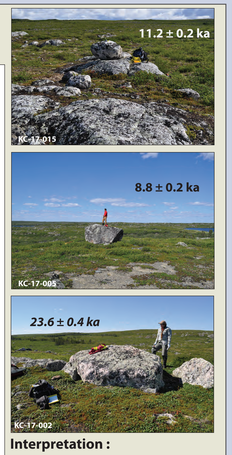


Interpretation :

- Five ages on the transect range from 12.3±0.3 to 10.3±0.4 ka, but demonstrate no clear spatial pattern, indicating that ice marginal recession occurred within the resolution of our dating technique.
- This pattern of ages may result from rapid retreat of the ice margin or widespread stagnation.

Middle Transect (Gacho Kue area)

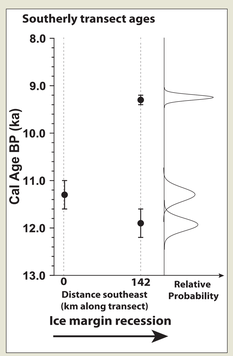


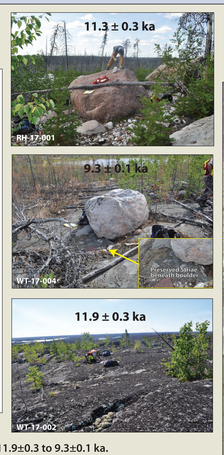


Interpretation :

- Five ages from the transect range from 14.8±0.3 to 8.6±0.2 ka, with one old outlier of 23.6±0.4 ka, interpreted to be erroneously old due to inheritance.
- The remaining four ages do not overlap at one-sigma, but overlap with ages from the northern transect, and are older than nearby radiocarbon ages.

Southern Transect (Great Slave Lake area)

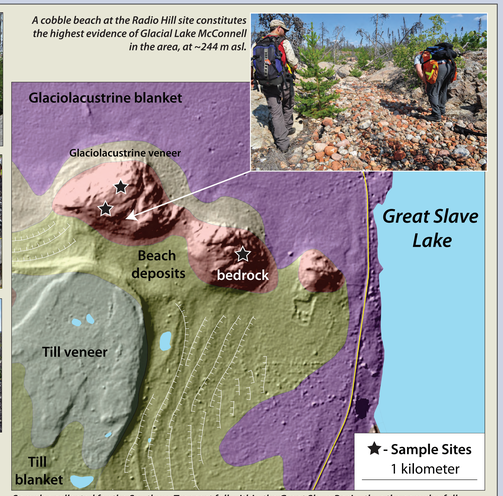




Interpretation :

- Three ages from the transect range from 11.9±0.3 to 9.3±0.1 ka.
- The two ages, one from a boulder and one from ice moulded bedrock, from our western site outside of Yellowknife are both older than a local radiocarbon age derived from wood (8.98-8.55 cal ka). At this site, the older age is from bedrock located at a higher elevation (by ~50 m). This may indicate that either the older age is over estimates deglaciation due to inheritance. Alternatively, the younger age, collected from the same elevation as the locally highest raised beach, may underestimate deglaciation due to glacial lacustrine shielding.
- Additional ages are needed to clarify the pattern of deglaciation along this transect.

A cobble beach at the Radio Hill site constitutes the highest evidence of Glacial Lake McConnell in the area, at ~244 m asl.



Samples collected for the Southern Transect fall within the Great Slave Basin, thus the samples fall within the area inundated by Glacial Lake McConnell. The time-transgressive nature of Glacial Lake McConnell filling is poorly constrained, Thus, to mitigate the effect of shielding from lake water, samples were collected from topographic highs located above evidence of lake inundation. An example of this shown in the figure above, where samples were collected from bedrock hills situated ~ 20 m above local beach deposits.

Preliminary Interpretations:

- The weighted mean and standard deviation of our new chronology places regional deglaciation at 11,100 ± 1,700 years ago, approximately 1,000 years sooner than indicated by minimum-limiting radiocarbon ages.
- This new chronology, placed in the context of other regional cosmogenic exposure ages from Reyes et al. (*see display 2616*), indicate that existing conceptual models for the timing and pattern of deglaciation of the northwest sector of the Laurentide Ice Sheet need to be updated to reflect new dating techniques.
- Our ages, in addition to those from Reyes et al., suggest either rapid ice margin retreat of northwest sector of the Laurentide Ice Sheet over 100s of kilometers during the Pleistocene-Holocene transition or rapid downwasting following widespread stagnation of the icesheet. Additional ages and regional field mapping may shed more light on the style of deglaciation.
- Our southern transect provides new constraints on the deglacial history of the Great Slave Basin, providing constraints on the timing of local ice margin retreat and proglacial inundation by Glacial Lake McConnell. Additional ages along this transect will be useful for understanding the dynamic reconfiguration of Glacial Lake McConnell in response to Laurentide Ice Sheet retreat.

Acknowledgements:

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