

## Stratigraphy and correlation of the Late Wisconsinan glacial events in the Lake Michigan basin

## Stratigraphie et corrélation des événements du Wisconsinien supérieur dans la partie ouest des Grands Lacs

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Résumé de l'article

*Stratigraphie et corrélation des événements du Wisconsinien supérieur dans la partie ouest des Grands Lacs.* Les seules corrélations valables entre les événements tardiglaciaires de régions aussi éloignées que la partie ouest des Grands Lacs et le sud du Québec dépendent de rétablissement de chronologies locales détaillées. Les travaux effectués dans le bassin du lac Michigan et les basses-terres du Saint-Laurent semblent les plus prometteuses à cet effet (de 14 000 à 8000 BP). Nous proposons, à la lumière de travaux récents dans la région du lac Michigan, une révision du modèle de déglaciation et de la nomenclature stratigraphique des événements tardiglaciaires. Le retrait, avec oscillations du front glaciaire, commence à dominer à partir de 17 000 ans BP, lorsque la glace quitte le système morainique de Lake Border. Ce retrait (plus de 400 km) culmine vers 13 300 ans BP. Après le recul de Cary-Port Huron, une réavancée (350 km) a mis en place le till de Shorewood. Un recul de moindre importance se produit ensuite, après quoi le till de Manitowoc est mis en place. Le retrait continu du front a finalement dégagé un exutoire vers l'est et le lac Chicago est tombé au bas niveau de Two Creeks. La déglaciation de Two Creeks n'était pas aussi étendue qu'on le croyait. La récurrence suivante de 125 km (ancien Valders), jusqu'à la moraine de Two Rivers, date d'environ 11 850 ans BP. Cette séquence d'événements tendrait à confirmer une déglaciation progressive, normale, contrôlée par le climat, plutôt qu'une déglaciation interrompue par une importante crue glaciaire post-Two Creeks. Du fait que le till de Valders est plutôt d'âge Woodford tardif, nous proposons le terme de Greatlakien pour remplacer le terme de Valders devenu trop ambigu.

# STRATIGRAPHY AND CORRELATION OF THE LATE WISCONSINAN GLACIAL EVENTS IN THE LAKE MICHIGAN BASIN

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**ABSTRACT** Meaningful correlations of late glacial events between areas as distant as the Great Lakes and southern Quebec depend on the establishment of detailed local chronologies, mostly from studies in the Lake Michigan basin and the St. Lawrence lowland now holding the most promise for a radiometrically controlled record of the late glacial (ca. 14,000-8000). Based on recent investigations in the Lake Michigan region, we propose a revision in the deglaciation pattern and stratigraphic nomenclature. Although oscillatory glacial retreat began to dominate over readvance about 17,000 years BP, we define late Wisconsinan as beginning at ca. 14,000 when the ice withdrew from the Lake Border Morainic system. Following the Cary-Port Huron retreat, the ice readvanced (350 km) depositing the red Shorewood Till. This was followed by a minor retreat and then by deposition of the Manitowoc Till. Continued retreat eventually uncovered an eastward outlet and Lake Chicago dropped to the Two Creeks low-water level. This deglaciation was not as extensive as previously assumed. The post-Twocreekan readvance (125 km) to the Two Rivers moraine occurred around 11,850 years BP. This sequence argues for a normal, climatically controlled progressive deglaciation rather than one interrupted by a major post-Twocreekan (formally Valderan) surge. Based on the knowledge that the Valders Till is late Woodfordian in age we have proposed the time-stratigraphic term "Greatlakean" as a substitute for the now misleading term "Valderan".

**RÉSUMÉ** *Stratigraphie et corrélation des événements du Wisconsinien supérieur dans la partie ouest des Grands Lacs.* Les seules corrélations valables entre les événements tardiglaciaires de régions aussi éloignées que la partie ouest des Grands Lacs et le sud du Québec dépendent de l'établissement de chronologies locales détaillées. Les travaux effectués dans le bassin du lac Michigan et les basses-terres du Saint-Laurent semblent les plus prometteuses à cet effet (de 14 000 à 8000 BP). Nous proposons, à la lumière de travaux récents dans la région du lac Michigan, une révision du modèle de déglaciation et de la nomenclature stratigraphique des événements tardiglaciaires. Le retrait, avec oscillations du front glaciaire, commence à dominer à partir de 17 000 ans BP, lorsque la glace quitte le système morainique de Lake Border. Ce retrait (plus de 400 km) culmine vers 13 300 ans BP. Après le recul de Cary-Port Huron, une réavancée (350 km) a mis en place le till de Shorewood. Un recul de moindre importance se produit ensuite, après quoi le till de Manitowoc est mis en place. Le retrait continu du front a finalement dégagé un exutoire vers l'est et le lac Chicago est tombé au bas niveau de Two Creeks. La déglaciation de Two Creeks n'était pas aussi étendue qu'on le croyait. La récurrence suivante de 125 km (ancien Valders), jusqu'à la moraine de Two Rivers, date d'environ 11 850 ans BP. Cette séquence d'événements tendrait à confirmer une déglaciation progressive, normale, contrôlée par le climat, plutôt qu'une déglaciation interrompue par une importante crue glaciaire post-Two Creeks. Du fait que le till de Valders est plutôt d'âge Woodford tardif, nous proposons le terme de Greatlakean pour remplacer le terme de Valders devenu trop ambigu.

**РЕЗЮМЕ** СТРАТИГРАФИЯ И КОРРЕЛЯЦИЯ ПОЗДНЕ - ВИСКОНСИНСКИХ ЛЕДНИКОВЫХ ПРОЦЕССОВ В БАСЕЙНЕ ОЗЕРА МИЧИГАН. Существенные корреляции поздне-ледниковых процессов в районах столь отдаленных друг от друга как Великие озера и южная часть Квебека зависят от установления подробных хронологий локального порядка. Эти хронологии могут быть составлены главным образом путем изучения бассейна озера Мичиган и долины реки Святого Лаврентия, так как там в настоящее время можно скорее всего получить радиометрически установленные данные о последнем Ледниковом периоде (14 000 — 8 000 лет тому назад). Основываясь на недавно проведенных исследованиях в районе озера Мичиган, мы предлагаем изменить взгляд на характер отступления ледников и пересмотреть стратиграфическую номенклатуру. Несмотря на то, что колебательное отступление ледников начало доминировать над их продвижкой примерно 17 тысяч лет тому назад, мы установили, что поздне-висконсинские ледниковые процессы подобного рода начались только 14 тысяч лет тому назад, когда ледники отступили от моренной системы озера Бордер. После отступления ледников в районе Кари-Порт Гурон, льды снова продвинулись (на 350 км.) отложив красную Шорвудскую глину. За этим последовало незначительное отступление ледника вызвавшее отложение Манитовокской глины. Продолжавшееся отступление ледников привело в конце концов к очищению ото льда восточной части озера Чикаго в результате чего уровень воды в нем упал до уровня Ту Крикс. Подобное отступление ледников не было столь крупным как предполагалось раньше. После очищения ото льда района Ту Крикс, примерно 11 850 лет тому назад наблюдалась новая продвижка ледников на 125км до моренной системы в районе Ту Риверс. Подобная последовательность свидетельствует о наличии нормального, климатически контролируемого, прогрессивного отступления ледников, а не о том, что подобное отступление было прервано крупным продвижением ледников вперед после того, как они очистили район Ту Крикс. Это наступление носило раньше название Вальдеранского наступления. Основываясь на доказательствах того, что возраст Вальдеранского тилля соответствует возрасту позднего Вудфордского, мы предложили заменить вводящий в заблуждение термин «Вальдеранский» термином «Великоозерный».

**INTRODUCTION**

In a recent series of papers (EVENSON, 1973a, 1973b; EVENSON *et al.*, 1974; MICKELSON and EVENSON, 1975; EVENSON *et al.*, 1976) we have proposed major revisions of the late glacial (ca. 14,000-7000) ice-front positions, rock- and time-stratigraphic nomenclature, climatic interpretations and deglaciation patterns for the Lake Michigan glacial lobe. These revisions are based on investigations in the type areas of the Valdres, Two Creeks, and Two Rivers deposits and on seismic investigations by LINEBACK *et al.* (1974) in the Lake Michigan basin. Because there have been numerous attempts to correlate late glacial chronologies and events in Québec (*i.e.* EVENSON and DREIMANIS, 1976; LASALLE and ELSON, 1975; OCCHIETTI, 1972; TERASMAE, 1959) with those in the Lake Michigan basin we feel that it is important that our new data be brought to the attention of those working in Québec and its environs. This paper is an encapsulated version of EVENSON *et al.* (1976) and EVENSON and DREIMANIS (1976). The reader is referred to these, and all the above mentioned papers, for details and a complete review of the development of the proposed revisions.

**GLACIAL HISTORY OF THE LAKE MICHIGAN BASIN (ca. 14,000-10,000)**

Table 1, taken from EVENSON and DREIMANIS (1976), is a correlation chart of the stratigraphic nomenclature for the Great Lakes region. This paper will concentrate on the explanation and justification of the revised nomenclature presented in the left hand column of the table as compared with that of WILLMAN and FRYE (1970; second from left); in addition, the table will serve as a frame of reference for those more familiar with one of the other chronologies shown.

Figure 1 is a time-space diagram for the Lake Michigan basin (EVENSON *et al.*, 1976). This diagram will serve as the basis for our discussion of the mode of deglaciation of the Lake Michigan basin. In addition, it can be used to present our revisions in the time- and rock-stratigraphic terminology for the region. Several important changes in nomenclature and ice front position are presented in this diagram and important conclusions, concerning the style of deglaciation and the concept of glacial surging in the Lake Michigan basin can be drawn from interpretation of this diagram. Formal rock-stratigraphic and time-stratigraphic units are shown in bold type. Informal units, drifts and moraines shown in italics. This diagram was constructed by plotting to scale, new ice marginal positions as presented and documented by EVENSON *et al.* (1976; see Fig. 1). Comparing this diagram with others for the same area (FRYE *et al.*, 1960, 1965, 1973) we see several important changes. For the first time a major retreat

YR. B.P. x 10 <sup>3</sup>	LAKE MICHIGAN LOBE		LAKE SUPERIOR AND EAST	EASTERN GREAT LAKES & ST. LAWRENCE REGION
	EVENSON, FARRAND, MICKELSON, ESCHMAN and MAHER (IN PRESS)	WILLMAN and FRYE (1970)	SAARHISTO (1974)	DREIMANIS and FARRON (1972)
7	HOLOCENE STAGE ABSOLUTE AGE UNKNOWN	HOL.	COCHRANE READVANCE	DRIFTWOOD STADIAL (BOUNDARIES UNDEFINED)
8				
9	GREATLAKEAN SUBSTAGE	VALDERAN SUBSTAGE	ALGONQUIN STADIAL	NORTH BAY INTERSTADIAL
10				
11				
12	TWOCREEKAN SUBSTAGE	TWOCREEKAN SUBSTAGE	VALDERS READVANCE	(VALDERS STADIAL)*
13	"PORT HURON" "CARY-PORT HURON" "CARY"	WOODFORDIAN SUBSTAGE	TWO CREEKS INTERSTADIAL	(TWO CREEKS INTERSTADIAL)* PORT-HURON STADIAL MACKINAW INTERSTADIAL
14	WOODFORDIAN SUBSTAGE		OLDER UNITS NOT DISCUSSED	PORT BRUCE STADIAL

NOTE: Informal geologic climate units in quotes.

TABLE 1. Time-stratigraphic units for the Great Lakes region. Note for (\*) in the right side column. The divisions in parentheses have not been recognized with certainty in this area, and therefore Lake Michigan lobe terms (after WILLMAN and FRYE, 1960) and dates after various recent sources have been used (from EVENSON and DREIMANIS, 1976).

*Unités chronostratigraphiques de la région des Grands Lacs. Note explicative concernant la marque (\*) dans la colonne de droite: les divisions entre parenthèses n'ont pas été fermement établies dans cette région; c'est pourquoi nous avons utilisé les termes se rapportant au lobe du lac Michigan employés par WILLMAN et FRYE (1960) et les dates suggérées par divers auteurs, notamment EVENSON et DREIMANIS (1976).*

(400 km) is proposed during the Cary-Port Huron (Mackinaw) interstade making this a major deglaciation event in the Lake Michigan basin. This retreat has been recognized for some time in the eastern Great Lakes (TAYLOR, 1913; LEVERETT and TAYLOR, 1915; FLINT, 1955; DREIMANIS, 1969; DREIMANIS and GOLDTHWAIT, 1973) and our identification of the event appears to suggest (see EVENSON and DREIMANIS, 1976, Fig. 2) retreat along the entire Great Lakes Laurentide ice margin. Evidence for the position of the Lake Mi-

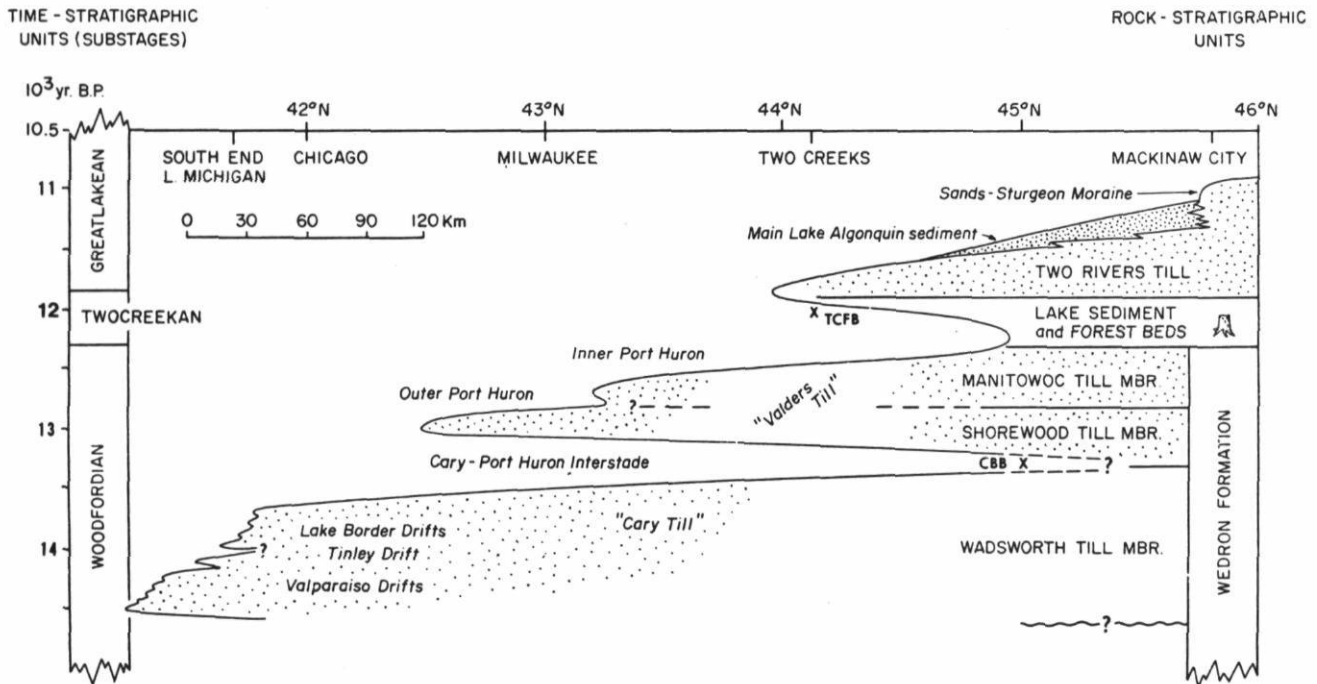


FIGURE 1. Time-distance diagram for the Lake Michigan basin. Vertical scale represents time in thousands of radiocarbon years BP; the horizontal scale is the approximate distance along the glacial path of the Lake Michigan Lobe. Formal rock-stratigraphic and time-stratigraphic terms shown in bold type. Informal units, drifts and moraines shown in italics; T.C.F.B. = Two Creeks Forest Bed; C.B.B. = Cheboygan Bryophyte Bed, these localities are projected into the lake basin along logical ice margins to maintain their proper stratigraphic position (from EVENSON *et al.*, 1976).

chigan ice-front during this interstade is provided by the Cheboygan County Bryophyte bed reported by FARRAND *et al.* (1969). Although no evidence can be presented to demonstrate the maximum extent of this retreat, the presence of the Bryophyte bed in Cheboygan County suggests deglaciation of the entire southern Peninsula of Michigan at this time (ca. 13,000 BP). This is in agreement with evidence farther east which suggests that the Huron, Erie and portions of the Ontario lake basins and southern St. Lawrence lowland were ice free (see Fig. 2 and p. 5; EVENSON and DREIMANIS, 1976).

**LATEST WOODFORDIAN ADVANCES**

Following the Cary-Port Huron retreat, the ice readvanced to the Shorewood-outer Port Huron limit as shown on Figure 1. This advance of over 350 km into the waters of Glacial Lake Chicago (195 m, a.t.) deposited red clayey till on land as far south as Milwaukee, Wisconsin and Muskegon, Michigan. This advance also deposited a prominent subaqueous end moraine on the

*Diagramme spatio-temporel du bassin du lac Michigan. L'échelle verticale représente le temps en milliers d'années <sup>14</sup>C BP; l'échelle horizontale représente les étapes approximatives tout au long du lobe du lac Michigan. Les termes lithostratigraphiques et chronostratigraphiques conventionnels apparaissent en caractères gras. Les unités informelles, les dépôts glaciaires et les moraines figurent en italique; T.C.F.B. = lit de la forêt de Two Creeks; C.B.B. = lit à Bryophyte de Cheboygan; ces deux localités sont projetées sur l'axe longitudinal du bassin du lac Michigan et associées à des positions logiques de la marge glaciaire afin de maintenir leur position stratigraphique véritable (d'après EVENSON *et al.*, 1976).*

floor of the Lake Michigan basin. The drift deposited during this advance is mapped in the Lake Michigan basin as the "Shorewood Till Member of the Wedron Formation" by LINEBACK *et al.* (1974) who assigned it a late Woodfordian age following EVENSON (1973). On land, this morainic system correlates with the outer Port Huron (Whitehall) moraine at Muskegon, Michigan (FARRAND and ESCHMAN, 1974) and with the red till limit (Valders till of BRETZ, 1951) occurring as far south as Milwaukee, Wisconsin and Muskegon, Michigan.

The next recorded event in the Lake Michigan basin is the deposition of the Manitowoc till (Fig. 1). The amount of retreat which occurred between the deposition of the Manitowoc and Shorewood tills is unknown, but the lithological similarity and lack of a terminal moraine for the Manitowoc till argues for simple retreat rather than significant retreat followed by readvance. Retreat from the Manitowoc limit occurred prior to the drop from the Glenwood Stage of Glacial Lake Chicago,

as Glenwood shoreline features are developed on the tills along the shore of Lake Michigan as far north as Two Rivers, Wisconsin and Manistee, Michigan (EVENSON, 1973a and b). Recent investigations by MICKELSON and EVENSON (1975) in the type areas of the Valders-Two Creeks-Two Rivers deposits have also demonstrated that the type Valders till is Port Huron in age rather than post-Twocreekan (Valderan) as previously assumed (see discussion of nomenclature which follows).

The multiple Port Huron event (Shorewood and Manitowoc tills) of the Lake Michigan basin has recognizable counterparts in the eastern Great Lakes region (LEVERETT, 1915; CHAPMAN and PUTNAM, 1966; KARROW, 1963), and if our correlations are correct (EVENSON and DREIMANIS, 1976), this may indicate that at this time the Laurentide ice activity in the central Great Lakes region was still synchronous with that in the east.

### TWOCREEKAN DEGLACIATION

Following the deposition of the Manitowoc Till Member, the Woodfordian ice retreated far enough north to uncover a low, eastward-draining outlet for glacial Lake Chicago and the water level in the Lake Michigan basin fell to the Two Creeks low water stage. At this time, the well known Two Creeks Forest bed developed at Two Creeks, Wisconsin (for details, see BROECKER and FARRAND, 1963; BLACK, 1970; EVENSON, 1973a and b). Some authors have interpreted the Twocreekan deglaciation as a major deglaciation involving considerable ice-front retreat (HOUGH, 1963) and climatic amelioration (ANDERSON, 1954). However, others (FARRAND *et al.*, 1969, 1974; PREST, 1970) have argued for minimal retreats just adequate to open an eastern outlet for the waters of the Lake Michigan basin. Based on the interpretation by FARRAND *et al.* (1969) that the Cheboygan bryophyte locality was not deglaciated during the Twocreekan retreat, we suggest the limit shown on Figure 1. This reduces previous estimates of Twocreekan deglaciation by at least 30 km. KARROW *et al.* (1975) have demonstrated that the Ontario basin was ice free during the Twocreekan Substage and there is an impressive array of evidence indicating that the southern part of the St. Lawrence Lowland was ice free in open connection with the sea.

### POST-TWOCREEKAN ADVANCE

The last major glacial event recorded in the Lake Michigan basin is the deposition of the Two Rivers Till — the till over the Two Creeks Forest Bed (Fig. 1). This till was named by EVENSON (1973a). Along the margins of the Lake Michigan basin the Two Rivers Till

can be separated from similar older red tills on the basis of shoreline development (EVENSON, 1973a). In the type region of the Valders Till, it is possible to separate the Valders Till and Two Rivers Till on the basis of: depth of carbonate leaching, distribution of buried forest beds, ice flow directional indicators and stratigraphic criteria (EVENSON, 1973a and b; MICKELSON and EVENSON, 1975). As indicated on Figure 1, the Two Rivers Till extends just south of the Two Creeks type locality. This interpretation reduces the extent of the post-Twocreekan readvance by nearly 175 km along the axis of the lake basin and precludes its correlation with either the type Valders Till at Valders, Wisconsin (as suggested by THWAITES and BERTRAND, 1957; and many others by usage) or the red tills occurring in the southern portion of the Lake Michigan basin (BRETZ, 1951). This reduction of both the Twocreekan retreat and the post-Twocreekan advance defines a post-Twocreekan advance of approximately 125 km.

Following the deposition of the Two Rivers Till, the ice retreated to the northwest possibly stopping at the Sands-Sturgeon Moraine (MARTIN, 1955) about 11,000 years BP. Following retreat from this moraine, the ice evacuated the western Great Lakes basins and their history from this point is recorded by a series of glacial lakes which are not the subject of this paper. The ice must have continued to retreat northward, but its history is not well documented or dated in the region north of the western Great Lakes region. SAARNISTO (1974) concludes from geological and palynologic evidence that the retreat of the ice sheet was interrupted by successive halts between 11,000 and 10,100 years BP — during his Algonquin Stadial (Table I), and that the ice had retreated north of the Hudson Bay divide by 9000 BP.

### INTERPRETATION AND REVISION OF NOMENCLATURE

The revision of the deglaciation history and stratigraphic relations in the Lake Michigan basin requires reappraisal of some well-known late-glacial events and revision of the nomenclature associated with this period of time. Our revision of the deglaciation style and the associated climatic implications are likely to influence the manner in which deglaciation sequences in other areas are correlated with those in the midwest and the nomenclatural revisions are keys in establishing clear, meaningful correlations with type time- and rock-stratigraphic units of this region. The changes are detailed elsewhere (EVENSON *et al.*, 1976) and only the major changes will be reviewed here.

The term "Valderan Substage" is replaced with the term "Greatlakean Substage" as shown on Figure 1. The Valderan Substage was proposed by FRYE and

WILLMAN (1960) to include those deposits younger than the Two Creeks Forest Bed and older than the top of the Cochrane till of HUGHES (1956, 1965). The name "Valderan" is derived from the Valders Till of THWAITES (1943) which was assumed to be correlative with the till over the Two Creeks Forest Bed; see discussion by FARRAND (1976) of Valders terminology. The type section of the Valderan is at the Two Creeks forest bed locality (FRYE and WILLMAN, 1960) and does not include the type Valders Till (of Thwaites) nor a unit which correlates with it (MICKELSON and EVENSON, 1975). The use of the term "Valders" for the till at Valders quarry has priority (as applied by THWAITES, 1943) and the definition of the Valderan Substage (of FRYE and WILLMAN, 1960) is invalid as it does not include the Valders Till as is suggested in its definition. We now restrict the use of the term "Valders Till" to the type till at Valders or its demonstrated equivalent. The term "Valderan Substage" is rejected as invalid on the basis of priority and definition. The rock-stratigraphic basis and type locality for the time-stratigraphic term "Greatlakean" remains essentially the same as that proposed by FRYE and WILLMAN (1960) for the Valderan Substage (see EVENSON *et al.*, 1976 for discussion and details).

The absolute age of the end of the Greatlakean is approximate at ca. 8000 years BP (HUGHES, 1965; WILLMAN and FRYE, 1970; EVENSON *et al.*, 1976). It marks the end of the Wisconsinan Stage (Table I) and is followed by the Holocene Stage as defined by WILLMAN and FRYE (1970, p. 126). This places the Pleistocene-Holocene boundary, as defined in the Great Lakes Region, somewhat younger than that favored for the worldwide reference boundary (INQUA, Paris 1969; TERASMAE, 1972). This is acceptable because we consider the Greatlakean and all other units of this rank or lower (*i.e.*, Woodfordian, Twocreekan, etc.) in the Great Lakes Region as local chronostratigraphic units as defined by the International Subcommittee on Stratigraphic Classification (1970 Article VII-H) and apply the term "Greatlakean" as suggested in Article VII-I. We make no attempt at this time to define a reference boundary between the Pleistocene and Holocene in terms of an international stratotype with worldwide validity. When defined formally, and if the age of 10,000 radiocarbon years BP is accepted, the worldwide Pleistocene-Holocene boundary will occur within the local time-stratigraphic Greatlakean Substage.

Our revision of the pattern of the late Wisconsinan deglaciation of the Lake Michigan basin (Fig. 1) argues for a normal, climatically controlled, progressive deglaciation rather than one interrupted by a major (320 km) post-Twocreekan surge as previously assumed. Surging was suggested by PREST (1970) and WRIGHT (1971) to explain the then-accepted 320 km advance that

appeared to be restricted to the Lake Michigan basin and unaccompanied by ice front advances elsewhere or by fluctuations in the pollen record (CUSHING, 1967; DAVIS, 1967, 1969). Our demonstration that the Greatlakean advance was approximately 175 km less extensive than previously assumed appears to harmonize the geologic and palynological data without requiring surging. In addition, LASALLE and ELSON (1975) have recently suggested that the emplacement of the St. Narcisse moraine may have been contemporaneous with the advance (called "Valders" by them) that deposited the Two Rivers Till over the Two Creeks Forest Bed in early Greatlakean time. Thus, they argue that the Greatlakean readvance was not restricted to the Lake Michigan basin as suggested by WRIGHT (1971). Like LASALLE and ELSON (1975), we do not reject the concept of Quaternary surging, however we do not feel it is supported or required by evidence associated with the Greatlakean ice activity in the Lake Michigan basin or eastern Canada.

Based on the similarity of radiocarbon age of the earlier Greatlakean events in the Lake Michigan basin (EVENSON *et al.*, 1976; SAARNISTO, 1974; BROECKER and FARRAND, 1963) and those of the St. Narcisse/St. Faustin system of Québec (PRICHONNET, 1977; LASALLE and ELSON, 1975; GADD *et al.*, 1972; LASALLE *et al.*, 1972; OCCHIETTI, 1972, 1974, 1976 and pers. comm.; TERASMAE and LASALLE, 1968) it is tempting to attempt correlations of these events (DREIMANIS, 1977). However, meaningful correlations of glacial events between these two areas involve a high degree of speculation and are fraught with special difficulty for several reasons. For example, the deviation in radiocarbon dates obtained on terrestrial vegetal materials and marine shells may be very large, the statistical errors on many of the available dates are very large, the effects of melt down associated with invasions of marine water are largely unknown as is the importance of continental versus maritime climate relative to the behavior of a major ice sheet retreating in an ameliorating climate. In addition, there is a vast area separating the areas where detailed studies have been performed. For these and other reasons, we are reluctant to propose correlations at this time. However, we continue to view with interest, the concept that it may be possible to correlate, both on radiocarbon chronologies and on the predicted response of the ice sheet to climatic change, the major late-glacial fluctuations recorded in the Maritime region of Canada and in the Great Lakes region of the United States and Canada.

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