# Late and Middle Holocene deposition of major and trace elements in Southern Sweden as detected in peatland stratigraphies.

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## Introduction

Wetlands cover approximately 15 per cent of the South Swedish land surface. Most of these wetlands are raised bogs only fed by precipitation and dry deposition of atmospheric particles. Hence, the peat bogs provide ideal sites for the study of atmospheric fallout since peat formation began.

The concentrations of 72 major and trace elements in peat samples of Holocene age from 10 dated raised bog stratigraphies in southern Sweden, are considered in terms of atmospheric deposition. The study of particulate matter from the stratigraphies gives additional information. With this background information, an attempt is made to evaluate the main sources of mineral matter and associated elements, and the influx variations during the last c. 8000 years. In the unaffected natural landscape sources of dust and other deposited matter are supposed to emanate in e.g. desert storms, marine aerosols, volcanism and cosmic influx. In addition, forest and peatland wild-fires produce charcoal and tar particles which are preserved in the peat. In the late Holocene perspective dust from human activity is added e.g. agriculture, industry and traffic.

## Methods

Measurements were made in 5-cm intervals giving a temporal resolution of appr. 50 years. Two different preparation techniques were used; 1/ peat samples were dried and burned. The ash was dissolved in Aqua Regie and the solutions were analysed with Inductively Coupled Plasma Mass Spectrometer technique. 2/ peat samples were treated in a sodium hydroxide solution, followed by a long decantation procedure, to separate particulate matter from peat plant tissue. Solid particles including charcoal and tar droplets were studies in light microscope and SEM-EDX. All together more than 1200 peat samples were analysed in this way. 14C datings of certain levels including more than 30 samples were made at the Uppsala AMS laboratory.

## Results

The chemical study showed that the deposition of various elements had changed during the time interval studied, temporally as well as spatially. A very uniform signal from all bogs investigated came from the element lead (Fig.1). In this way lead was used to make a mutual correlation between the different stratigraphies where datings were sparse. The lead lies at very steady levels from 8000 to 4000 BP with values around 100 ppm (internally of the elements investigated). From 4000 to 2500 BP there is a gentle rise to c. 200 ppm. At 2500 BP there is a dramatic rise in lead and a peak of around 1000 ppm is centred at 2000 BP. From here levels decline to c. 500 ppm at 1500 BP and these levels are kept until 1200 BP when another steep rise begins. Maximum levels are found in subsurface layers with values around 20,000 ppm. In the top 10 cm of unconsolidated recent peat there is another relatively strong decline to values below 8000 ppm.

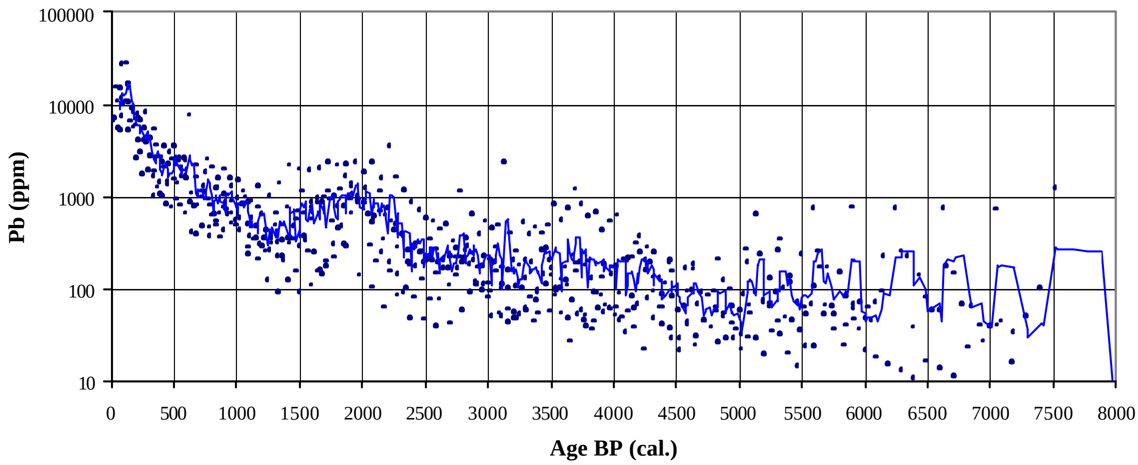


*Fig. 1 The distribution of lead (Pb) in the 10 bogs investigated*

Since the heavy metal lead is a rare element in natural undisturbed environments, there is little doubt that the general rise starting 4000 was caused by increased human activity. The sharp rise, the peaking levels at 2000 BP and the decline until 1500 could most likely be attributed to the rise and fall of the Roman Empire. The British Isles were important sources of lead and with general westerlies approaching Scandinavia from that direction the deposition was probably the result of mining activities in that area. The strongest rise appearing at the subsurface 30-40 cm of the stratigraphies is attributed to industrialism and in the latest phase to the use of leaded petrol. The decline at the top could easiest be interpreted as a result of the change from leaded fuels to unleaded products.

The cosmic component, which might be of the greatest interest from a Tunguska perspective, could be studied by the varying influx of elements relatively abundant in cosmic matter e.g. the Platinum group metals (Ru, Rh, Pd, Os, Ir and Pt). An index including all the elements measured was constructed and compared to the typical cosmic, terrestric and marine abundance. A high index compared to the respective group indicates a closer relationship to that group i.e. a high Platinum group index as compared to the cosmic relationship indicates that the deposition of cosmically derived material was higher.

The Holocene record shows a periodically increasing cosmic signal peaking at 3700 BC, 3400 BC, 2700 BC, 2300 BC, 2100 BC, 1500 BC, 1000 BC, 750 BC, 250 AD, 500 AD, a strong and broad peak between 850 AD and 1300 AD and 1550 AD (Fig.2).

The SEM-EDX study of particulate matter showed that during the above period the deposition of meteorite fragments and spherules of various kind. Most of these spherules are of ferric types made out of iron but there are also glass spherules varying from colourless transparent

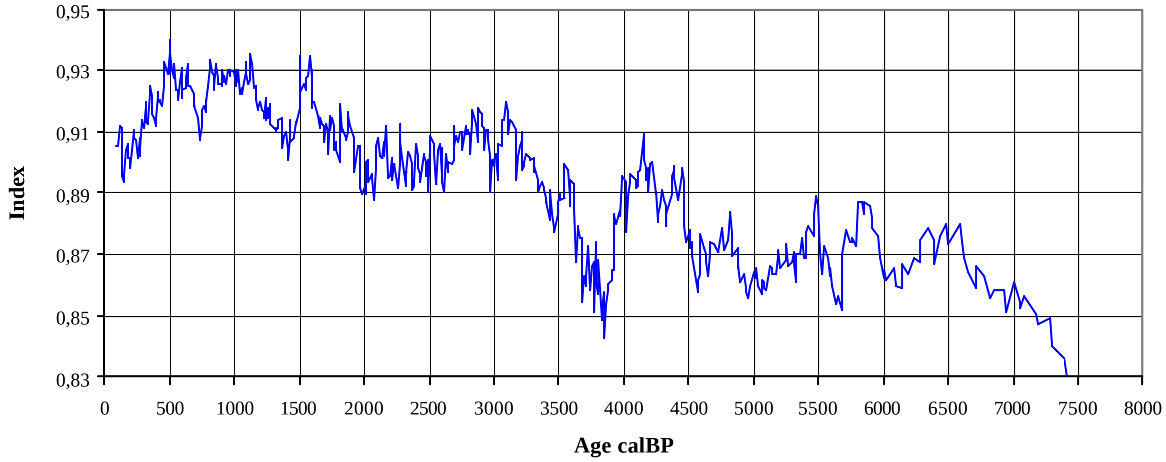


*Fig.2 Platinum group metals as compared to cosmic abundance*

types to yellow and brown types. Transitions between pure iron spherules and glassy types occur.

## Conclusions

I have little doubt that cosmic material would be deposited and stored by the growing peat layers of the world, considering the large annual influx of such material. Whether this influx is dust sized, or emanate as fragments from the bombardment of larger cosmic bodies is hard to tell. The occurrence of melted fragments in the form of small spherules at the stratigraphic levels where the cosmic signal is strong, points at a collision history, bearing in mind the findings at the K/T boundary. Since only few Holocent impact craters are known to exist, this on the other hand favoures the cosmic dust possibility. From other sources we know that climate has shifted rapidly during the Holocene. Many of the cosmic peaks identified in the peatland stratigraphies coincide with periods of climate detoriation and cultural downturns. Whether these shifts and downturns could be attributed to cosmic activity is a question that could be resolved by further studies, including the analyse of material from the Tunguska epicentre area.