Géographie physique et Quaternaire



Amino Acid Evidence Indicating Two or More Ages of Pre-Holocene Nonglacial Deposits In Hudson Bay Lowland, Northern Ontario Établissement par les acides aminés d'au moins deux époques de mises en place avant l'Holocène de dépôts non glaciaires dans les basses terres de la baie d'Hudson, nord de l'Ontario

Philip H. Wyatt

Volume 44, numéro 3, 1990

The Last? Interglaciation in Canada

Le dernier (?) interglaciaire au Canada

URI : https://id.erudit.org/iderudit/032838ar DOI : https://doi.org/10.7202/032838ar

Aller au sommaire du numéro

Éditeur(s)

Les Presses de l'Université de Montréal

ISSN

0705-7199 (imprimé) 1492-143X (numérique)

Découvrir la revue

érudit

Citer cette note

Wyatt, P. H. (1990). Amino Acid Evidence Indicating Two or More Ages of Pre-Holocene Nonglacial Deposits In Hudson Bay Lowland, Northern Ontario. *Géographie physique et Quaternaire*, 44(3), 389–393. https://doi.org/10.7202/032838ar

Résumé de l'article

Les études par les acides aminés ont permis d'identifier des sédiments non glaciaires d'avant !"Holocène passablement plus jeunes que les sédiments de la Mer Bell de la Formation de Missinaibi. L'unité plus jeune est représentée par des sédiments marins des rivières Severn et Abitibi. Les matériaux organiques enfouis de la Beaver River sont corrélés avec les sédiments marins plus jeunes des rivières Abitibi et Severn grâce aux analyses des acides aminés. En tenant pour acquis que les sédiments de la Mer Bell datent du dernier interglaciaire (130-120 ka). les sédiments non glaciaires plus récents ont pu être mis en place tard au cours du stade isotopique 5 (80-75 ka). Les études paléoécologiques menées sur les sédiments organiques de Beaver River montrent que le climat était au moins aussi chaud que maintenant.

Tous droits réservés © Les Presses de l'Université de Montréal, 1990

Ce document est protégé par la loi sur le droit d'auteur. L'utilisation des services d'Érudit (y compris la reproduction) est assujettie à sa politique d'utilisation que vous pouvez consulter en ligne.

https://apropos.erudit.org/fr/usagers/politique-dutilisation/

Cet article est diffusé et préservé par Érudit.

Érudit est un consortium interuniversitaire sans but lucratif composé de l'Université de Montréal, l'Université Laval et l'Université du Québec à Montréal. Il a pour mission la promotion et la valorisation de la recherche.

https://www.erudit.org/fr/

Note

AMINO ACID EVIDENCE INDICATING TWO OR MORE AGES OF PRE-HOLOCENE NONGLACIAL DEPOSITS IN HUDSON BAY LOWLAND, NORTHERN ONTARIO

Philip H. WYATT, Wyatt Geoscience, 96 Coolspring Crescent, Nepean, Ontario K2E 7M8.

ABSTRACT Amino acid studies have identified pre-Holocene nonglacial sediments in the Hudson Lowland which are significantly younger than Bell Sea sediments of the Missinaibi Formation. This younger unit is represented by marine sediments on the Severn and Abitibi rivers. Buried organic material on Beaver River is correlated with the younger Severn and Abitibi river marine sediments based on amino acid evidence. Assuming that Bell Sea sediments are of last interglacial (130-120 ka) age, the younger nonglacial sediments may have been deposited late in ¹⁸O stage 5 (80-75 ka). Paleoecologic studies of the Beaver River organics indicate climate at least as warm as present.

INTRODUCTION

Hudson Bay Lowland is located near the geographic centre of the area occupied by the Laurentide Ice Sheet and the occurrence of pre-Holocene nonglacial deposits in this area therefore has marked implications regarding ice volume change.

Relative age constraints for buried peat on the Beaver River (Fig. 1) have been obtained using amino acid analysis of reworked shells from fluvial gravels which underlie the peat. The resulting chronologic interpretation places significant constraints on regional climate history.

PREVIOUS RESEARCH

McDonald (1969, 1971) conducted the first comprehensive study of Quaternary stratigraphy in the Hudson Bay Lowland. He reported a two till sequence overlying nonglacial deposits that were best exposed in the Moose River basin (Fig. 1). This suite of nonglacial deposits, originally studied by Terasmae and Hughes (1960), was formally named the Missinaibi Formation by Skinner (1973) and assumed to be last interglacial in age (Prest, 1970). The Missinaibi Formation includes marine sediments of the Bell Sea (marine incursion immediately following deglaciation), forest and peat member beds, and overlying laminated silts deposited in a proglacial lake environment. McDonald concluded that the central part of the Lowland and

Manuscrit reçu le 30 mai 1990; manuscrit révisé accepté le 18 juin 1990.

RÉSUMÉ Établissement par les acides aminés d'au moins deux époques de mises en place avant l'Holocène de dépôts non glaciaires dans les basses terres de la baie d'Hudson, nord de l'Ontario. Les études par les acides aminés ont permis d'identifier des sédiments non glaciaires d'avant l'Holocène passablement plus jeunes que les sédiments de la Mer Bell de la Formation de Missinaibi. L'unité plus jeune est représentée par des sédiments marins des rivières Severn et Abitibi. Les matériaux organiques enfouis de la Beaver River sont corrélés avec les sédiments marins plus jeunes des rivières Abitibi et Severn grâce aux analyses des acides aminés. En tenant pour acquis que les sédiments de la Mer Bell datent du dernier interglaciaire (130-120 ka), les sédiments non glaciaires plus récents ont pu être mis en place tard au cours du stade isotopique 5 (80-75 ka). Les études paléoécologiques menées sur les sédiments organiques de Beaver River montrent que le climat était au moins aussi chaud que maintenant.

Hudson Bay proper were likely occupied by ice from Missinaibi time until deglaciation about 7500 BP. This conclusion was not, however, supported by later amino acid studies of Shilts (1982) and Andrews *et al.* (1983). They inferred that Hudson Bay had probably been deglaciated two or three times since Missinaibi time. Such a series of glacial/nonglacial events could not be reconciled with the reported two-till stratigraphy.

Analysis of amino acid geochronology by Wyatt (1989) and lithostratigraphy by Thorleifson (1989) have refined the relative chronology and stratigraphy of sediments in the Central Lowland, identifying a four till sequence which *postdates* sediments of the Missinaibi Formation.

As outlined by Miller (1982), and Miller and Hare (1980), the amino acid technique involves measuring the degree of degradation of indigenous proteinaceous residues preserved in the carbonate shells of molluscs. Degradation progresses with time elapsed since the organism died. The reaction used in these studies is the racemization or epimerization of L-amino acids, the form found in original protein, to their D-configuration. Not all amino acids are suitable for geochronologic studies due to various competing decomposition reactions. In this study, the reaction used is the epimerization of the protein amino acid L-isoleucine to its non-protein diastereomer D-alloisoleucine. The ratio of the two isomers in a shell is expressed as alle/lle (alloIsoleucine/Isoleucine). The epimerization reaction is reversible; the alle/lle ratio increases from near zero in a living shell, to an equilibrium ratio of about 1.30.

The rate at which this reaction proceeds is strongly temperature dependent, approximately doubling for every 4°C increase in temperature between -10 and +20°C. Thus, the alle/lle ratio in shells from different deposits can be directly compared only if the shells have experienced closely similar thermal histories. The reaction rate of different taxa may also vary so that data from a single species are required for direct comparison (Miller, 1982).

The amino acid geochronology of Hudson Bay Lowland was first established by Shilts (1982) and Andrews *et al.* (1983). They determined that epimerization ratios of *in situ* and transported shells recovered from till and marine and fluvial sediments, clustered into at least four groups. Of these four groups, the highest ratios were in shells from Bell Sea sediments, the youngest ratios were in shells from Holocene Tyrrell Sea sediments, and at least two groups of ratios indicated that Hudson Bay was colonized by molluscs for certain periods between the incursion of Bell and Tyrrell seas. These data implied a departure from the concept of a stable Laurentide Ice Sheet existing through most of the Wisconsinan Stage, because Bell Sea sediments are considered to be part of the Missinaibi Formation deposited during the last (Sangamon) interglaciation (Skinner, 1973).

Andrews *et al.* (1983) proposed alternate interpretations of the cluster groups, although their preferred interpretation was that Bell Sea sediments were deposited at the onset of the last interglacial period, about 130,000 yr BP. This required a long-



FIGURE 1. Location map of Hudson Bay Lowland, encompassing central Lowland and Moose River basin.

Localisation des basses terres de la baie d'Hudson, y compris les basses terres centrales et le bassin de Moose River.

term average diagenetic temperature for Bell Sea shells of $+0.6^{\circ}$ C. Using this temperature, the ages of the intermediate shells with ratios between those of the last interglacial Bell Sea and Tyrrell Sea were calculated. It was concluded that Hudson Bay may have been ice-free along its southern shore about 35,000, 75,000 and 105,000 yr ago.

The principle hypothesis of Andrews *et al.* (1983), derived from the fact that alle/lle ratios of bivalves from glacial units were intermediate between ratios from Bell Sea sediments and Tyrrell Sea sediments. They concluded that there must have been marine incursions at intermediate time(s) during the Wisconsinan. Objections to this interpretation were raised by Dyke (1984) including the argument that glacially transported shells would have experienced significantly different thermal environments which might account for all the variations in ratios in the Lowland. Dyke (1984) stressed that all we know of the age of the Missinaibi Formation is that it is >72,500 years old (Stuiver *et al.*, 1978), and that no marine sediments of Wisconsinan age are known from any part of the Lowland. Several pieces of new information allow us to address these concerns.

GEOCHRONOLOGICAL ANALYSES

MARINE SEDIMENT

Although pre-Holocene subtill marine sediments are rare in the Lowland, two occurrences with intermediate shell ratios have been identified. Subtill marine sediments occur approximately 50 m above present sea level, on the Severn River (Fig. 1). These sediments contain abundant Hiatella arctica with alle/lle ratios averaging 0.138 \pm 0.014 (n = 29, Fig. 2). Thermoluminescence dating of these sediments by Forman et al. (1987) produced an age of 74,000 \pm 10,000. Subtill marine deposits on Abitibi River (Fig. 1), were previously correlated with Bell Sea sediments (Prest, 1970; Skinner, 1973). Amino acid analyses of Hiatella arctica collected from this unit yielded alle/lle ratios of 0.119 \pm 0.015 (n = 20; Fig. 2). A collection of Hiatella arctica obtained from Bell Sea sediments on the Kwataboahegan River yielded a mean alle/lle ratio of 0.243 ± 0.035 (n = 16, Fig. 2), slightly higher than the result of 0.202 quoted by Andrews et al. (1983).

Tyrrell Sea sediments from various locations throughout the Lowland yielded *Hiatella* with alle/IIe ratios of 0.033 \pm 0.006 (n = 17). Results of amino acid analyses for the four marine units are plotted in the frequency histogram (Fig. 2).

BEAVER RIVER PEAT

Peat and fluvial gravel on Beaver River (Figs. 1 and 3), were deposited in a channel cut into brownish-grey till of undetermined position in the stratigraphic sequence. Stratified diamicton overlying the peat, contains reworked organic matter, and has shell fragments with Severn River marine unit ratios or lower. The peat unit has a maximum thickness of 0.75 m.

The untreated peat was first dated by the University of Waterloo Isotope Laboratory, yielding an age of $37,040 \pm 1660$ years BP (Wat-1378, $\delta^{13}C = -27.7\%$ modern carbon = 0.99%). Dating of the Beaver River peat with rigorous pretreatment (NaOH, HCI) at the G.S.C. radiocarbon lab

FIGURE 2. Alle/IIe ratios of *Hiatella arctica* taken from *in situ* marine units in the Hudson Bay Lowland.

Rapports Alle/IIe de Hiatella arctica prélevés dans les unités marines in situ des basses terres de la baie d'Hudson.



yielded an age of >38,000 years BP (GSC-4146, δ^{13} C = -27.9%) with subsequent high pressure analysis yielding an age of >51,000 years BP (GSC-4423). The alle/lle ratios of shell fragments taken from fluvial gravels underlying the peat, are however, significantly lower than Bell Sea ratios. Two fragments with *Hiatella* amino acid assemblages have alle/lle ratios of 0.105 and 0.153. Three other fragments with similar but unidentified amino acid assemblages, have ratios of 0.092, 0.141, and 0.145. It is inferred from these ratios, that the Beaver River peat was deposited during the nonglacial episode which began with the marine incursion represented by the Severn River marine unit.

PALEOECOLOGICAL ANALYSES

Palynological data for the Beaver River peat reported by Mott (unpublished GSC Palynological Report 88-13) are similar throughout the profile suggesting that climate varied little during time of deposition of the peat. *Sphagnum* (sphagnum moss) spores dominate the spectra indicating that deposition occurred in a bog environment. Ericaceae (heath plants), Gramineae (grass) and Cyperaceae (sedge) pollen values show that these taxa occurred on the wet bog surface as well. Low values for *Alnus* (alder) and *Salix* (willow) attest to the presence of these shrubs in suitable locations nearby. Small amounts of *Artemesia* (sage) and other herbaceous pollen taxa indicate that open, drier upland areas were not locally abundant.

Picea (spruce) pollen, which ranges between 40 and 50% of the pollen sum, indicates that spruce trees were abundant in the area and probably covered somewhat drier uplands in the region and may have been present on the bog surface as well. Other tree taxa represented include *Pinus* (pine) at approximately 20%, *Betula* (birch) at 10% or less, and minor



FIGURE 3. Buried peat occurrence on the Beaver River. Note the gravel underlying the peat unit.

Unité de tourbe enfouie de la Beaver River. À noter le gravier sous l'unité de tourbe.

amounts of other tree taxa. These values indicate that pine and birch trees were sparsely represented, if present at all.

The pollen spectra from the Beaver River site are very similar to those obtained for other buried organic deposits in the Hudson Bay Lowland (Terasmae and Hughes, 1960; Skinner, 1973; Dredge and Nielsen, 1985; Nielsen *et al.*, 1986). It is the opinion of Mott (1988), based on palynological findings, that correlation of these sediments with the "Missinaibi Formation" is suggested, with northern boreal to forest tundra conditions and climate as warm or warmer than the present. The question which arises from the aminostratigraphic work is whether or not there exists two (or more) paleoecologically similar but stratigraphically different organic marker units. Fossil arthropod (unpublished GSC Report 88-13) and plant macrofossil (unpublished GSC Report 88-28) analysis of the Beaver River peat by Matthews were not as revealing as pollen work due to dominance of mosses in the sample and the commensurately low abundance and poor preservation of insect and higher plant remains. Fossil insects found included beetles such as Carabidae (ground beetles), Staphylinidae (rove beetles), and Scolytidae (bark beetles). Specimens of Diptera (flies), Hymenoptera (wasps and ants), and Arachnida such as Oribatei (oribatid mites) were also present. Matthews stated that the only conclusion possible, given the limited evidence, is that climate at the time of deposition was probably no colder than present.

DISCUSSION

The Abitibi River marine unit and Bell Sea sediments along the Kwataboahegan River are in similar thermal environments due to their close proximity. Their difference in alle/Ile ratios, 0.119 vs. 0.243 can therefore only be attributed to a different age for the sediments. If the shells were the same age, a diagenetic temperature difference of more than 4°C would be required between sites to produce the difference in ratios. The Abitibi River marine unit of the Moose River basin, is here considered to be time correlative with the Severn River marine unit (alle/Ile = 0.138) of the Central Lowland. The slight difference in alle/Ile ratios may be due to subtle thermal contrasts. Both intermediate age marine units were deposited over isostatically depressed land, indicating an episode of glaciation postdated deposition of the Bell Sea.

The four till sequence of the Central Lowland postdates the Bell Sea sediments (Fig. 4). Based on amino acid results, the buried peat deposits along the Beaver River have been correlated with the Severn River marine unit. The Beaver River peat and Severn River marine unit represent a significant period of climate amelioration which postdates the Bell Sea sediments of the Missinaibi Formation. Assuming an early 18O Stage 5 age (Chappell and Shackleton, 1986) for the Missinaibi Formation (130-120 ka), the Beaver River peat may have been deposited in Stage 5a (approx. 80 ka.) It is also possible that in situ Bell Sea sediments and overlying organics on the Kwataboahegan River are of pre-Sangamonian age, perhaps belonging to ¹⁸O Stage 7. The stratigraphy of the Moose River basin is likely more complex than presented by Skinner (1973). based on the occurrence of two pre-Holocene marine units of different age.

It has been established that Severn and Abitibi marine sediments are correlative and have been dated by thermoluminescence at approximately 74 ka (Forman *et al.*, 1987). Bell Sea sediments are older as revealed by amino acid data and are possibly ¹⁶O Stage 5e age. Amino acid data from shells extracted from gravel below the Beaver River peat, indicate that the peat is of similar age or younger than the Severn/Abitibi marine sediments, but >51 ka according to radiocarbon dating. Mott (unpublished GSC Report 88-13) indicated that the paleoecology of the Beaver River peat is equivalent to that of the Moose River basin Missinaibi sites.

The simplest interpretation of this data is that Severn/Abitibi marine sediments and Beaver River peat are ¹⁸O Stage 5a age,



FIGURE 4. Composite column for the central Lowland (after Wyatt, 1989). Italicized numbers indicate the range of Alle/Ile ratios for *Hiatella arctica* fragments extracted from a unit.

Stratigraphie des basses terres centrales (d'après Wyatt, 1989). Les nombres en italique donnent l'étendue des rapports Alle/lle des fragments de Hiatella arctica prélevés dans une unité.

about 80-75 ka based on thermoluminescence dating. By extrapolation based on amino acid data, Bell Sea sediments are ¹⁸O Stage 5e age, about 130-120 ka. The paleoecology of Beaver River peat is indistinguishable from Moose River basin Missinaibi sites. There are at least two alternative interpretations including: 1) a possibility that there are two ages of organic deposits in the Moose River Basin which are paleoecologically indistinguishable, and 2) the thermoluminescence date is flawed and Bell Sea sediments are ¹⁸O Stage 7 or older and Severn/Abitibi marine units and Beaver River peat are ¹⁸O Stage 5e age.

SUMMARY

In conclusion it is inferred that at least two pre-Holocene nonglacial units exist in the Hudson Bay Lowland. The preferred interpretation is that Bell Sea sediments and associated organics on the Kwataboahegan River are last interglacial in age (approx. 130-120 ka). Significant glaciation was established through the middle of ¹⁸O Stage 5, waning later in Stage 5 (around 75 ka) to permit marine incursion and deposition of the Severn/Abitibi River marine units. This was followed by isostatic uplift and the growth of organics represented by the Beaver River peat. No other stratigraphically younger nonglacial units have been discovered so far.

REFERENCES

- Andrews, J. T. and Barry, R. G., 1978. Glacial inception and disintegration during the last glaciation. Annual Review of Earth and Planetary Science, 6: 205-228.
- Andrews, J. T., Shilts, W. W. and Miller, G. H., 1983. Multiple deglaciation of the Hudson Bay Lowlands since deposition of the Missinaibi (last interglacial?) formation. Quaternary Research, 19: 18-37.
- Chappell, J. and Shackleton, N. J., 1986. Oxygen isotopes and sea level. Nature, 324: 137-140.
- Dredge, L. A. and Neilson, E., 1985. Glacial and interglacial deposits in the Hudson Bay Lowlands: a summary of sites in Manitoba. *In* Current Research, Part A, Geological Survey of Canada, Paper 85-1A: 247-257.
- Dyke, A. S. 1984. Multiple deglaciation of the Hudson Bay Lowlands since deposition of the Missinaibi (last interglacial?) formation. Discussion. Quaternary Research, 22: 247-252.
- Forman, S. L., Wintle, A. G., Thorleifson, L. H. and Wyatt, P. H., 1987. Thermoluminescence properties and age estimates for Quaternary raised marine sediments, Hudson Bay Lowland, Canada. Canadian Journal of Earth Sciences, 24: 2405-2411.
- McDonald, B. C., 1969. Glacial and interglacial stratigraphy, Hudson Bay Lowland, p. 78-99. *In P. J.* Hood, ed., Earth science symposium on Hudson Bay. Geological Survey of Canada, Paper 68-53.
- 1971. Late Quaternary stratigraphy and deglaciation in eastern Canada, p. 331-353. In K. Turekian, ed., The Late Cenozoic glacial ages. Yale University Press, New Haven.

- Miller, G. H., 1982. Quaternary depositional episodes, western Spitsbergen: aminostratigraphy and glacial history. Arctic and Alpine Research, 14: 321-340.
- Miller, G. H. and Hare, P. E., 1980. Amino acid geochronology; integrity of the carbonate matrix of mollusk fossils, p. 415-444. *In P. E. Hare*, T. C. Hoering and K. King, eds., Biochemistry of Amino Acids. John Wiley, New York.
- Nielsen, E., Morgan, A. V., Morgan, A., Mott, R. J., Rutter N. W. and Causse, C., 1986. Stratigraphy, paleoecology, and glacial history of the Gillam area, Manitoba. Canadian Journal of Earth Sciences, 23: 1641-1661.
- Prest, V. K., 1970. Quaternary geology of Canada, p. 676-758. In R. J. W. Douglas, ed., Geology and Economic Minerals of Canada. 5th ed., Geological Survey of Canada Economic Geology of Canada Series, No. 1, Ottawa.
- Shilts, W. W., 1982. Quaternary evolution of the Hudson/James Bay region. Le Naturaliste canadien, 109: 309-332.
- Skinner, R. G., 1973. Quaternary stratigraphy of the Moose River basin, Ontario. Geological Survey of Canada, Bulletin 225, 77 p.
- Stuiver, M., Heusser, C. J. and Yang, I. C., 1978. North American history extended to 75,000 years ago. Science, 200: 16-21.
- Terasmae, J. and Hughes, O. L., 1960. A palynological and geological study of Pleistocene deposits in the James Bay Lowlands, Ontario. Geological Survey of Canada, Bulletin 62, 15 p.
- Thorleifson, L. H., 1989. Quaternary stratigraphy of the central Hudson Bay Lowland, northern Ontario, Canada, Ph.D. thesis, University of Colorado, Boulder, 363 p.
- Wyatt, P. H., 1989. The stratigraphy and amino acid chronology of Quaternary sediments in central Hudson Bay Lowland. M.Sc. thesis, University of Colorado, Boulder, 119 p.