"Late Pleistocene Age of the Type Temple Lake Moraine, Wind River Range, Wyoming, U.S.A."

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Note

LATE PLEISTOCENE AGE OF THE TYPE TEMPLE LAKE MORAINE, WIND RIVER RANGE, WYOMING, U.S.A.*

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ABSTRACT The type Temple Lake moraine lies about 3 km beyond and roughly 120 m lower than the modern glacier margin and the Gannett Peak (Little Ice Age) moraines deposited in the last few centuries. Because numerous glacial deposits throughout the western United States have been correlated to the Temple Lake moraine its age is important. We retrieved two sediment cores up to six meters long from Rapid Lake, outside the outer type Temple Lake moraine. The 383-413 cm depth dates 11,770 ± 710 yrs (GX-11,772), which we believe reflects the time when silt flux into Rapid Lake was abruptly reduced by the formation of a new sediment trap at Miller Lake as the valley glacier receded from its position at the outer Temple Lake moraine. A radiocarbon date of 11,400 ± 630 yrs BP (GX-12,719) obtained from the lower basin of Temple Lake, inside the inner type Temple Lake moraine, supports this interpretation. Sediments from Miller Lake, inside the outer Temple Lake moraine, that date 8300 ± 475 yrs BP (GX-12,277) are probably well above the bottom of the lake sediment sequence and possibly thousands of years younger than the moraine. We feel that the type Temple Lake moraine dates about 12,000 yrs BP, thus is Late Pleistocene in age. This interpretation is supported by maximum percentages of organic detritus in lake sediments between 10,000 and 8,000 yrs BP, and challenges BEGET's (1983) suggestion that the type Temple Lake moraine is early Holocene in age, a period he calls "Mesoglaciation".

RÉSUMÉ *L'attribution d'un âge pléistocène supérieur à la moraine de référence de Temple Lake, Wind River Range, Wyoming, É.-U.* La moraine de référence de Temple Lake repose à environ 3 km au-delà (approximativement 120 m plus bas) de la marge glaciaire moderne et des moraines de Gannett Peak (Petit Âge glaciaire) mises en place au cours des derniers siècles. Il est d'autant plus important de connaître l'âge de cette moraine que plusieurs dépôts glaciaires à travers l'ouest des États-Unis lui sont associés. On a recueilli deux carottes de sédiments jusqu'à 6 m de long du Rapid Lake, à l'extérieur de la moraine externe de référence de Temple Lake. La datation de 11 770 ± 710 BP (GX-11,772), enregistrée à 383-413 cm de profondeur, pourrait représenter le moment où le flux limoneux dans le Rapid Lake a grandement été réduit en raison de la formation d'un piège à sédiments au Miller Lake alors que le glacier de vallée se retirait de la moraine externe de Temple Lake. La datation au radiocarbone de 11 400 ± 630 BP (GX-12,719) recueillie dans le bassin inférieur du Temple Lake, à l'intérieur même de la moraine interne, corrobore l'interprétation ci-dessus. Les sédiments du Miller Lake, à l'intérieur de la moraine externe de référence de Temple Lake, qui datent de 8300 ± 475 BP (GX-12,277), se situent probablement bien au-dessus de la base de la séquence de sédiments lacustres et sont vraisemblablement des milliers d'années plus jeunes que la moraine. Les auteurs croient que la moraine de référence de Temple Lake date d'environ 12 000 BP, donc du Pléistocène. La mesure de pourcentages maximaux, entre 10 000 et 8000 BP, de débris organiques dans les sédiments lacustres confirme cette interprétation et permet de rejeter l'hypothèse de BEGET (1983) selon laquelle la moraine de Temple Lake daterait du début de l'Holocène, période qu'il appelle « Mésoglaciation ».

INTRODUCTION

In the southern Wind River Range of Wyoming the Temple Lake moraine system lies about 3 km beyond and roughly 120 m lower than the modern glacier margin and the Gannett Peak (Little Ice Age) moraines deposited in the last few centuries (Fig. 1). Because numerous glacial deposits throughout the western United States have been correlated to the type Temple Lake moraine, its climatic implications are significant. The age of this moraine, however, has been the subject of a long-standing controversy. In the Temple Lake valley (Fig. 1) are three paternoster lakes from which we retrieved sediment cores in order to obtain continuous records of environmental changes in the area. The purpose of this paper is to report radiocarbon ages from the basal portions of the sediment cores that have a bearing on the age of the type Temple Lake moraine.

MOSS (1951) concluded that the Temple Lake moraine was deposited by an apparent minor period of glaciation between the Pinedale maximum and the Holocene climatic optimum, thus during late-glacial (pre-Altithermal) time (Fig. 2). However, RICHMOND (1965) suggested that the Temple Lake was a two-fold event that occurred between 3000 and 1000 yrs BP, thus he assigned a Neoglacial age to the Temple Lake moraine. But, CURREY (1974) dated organic material from an interridge bog on the inner type Temple

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moraine at about 6500 yrs BP. MILLER and BIRKELAND (1974) collected relative dating data and concurred with CURREY (1974) that the type Temple Lake moraine was pre-Neoglacial in age. Thus, BEGET (1983) suggested that the type Temple Lake moraine and similar deposits in the North American Cordillera could be early Holocene in age, and date to a period he calls "Mesoglaciation".

METHODS

Sediment cores were obtained from Rapid, Miller, and Temple Lakes (Fig. 1) with a modified Livingstone piston corer from a platform system supported by inflatable boats. Detrital organics (fine fraction) from the sediment cores were radiocarbon dated after pretreatment with dilute HCl to remove any carbonate. Organic carbon percentages were determined by both weight-loss-on-ignition at 550°C for two hours (BENGTSSON and ENELL, 1986) and the modified Walkley-Black titration method (GAUDETTE *et al.*, 1974). Because weight-loss-on-ignition measurements may be determined more rapidly and less expensively, Walkley-Black determinations were used only for calibration of the weight-loss-on-ignition curves. Organic carbon percentages presented in this paper are based on the molar ratio of carbon in the generalized organic formula, $n(CH_2O)$. As suggested by BENGTSSON and ENELL (1986), carbon in lacustrine sediments represents 12/30 of the total organic matter, as determined by weight-loss-on-ignition. The percentage variations of organic material match favorably densitometric trends determined from X-radiographs of lacustrine sediment cores, and together are believed to indicate the amount of upvalley glacier activity (KARLÉN, 1976). Thus, during periods of high glacier activity greater amounts of inorganic silt are believed to reach downvalley lakes resulting in relative decreases in the amounts of organic-rich material being deposited. Similarly, during periods of low glacier activity, the amounts of organic-rich material deposited in the lake basins are relatively high compared to the amounts of inorganic silt being deposited. Although LEONARD (1986) assumed that the flux of organic material into a lake basin remains constant, and that inorganic sedimentation rates vary through time, the relative abundance of organic material nevertheless changes in-

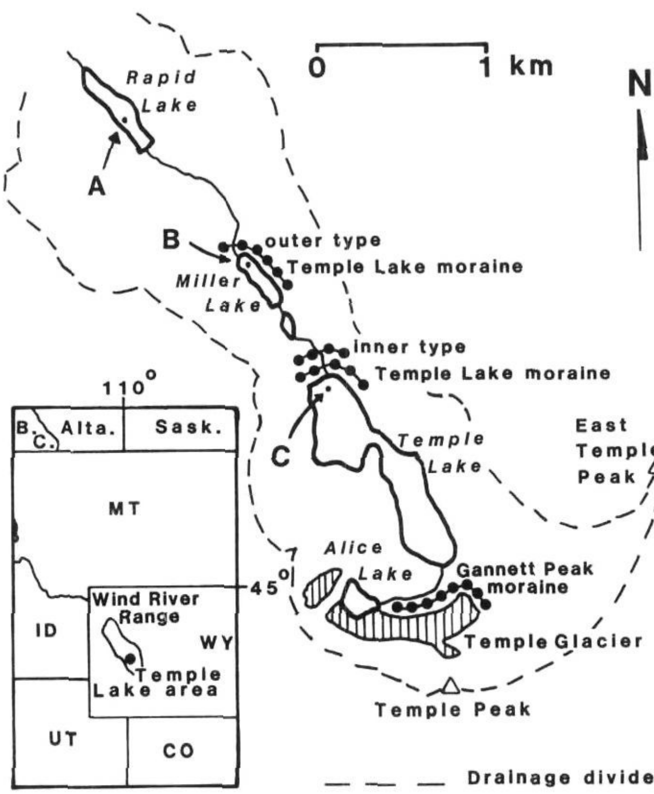

FIGURE 1. Schematic map of the Temple Lake valley showing the spatial relationship between lakes and type Temple Lake moraine system. Location of sediment cores shown by A, B, and C. See text for discussion.

Carte schématique de la vallée de Temple Lake montrant les relations spatiales entre les lacs et le système morainique de référence de Temple Lake. La localisation des sites de carottage est identifiée par A, B et C.

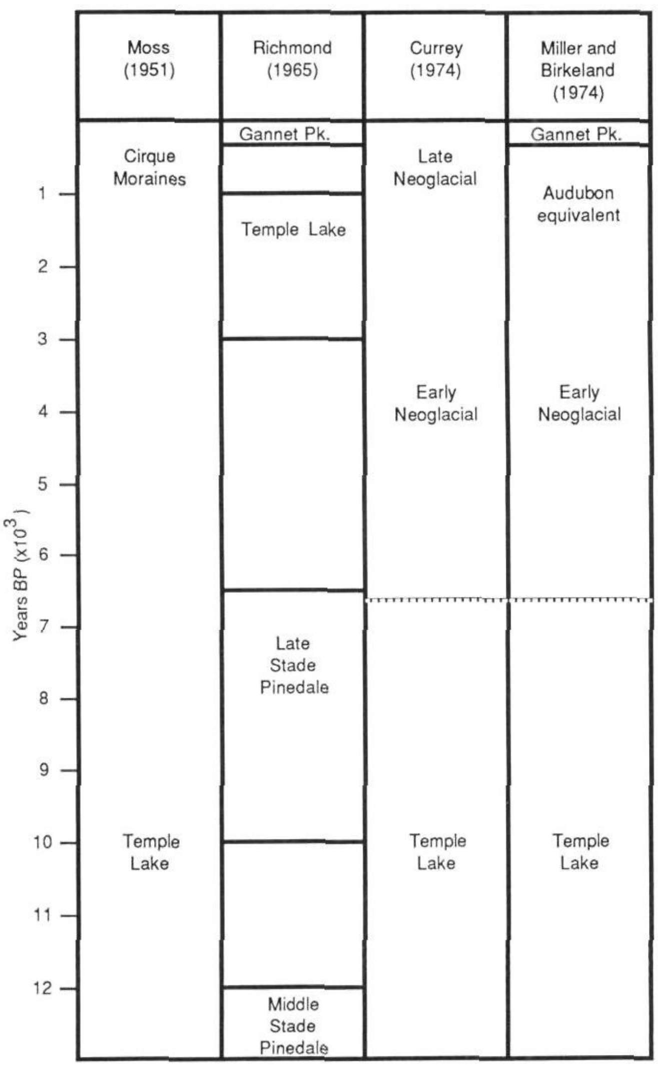

FIGURE 2. Development of the late Pleistocene and Holocene chronologies for the Temple Lake valley.

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versely with glacier activity, and thus provides a valuable proxy record of climatic or environmental change.

RESULTS

Two sediment cores up to six meters long and less than one meter apart were retrieved from 11.0 meters of water in Rapid Lake downvalley from the outer type Temple Lake moraine (A on Fig. 1). Rapid Lake Core 85-1 consists of an upper 3.8 m of organic-rich silt and clay (gyttja) with a 0.3 m laminated transitional zone separating a lower 2.0 m of inorganic silt, sand, and gravel (Fig. 3). Dry sediment Munsell colors reflect these three zones, ranging from 5Y 3/1 to 5Y 2/1 in the upper gyttja zone, changing to 5Y 5/3 in the transitional zone, and to 5Y 5/1 in the lower inorganic zone. As reported in ZIELINSKI and DAVIS (1986), the transitional zone (383-413 cm) yielded a radiocarbon age of 11,770 ± 710 yrs BP (GX-11,772) (Table I). Organic carbon trends in Rapid Lake Core 85-1 correlate to the lithostratigraphy, with high organic percentages (5-10%) in the upper 3.8 m, 2-5% in the transitional zone, and low organic percentages (less than 2%) in the lower 2.0 m of core (Fig. 3).

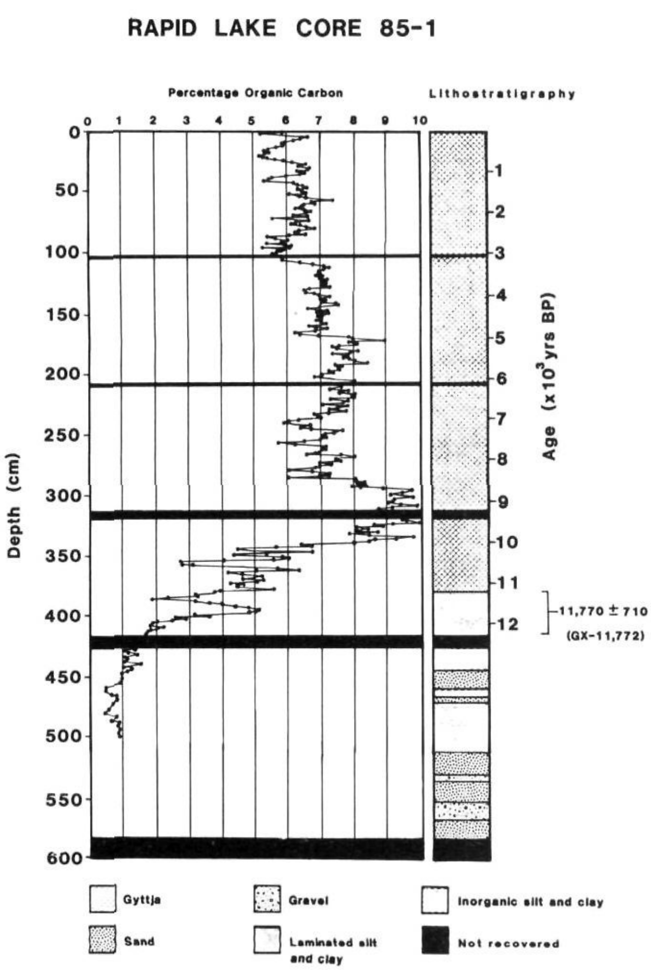

FIGURE 3. Lithostratigraphy and percentage organic carbon trends of Rapid Lake Core 85-1.

La lithostratigraphie et les taux de carbone organique, carotte n° 85-1, Rapid Lake.

An 85-cm long sediment core was obtained from 10.5 m of water in Miller Lake located inside the outer type Temple Lake moraine (B on Fig. 1). Miller Lake Core 3 is dominantly gyttja with dry Munsell colors of 5Y 3/1 to 5Y 2/1, although there are several sand lenses in two parts of the upper 28 cm (Fig. 4). The bottom eight centimeters of this core (77-85 cm) yielded a radiocarbon age of 8300 ± 475 yrs BP (GX-12,277) (Table I), as previously reported by ZIELINSKI and DAVIS (1986). Organic trends here reach a maximum in the lower 55 cm or early Holocene part of the core, with generally lower values in the upper 30 cm. These trends correlate well with those from roughly the same time period in Rapid Lake Core 85-1.

A 74-cm long sediment core obtained from 10.5 meters of water in the lower basin of Temple Lake, inside the inner type Temple Lake moraine (C on Fig. 1), consists of an upper 39 cm of gyttja with a 19-cm transitional zone (39-58 cm)

TABLE I

Radiocarbon dates and lacustrine sediment data

Radiocarbon Date (yrs BP)	Laboratory Number	Location	Sediment Depth (cm)
11,770 ± 710	GX-11,772	Deepest part of Rapid Lake	383-413
8,300 ± 475	GX-12,277	Lower end of Miller Lake	77-85
11,400 ± 630	GX-12,719	Lower end of lower basin in Temple Lake	49-58

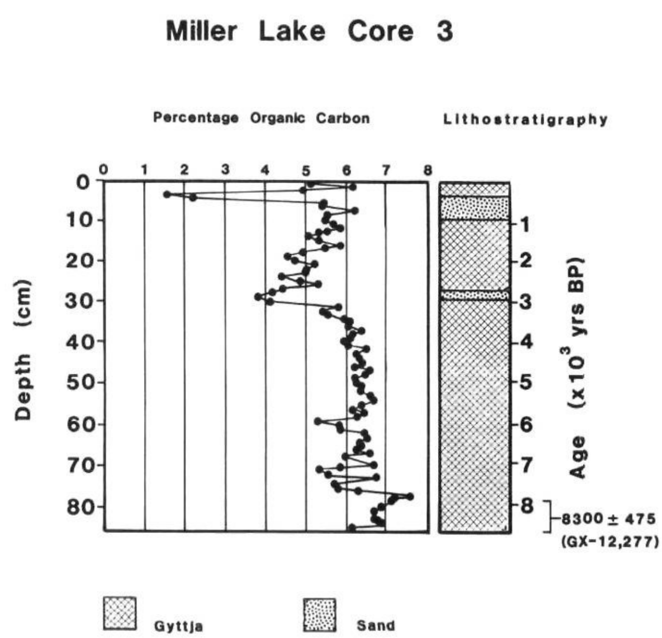

FIGURE 4. Lithostratigraphy and percentage organic carbon trends of Miller Lake Core 3.

La lithostratigraphie et les taux de carbone organique, carotte n° 3, Miller Lake.

separating the lower 16 cm of inorganic silt and sand (Fig. 5). Dry Munsell colors throughout these three zones are similar to those in Rapid Lake Core 85-1. The lower nine centimeters of the transitional zone (49-58 cm) yielded a radiocarbon age of 11,400 ± 630 yrs BP (GX-12,719) (Table I). Organic carbon trends in sediments from Temple Lake (Fig. 5) do not correlate well to trends in sediment cores from Miller and Rapid lakes. However, the sediment accumulation rate is much slower and the chronology presented for Lower Temple Lake Core 7 may shift as additional radiocarbon dates become available (ZIELINSKI, 1987).

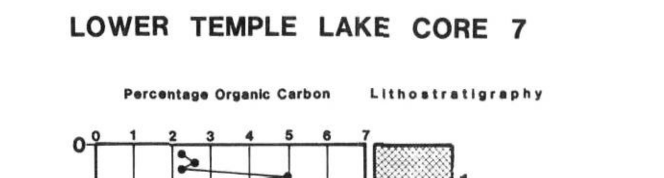

FIGURE 5. Lithostratigraphy and percentage organic carbon trends of Lower Temple Lake Core 7.

La lithostratigraphie et les taux de carbone organique, carotte n° 7, Temple Lake.

DISCUSSION

The 11,770 ± 710 yrs BP date obtained from the transitional zone in Rapid Lake Core 85-1 could mark the time when silt flux into Rapid Lake was abruptly reduced by the formation of a new sediment trap at Miller Lake as the valley glacier receded from its position at the outer type Temple Lake moraine (Fig. 6). A radiocarbon date of 11,400 ± 630 yrs BP obtained from lower Temple Lake inside of the inner type Temple Lake moraine supports this interpretation. Although the 8300 ± 475 yrs BP date obtained from Miller Lake is early Holocene in age, the material dated is certainly not from the basal portion of the lake sediment sequence. The age of the Miller Lake basin may be substantially older because minimum-limiting dates from the basal portions of lakes and bogs could be up to several thousand years too young due to the time lag between glacier recession and the sealing of lake or bog bottoms with sediment (DAVIS and DAVIS, 1980). Thus, we feel that the type Temple Lake moraine system probably dates to about 12,000 yrs BP, and is thus Late Pleistocene not Early Holocene in age as suggested by BEGET (1983). Maximum organic carbon percentages in the Early Holocene portions of these sediment cores further challenge the hypothesis of climatic deterioration during this time period. The Late Pleistocene age of the Temple Lake moraine together with organic trends in the Early Holocene suggests that the glacial chronology of the southern Wind River Range is not unlike to that originally proposed by MOSS (1951).

Although the interpretation of the radiocarbon ages with respect to the type Temple Lake moraine is rather straightforward, there may be questions raised concerning possible contamination of the radiocarbon-dated material. We feel, however, that contamination is minimal as there were no apparent rootlets or slump material in the dated portions that could give an erroneous age. Moreover, bulk chemistry of the local bedrock, as determined by BENEDICT (1982), failed to indicate the presence of minerals, such as

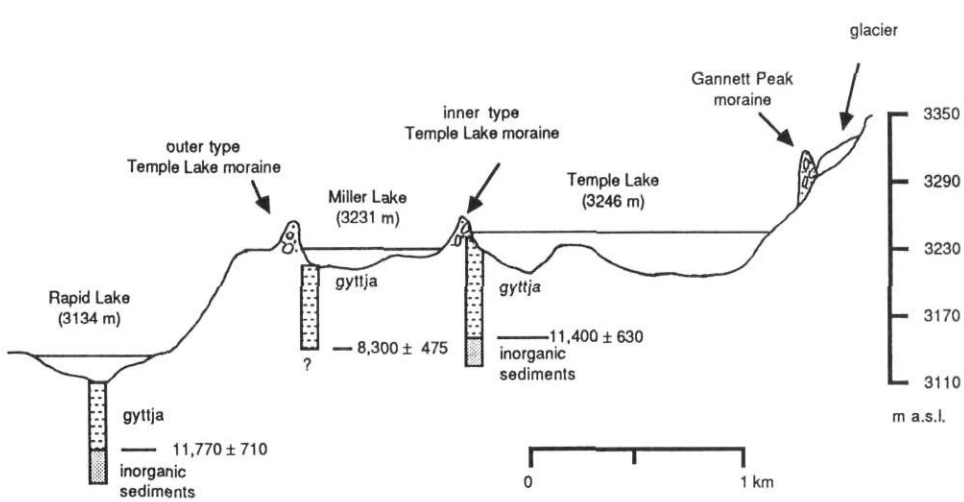

FIGURE 6. Schematic profile showing the spatial and altitudinal relationships between the radiocarbon dated, lacustrine sediment cores and the type Temple Lake moraine system.

Profil schématique montrant les relations spatiales et altitudinales entre les carottes de sédiments lacustres datées au radiocarbone et le système morainique de référence de Temple Lake.

graphite, which could cause a radiocarbon age to be too old. Too old an age may also be obtained due to a long mean residence time of radiocarbon in the lake water. We need to obtain radiocarbon dates from near-surface sediments of these cores to establish mean residence times, however, unpublished work by DAVIS from Arapaho Cirque in the Colorado Front Range suggests that mean residence times in alpine lakes may only be on the order of a few hundred years. A residence time of this magnitude would not considerably alter our proposed age of 12,000 yrs BP for the type Temple Lake moraine, especially when a minimum-limiting date from the basal portion of the lacustrine sediment sequence may be thousands of years too young due to lag times of sediment accumulation following deglaciation.

CONCLUSIONS

1) The type Temple Lake moraine was deposited around 12,000 yrs BP.

2) Percentage organic detritus in lacustrine sediments in the Temple Lake valley generally reach a maximum during the Early Holocene.

3) Evidence is lacking in Temple Lake valley for "Mesoglaciation", BEGET's (1983) proposed Early Holocene period of glacial advance similar in magnitude to Neoglacial periods of advance.

4) The Late Pleistocene age of the type Temple Lake moraine, together with detrital organic trends through the Early Holocene, suggests that the Holocene glacial chronology for the Wind River Range is similar to that originally proposed by MOSS (1951).

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