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NOTES AND COMMENTS

TOWARD AN ABSOLUTE CHRONOLOGY AT ELK LAKE, MINNESOTA

GERALD E. AARDSMA

Aardsma Research and Publishing, Loda, Illinois 60948-9651 USA

ABSTRACT. Radiocarbon measurements on organic carbon from the varved cores of Elk Lake, Minnesota suggest that the varve count may underestimate calendar years by 18% for the most recent 3800 varve years.

INTRODUCTION

Anderson *et al.* (1993) report a Holocene chronology constructed by counting varves in a 22-m series of cores recovered from the deepest portion of Elk Lake in Minnesota (47°12′N, 95°15′W). Sprowl (1993) used multiple varve counts from four parallel cores recovered from Elk Lake to estimate the counting precision of Elk Lake varves. He found that the imprecision averaged 12% at the 95% confidence level. However, Sprowl observed that counting errors were probably not normally distributed since the probability of counting too few varves seemed greater than that of counting too many. The problem of uncounted varves suggests that Elk Lake varve years underestimate calendar years by an unknown amount.

Anderson *et al.* (1993) reported 16 radiocarbon measurements on organic material from the Elk Lake cores. The purpose of the present analysis is to estimate the fraction of uncounted varves at Elk Lake using these ^{14}C measurements.

METHODS

Two equations are involved in this problem. First is the relation between the ^{14}C ages of lacustrine and terrestrial samples

$$A_{atm}(t) = A_{lake}(t) - A_{old}(t)\ . \qquad (1)$$

In this equation, $A_{atm}(t)$ is the ^{14}C age of a terrestrial sample, $A_{lake}(t)$ is the ^{14}C age of an organic sample that grew in Elk Lake, and $A_{old}(t)$ is the contribution to the ^{14}C age of the lake sample from the presence of old carbon in Elk Lake (*i.e.*, due to the reservoir effect).

The second equation provides an explicit relation between Anderson's varve number and calendar years, t

$$t = -((1+f)V + 23)\ . \qquad (2)$$

In this equation, f is the fraction of varves that have gone uncounted and V is the varve number (counted from the top of the core). The time variable, t, is chosen to be zero in AD 1950, in agreement with the standard ^{14}C convention. The value 23 results from the fact that $t = 0$ corresponds to AD 1927 in the varve chronology (Anderson *et al.* 1993: 40). (AD 1927 is the estimated date of the uppermost varve to be recovered for the Elk Lake chronology. This date is based upon a known (AD 1903) horizon. More recent varves are suspected to have been disrupted by coring activities since 1967.)

The time-dependent reservoir effect at Elk Lake, $A_{old}(t)$ in Equation (1), is unknown. The lake is located in calcareous glacial till, so the effect is substantial. It is necessary to approximate this quantity in some way in order to proceed.

The climate at Elk Lake has shifted from postglacial through prairie to modern mesic forest stages during the >10,000 yr of the lake's history (Anderson 1993). It is unlikely that the contribution of old carbon to the lake has been constant throughout these climate changes. However, the shift to modern climatic conditions took place *ca.* 3800 varve yr ago. It seems reasonable to expect the long-term average of the reservoir effect to have been approximately constant for at least the past 2800 varve yr. Weathering rates of the calcareous till surrounding the lake would not be expected to change significantly during this latter part of the modern climatic stage at Elk Lake. Thus, I have approximated $A_{old}(t)$ by a constant, A_{old}, and restricted the following analysis to the past 2800 varve yr.

To solve Equations (1) and (2) in this approximation, I proceeded as follows. Nine of Anderson's ^{14}C samples fall within the past 2800 varve yr. I chose a value for f, and used it to compute t for each of these nine samples. $A_{atm}(t)$ can then be obtained from the calibration table of Stuiver and Becker (1993). According to Equation (1), with A_{old} substituted for $A_{old}(t)$, a plot of $A_{atm}(t)$ *vs.* $A_{lake}(t)$ for these nine samples should yield a straight line with unit slope for the correct choice of f. I used a standard unweighted linear regression analysis to compute the slope of $A_{atm}(t)$ *vs.* $A_{lake}(t)$ for various choices of f.

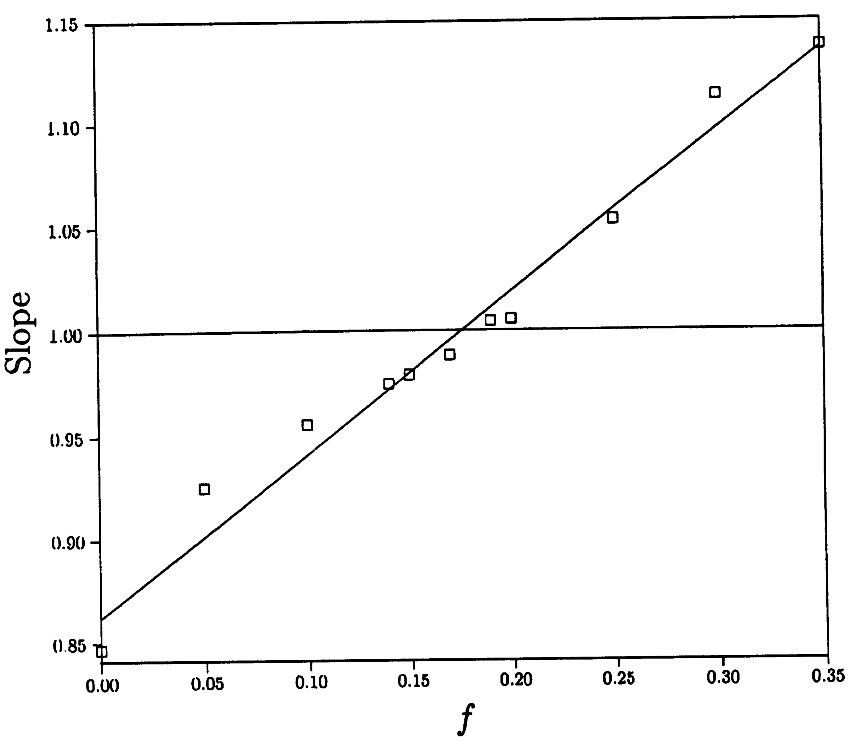

Fig. 1. Calculated slopes of $A_{atm}(t)$ versus $A_{lake}(t)$ for nine ^{14}C samples resulting from various choices of f. The diagonal line results from a linear regression applied to the data points shown.

Results

Figure 1 shows the calculated slopes resulting from different choices of f. The line drawn through the data intersects the slope = 1 line at $f = 0.18 \pm 0.02$. (The reservoir effect for this value of f is found to be 600 ^{14}C yr.) This implies that 18% of annual varves have gone undetected in the Elk Lake varve chronology during the most recent 2800 varve yr. This is a large percentage, but it is not incommensurate with Sprowl's measured varve counting imprecision of 12% at Elk Lake mentioned above.

Conclusion

This result implies that the end of the prairie period at Elk Lake, which occurred 3800 varve yr ago, should be dated to 2500 BC.

References

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