Source: Levanic T, Gricar J, Hafner P, Krajnc R, Jagodic S, Gärtner H, Heinrich I, Helle G (eds.) (2010): TRACE - Tree Rings in Archaeology, Climatology and Ecology, Vol. 8: Proceedings of the DENDROSYMPOSIUM 2009, April 16th – 19th 2009, Otočec, Slovenia. GFZ Potsdam, Scientific Technical Report STR 10/05, Potsdam, p. 41 - 45.

Air pollution recorded in Scots Pine growing near a chemical plant, preliminary results and perspective (Upper Silesia, southern Poland)

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Introduction

Tree-ring analysis was frequently used to study the influence of industrial pollution occurring from the 19th century onwards on tree stands (Schweingruber et al. 1985). Many studies were carried out in the 1970s when air pollution emissions were particularly high. The studies were located near different sources of pollution (Ashby & Fritts 1972, Vinš & Mrkva 1973). The study of Thompson (1981) for example revealed different intensities of radial growth reduction of trees depending on their distance from the pollution source and the amount of pollution emitted to the atmosphere. Simultaneously it was demonstrated that the relationship between tree-ring width and climate was altered in trees growing near sources of pollution (Nash et al. 1975). A study carried out by Schweingruber et al. (1985) applied a new methodology based on analyzing pointer years and abrupt growth release. The study in the Swiss Rhone Valley (Canton of Valais), apart from showing the number, degree, spatial and temporal distribution of tree-ring growth reductions, allowed the result to be related to the condition of the tree tops. It was found that the impact of both a deterioration or an improvement in environmental conditions is evident a few years earlier in tree rings than the effect is visible in tree tops (Schweingruber 1985, Kontic & Winkler-Seifert 1987). In the last 20 years studies carried out in different parts of the world have often been located around individual emission sources of pollution, for example around a non-ferrous smelter in the Kola peninsula (Nöjd et al. 1996), surrounding a chemical plant near in the City of Oulu in Finland (Jämbäck et al. 1999), in the neighborhood of a metal extraction and processing plant in Norilsk, Russia (Ivshin & Shiyatov 1995), near a great urban and industrial centre in Poland (Krąpiec & Szychowska-Krąpiec 2001, Danek 2007), and around a copper smelter in Utah state, USA (Kennedy-Sutherland & Martin 1990). In addition to studies of the exposure of tree stands to pollution emissions based on tree-ring width analyses, fluctuations in wood density and heavy metal concentrations in rings have recently been used (Ferretti 2002).
The objective of the study was to assess the influence of the pollution emitted by the Chemical Plant in Tarnowskie Góry on the condition of pines growing in the vicinity of the plant.

Tarnowskie Góry Chemical Plant history

The Tarnowskie Góry Chemical Plant has been in existence since 1922. It is located in closed pine forest on the site of a former steelworks and paper plant. In 1995, the Chemical Plant went into liquidation. Severe environmental pollution in the vicinity of the plant caused its recording on the list of the 80 greatest polluters in Poland in 1994. However, studies of the environmental impact of the chemical plant have so far only referred to the pollution of rivers, lakes and ground water. The chemical plant's impact on air quality has not previously been studied, largely due to the unreliability of the data available concerning the air pollution emitted during the plant's operation. The Tarnowskie Góry Chemical Plant principally manufactured barium compounds, hydrochloric acid, and hard carbon black (Biernacki 1983). Its operation has lead to the death of pine trees lying within a radius of about 1 km surrounding the plant. Although no pollution data are available, the amount of individual chemical compounds produced in Tarnowskie Góry Chemical Plants are

existent. Additional information allowing to quantify the degree of the harmfulness of individual compounds were sourced from technicians who worked with these compounds. The first important part of manufactured compounds in the chemical plant focused on organic chemistry mainly carbon black producing. The second part were inorganic chemistry compounds, mainly the production of lithopone. Both black carbon and lithopone were especially harmful substances to the environment. Corrosive clouds containing naphthalene oil and anthracene oil were emitted to the atmosphere during the production of black carbon and great amounts of sulphur dioxide and hydrogen chloride were emitted during the production of lithopone. The greatest amount of black carbon was produced between 1955-1970, the maximum quantity of lithopone from 1965 to 1985 (Fig. 1).

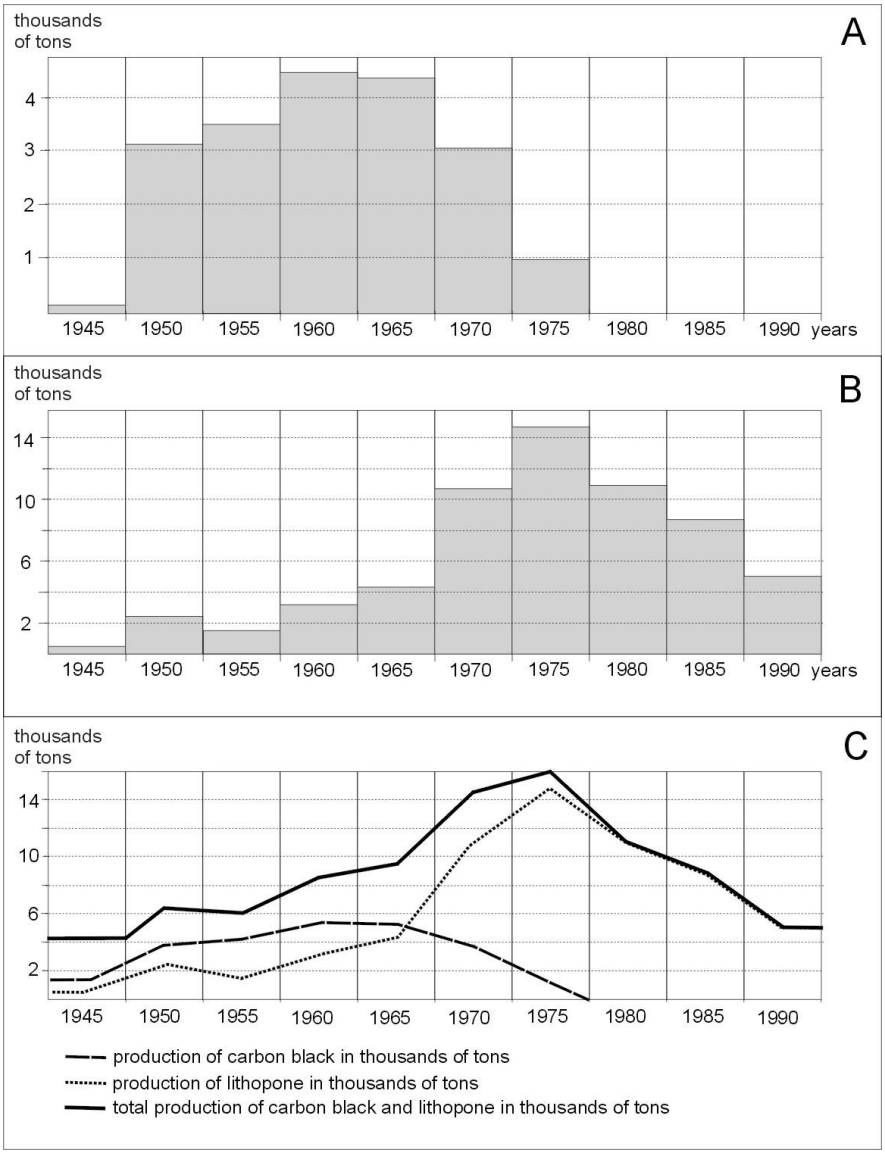

Figure 1: The production volume at the Chemical Plant in Tarnowskie Góry (A – black carbon volume, B - lithopone volume, C – volume in total).

Tree sampling strategy and core study processing

Ninety-six cores were collected from pines growing on four sites situated 5 km from the plant. Cores were only sampled in an area with dry-mesic pine forest (Fig. 2a). After polishing the samples extremely narrow rings were found which had been produced in the 1960s and 1970s (Fig. 2b). Therefore the skeleton plot technique was used to find the missing rings. Next a chronology was developed for pines affected by pollution growing up to 5 km kilometres from the

plant and in an area at least 20 km from the plant as a reference. The charts were compared so as to identify the influence of pollution on the annual rings of the trees.

Figure 2: A -Typical site where samples were collected, B - one of the cores collected near the chemical plant with clearly visible ring suppression between 1950 and 1970.

Air pollution detected in tree rings - preliminary results

All of the pines studied which were growing within a 5 km radius from the Chemical Plant in Tarnowskie Góry produced suppressed annual rings between 1950 and 1980 (Fig. 3). There is evidence that the growth of these trees during the respective period was directly influenced by the amount of pollution emitted by the chemical plant in Tarnowskie Góry. Figure 4 clearly shows the inverse proportionality between the productivity of the chemical plant studied and tree-ring width.
The annual ring reduction was particularly significant in the 1960s and 1970s. The productivity of the plant quintupled from the 1950s to the 1970s and as from the 1930s to the 1970s it even increased by 15 times. In the case of pines growing 5 km from the plant, the annual rings produced in the 1960s and 1970s are on average ten times narrower than those produced earlier and after 1995. Missing rings have been identified in the ring sequences of these trees, particularly in the 1960s when the hydrochloric acid line was launched in the plant. Numerous annual rings for that period were missing from the record in the cores of more than half of the trees cored. This means that in this period the chemical plant was emitting a particularly large amount of pollutants. That period was marked by the use of new technology which led to the launch of new production lines and large emissions of air pollution. It seems that it was specifically the manufacturing of hydrochloric acid that was the main factor in the degradation of tree stands around the Chemical Plant in Tarnowskie Góry. Annual rings have been slightly larger since 1971 when hydrochloric acid production was discontinued, despite the increase in production of the remaining compounds produced at the Chemical Plant. The trees have not been producing strongly suppressed annual rings since 1982 when the production volume of the chemical plant started decreasing and environment-friendly technology started to be introduced.

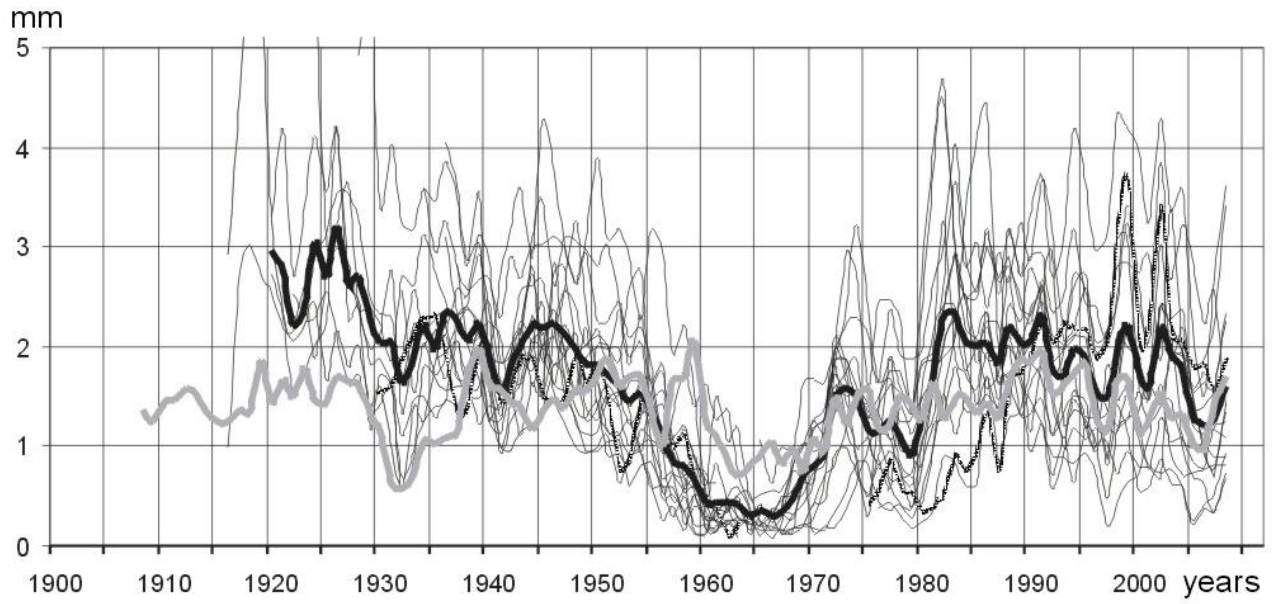

Figure 3: Charts of annual rings together with local chronology from an area situated 5 km from the chemical plant (black colour) and a local chronology from an area situated 20 kilometres away (grey colour).

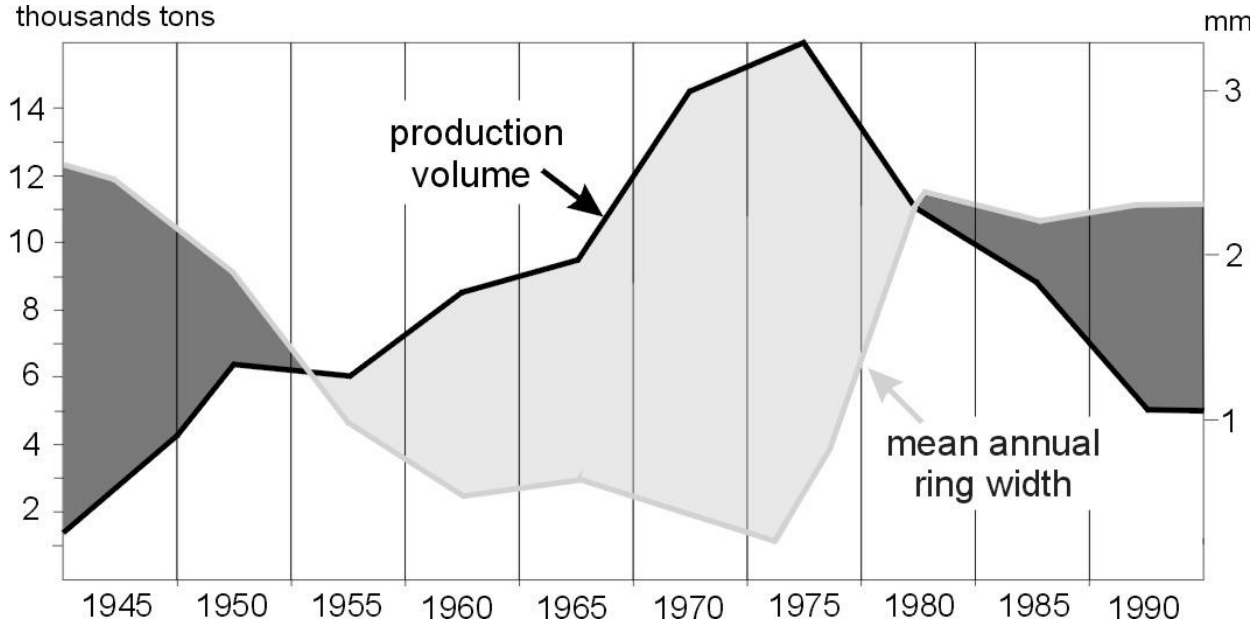

Figure 4: A comparison of the production volume curve at the chemical plant (black curve) with the curve of annual rings (grey curve). The light grey area marks a period in which production increased and the annual rings were suppressed.

Air pollution detected in tree rings – perspective

In future, we plan to use statistical methods to detect what was the climatic control of the tree rings formed before, during and after the operation of the chemical plant. We will also study wood anatomical features at a time when rings were strongly suppressed to find anomalies controlled by the impact of the pollution.

A rise in the frequency of infant mortality, pulmonary cancer and other diseases was recorded in the town of Tarnowskie Góry. A high number of cases was observed during the 1960s and 1970s.

At that time samples from trees growing around the plant showed extremely suppressed rings. Based on this, we will try to find what was the impact of the emissions on the health of people living near the chemical plant at this time. We will use statistics to compare the periods with tree-ring reduction to periods with great pollution emissions to the atmosphere and the annual resolution of individual disease variability in the city of Tarnowskie Góry.

Acknowledgements

This work was sponsored by the State Committee for Scientific Research grant no. N N306 317135. The authors wish to thank Mr. Stanisław Malik, former head of Department of Inorganic Chemistry for valuable informations regarding the pollution and production of chemical plants in Tarnowskie Góry.

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