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INFLUENCE OF CREMATORY PROCESSES
ON TRACE ELEMENT CONTENT IN HUMAN TEETH


Abstract. The chemical composition of 12 untreated teeth from the contemporary population of north-eastern Poland was analyzed. Tooth halves were burned in a flame, imitating crematory methods. The material, in quartz crucibles, was placed in the flame’s inner cone with continuous temperature monitoring, using a Cr-Ni thermocouple. In parallel, as a control, a pig’s head was burned to determine the degree of incineration and calcination of the bones. Comparing the chemical composition (determined using Anodic Stripping Voltammetry ASV) of the unburned halves of the teeth and the corresponding burned ones from the same specimen, a statistically significant decrease in Pb and Cd quantity was observed in the burned material. No changes in Cu concentration were observed. This model can be used to extrapolate the results of teeth and bone chemical analyses from crematory graves to modern populations. Based on the model developed, an attempt was made to determine the real (*ante mortem*) concentration of the investigated elements in 20 randomly selected teeth from crematory graves at one Bronze Age site (southern Poland).

Key words: cremation, trace element, teeth

Introduction

Modern paleoanthropological research uses chemical and physical methods on a larger scale to analyze bone material in order to increase information and knowledge related to the biological status of human groups, the palaeolithic diet and the

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Analysis of trace elements in human bones and teeth from skeleton graves does not pose difficulties, except for some basic methodological problems such as diagenetic absorption post mortem (Aufderheide 1989; Sandford 1993; Edward, Benfer 1993). In most cases the bone material, the teeth in particular, is preserved in a sufficiently good condition to perform such analyses. In analyses of prehistoric crematory cemeteries (the cremation ritual was common in Europe during the Bronze Age and the Iron Age (Subira, Malgosa 1993) the possibility of applying osteological methods and chemical analyses is very limited, because the bone material has been, both morphologically and chemically, altered by thermal processes (Piontek 1975; Strzałko, Piontek 1974).

Classical methods of trace element analysis (such as ASV, AAS, ICP and scanning microscope analysis) have indicated that prehistoric human populations had statistically significant lower content of toxic microelements such as lead, cadmium and mercury, as well as biogenic copper and zinc compared to modern populations (Barry 1978; Subira, Malgosa 1993).

To verify the conclusions of previous analyses we performed an experiment to determine whether cremation influences changes in the levels of trace elements in bone material (teeth) from crematory graves.

Material and methods

The chemical composition of 12 untreated human teeth from the contemporary population of the Białystok region was analyzed.

Each tooth was carefully washed with spectrally pure water obtained using a Millipore Water Purification System (18 Mh Ω/cm) and dried in a dryer, then split into two halves along the main tooth axis. The obtained complementary tooth halves were incinerated in a fire imitating crematory pyres prepared according to the way described by Piontek (1975). The material was placed in quartz crucibles in the fire’s core (the temperature was controlled using a Cr-Ni thermocouple). In parallel, a pig’s head was burned as a control to determine the degree of incineration and calcination of the bones.

Each of the incinerated and corresponding non-incinerated tooth halves was ground in an agate mortar to obtain a fine powder. Teeth from crematory ash graves from Opatowiec (800–500 B.C.) were prepared. The prepared samples were weighed and mineralized using a mixture of spectrally pure nitric and perchloric acids (Nitric acid 65% Suprapur 441, Merck; Perchloric acid 70% Suprapur 517, Merck) on a graphite heating plate. Blanks were prepared as a background for the analyses.

The trace element analyses (Pb, Cd and Cu) were performed using MAV–Radius equipment and the Anodic Stripping Voltammetry method (Wang 1985), with simultaneous AAS intercalibration. Ultrapure TITRISOL Merck standards were used during the analysis.
Results

The changes in the levels of the analyzed elements in particular specimens and teeth from the burned pig's head are shown in Figures 1, 2.

Fig. 1. The changes in the Pb levels before and after cremation

Fig. 2. The changes in the Cd levels before and after cremation
The average content of lead, cadmium and copper in the complementary teeth halves before and after incineration is shown in Table 1.

The levels of the tested heavy metals from crematory graves, before and after the correction in terms of the results from the model analyses, are shown in Table 2.

Discussion

Conclusions are generally drawn on the assumption that the results of chemical analyses of samples from crematory graves can be compared directly to similar analyses of bones and teeth from skeleton graves and contemporary materials. This has led to the conclusion that the living environment and nutrition of the Bronze Age and the Iron Age humans were better because the levels of toxic heavy metals were lower.

To verify this conclusion, which we assume to be wrong, we undertook to develop a model allowing the transposition and interpretation of the results of crematory graves analyses between historical and contemporary populations.

Considering the melting and vaporization points ($T_m$ and $T_v$) of particular elements (Ciba 1989) it could be expected that the ones with low melting and vaporization temperatures will disappear during incineration both in the bone material and around the fire core (wood and soil).

This assumption was confirmed in analyzing particular specimens (Figs. 1, 2) and in the overall analysis (Tab. 1). The difference between means test for small numbers which was used in the statistical analysis confirmed the hypothesis ($p<0.05$) concerning the absence of differences in Pb and Cd content before and after incineration of the bone material.

### Table 1

Mean levels of Pb, Cd and Cu in complementary halves of teeth before and after cremation ($\mu$g/g)

<table>
<thead>
<tr>
<th></th>
<th>Pb</th>
<th>Cd</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Before cremation</td>
<td>13</td>
<td>2.57</td>
<td>2.32</td>
</tr>
<tr>
<td>After cremation</td>
<td>13</td>
<td>0.98*</td>
<td>1.11</td>
</tr>
</tbody>
</table>

* Significant differences $p<0.005$.

### Table 2

Concentration of Pb, Cd and Cu in the human teeth from Opatowiec (800–500 B.C.) ($\mu$g/g)

<table>
<thead>
<tr>
<th></th>
<th>Pb</th>
<th>Cd</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Before correction</td>
<td>9</td>
<td>2.89</td>
<td>1.48</td>
</tr>
<tr>
<td>After correction</td>
<td>9</td>
<td>4.70</td>
<td>–</td>
</tr>
</tbody>
</table>
No statistically significant changes in copper content were observed. This element has melting and vaporization temperatures higher than 1,000°C, and the measurements using the sensitive Cr-Ni thermocouple indicated a temperature range of 320–890°C.

Comparative analysis of the chemical composition of bones and teeth from crematory graves should be corrected for the natural thermal decrease in Pb and Cd levels and other trace elements not analyzed by us with $T_m$ and $T_v < 1,000°C$.

It should be supposed that the copper concentrations we measured (Tab. 2) in the human population of Opatowiec (800 B.C.) could probably be the levels in living individuals. Comparing these concentrations with the amount of copper accumulated in human teeth from medieval and contemporary populations indicates that they are higher. This could indicate a high proportion of fish, honey and especially meat in the diet (Christian 1988) of the population from Opatowiec.

Diagenetic *(post mortem)* absorption of this element while the remains were in the ash graves cannot be excluded. Unfortunately, the material used for analyses had been previously washed and no soil pH or microelement level analyses were made in the surroundings of the ash graves.

Using the model’s correction for the decrease in the levels of Pb and Cu (Tab. 2), we obtain the levels of these elements which fit within the range of the results obtained in populations with lower levels of exposure (Głąb, Szostek 1993; Gil et al. 1994; Bercovitz 1993). Nevertheless, they are lower than in populations from highly urbanized, environmentally threatened regions (Szostek 1992; Burde 1975).

The following conclusions can be drawn based on our studies:

1. Incineration of the teeth in a fire imitating historical crematory methods produced an average 62% decrease in lead and a 50% decrease in cadmium content.
2. No quantitative change in copper content was observed.
3. Analyses of trace element content in cremated human and animal remains should be corrected for the influence of high temperatures on losses of elements with relatively low melting and vaporization points.

To verify the conclusions and hypotheses concerning the probability of correct extrapolation of the results of chemical analyses of crematory graves to contemporary and historical populations, the influence of diagenetic absorption should be tested, and more material should be analyzed.

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**References**


