Heavy trace elements in ancient Norwegian teeth

AUDUN ATTRAMADAL & JON JONSEN

Department of Microbiology, Dental Faculty, University of Oslo, Norway

Attramadal, A. & Jonsen, J. Heavy trace elements in ancient Norwegian teeth. *Acta Odontol. Scand.* 36, 97–101

The present work was undertaken in order to determine the content of lead, cadmium, copper and zinc in 26 teeth retrieved from burial-grounds in various parts of Norway, dated from A.D. 200 up to 1850. The analyses were made by differential pulse stripping voltammetry on hydrochloric acid digests of the teeth. High levels of lead were found in teeth dated from ca A.D. 1500 from Gimsøy Kloster and Tønsberg. Teeth originating from A.D. 200 showed a high content of Cd, Cu and Zn.

Key-words: Lead; cadmium; zinc; copper; human teeth

Audun Attramadal, Department of Microbiology, Dental Faculty, University of Oslo, Blindern, Oslo 3, Norway

The content of trace metals in mineralized tissues is taken as an indication of the body burden of these metals. Trace metals such as lead and cadmium have no known physiological function in biological systems, and they are toxic at excessive levels. To-day both lead and cadmium are rapidly becoming a potential threat to human health. Lead analyses of snow layers from Greenland and Antarctic glaciers have revealed that an increasing atmospheric pollution has taken place during the last few decenniums (4). Although most reports on cadmium agree that pollution is not an urgent problem at present (6), the major sources of contamination are connected with industrial activities and are increasing in number and importance.

Trace metal analyses of mineralized tissues from archaeologic excavations are most extensive for lead. Such analyses have shown that in different communities in ancient and medieval times, increased lead levels are often found, probably as a result of extensive use of lead and lead compounds in connection with the preparation of food and drinks (2). The present analyses were undertaken in order to determine the lead, cadmium, copper and zinc content in teeth from Norwegian burial-grounds, dating from A.D. 200 up to 1850.

Received for publication, November 29, 1977

MATERIALS AND METHODS

Teeth: The human teeth were obtained from the Institute of Anatomy, University of Oslo, and originated from the following locations:

1. Bolstad, Gjerpen, dating from 2.–3. century A.D.
2. Gimsøy Kloster, dating from before 1500.
3. Petrikirken, Tønsberg, dating from before 1500.
4. Bjølstad kirke, Heidal, dating from around 1700.
5. Tingvoll kirke, dating from before 1780.
6. Årøen, Alta, dating from around 1830.

The locations of these burial sites appear from Fig. 1.

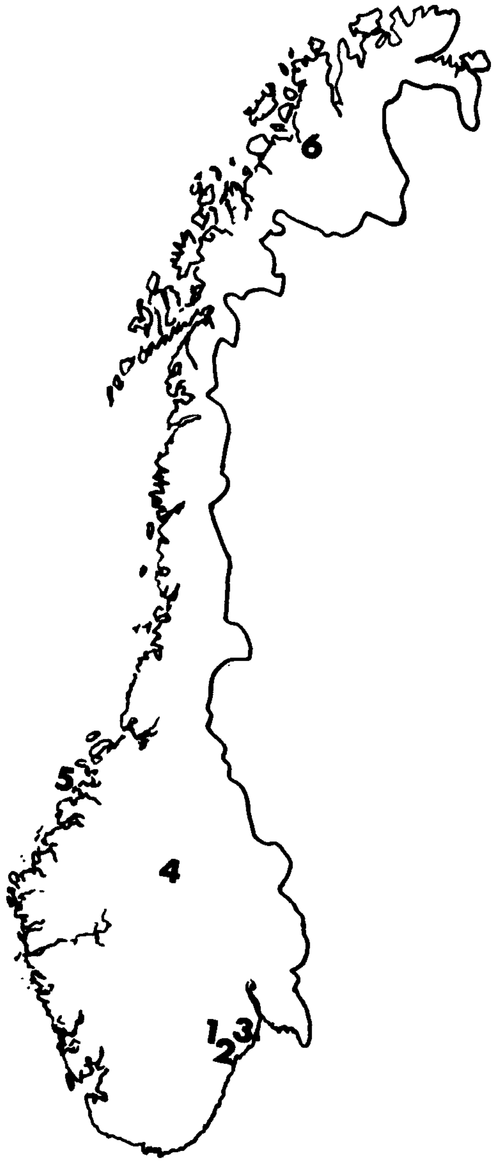

Fig. 1. Location of burial sites. 1. Bolstad, Gjerpen. 2. Gimsøy Kloster. 3. Petrikirken, Tønsberg. 4. Bjølstad kirke, Heidal. 5. Tingvoll kirke. 6. Årøen, Alta.

Solutions: Double glass distilled water was used throughout the analyses. All reagents were of supra-pure quality (Merck). Sodium acetate buffer, 0,1 M, pH 4.7, was used as electrolyte and solvent for the digested tooth material.

Preparation of samples: The teeth were initially brushed free of soil and then washed in 2 ml distilled water. Analyses of the water showed no significant increase in the content of the trace metals, and the washing procedure was therefore later omitted. The teeth were weighed and dissolved in 5 ml hydrochloric acid in polyethylene vials. After complete digestion, the solution was dried by heating to 100°C, and the residue was redissolved in acetate buffer to make the initial tooth weight 10 per cent of the solution (w/v).

Apparatus: The samples were analysed by differential pulse stripping voltammetry (Model 174 Polarographic Analyzer, Princeton Applied Research, Princeton, New Jersey, U.S.A.). The instrument was worked at a scan rate of 5 mV/s, drop time 0.5 s, modulation amplitude 50 mV and a current range between 0.02 and 0.2 mA. The initial potential was set at –900 mV for the lead, cadmium and copper analyses, and at –1300 mV for the zinc analyses. A Metrohm E410 hanging mercury drop electrode was used as working electrode, with a Metrohm EA427 reference electrode. To

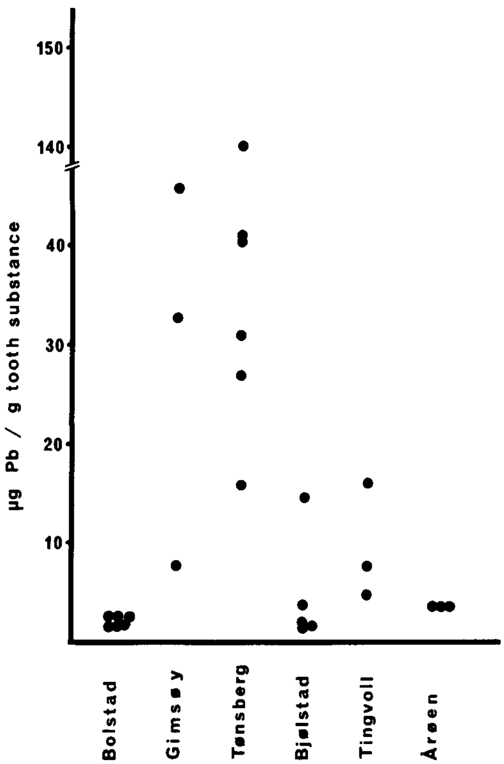

Fig. 2. Lead levels in ancient Norwegian teeth from various burial sites.

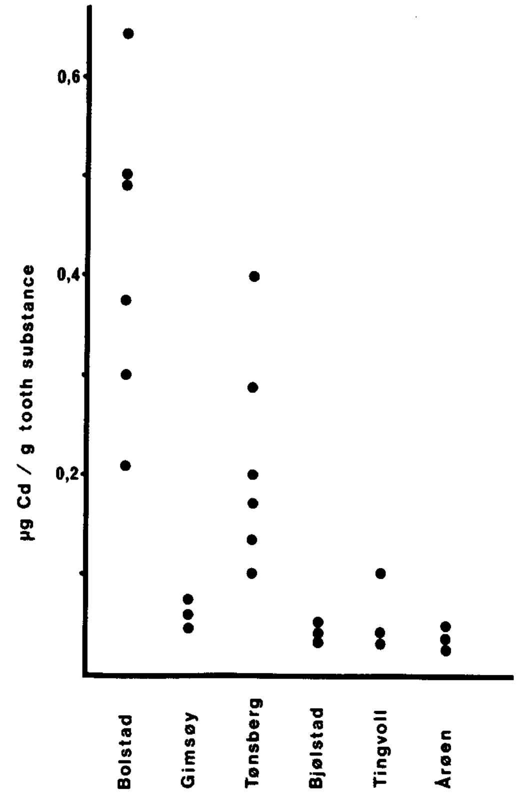

Fig. 3. Cadmium levels in ancient Norwegian teeth from various burial sites.

avoid contamination of the samples, the reference electrode was placed behind a sintered glass bridge containing acetate buffer. The electrolyte cell (Metrohm EA 875) was siliconized, and the sample was stirred by a teflon-covered magnetic bar.

Analysis: 2.5 ml of the tooth digest solution was added to 7.5 ml acetate buffer in the electrolyte cell, highly purified nitrogen was bubbled through the cell while the magnetic stirrer was operated at 60 r.p.m. After 10 min, a fresh mercury drop was extruded, and the electrode was plated for 3 min. Thereafter the nitrogen supplys was cut off, and the stirring stopped. After a rest period of 15 s, the stripping voltammogram was recorded. The metal concentration was determined by the method of standard addition. 25 and 50µl samples of standards were added to the electrolyte cell, and the plating and stripping procedure repeated.

The analyses of one metal was not influenced by the addition of the other metals to the test sample.

Differential pulse stripping voltammetry may be used at a very high sensitivity. The method and instrument settings employed in the present study gave a detection limit of about 0.01µg Cd, 0.1µg Pb or Cu, and 0.5µg Zn per g tooth material.

RESULTS

Figs. 2 to 5 show the content of lead, cadmium, copper and zinc in teeth from the various regions. A wide variation is seen for all the metals. The teeth from Gimsøy kloster and Tønsberg showed elevated lead levels,

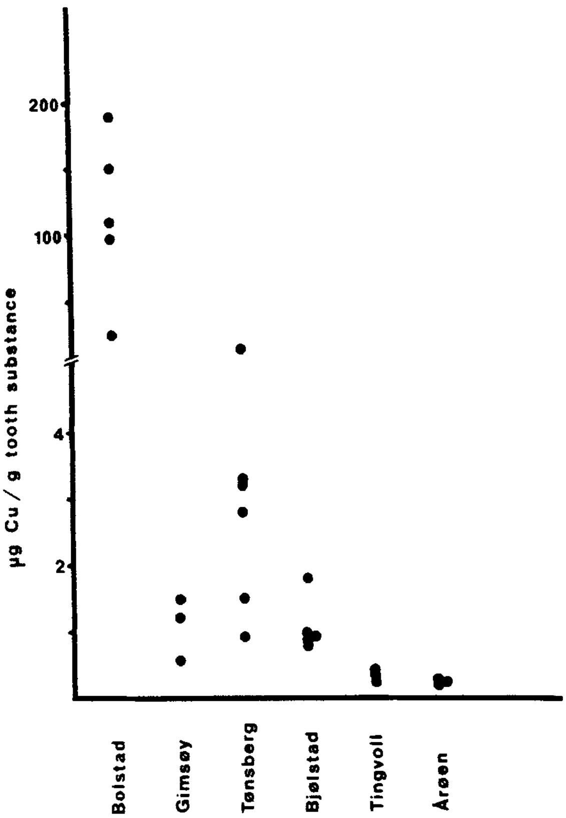

Fig. 4. Copper levels in ancient Norwegian teeth from various burial sites.

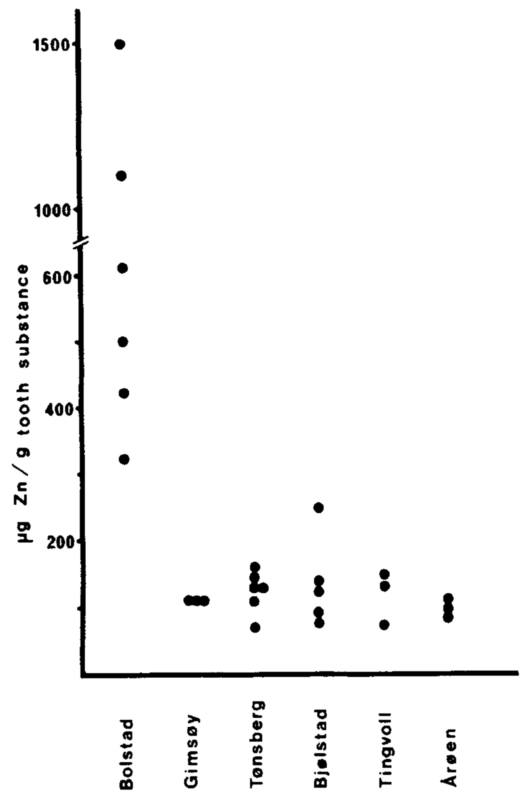

Fig. 5. Zinc levels in ancient Norwegian teeth from various burial sites.

one tooth from the latter site displaying a lead content of 140μg/g. The cadmium levels were below 0.2μg/g on the average, apart from Bolstad, where a mean of 0.4μg/g was found. While the cadmium content in the teeth from Bolstad and Tønsberg varied widely, the teeth from all the other areas exhibited remarkably constant cadmium levels. Copper was found in amounts less than 5μg/g in all groups but one; the teeth from Bolstad showed very high copper levels, with an average of 115μg/g. Zinc was the metal which showed the least variation; apart from Bolstad where the teeth contained Zn in amounts which varied between 300 and 1500μg/g, averaging 740μg/g, the teeth from the other regions showed levels around 100μg/g.

DISCUSSION

Analyses of the trace metal content in ancient mineralized tissues have mainly been made on bone. Very few references to analyses of dental tissues exist.

The teeth retrieved at Bolstad contain significantly higher levels of Cd, Cu and Zn than teeth from the other burial sites. Dating from the 2.–3. century A.D., these teeth have been in contact with the soil for about 16 centuries, and it might be thought that the elevated levels of these metals could have been attained by uptake from the soil. Observations indicate that the change of trace metals in bone tissue buried in soil is insignificant (2). Teeth, consisting of denser and more highly mineralized structures than bone tissue, should thus represent an even more stable sample from individuals of the past. The transfer of trace metals to and from buried teeth is thought to be an exceedingly slow process. Thus little penetration of trace elements into the bulk of the tooth structure was found in up to 5000 year old teeth (5). The increased levels observed in the present study are thus more likely to have been deposited in vivo.

From Fig. 2 it is seen that lead is present in lowest amounts in teeth from A.D. 200, but also the lead content in teeth from Årøen, Tingvoll and Bjølstad, dated from 1700–1850, is low and does not deviate significantly from the lead content of contemporary Norwegian teeth (1). Årøen, Tingvoll and Bjølstad were typical rural communities in relatively remote and isolated areas. Teeth from Gimsøy Kloster and Tønsberg on the other hand both exhibited remarkably high levels of Pb. The teeth from these graveyards originates from immediately before 1500 A.D. Up to 1200 A.D. the lead intake originated from natural sources only, but from this age lead was used in the glazing of kitchenware. From the end of the Middle Ages utensils made of pewter containing lead were in general use. Gimsøy Kloster and Tønsberg were both trading centers. In addition it is possible that the teeth from these places at least partly originate from closed communities such as monasteries where an extensive use of lead-containing kitchenware may have occurred. That the lead exposure, at least within groups of the population, was high in the Medieval Ages is consistent with the observations of high lead levels in bone samples from the 11. to the 19. centuries from Polish monasteries, probably caused from dietary habits and contamination of food (3).

The high level of cadmium and copper in teeth from the 2. century is surprising. At least the intake of cadmium should at this time take place entirely from natural sources. Cadmium and zinc occur naturally together, and it is seen that the high cadmium content is related to a high zinc content in the teeth. This correlation between cadmium and zinc is, on the other hand, not found in the teeth from Tønsberg.

In conclusion, as judged from the small material available for analysis in the present investigation, the content of Pb, Cd, Cu and Zn in ancient Norwegian teeth do not in general differ significantly from the levels found in contemporary teeth.

REFERENCES

1. Attramadal, A. & Jonsen, J. The content of lead, cadmium, zinc and copper in deciduous and permanent teeth. Acta Odont. Scand. 1976, 34, 127–131
2. Grandjean, P. Bly i danskere. Trykteknik, København 1973
3. Jaworowski, Z. Stable lead in fossil ice and bones. Nature 1968, 217, 152–153
4. Murozumi, M., Chow, T. J. & Patterson, C. Chemical concentrations of pollutant lead aerosols, terrestrial dusts and sea salts in Greenland and Antarctic snow strata. Geochim. Cosmochim. Acta 1969, 33, 1247–1294
5. Steadman, L. T., Brudevold, F., Smith, F. A., Gardner, D. E. & Little, M. F. Trace elements in ancient Indian teeth. J. Dent. Res. 1959, 38, 285–292
6. Webb, M. Cadmium, Brit. Med. Bull. 1975, 31, 246–250