

ON $\delta^{18}\text{O}$ OF COMBUSTION-DERIVED CO_2

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INTRODUCTION

Exchange rates within the Global Carbon Cycle, between oceans, atmosphere and terrestrial biosphere – including the anthropogenic CO_2 production – are being traced by concentration and isotope ratio measurements of atmospheric CO_2 . The background value of the stable isotope ratio of oxygen in atmospheric CO_2 is determined by oxygen exchange with the ocean surface waters. During contact with leaf water, the signature of this then evaporation-enriched groundwater (the extent still being dependent on plantphysiological and environmental parameters), will be imprinted on CO_2 diffusing back out of the leaf stomata. From water cycle studies the continental effect (Rayleigh-distillation) is known, leading to precipitation strongly depleted in $\delta^{18}\text{O}$ over e.g. Siberia. This signal is also transferred into plant material. These main mechanisms within the ^{18}O -cycle are known or under investigation. The $\delta^{18}\text{O}$ source term for atmospheric CO_2 derived from biomass burning and anthropogenic fossil fuel combustion, however, is less well-known.

In simulation studies $\delta^{18}\text{O}$ of combustion-derived CO_2 normally is set to -17‰ vs. VPDB- CO_2 [e.g. Ciais *et al.*, 1997], which corresponds to an unfractionated transfer of oxygen from atmospheric molecular oxygen into CO_2 , and does not account for any oxygen content of the fuel substances to be transferred into the produced CO_2 . An oxygen isotope fractionation during combustion had first been described by Zimnoch [1997], we present the results of a more systematic investigation, i.e. by applying controlled differing combustion regimes.

INTRINSIC AND GEOGRAPHICAL VARIATIONS OF $\delta^{18}\text{O}$ IN PLANT MATERIAL

We measured oxygen isotope variations of plant material in a survey from southern to northern and from western to eastern Europe and Siberia as a rough study of the variability of plant material $\delta^{18}\text{O}$. Even between Central Germany and Northern Sweden we observed an offset of about 5‰ , the higher values being attributed to Germany, as expected. This could be independently confirmed for e.g. wood, needles and cones of a *Picea* species by Pyrolysis-IRMS, as shown in figure 1.

The variations between different parts of the same plant are also in the order of 5‰ . In total we could easily find a range of 10‰ in $\delta^{18}\text{O}$ of the plant material.

ISOTOPE FRACTIONATION DURING COMBUSTION

Different parts of plants (e.g. needles, leaves, wood, bark) were then combusted under varying burning regimes. The same procedure was applied to usual (fossil) fuels, i.e. peat, lignite, anthracite and natural gas. The combustion-derived CO_2 showed variations between the expected non-fractionated $\delta^{18}\text{O}$ of -17‰ and -23‰ vs. VPDB- CO_2 . The influence of the material's own $\delta^{18}\text{O}$ and its water content on the final product CO_2 will be discussed.

An estimation of the influence of anthropogenic combustion and biomass burning on the global $\delta^{18}\text{O}$ of CO_2 will be made. Though on the longer term the signal will be “washed out” by oxygen isotope exchange with the oceans or the biosphere, it is important to account in model computations for the deviation from the non-fractionated isotope transfer from O_2 to CO_2 . Though the signal is certainly strongly

diluted in the atmosphere, the combustion-fractionation also leaves an isotope effect on the atmospheric molecular oxygen, getting slightly enriched in $\delta^{18}\text{O}$.

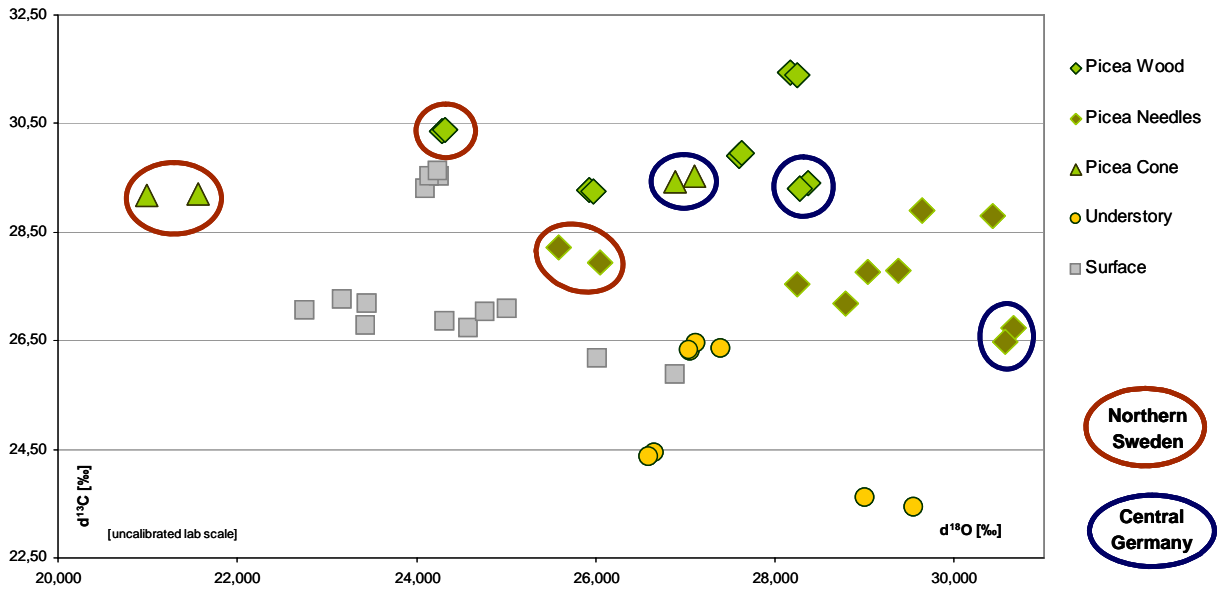


Fig. 1: $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ (both on an uncalibrated lab-scale) of different plant parts from different regions; the three left-most circles identify the samples from northern Sweden.

CONCLUSIONS

Our laboratory study shows the importance of the usage of plant material $\delta^{18}\text{O}$ maps for the implementation of biomass burning into isotopic carbon cycle simulations. Also for biomass-burning, but even more so for fossil fuel combustion, a parameterization of the combustion processes, from smouldering bush fires via fairly controlled house heating to high-efficiency industrial combustion is needed in order to resolve and model regional patterns of fossil-fuel usage and biomass burning hot spots.

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