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SOME REMARKS ON THE INTERPRETATION AND CALIBRATION OF RADIOCARBON DATING

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INTRODUCTION.

The natural radiocarbon isotope ^{14}C is created in the upper layers of the atmosphere. It reacts almost immediatly with oxygen to form carbon dioxide ($^{14}CO_2$) which mixes with the non radioactif carbon dioxide ($^{12}CO_2$) from the atmosphere. In this way radiocarbon enters the carbon cycle. In oceans, seas and lakes it is transformed into carbonate and bicarbonate. By fotosynthesis radiocarbon is build in plantcells and indirectly in animals. Through the dynamic equilibrium in the oceans, by the death of plants and animals and the process of putrefaction, the carbon is recycled. Assuming that there is an equilibrium in the production and consumption of ^{14}C, the radiocarbon content of each carbon reservoir (biosphère, atmosphere, oceans, etc...) will be stable : the material stays "modern". Between these reservoirs there exists an important difference. The so called "reservoir age" of seas can differ from place to place on earth. Seas in the northern part of Europe showed reservoir ages from 300-400 years. So in most cases of marin shell dating a control sample, from the turn of the century to about the time of World War II, is necessary (fig. 1).

When material becomes isolated from the exchange reservoir (e.g. : a tree is cut, organic plantmaterial is stored in a deposit, an animal dies) there is no more take up of radiocarbon an due to the radioactive decay (Libby Half-Time = 5570 years) the activity of the sample is decreasing. A radiocarbon date indicates in fact the moment when the sample leaves the carbon cycles. To date a geological phenomenon one must be sure that there is a close relationship between the geological event and the sample.

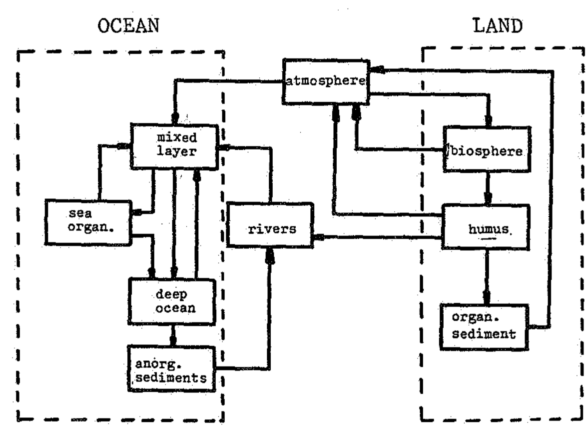

Fig. 1 (after Mook)

SAMPLES AND SAMPLE PROBLEM.

Organic carbon stored in a deposit such as peat, wood, soils, etc... is unfortunately not entirely isolated from geological and biological activity. Charcoal is a very good dating material because of its chemical inertness. Still it can be polluted by modern roots and carbonate. This pollution is in most cases

(*) Koninklijk Instituut voor het Kunstpatrimonium, Jubelpark 1, B-1040 Brussel (België) obvious and can easily be removed in the laboratory. It becomes more difficult in case of polluted peat samples. These have to be washed with a hot alkaline solution to remove the younger humid acid fraction. Well preserved samples resist this treatment without any problem. Strongly contaminated samples however are also chemical unstable and a chemical attack intends to dissolve the sample completely. In this case, the reaction time or the strenght of the solution has to be decreased although the possibility that the sample remaines contaminated still exists.

Most fossil soils cannot be dated at all, even when the organic material is obtained by fractionation techniques. Although often slow, recent carbon is continuously incorporated into the organic matter. Exception can be made for truly fossilised soils underlying an impermeable layer.

Terrestrial shells often give good radiocarbon dates when corrected for isotopic fractionation (this fractionation occurs when carbon is chemically transformed from one molecule into another).

In most case the correction is small. Even carbonates from pedological origine seem usefull as a dating material.

Still pollution is very important and can change the date dramatically (fig. 2).

INTERPRETATION OF A DATE.

The laboratory always gives results as conventional radiocarbon years, expressed in years BP (before present). This means that the dates are given previous to 1950, with the use of the conventional Libby Half-Life of radiocarbon (5570 years). This Half-Life is 3% smaller than recent measurements have shown (5730 years). Still it is used to avoid confusion with earlier published date-lists. The date is only a conventional date which will stay always unchanged and valid, wether new corrections

Apparent age of a 2,000 year old sample polluted by different concentrations of modern, 1,000 year old, 5,000 year old, 10.000 year old and infinite old carbon.

Apparent age of a 10,000 year old sample polluted by different concentrations of modern, 5,000 year old, 15,000 year old and infinite old carbon.

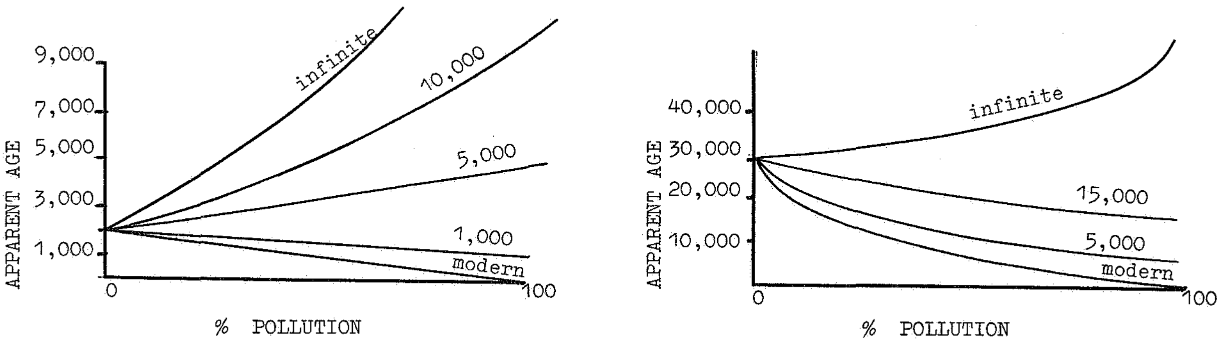

Fig. 2

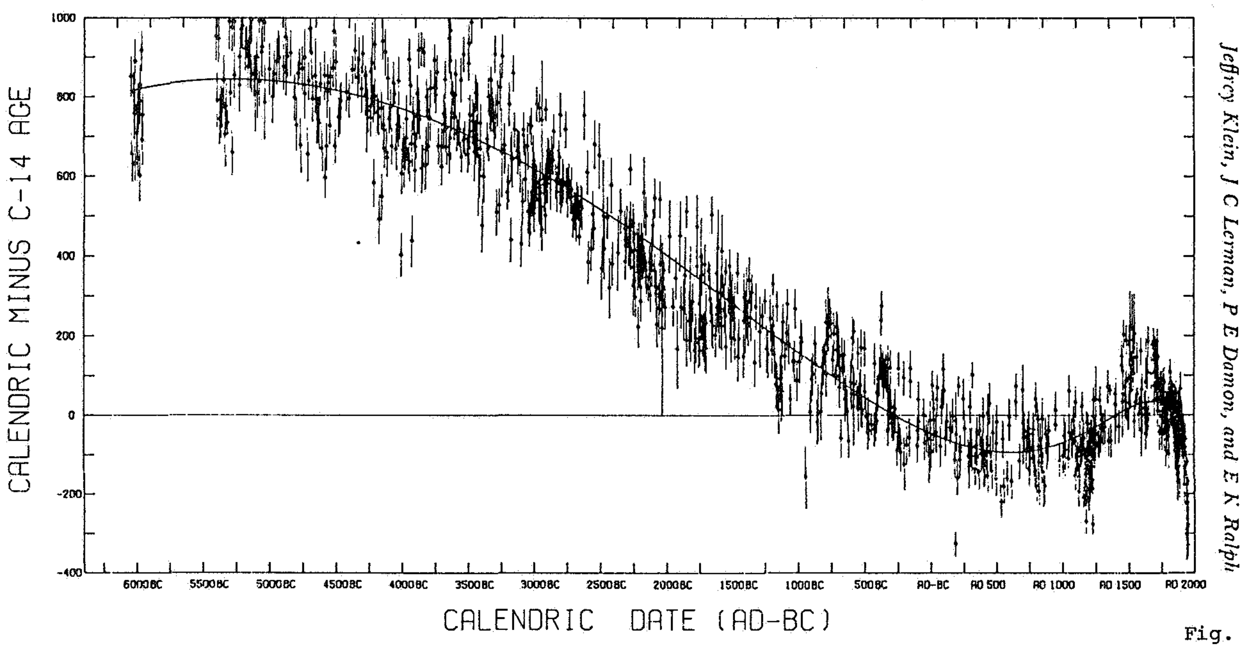

Fig. 3

may be found or not to convert radiocarbon years into calendar years. That there exists an important difference between radiocarbon and calender years is shown by fig. 3.

Upon this general trend there are smaller variations which makes it sometimes difficult to calculate a precise date. At the moment there is a good calibration curve by KLEIN *et al.* which goes back to about 7,000 BP.

Since radiocarbon dating is a technique based on radioactivity, statistics have to be taken in account. It is impossible, even with a perfect counting installation, to give an exact date. The uncertainty is built in the nature of the phenomenon itself. For this reason dates are always given ± one standarddeviation. This means that in 68 % of the cases the conventional radiocarbon age of the sample lies between the give age plus or minus the standarddeviation. This standarddeviation is only due to counting statistics. Errors due to manipulation of the sample are never included.

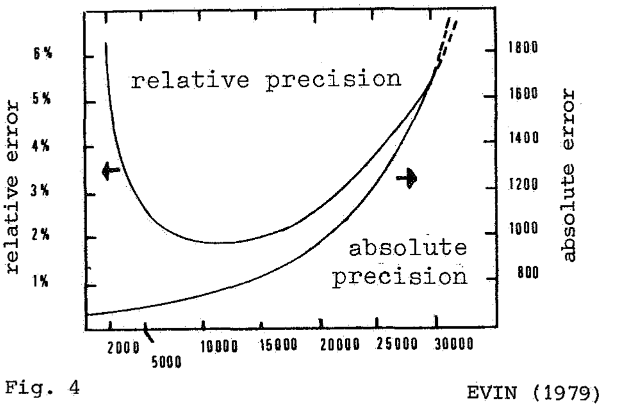

Fig. 4 EVIN (1979)

Fig. 4 gives an idea about the precision of a radiocarbon date. The optimum dating range goes from about 2,000 BP to 30,000 BP. In younger periods some good results can be obtained when multiple-sample experiments are taken. Multisample experiments are in fact always better because they not only give better statistics but also give a better control of the manipulation and liability of the sample.

Samples younger than about 1,650 AD cannot be dated at all.

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