POSSIBLE DEPLETION IN ^{14}C IN TREES GROWING IN CALCAREOUS SOILS

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ABSTRACT. ^{14}C activities of decadal samples from beech trees growing under extreme calcareous conditions were compared to ^{14}C activities of decadal samples of the same age from a beech tree growing in a normal mold soil in order to see whether part of the carbon assimilated during photosynthesis might originate from ^{14}C-deficient carbonates in the soil. The calcareous soils contained from 18 to 52% calcium carbonate, and this carbonate had a mean ^{14}C age of 10,200 to 17,600 years BP. A comparison was also made with the ^{14}C activity of contemporaneous samples from Douglas Fir from the US North Pacific (Stuiver, 1982).

No significant depletion in ^{14}C activity in beech trees growing in the highly calcareous soils was detected. The measured mean difference in ^{14}C activity in beech trees from calcareous and non-calcareous sites corresponds to an uptake of 0.12 ± 0.3% carbon from soil carbonates in the calcareous sites.

INTRODUCTION

It is a prerequisite for a universal ^{14}C time scale that regional variations in the ^{14}C content of suitable organic materials are minimal compared to dating errors. A large number of comparisons between the ^{14}C activity of wood grown in North America and in Europe between AD 950 and the present have shown that regional or continental variations in the atmospheric ^{14}C levels of the northern hemisphere have indeed been small (Stuiver, 1982). The application of a universal calibration curve for the whole northern hemispfere, therefore, seems justified.

However, this concordance may be upset in specific cases if soil CO_2 and soil carbonate, deficient in ^{14}C, could enter via the root system into the photosynthetic pathways and be assimilated together with atmospheric CO_2 during photosynthesis. This mechanism might be considered because inorganic minerals from the soil are known to take part in the intermediate photosynthetic processes.

In order to investigate this possibility, which does not seem to have attracted much attention, neither from ^{14}C laboratories nor from plant physiologists, the ^{14}C activity of

annual rings of a known age from two beech trees which had grown in extremely calcareous soils was measured and compared to the ^{14}C activity of annual rings of the same age from a beech tree which had grown in a normal mold soil. The distance between the calcareous and the non-calcareous sites was only ca 20km. The ^{14}C activity was further compared to the supposed mean hemispheric ^{14}C activity of tree rings from the northern hemisphere as given by Stuiver (1982).

DENDROCHRONOLOGIC MATERIAL

Extreme calcareous conditions prevail in a small protected test forest at Allindelille in the middle of Zealand, Denmark. In parts of the forest, pre-Quaternary carbonates crop up to the surface or are covered only by a thin layer of mold soil which, itself, contains up to 50% carbonates. Beech trees growing in this soil are chlorotic and develop light yellow leaves because the strongly alkaline conditions inhibit an uptake of iron from the soil.

Two beech trees (Fagus sylvatica) from such a chlorotic grove were felled and the annual rings were counted dendrochronologically and divided into decadal samples. The first beech tree, Al I, was ca 160 years old and mold soil taken 5 to 15cm below the surface, directly at the stub, contained ca 18% $CaCO_3$ relative to the dry weight of the soil. This carbonate had a mean ^{14}C age of 10,260 $\pm$ 155 years BP ($\delta^{13}C$ = -2.4 ^{o}/oo PDB). The second beech tree, Al II, was 75 years old and grew in a soil that contained ca 52% carbonates of a mean ^{14}C age of 17,620 $\pm$ 310 BP ($\delta^{13}C$ = +1.3^o/oo PDB).

For comparison, decadal samples of ages identical to those from Allindelille were taken from a third beech tree (Fagus sylvatica) that had grown in a normal mold soil with < 1% carbonate. The beech tree, So I, grew in wooded grounds at the outskirts of a minor town, Sorø, ca 20km from Allindelille.

^{14}C ACTIVITIES

All the tree-ring samples were extracted with diluted acid and hydroxide (de Vries pretreatment), and the ^{14}C activities were measured in a CO_2 gas counter. All measurements were corrected for isotopic fractionation and normalized to $\delta^{13}C$ = -25.0^o/oo PDB. $\delta^{13}C$ values ranged from -24.9 to -26.0 ^{o}/oo for the chlorotic beech trees (lowest for Al II which had grown in the most alkaline soil), and from -23.3 to -24.0^o/oo for the normal beech tree.

The measured activities are listed in table 1 as conventional and normalized ^{14}C ages. The very precise ^{14}C ages measured by Stuiver (1982) on decadal samples of similar ages taken from Douglas Fir (Pseudotsuga menziesii) from the Paci-

TABLE 1. ^{14}C activity of tree rings from calcareous and non-calcareous sites

Annual rings   Conventional ^{14}C years BP

AD	Beech calcareous Al I	Beech calcareous Al II	Beech non-calcareous So I	Douglas Fir US Pacific (Stuiver,1982)
1850-1860	29 ± 35		48 ± 40	116 ± 10
1870-1880	61 ± 40		43 ± 40	113 ± 10
1890-1900	149 ± 40		70 ± 40	82 ± 10
1900-1910		143 ± 40*	62 ± 40	75 ± 10
1910-1920		122 ± 40	133 ± 40	114 ± 10
1920-1930		141 ± 40	164 ± 40	132 ± 10
1930-1940		123 ± 40	126 ± 40	150 ± 10

Mean of paired differences:

    Al I and Al II minus So I   :   +8 ± 20 ^{14}C years
    Al I and Al II minus Douglas Fir: −7 ± 15 ^{14}C years
    So I minus Douglas Fir   : −20 ± 16 ^{14}C years

*Represents only annual rings 1903-1910

fic Northwest of the US are also listed in table 1. These ^{14}C ages are supposed to be close to the mean ages of contemporaneous wood from the northern hemisphere.

Table 1 shows that no significant systematic deviations between the ^{14}C activities of contemporaneous samples from the chlorotic beech trees (Al I and Al II) and from trees growing in normal soils could be found. Paired differences between the ^{14}C ages of Al I or Al II and So I (8 pairs) have a mean value of +8 ± 20 years, and the paired differences between Al I or Al II and the Douglas Fir (8 pairs) have a mean value of −7 ± 15 years. It may also be noted that the paired differences between the ^{14}C ages of contemporaneous samples from the normal beech tree from Denmark (So I) and from Douglas Fir from the US (7 pairs) have a mean value of −20 ± 16 years. This is an approximate measure of either the difference in atmospheric ^{14}C levels between Denmark and the US Pacific coast, or of the laboratory bias of the Copenhagen ^{14}C lab relative to the Seattle ^{14}C laboratory.

CONCLUSION

The mean difference between ^{14}C ages of contemporaneous decadal samples from beech trees growing in highly calcareous soils and in a normal mold soil was measured to +8 ± 20 years. Hence, a significant assimilation of soil CO_2 or soil carbonate during photosynthesis could not be detected. If the ^{14}C ages of the soil carbonate (ca 10,200 to 17,600 BP) are taken into consideration, the measured mean difference in ^{14}C ages correspond to an uptake in tree rings of 0.12 ± 0.3% carbon from soil carbonate in the beech trees growing in highly calcareous soils. Only in very special cases could a possible assimilation of this magnitude constitute a source of error in ^{14}C dating.

ACKNOWLEDGMENTS

REFERENCE

Stuiver, Minze, 1982, A high-precision calibration of the AD radiocarbon time scale: Radiocarbon, v 24, p 1-26.