Géographie physique et Quaternaire

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Volume 41, numéro 2, 1987

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URI : https://id.erudit.org/iderudit/032677ar
DOI : https://doi.org/10.7202/032677ar

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Éditeur(s)

Les Presses de l'Université de Montréal

ISSN

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

Découvrir la revue

Citer cet article

St-Onge, D. A. (1987). An Introduction to the Continental Record of the Laurentide Ice Sheet. *Géographie physique et Quaternaire*, *41*(2), 187–188. https://doi.org/10.7202/032677ar

Résumé de l'article

Les dépôts abandonnés par la calotte laurentidienne relatent bien imparfaitement son évolution. Les séquences sédimentaires sont incomplètes et peu d'entre elles sont antérieures au retrait des derniers glaciers. De plus, en l'absence de méthodes de datation absolue des dépôts au-delà des limites du radiocarbone, la position chronostratigraphique d'un sédiment est généralement déterminée en comptant les unités de haut en bas. Conséquemment, les estimations de l'âge des unités varient de façon importante d'un auteur à l'autre.

Géographie physique et Quaternaire, 1987, vol. XLI, n° 2, p. 187-188, 1 fig.

AN INTRODUCTION TO THE CONTINENTAL RECORD OF THE LAURENTIDE ICE SHEET*

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ABSTRACT The record of the Laurentide Ice Sheet is not well preserved in terrestrial deposits. Sediment sequences are incomplete and few record events older than the last ice retreat. Furthermore, in the absence of absolute dating methods for deposits older than the limit of radiocarbon dating, units are generally assigned a chronostratigraphic position by "counting from the top". As a result age estimates of many units can differ significantly between authors.

RÉSUMÉ *Introduction à l'inventaire des données terrestres sur la calotte glaciaire laurentidienne*. Les dépôts abandonnés par la calotte laurentidienne relatent bien imparfaitement son évolution. Les séquences sédimentaires sont incomplètes et peu d'entre elles sont antérieures au retrait des derniers glaciers. De plus, en l'absence de méthodes de datation absolue des dépôts au-delà des limites du radiocarbone, la position chronostratigraphique d'un sédiment est généralement déterminée en comptant les unités de haut en bas. Conséquemment, les estimations de l'âge des unités varient de façon importante d'un auteur à l'autre.

The following four papers summarize the history of the Laurentide Ice Sheet based on the evidence from the terrestrial stratigraphic record. The growth and decay of the last Quaternary ice sheet to cover large parts of continental North America is discussed under the following headings which represent geologic time slices:

(1) Sangamonian Stage
(2) Wisconsinan Stage:
  (a) Early Wisconsinan Substage
  (b) Middle Wisconsinan Substage
  (c) Late Wisconsinan Substage and Holocene Series

The Laurentide Ice Sheet, in its various phases of growth and retreat, spanned the Wisconsinan Stage, which follows the Sangamonian Stage and retreat continued into the Holocene. In discussing the temporal aspects of the Laurentide Ice Sheet it is first necessary to define the terminology used. The Sangamon Interglaciation and Wisconsin Glaciation are geologic-climate units used for the last interval when climate was similar to present and for the last glacial period respectively. Geologic-climate units are time transgressive. Chronostratigraphic units are not time transgressive, those used in this paper for the Late Pleistocene terrestrial record are Sangamonian and Wisconsinan stages (see introductory paper for definitions).

The oxygen isotopic ratios ($^{18}O/^{16}O$ ratio) for planktonic and benthonic foraminifera from ocean bottom cores give a rough approximation of global ice volume and hence of climatic changes extending through all of the Quaternary (for a good summary see BOWEN, 1978, p. 57-76). The sequence of climatic changes, identified by this geologic thermometer invented by UREY (1947), was transferred into a chronostratigraphic series by tying the sequence to paleomagnetic stratigraphy (SHACKLETON and OPDYKE, 1976). These chronostratigraphic units are called oxygen isotope stages and are referred to by numbers with even numbers referring to times of extensive glacial ice and odd numbers to times when glacial ice extent was not too different from present. Stage 5 corresponds to the Sangamonian and stage 1 begins about 11 ka and includes all of the Holocene (Fig. 1).

By its very nature terrestrial stratigraphy is a poor indicator of the extent of an ice sheet. Only when dealing with till or ice contact sediments can we be certain that glacier ice either covered or was in the vicinity of the site under investigation. Other sediments, including organics, can only give a coarse indication of climatic conditions and, by inference, of amount of ice which may still have been present some distance away. The absence of glacial sediments makes it very difficult to determine where the ice was, let alone how important it may have been at that particular "time". Indeed the absence of glacial sediments does not necessarily mean the absence of glacier ice; there could have been a lack of deposition, *e.g.* a cover of cold based ice, or, subsequent erosion could have removed the evidence.

Further, the study of the terrestrial deposits in any interval of the Quaternary, except for the Late Wisconsinan and Holocene is seriously hampered by the very irregular distribution of continental deposits, which further tend to be destroyed or extensively modified by subsequent erosion. Also very importantly, the lack of a reliable dating technique beyond the limit of the radiocarbon method imposes severe constraints on age determination (OERLEMANS and VAN DER VEEN, 1984). For these reasons the assignment of sediments to a given stage or substage is generally tentative and usually is based on indirect evidence such as climatic conditions indicated by fossils or, on relative position in the stratigraphic succession.

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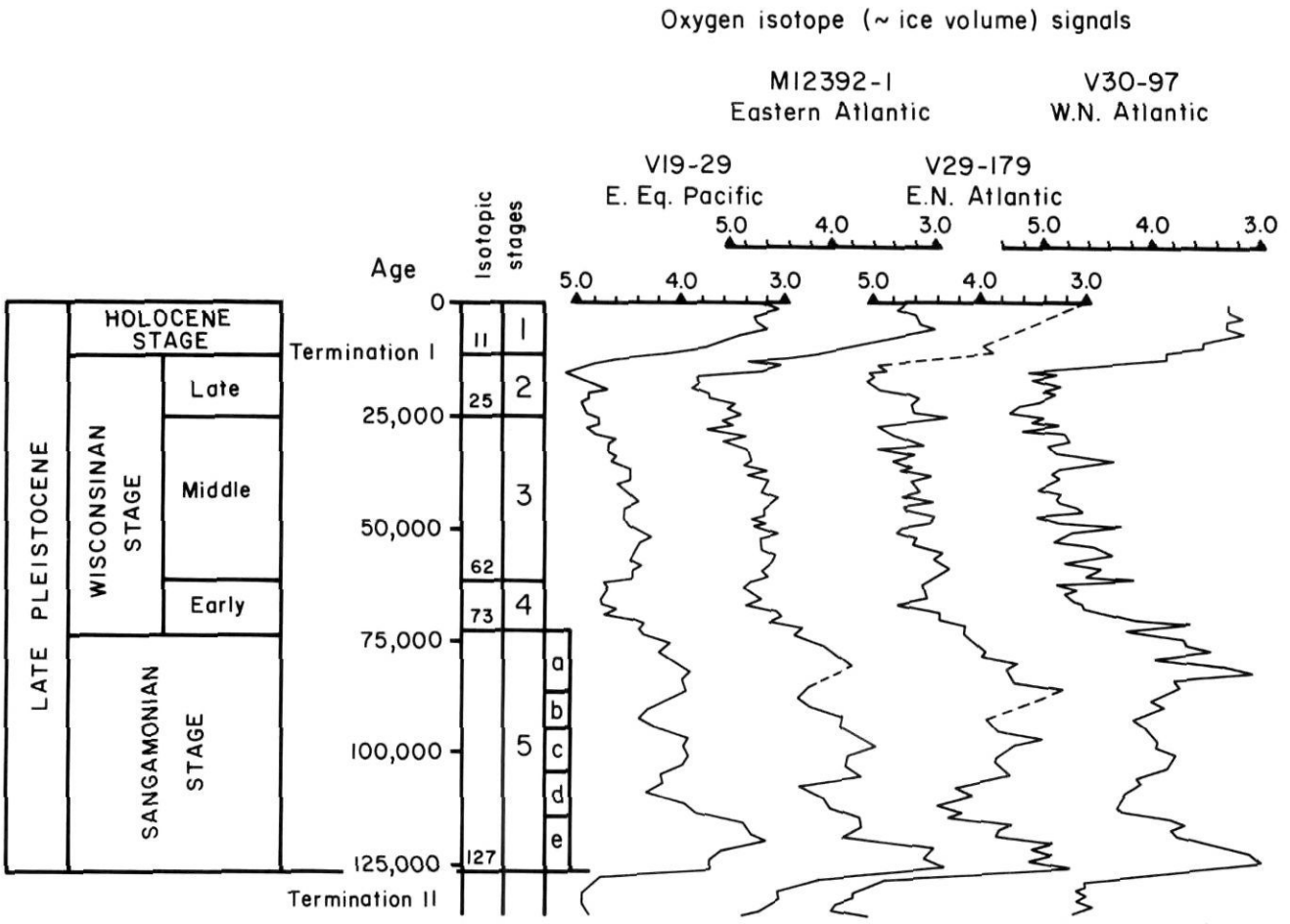

FIGURE 1. Ice volume curves based on oxygen isotopic records measured on benthic foraminifera in cores from widely separated regions (modified from RUDDIMAN and McINTYRE, 1981).

Courbes des volumes de glace fondées sur les valeurs des isotopes de l'oxygène mesurées à partir des foraminifères benthiques extraits de carottes provenant de régions très dispersées (d'après RUDDIMAN et McINTYRE, 1981).

The result, as will be shown below, is that correlation of units with the chronostratigraphic record varies significantly from one author to another. An example of this is the somewhat erratic and at times baffling wandering of Sangamon Interglacial units through geologic time (SKINNER, 1973, p. 9) extending from the Mesozoic to the Late Pleistocene (Wisconsinan). This clearly shows that, in the absence of absolute dating techniques:

(a) the assignment of a unit to a chronostratigraphic position is generally very tentative and is based on the assumption that no important units are missing when counting "from the top" or "from the base". (Not wishing to assume all units were present McDONALD (1969) concluded that the Missinaibi interval was simply an interglaciation of the Pleistocene; making the assumption that no units had been removed by erosion SKINNER (1973) concluded that the Missinaibi Formation probably represents the Sangamonian Stage.)

(b) entirely satisfactory positioning of units in a chronostratigraphic sequence is only possible in environments where sedimentation is continuous and proceeds at a reasonably uniform rate. Appropriate conditions for such a sequence generally do not occur in terrestrial environments.

(c) because the oceanic record is more complete and, so far, more detailed, it must be considered the best model against which the far more problematic terrestrial records should be evaluated.

The unravelling of the complex history of the Laurentide Ice Sheet will continue to provide exciting scientific challenges to the uninhibited scientists who consider present models for what they really are: constructions of the mind which allow us to establish order in the world around us. These hypotheses and theories however should never be mistaken for "Truth". It is on this basis that the following four papers on the temporal aspects of the Laurentide Ice Sheet are presented.

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