GEOCHRONOMETRIA Vol. 18, pp 19-22, 2000 – *Journal on Methods and Applications of Absolute Chronology*

RADIOCARBON CONCENTRATION MEASUREMENTS IN CONTEMPORARY TREE RINGS FROM UPPER SILESIA

ANDRZEJ Z. RAKOWSKI, SŁAWOMIRA PAWEŁCZYK and ANNA PAZDUR

Department of Radioisotopes, Institute of Physics, Silesian University of Technology, Krzywoustego 2, Pl-44-100 Gliwice, Poland
(e-mail: rakowski@zeus.polsl.gliwice.pl, slawa@fizyka.matfiz.polsl.gliwice.pl, pazdur@zeus.polsl.gliwice.pl)

Abstract. Upper Silesia is an example of the most industrially changed natural environment in Poland. This state is a consequence of mining development in the last 150 years as well as accumulation of a number of towns and industrial companies with high impact to the environment. A decrease of radiocarbon concentration resulted from the "Suess effect" was observed in the Upper Silesia region. Estimation of this effect, on the basis of carbon isotope analysis in annual tree rings collected from trees growing in the region considered, has been carried out.

1. INTRODUCTION

Investigations of ^{14}C isotope concentration provide valuable information used e.g. for assessment of the degree of environmental pollution. Anthropogenic changes of radiocarbon concentration are particularly visible on contemporary industrial areas.

Industry development lasting from 19th century involves high demand of energy. This implies increase of mining and fossil fuel combustion, mainly coal and petroleum, that causes the change of isotopic carbon composition in the natural environment. Fossil fuel combustion results in emission of CO_2 to the atmosphere lacking ^{14}C isotope. This reflects in decrease of radiocarbon concentration in relation to concentration of other carbon isotopes. This is the point of the "Suess effect". The decrease is calculated according to the following formula:

$$^{14}S = \frac{\Delta^{14}C - \Delta^{14}C_0}{1000 + \Delta^{14}C} \cdot 100\% , \qquad (1)$$

where:

$\Delta^{14}C$ – radiocarbon concentration in the sample examined,

$\Delta^{14}C_0$ – radiocarbon concentration in the "clean air".

Because of increase of radiocarbon concentration, due to nuclear weapon tests, there exist serious obstacles associated with determination of radiocarbon concentration in the "clean air" required to evaluate the absolute value of the Suess factor (Keeling, 1979; Nydal and Lovseth, 1983; Awsiuk and Pazdur, 1986, 1995). However, it is possible to determine local underrating of radiocarbon concentration in the area of large industry agglomeration. This requires assessment of ^{14}C concentration level in examined industrial area and in the region where influence of anthropogenic sources of "dead" CO_2 emission is negligible.

2. THE "SUESS EFFECT" IN TREE RINGS FROM UPPER SILESIA

Carbon dioxide emission in Upper Silesia comes from two sources. The first source, which varies seasonally very little is particularly electric power industry. The second, strongly dependant on the season of the year, is fossil fuel combustion.

Measurements were based on tree rings samples-pine (*Pinus silvestris*) and poplar (*Populus Nigra*).

As it is commonly known, carbon constitutes a component of the biosphere, hydrosphere and atmosphere of the Earth shell. It is a basic element of organic components being a building material of the living matter. In the atmosphere carbon appears mainly in the form of carbon dioxide. Coherency of carbon circulation is generally assured by the atmosphere. Buffering role assuring equilibrium in the system play oceans. An intensive exchange exists between the atmosphere and the biosphere (Stuiver and Quary, 1981). Autotrophic plants absorb carbon in the photosynthesis process. They return its small amount to the atmosphere during respiration.

Measurements of radiocarbon concentration in single tree rings were done with β – radiation liquid spectrometer of the type Quantulus 1220 (Pawlyta *et al.*, 1998).

^{14}C concentration values in the so called "clean air" were taken from a work by Nydal. He collected atmospheric CO_2 on Spitsbergen and Cape Nordkapp in

northern Norway from 1962 to 1980. Experimental points were approximated by exponential curve to find the relation of $\Delta^{14}C_0$. This relation, describing the decay in time of excess $\Delta^{14}C$ concentration in the atmosphere caused by nuclear weapon tests on the turn of the fifties, can be expressed as (Nydal and Lovseth, 1983):

$$\Delta^{14}C_0 = 372 \exp(-0.0582\ t), \quad (2)$$

where t is the time counted from 1976.

A decrease of radiocarbon concentration was observed in Upper Silesia. Changes of $\Delta^{14}C$ can be described by mathematical relations. The result obtained for Ruda Śląska is (Rakowski, 1994):

$$\Delta^{14}C = 680 \exp(-0.0677\ t). \quad (3)$$

For comparison, the earlier result obtained for Chorzów is:

$$\Delta^{14}C = 675 \exp(-0.0591\ t). \quad (4)$$

In both cases "t" is the time counted from 1965 (Rakowski *et. al.*, 1996)

This comparison is presented on **Fig.1.**

The mean value of ^{14}S, which describes a decrease of radiocarbon concentration in the natural environment due to the Suess effect, in 1965-1995 for Ruda Śląska, can be presented as follow:

$$^{14}S = -4.1 \pm 0.9\%, \quad (5)$$

and similarly for Chorzów:

$$^{14}S = -2.3 \pm 1.2\%. \quad (6)$$

Time diagram of the parameters ^{14}S for Chorzów and Ruda Śląska is presented on **Fig. 2.**

3. CONCLUSIONS

Differences in ^{14}C concentration for the two regions mentioned above come from a variety of tree species used in the experiments. Due to different vegetation periods, the record of carbon isotopic changes in annual tree rings in pine covers longer time than in a deciduous tree, like poplar.

The overall annual effect of ^{14}C concentration decrease is impossible to be evaluated by investigation of this concentration in annual rings growth because of the plant vegetative period in our climatic zone. In winter and late autumn cambium cells do not split, i.e. annual

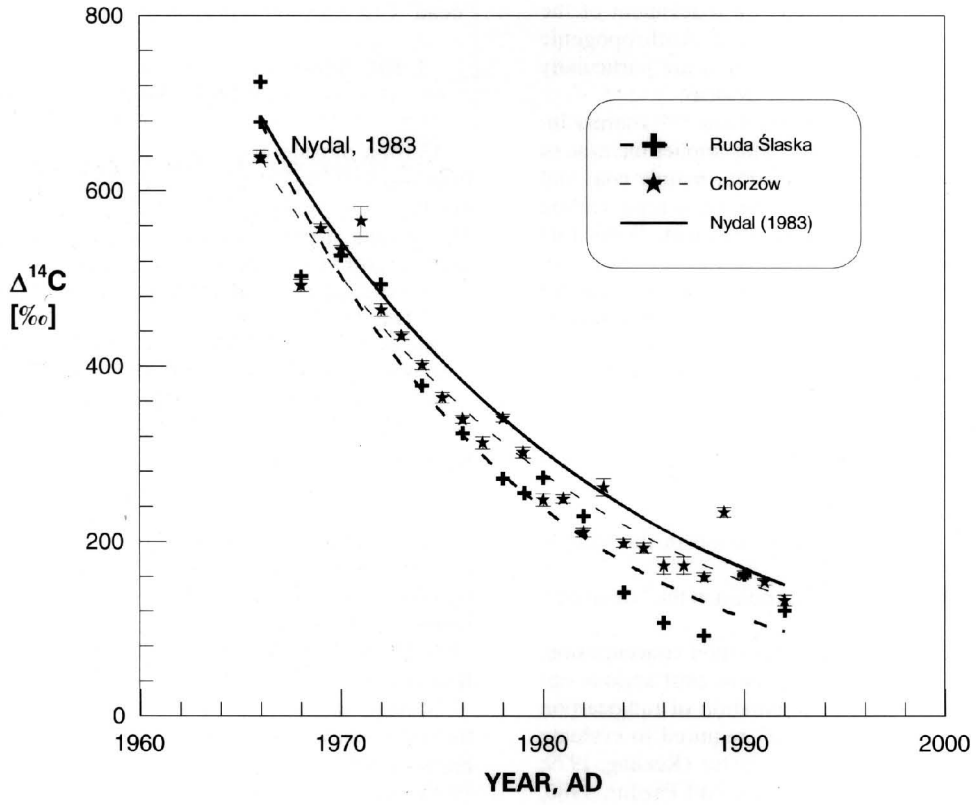

Fig. 1. *Variations of $\Delta^{14}C$ in tree-rings from Upper Silesia (southern Poland). Values referred to radiocarbon concentration in the "clean air" are marked as the solid line.*

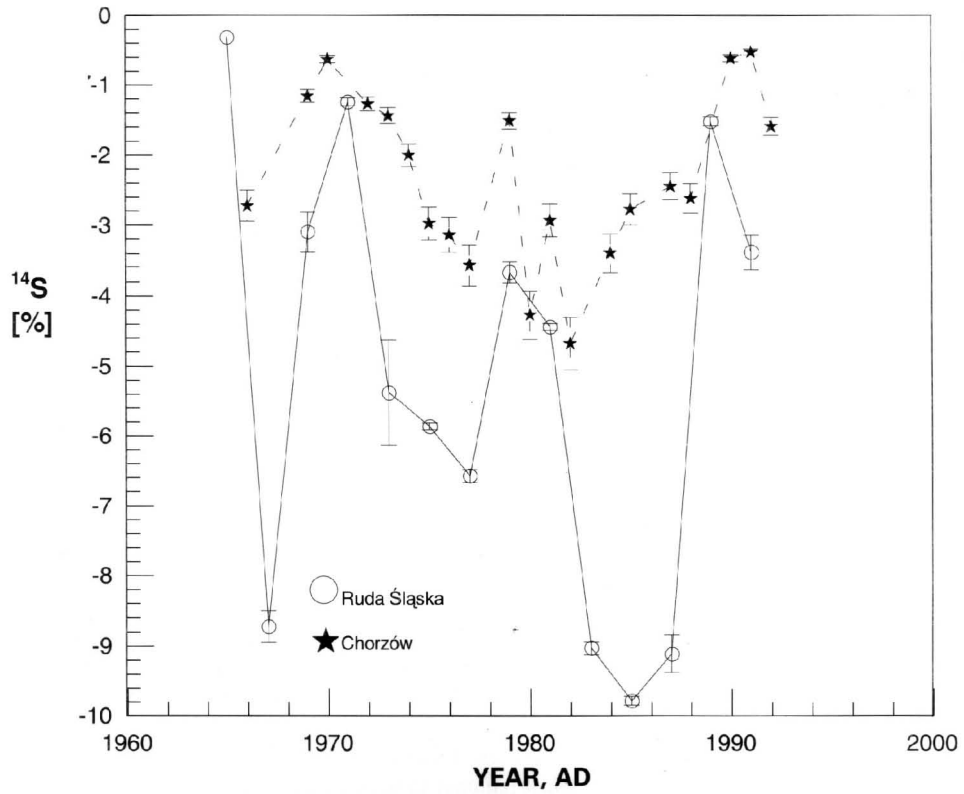

Fig. 2. *Variations of ^{14}S in tree-rings from Upper Silesia (southern Poland).*

tree rings do not grow. Thus, while investigating radiocarbon concentration in annual tree rings, the growth of anthropogenic CO_2 introduced to the atmosphere in autumn-winter time is not taken into account.

ACKNOWLEDGEMENTS

This study was supported by the State Committee for Scientific Research (KBN) under the research grant No. 6 P04G 074 10 and by the Institute of Physics, Silesian University of Technology, under research projects BW including BW project 2000.

REFERENCES

Awsiuk R. and Pazdur M. F., 1995: Antropogeniczne zmiany koncentracji radiowęgla w środowisku (Anthropogenic changes of radiocarbon concentration in environment). *Zeszyty Naukowe Politechniki Śląskiej, Seria Matematyka-Fizyka, Z. 77. Geochronometria* 11: 159-182.

Awsiuk R. and Pazdur M. F., 1986: Regional Suess effect bin the Upper Silesia urban area. *Radiocarbon* 28: 655-660.

Keeling C. D., 1979: The Suess effect: ^{13}C, ^{14}C interrelation. *Environ. International* 2: 229-300.

Nydal R. and Lovseth K., 1983: Tracing bomb C in the atmosphere, 1963-1980. *Journal of Geophysical Research* 88: 3621-3642.

Pawlyta J., Pazdur A., Rakowski A. Z., Miller B. F. and Harkness D. D., 1998: Commissioning of a Quantulus 1220 Liquid Scintillation Beta Spectrometer for Measuring ^{14}C and ^{3}H at Natural Abundance Levels. In: Mook W. G. and van der Plicht J., eds, *Proceedings of the 16th International Radiocarbon Conference, June 16-20, 1997. Radiocarbon* 40(1): 201–210.

Rakowski A. Z., 1994: Badanie antropogenicznych zmian koncentracji radiowęgla na terenie Górnego Śląska (The investigations of anthropogenic changes of radiocarbon concentration in the Upper Silesia region). *MSc Thesis, manuscript.*

Rakowski A. Z., Pazdur M. F., Pazdur A. and Miller B. F., 1996: Antropogeniczne zmiany składu izotopowego węgla w atmosferze Górnego Śląska (Anthropogenic changes of carbon isotope composition in Upper Silesia atmosphere). *Zeszyty Naukowe Politechniki Śląskiej, Seria Matematyka-Fizyka, Z. 79. Geochronometria* 13: 143-155.

Stuiver M. and Quary P. D., 1981: Atmospheric ^{14}C changes resulting from fossil fuel CO_2 release and cosmic ray flux variability. *Earth Planetary Science Letters* 53: 349-362.