RADIOCARBON DATING OF BURIED TREES AND CLIMATE CHANGE IN WEST-CENTRAL OKLAHOMA

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ABSTRACT. Eleven radiocarbon dates and tree-ring analyses of 3 juniper logs demonstrate the potential for ^{14}C analysis of buried logs in the American Midwest. Three junipers (*cf. Juniperus virginiana*) were recovered from 9.20, 10.50, and 10.60 m in the fill of Carnegie Canyon, west-central Oklahoma. Their ^{14}C ages are calibrated between 3300 and 2800 yr ago. A negative correlation of tree rings and $\Delta^{14}C$ ($p = 0.013$) supports the findings of Schmidt and Gruhle (1988), who demonstrate the association of global cooling with reduced solar activity.

Introduction

Perhaps the strongest evidence for a causal connection between solar variability and climate change is that of Schmidt and Gruhle (1988), who demonstrate that narrow tree rings (an indicator of, *e.g.*, cooling) are associated with high $\Delta^{14}C$ values (an inactive Sun) in buried logs of southern Germany. To our knowledge, no other dendroclimatic analysis has demonstrated a direct correspondence of climatic change and positive ^{14}C anomalies. Such an association is not unlikely, however, because a direct association between tree-ring data and the 22-yr sunspot cycle (an index of solar activity) has been demonstrated by Meko, Stockton and Blasing (1985) for the American Midwest. Additional studies have shown a correspondence of climate change and ^{14}C anomalies using other climatic proxies (de Vries 1958; Eddy 1967, 1977; Jirikowic, Kalin and Davis 1993; Davis 1992, 1994).

A possibility for replicating Schmidt and Gruhle's (1988) findings exists in the American Midwest. More than 63 buried logs (mostly juniper, *cf. Juniperus virginiana*) were exposed by scouring and headwall cutting at Carnegie Canyon, 4 km east of Carnegie, Oklahoma (Lintz and Hall 1983; Hall and Lintz 1984). Boreholes through the late-Holocene fill indicate that the buried canyon is up to 120 m wide and 30 m deep (Hall and Lintz 1984). Eight standard ^{14}C dates for logs buried from 7.5–11 m have calibrated ages of 3380–2780 yr BP (Table 1).

These ages predate and overlap a major $\Delta^{14}C$ anomaly (the "Hallstattzeit disaster", 2800 cal BP) investigated by Schmidt and Gruhle (1988). Our goal has been to reinvestigate the Carnegie Canyon deposit, attempting to find tree-ring series that span the Hallstattzeit disaster. By comparing tree-ring widths and $\Delta^{14}C$ values for the Carnegie Canyon junipers, we hope to evaluate Schmidt and Gruhle's (1988) results.

Methods

Sections of the Carnegie Canyon logs were deposited at the University of Arizona Laboratory of Tree-Ring Research and elsewhere (Lintz and Hall 1983). Eight well-preserved, undated cross-sections were surfaced and the rings counted along two radii per section. The rings were clearly annual, and false rings were readily identified. Numerical analyses demonstrated that crossdating was possible among specimens.

Three of the longest series were ^{14}C dated (Table 2). To obtain sufficient carbon, adjacent 9-ring segments (14 rings for 2 samples) were dated. Three dates were obtained for CAR181 and CAR070, 5

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TABLE 1. Calibration of Previously Published ^{14}C Ages of Carnegie Canyon Buried Logs

Depth (m)	Lab no.	^{14}C age (yr BP)	Calibrated age (cal BP)
7.50	Beta 2783	2710 ± 60	2780
8.70	Beta 2782	2760 ± 60	2845, 2800
8.30	Beta 2775	2870 ± 50	2990, 2960
10.50	Beta 2779	2870 ± 50	2990, 2960
10.60	Beta 2777	3010 ± 50	3200, 3190, 3180, 3170, 3145, 3085
8.70	Beta 2781	3020 ± 50	3234, 3210
9.20	Beta 2624	3060 ± 50	3320, 3310, 3300, 3270, 3210
10.00	Beta 2778	3150 ± 60	3375, 3360

TABLE 2. Calibrated Ages of Carnegie Canyon Buried Junipers

Tree no.	Depth (m)	Rings dated	Lab no.	^{14}C age (yr BP)	Calibrated age (cal BP)
CAR181	9.20	21–31	A-6633	2820 ± 40	2920, 2905, 2885
		31–40	A-6634	2865 ± 45	2995, 2960
		121–130	A-6765	2715 ± 50	2785
CAR271	10.50	131–140	A-7176	2995 ± 70	3190, 3150, 3090
		151–160	A-7175	2960 ± 70	3160, 3135, 3105, 3080, 3070
		181–190	A-7174	2950 ± 70	3155, 3130, 3100, 3090, 3080, 3055
		210–215	A-7173	3015 ± 55	3230, 3190, 3170, 3150, 3145, 3090
		251–260	A-7172	2950 ± 55	3155, 3130, 3100, 3080, 3055
CAR070	10.60	21–30	A-6635	2920 ± 50	3135, 3035, 3010
		31–40	A-6636	3055 ± 45	3310, 3250, 3215
		81–94	A-6765	3030 ± 35	3210

for CAR 271. Each wood sample was cut into matchstick-sized pieces, ground to powder with a Wiley mill, then ultrasonically cleaned and Soxhlet-extracted in toluene and ethanol. After bleaching and rinsing, the extracted white cellulose was converted to carbon dioxide, lithium carbide, acetylene, and finally synthesized to benzene. The benzene samples were measured at the Laboratory of Isotope Geochemistry, University of Arizona, using an upgraded Packard Tri-Carb® 460C liquid scintillation counter.

RESULTS

The ages of the three dated logs were precisely determined by wiggle-matching (*cf.* Long, Andresent and Klein 1987) the $\Delta^{14}C$ anomalies of the logs' dates with the master chronology of global $\Delta^{14}C$ anomalies (file UWTEN93.14C, distributed with the CALIB 3.0 program [Stuiver and Reimer 1993]). The oldest counted ring for the three logs is 2816 yr. Thus, we were unable to evaluate the climatic effects of the Hallstattzeit (= Homeric; see Davis 1992, 1994) ^{14}C anomaly.

The dearth of Hallstattzeit-age logs may, in itself, result from climate change, because aggradation begins throughout the Midwest soon after 3000 BP (Hall and Lintz 1984; May 1992). Rapid burial associated with Hallstattzeit climatic change may have preserved the Carnegie Canyon logs but prevented further growth in the valley floor.

The tree-ring indices (Fig. 1) show a negative correlation with the overall trend and the fluctuations of the ^{14}C curve. We statistically compared 10-yr averages of tree-ring indices with decadal $\Delta^{14}C$ values in the file UWTEN93.14C (Stuiver and Reimer 1993). The r^2 value for the comparison is 0.14, $p = 0.013$ (Fig. 2). We do not consider this a robust finding because only two trees were included in the analysis. A chronology based on several overlapping tree series should be developed.

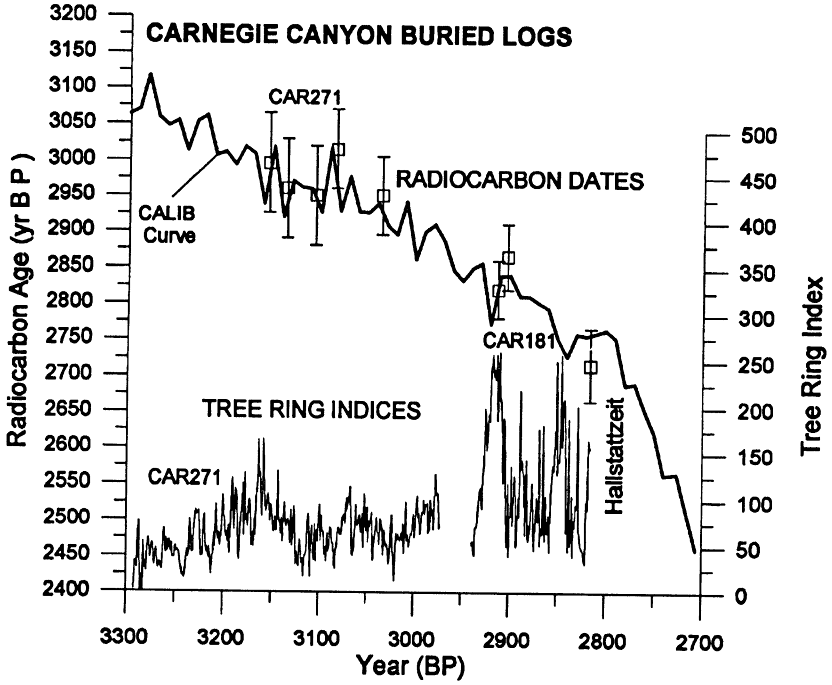

Fig. 1. Comparison of tree-ring indices with ^{14}C dates for two logs from Carnegie Canyon (CAR271 and CAR181). Upper dark curve is the decadal ^{14}C values in file UWTEN93.14C (Stuiver and Reimer 1993). Individual dates for CAR271 and CAR181 are shown ± 1 σ.

Conclusion

The negative association of tree-ring widths and ^{14}C anomalies is consistent with Schmidt and Gruhle's (1988) association of climate change with solar activity. Even though the series did not span the major Hallstattzeit anomaly, a negative association between tree rings and $\Delta^{14}C$ is demonstrated. The solar modulation of ^{14}C production and of climate is a potentially powerful tool in Quaternary science. Further investigation, using tree-ring series of the appropriate age, is warranted.

This analysis also demonstrates the potential for ^{14}C analysis of buried logs in Carnegie Canyon, in particular, and the American Midwest, in general. Buried logs have been a primary source of material for the ^{14}C calibration curve.

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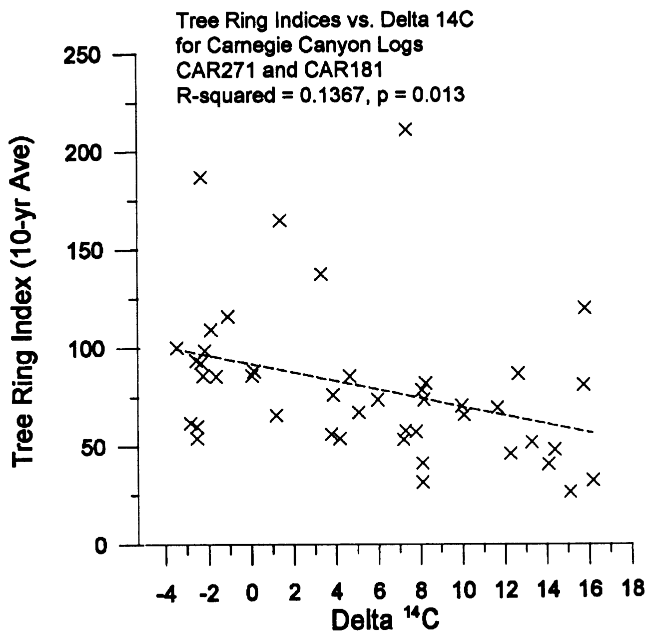

Fig. 2. Bivariate plot of $\Delta^{14}C$ anomalies (file UWTEN93.14C [Stuiver and Reimer 1993]) with tree-ring indices for logs CAR271 and CAR 181 from Carnegie Canyon. The regression line (– – –) demonstrates a negative correlation of ring indices and ^{14}C anomalies, *i.e.*, positive anomalies are associated with reduced growth.

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