grams, it will be offered for publication elsewhere. In this model, many of the faults in Southland (for example, the Livingstone and Hollyford faults) are related directly to the distortion which Cullen rightly points out has occurred.

In short, I agree with Cullen's observations that further evidence for crustal distortion should be sought, and that the Alpine Fault with its 480 km offset is only part of the whole story. Apart from this, however, his paper seems to offer nothing positive, and indeed fails to recognise that I have always accepted that such distortion must have occurred. If he has a different regional reconstruction, or a detailed model for the deformation of New Zealand, it might help if this was illustrated by accurate diagrams rather than sketches.

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Dendrochronology and ^{13}C content in atmospheric CO_2

FARMER and Baxter[1] have published $\delta^{13}C$ values from the wood of tree rings, indicating a decrease over the last 70 yr, which they attribute to the CO_2 increase of the twentieth century. The result, in general, was expected but some implications seem to be questionable, as we can conclude from our results[2-4].

When studying the decrease of ^{13}C in atmospheric CO_2, wood samples have to be selected very carefully. Samples selected from industrial or forest areas do not give reliable information about the average atmospheric composition[5]. The ideal recorder would be a free-standing tree on a small island far out in the ocean. We analysed tree rings of 10 trees (Fig. 1) and recognised large individual variations both in the absolute data and in the trend.

The processing of the samples is also important. It is well known that a network of resin channels permeates the wood tissue and contains soluble organic matter which cannot be correlated to the age of the wood structure. Furthermore, the components which form the wood, cellulose and lignin, have different isotopic compositions. We found a difference between the $\delta^{13}C$ values of cellulose and lignin prepared from the same wood, of almost 3 ‰. The ratio of lignin to cellulose cannot be expected to remain

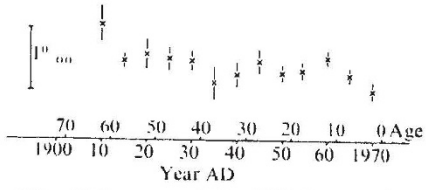

Fig. 1 Average relative ^{13}C decrease in the wood (cellulose) of tree rings during the past 70 yr obtained from 10 free-standing trees; *Quercus robur* (4), *Q. petraea* (1), *Pinus maritima* (2), *Q. lusitanica* (2), *Platanus acerifolia* (1). Each point represents a 5-yr average.

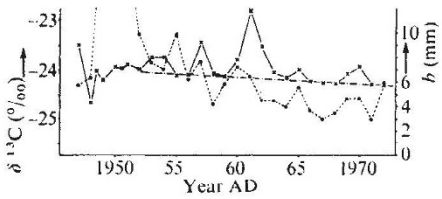

Fig. 2 *Platanus acerifolia* (Azores), showing correlation between ring width, *b* (dotted line) and $\delta^{13}C$ (PDB) values (solid line).

constant over the lifetime of the tree[6], so that the preparation of one pure component is necessary. The chemical preparation of cellulose[7], if done carefully, does not introduce artificial isotope fractionation.

Another complication arises from the fact that there are normally considerable variations in the ^{13}C content even within one single tree ring of the order of 1‰. That demonstrates clearly the necessity for matching wood taken from the same year but from different positions on the tree. Furthermore, a correlation between ring width (climate ?) and ^{13}C content has been observed (Fig. 2).

Finally, concerning the interpretation of ^{13}C curves with respect to excess CO_2 in the atmosphere, it has to be taken into account that the exchange rate of isotopic CO_2 molecules between the atmosphere and the oceans is faster than the net flux of CO_2 into the oceans (H.D.F. and L.W., and K. Wagener and H.D.F., unpublished). This means that without any further information it is not possible to draw any direct conclusions from ^{13}C measurements about the actual CO_2 excess in the atmosphere, even if the fractionation factors are constant.

A detailed presentation of our results will be given elsewhere.

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DRS FARMER AND BAXTER* REPLY—The data of Freyer and Wiesberg[1] represent a welcome and significant contribution to the preliminary study of $\delta^{13}C$ trends in recent wood. It is gratifying that their results agree closely with our own[2] (Fig. 1) and thereby seem reasonably to negate their criticisms of the different procedures. Although suggestive of a common temporal trend in $\delta^{13}C$, their presentation of data as average deviations over 5-yr periods for 10 trees of differing species and locations does not permit inspection of the individual $\delta^{13}C$ trend for each tree. They thus preclude any precise assessment of discrepancies caused by variations in species or location. Such discrepancies were, for example, noted in our oak and larch data but, of course, are now obscured by the averaging process.

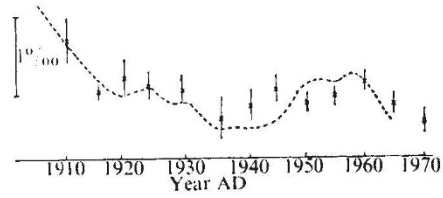

Fig. 1 Comparison of $\delta^{13}C$ trends in twentieth century wood. Dotted line, mean of data from the same UK oak and larch samples as we reported previously[2]. The points and accompanying errors are those of Freyer and Wiesberg[1] representing the averaged data on 10 selected trees.

In response to specific comments about procedure we would assert that, first, the European larch was indeed selected from a free-standing and exposed situation and yet showed a similar $\delta^{13}C$ trend to the forest oak. Second, the dangers of inducing fractionation or contamination during cellulose extraction seem comparable to the possible risks in using whole wood. Third, concerning the ever present difficulty in obtaining a representative biospheric sample, the suggestion of Freyer and Wiesberg, though admirable in intention, could well result in a logistical problem of overwhelming proportions without guaranteeing the comparable representativeness of every sample.

Extreme caution in data interpretation was initially urged by us, and Freyer and Wiesberg are correct to reinforce this view. Nevertheless, it remains undeniable that during the first 20–30 yr of this century, recorded levels of $\delta^{13}C$ show an unexpected decline which could not have been caused even by complete retention of all the fossil CO_2 introduced into the atmosphere. Furthermore, the CO_2 levels deduced from our $\delta^{13}C$ values for 1900–1920 agree well with those of Callendar's exhaustive summary[3], leading to the postulate of an additional biogenic source of CO_2.

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