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Chemical Analyses of Archaeological Bone-Samples: Evidence for High Lead Exposure on the Faroe Islands

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The Faroes, a group of rocky islands in the Atlantic Ocean located between Iceland, Scotland and Norway, were colonized by the Vikings about 800 A.D. The origin of the population is primarily Danish and Norwegian. Farming was limited by geographical and climatic conditions but sheep raising contributed significantly to the Faroese economy. Fishing and hunting for pilot whales were also important activities. Lacking metals, timber and grain, the Faroe Islands had important commercial relations to Denmark and Norway.

On these remote islands, exposure to environmental chemicals must have been low. Recent measurements of air pollution with lead have shown very low results (OECD, 1977). Lead was never mined on the Faroe Islands, and the importance of lead during the period of monopolized commerce was minimal. Thus, human exposure to lead must be expected to be of a very low order of magnitude.

Lead is a heavy metal with a low melting point and useful physical and chemical characteristics. Lead is probably the nonferrous metal which has the widest spectrum of applications, and it has been in use for several thousand years. Currently, lead pollution from automobile exhausts, lead compounds in old paint and ceramic glazes, and occupational exposures cause much concern (WHO, 1977). Subtle forms of chronic lead poisoning may cause interference with blood formation and nervous system functions.

Due to the low solubility of lead phosphate, lead accumulates in the skeleton. Thus, bones and teeth contain about 95 percent of the total body burden (WHO, 1977). Lead is probably incorporated in the hydroxyapatite crystals in the bone matrix, from where any leaching must be a very slow process. Archaeological samples of skeletons may, therefore, be used for analyses of body burdens of lead in the past. This approach has been used previously in several countries, i.e., Poland and Denmark (Jaworowski, 1968; Grandjean, 1973). These studies have indicated that lead exposures were very high during past time periods, particularly during the 18th and 19th centuries. These high lead levels have been traced to several lead sources: water pipes of lead, lead additives in wine and beer, lead compounds in cosmetics, paint, and drugs, pewter containing lead, and ceramic glazes. Similar lead sources may have occurred on the Faroe Islands, though definite evidence is lacking.

MATERIAL AND METHODS

We have examined an extensive skeletal material (N = 27) from two locations, Kirkjubø and Sand churches, cf. Table 1.

The Mediaeval graves at Kirkjubø were originally situated outside the church, but the area was later incorporated into the church. The three individuals examined may have had an important social position since they were buried close to the walls of the church. The 18th century graves under the church floor belonged to wealthy farmers. No information, however, is available about any distinction between graves in the different parts of the church (Dahl, 1977).

Kirkjubø was the center of cultural and religious life during several centuries. Sand church, however, was a small village church. Mediaeval skeletons were found under the floor of the second of the total of six churches which were built on top of each other in Sand. Archaeological and anthropological evidence

Table 1. Skeletal material which has been examined for lead.

Time period	Grave No.	Age	Sex	Lead (ug/g)
		Kirkjubø		
Early Mediaeval Ages	11	Mat.	M	42
	15	Sen.	M	240
	19	Mat.	F	33
18th century (nave)	1 a	Sen.	M	10
	3	Mat.	M	120
	4	Mat.	M	4
	16	Mat.	F	34
	6 b	Sen.	M	21
18th century (choir)	II	Mat.	M	85
	III	> 20 yrs.	F	109
	IV A	Mat.	M	156
	V A/B	> 20 yrs.	?	108
	V A/B	> 20 yrs.	?	99
	VI A	Ad.	M	53
	VI B	Mat.	M	15
	VI C	> 20 yrs.	?	11
	XII	Sen.	M	67
	XI A1	Mat.	M	140
		Sand		
Early Mediaeval Ages	7	Mat.	F	36
	8	Newb.	?	1.4
	9	3 mths.	?	0.5
	14	Ad.	M	45
	16	Mat.	M	17
	19	Mat.	F	14
	20	Mat.	M	11
	21	Newb.	?	2.7
	25	Mat.	M	54
18th century	I – II	> 20 yrs.	?	39
	II A/B	Mat.	?	29
	V	Mat./Sen.	M	38

Ad. = 20–35 years. Mat. = 35–55 years. Sen. = > 55 years.

suggests that the church may have belonged to a nearby manor and that the individuals buried in the church were all related (Krogh, 1975; Andersen, 1978). The 18th century graves under the eastern part of the fifth church may have belonged to ministers and their relatives.

Most skeletons were quite well preserved under the floors of the two churches. The early graves from Kirkjubø were, however, originally outside the church, but were later covered by the extended church construction. During the excavations, a few objects made of lead were found, i.e., weights, seals, etc. None of these objects were found in the graves, however. Due to the fairly good condition of the bone material and the negligible risk of post mortem contamination, these samples were suitable for lead analysis.

The lead determination of bone was carried out as described by Grandjean et al. (1979). This method has an average correlation of variation of 10% and an almost complete recovery of lead. Thus, the results obtained with this method are more accurate than the previously published results (Grandjean, 1973). A vertebral body was analysed from all skeletons, and the dissection of the bone sample was carried out as described by Grandjean (1973). A reference material from present-day Denmark was obtained at autopsy at the Institute of Forensic Medicine in Copenhagen. The present-day samples were taken from the temporal bone (Grandjean et al., 1979), which may contain about 50% more lead than the vertebral body.

RESULTS

The result for each skeleton is given in Table 1. All lead levels are given in μg/g (parts per million) dry weight. Lead is usually accumulated with age, and males often have higher lead levels than females. In this study, however, no such sex or age relationship could be found, except for very low levels in the three child skeletons. The average lead levels of the adult skeletons are given in Table 2. The high average level in the earliest Kirkjubø skeletons is due to one single sample with a lead level of 240 μg/g. Otherwise, the lead levels in Sand and kirkjubø seem to be similar. A striking difference was found in the average lead levels of the 18th century skeletons from the two Kirkjubø groups.

The most important finding was the difference between the lead levels of the archaeological samples compared to 22 present-day samples from Copenhagen. The latter samples had been obtained from males and females of comparable age groups. The lead level in the vertebral body was not measured in the fresh samples, but would be expected to be somewhat lower than the lead level in the temporal bone. Thus, the lead concentration in the archaeological samples average about 10-fold above the present-day level in Denmark.

Table 2. Summary of lead levels in bones from adults.

Time period	Location	Average lead (ug/g)	
Early Mediaeval Ages	Kirkjubø	105	(N = 3)
Early Mediaeval Ages	Sand	30	(N = 6)
18th century	Sand	35	(N = 3)
18th century	Kirkjubø (nave)	38	(N = 5)
18th century	Kirkbujø (choir)	84	(N = 10)
Present	Copenhagen	6.5*	(N = 22)

* From Grandjean et al. (1979).

DISCUSSION

Current environmental pollution by lead adds to the human burden of this metal. The natural lead levels, to which *Homo sapiens* originally adapted, were much lower. On the basis of geological and ecological measurements, Patterson (1965) suggested that the natural lead exposure of humans would be about 1% of present day level. Since then, archaeological bone samples from pre-metallurgical time periods have been analysed (Grandjean et al., 1979; Ericson et al., 1979). On the basis of these measurements, a natural lead concentration in the vertebral body can be calculated at about 0,1–0,2 μg/g. Compared to this level, several archaeological samples from the Faroe Islands contain more than 100-fold excess of lead.

The sources of such high lead exposures are not known in detail. Water pipes of lead were not used, but wealthy people could afford pewterware and ceramics. No information is available on the extent of the use of lead compounds in paints, cosmetics, drugs, wine additives, etc.

A previous study of bone samples from 1711 showed an average lead level of 5-fold above the present day average (Grandjean, 1973). High lead levels in medieavel samples were also found in this study and in one by Jaworowsky (1968). Despite the remoteness of the Faroe Islands and the lack of natural sources of high lead exposure, imported goods resulted in extremely high lead exposures during the past centuries.

A toxicological evaluation of these findings is very difficult because the lead content of the skeleton is supposed to be almost inert. Toxic effects are due to lead in brain, bone marrow and blood (WHO, 1977), and these levels are difficult to estimate from the present findings. Lead levels in target organs must, however, have been elevated, perhaps as much as in the skeleton. Thus, it may be speculated that chronic lead poisoning, and perhaps acute cases, were rather prevalent on the Faroe Islands in the past. Lead toxicity may, therefore, have contributed to the morbidity, mortality, and perhaps fertility patterns on the islands. Similarly high levels may have been prevalent in the Roman Empire, and Gilfillian (1965) has suggested that lead poisoning contributed to the fall of the Roman Empire. Though this hypothesis has not been proved, it indicates the possible significance of wide-spread lead poisoning.

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