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Trace Elemental mapping of Camel teeth and bones from Sudan using Nuclear Microprobe Technique

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Abstract
Geographically, the camels are distributed throughout the tropical and subtropical dry zones of Sudanese central, northern and western regions. The camel embodies one of the essential elements of the culture and agriculture of these regions. Camel is the ideal domestic animal in deserts with long, dry hot periods of eight months or more and scarce. It is used for transporting goods and people as well as for providing milk. Milk is often the only regular food source for its owners its milk is very healthy because its mostly browsing on the ornamental and medicinal species. The camel's meat, wool and leather are also widely utilized. In some part of East Africa, the animal is bled regularly and its blood consumed fresh or mixed with milk. The camel is universally highly valued and provides social standing for its owner.
Teeth and bones of different age camels from Sudan were studied to determine the concentration of trace elements (TE) and mapping by nuclear microprobe (NMP). Interest was focused on determining levels of variability in elemental concentration of trace elements such as Na, P, Cl, Ca, Fe, Ni, Cu, Co and Zn by Micro-Particle Induced X-ray Emission (μPIXE). Analysis were done using 1.5 MeV protons GUIX and GeoPIXEII software were used.

Keywords: Nuclear Microprobe; hard tissues; PIXE
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Introduction

Numerous adaptations have allowed the camel to survive the incredibly harsh environment of the desert. Heat storage within the body of the camel, selective brain cooling, fur, concentrated urine from unique kidneys, respiration mechanisms, and hormones all serve as important characteristics for the camel in terms of thermoregulation. During the hot desert day, camels are able to significantly increase their body temperature and store heat during the hot desert day. The purpose of storing heat is to conserve water that would otherwise be lost to evaporation. the conservation of water in the desert is essential for the camel in times when water is scarce. At night when the temperature drops noticeably, the stored heat in the camel dissipates so that the body temperature of the camel returns to a normal level.[7]. Although Sudan lies within the tropics, the climate ranges from arid in the north to tropical wet-and-dry in the far southwest. Temperatures do not vary greatly with the season at any location; the most significant climatic variables are rainfall and the length of the dry season. Temperatures are highest at the end of the dry season when cloudless skies and dry air allow them to soar. In Khartoum average 21 °C in January. [2,1] This study is a screening result of these differences in tropical climate environments, food availability, regional food habits and traditions. The present study concentrates on the determination of trace elements (TE) in camels' bones and teeth by nuclear microprobe (NMP) [14, 12, 11]. Interest was focused on determining levels of variability in elemental concentration of Ca and TE throughout selected micro-regions of group of camels from certain geographical region in Sudan. The objective of this study to assess the concentration profiles of light elements and metals in the tooth surface and bones by nuclear microprobe.

Materials and Methods

A set of teeth and bones from the eastern region of Sudan were investigated. Samples were washed with distilled water and rinsed with ethanol and allow to dry at room temperature. Prior to Micro-Particle Induced X-ray Emission (μPIXE) analysis samples were carbon-coated to prevent charging during irradiation. The dominant elements as determined by PIXE were Mg, P, Na, S, Cl, K, Ca, Fe, Co, Cu and Zn. They were embedded in epoxy at room temperature. Cross sections through the core were cut with a diamond saw. The resulting flat surfaces were carbon coated prior to proton bombardment. Beryllium absorber 25 μm thick was interposed between target and

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the PGT detector to reduce the high intensity Ca X-ray signals. Pile-up rejection was controlled by a beam-on-demand system, which deflected the proton beam temporarily to allow for correct digital pulse processing at high-count rates. All samples were irradiated at the Nuclear Microprobe (NMP) facility, at the Materials Research Department, iThemba LABS, South Africa utilising the 6 MeV Van de Graaff accelerator. More detailed description of the experimental set-up has been reported previously [10, 9, 8]. Proton beams with energy of 1.5 MeV were selected for analysis. Beam currents range of ~50~100 pA were used to prevent evaporation of elements. Selected micro-regions were scanned with focused proton beam of 2 – 3 µm spot size. True, overlap-resolved elemental maps as well as total micro-PIXE data were obtained using the technique of Dynamic Analysis (DA) [6, 14, 5] implemented at the iThemba LABS NMP, together with the software package Geo-PIXE II.[4] Studies on the determination of TE in camels' bones and teeth by nuclear microprobe [15, 3] have shown the strength of NMP application to focus on determining levels of variability in elemental concentration of Ca and TE throughout selected micro-regions of those samples.

Results and Discussion

Elemental mapping was not the primary aim of this investigation, as we were specifically interested in the concentration levels as deduced from the total X-ray yield of the particular irradiated area on the other hand the irradiated scanning areas were at ~500 μm^2. Analysis by micro-PIXE of this camels teeth showed a rather homogeneous elemental distribution for trace elements The results presented in table1 which shows concentration of selected elements in ($\mu g g^{-1}$) of the teeth such as Na, Mg, P, Cl K, Mn and Ca, on the other hand table2 shows the concentrations of bones in($\mu g g^{-1}$). From the tables of both teeth and bones we see the variation of the elements; Ca is rich as well as P where other elements are less concentrated depending on the area of irradiation, the maps Fig. 1a. is for teeth showing the selected elemental mapping for the elements Ca, P, Mg and Na. Fig1b showing the elemental mapping for the same elements for bones and by looking there is no significant difference for some of the elements such as Ca and P. Elemental Mapping distribution are of the 64 x 64 pixels (scan size~500 μm^2) square data matrix for maps, however the statistics show the ratio is ~1 except the ratio of Mg which is ~6 showing significant difference between teeth and bones in Mg element.
Elemental mapping of these camels hard tissues samples are measured with 1.5 MeV protons 6 MeV Van de Graaf accelerator using Particle Induced X-ray Emission(PIXE). Fig3. showed a rather homogeneous elemental distribution of Ca, P and Mg. and as well as for bone in Fig4.

Conclusion

In the micro analysis of small areas of camels hard tissues it is of extreme importance the optimization of experimental parameters which will determine the accuracy and minimisation of the minimum detection limits..
The presented results by the micro analysis of camels' samples hard tissues it is of extreme importance the optimization of experimental parameters which will determine the accuracy and minimisation of the minimum detection limits of trace elements. Recently there has

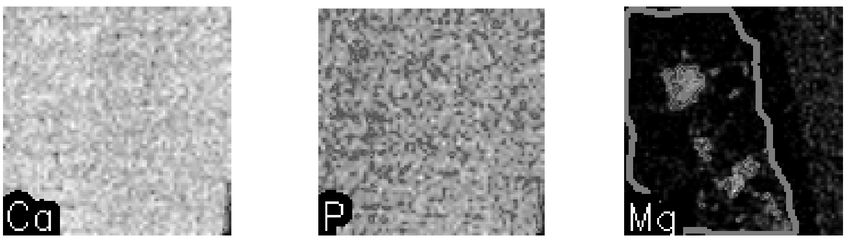

Figure 1a: Elemental Maps of Ca, P, Mg and Na for teeth

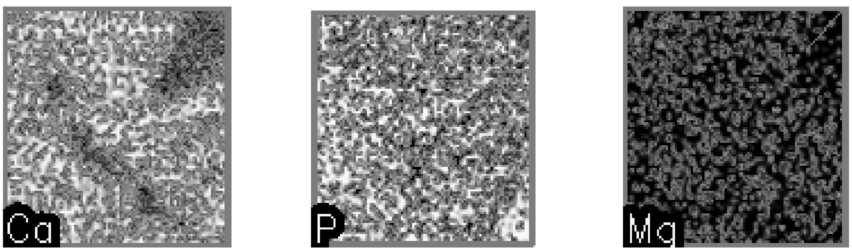

Figure 1b: Elemental Maps of Ca, P, Mg and Na for bones

Table 1: Descriptive statistics of the teeth sample concentration levels: mean standard deviation (STD) and relative error

		Na	Mg	P	S	CL	K	Ca	Mn
Teeth	Mean	2332.3	7887.8	73283.3	1244.5	642.8	1433.0	172101.8	619.3
	Standard deviation	739.0	3243.5	24001.8	726.0	119.6	916.3	47632.7	60.2
	Relative error	31.7	41.1	32.8	58.3	18.6	63.9	27.7	9.7
	Ratio (Teeth/Bone)	0.8	5.5	0.9	1.7	0.8	2.3	0.8	0.8

Table 2: Descriptive statistics of the bones sample concentration levels: mean standard deviation (STD) and relative error

Bone	Mean	2880.0	1442.7	85690.3	735.0	813.7	619.5	221459.0	741.0
	Standard deviation	73.5	319.6	10081.7	82.0	51.7	132.2	27447.1	164.0
	Relative error	2.6	22.2	11.8	11.2	6.4	21.3	12.4	22.1

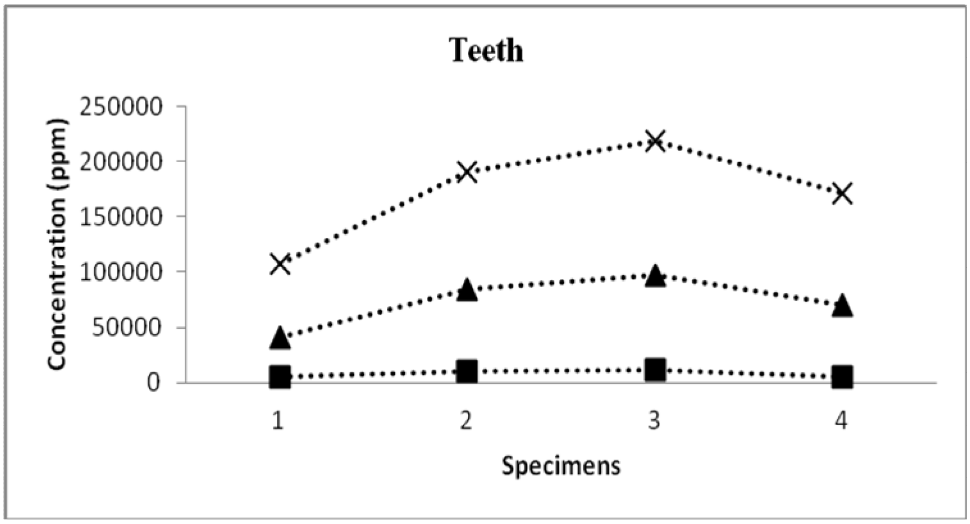

Figure2 PIXE concentration data ($\mu g g^{-1}$) as determined by GeoPIXE II for teeth specimens showing the overall trend for the trace elements Ca, P and Mg

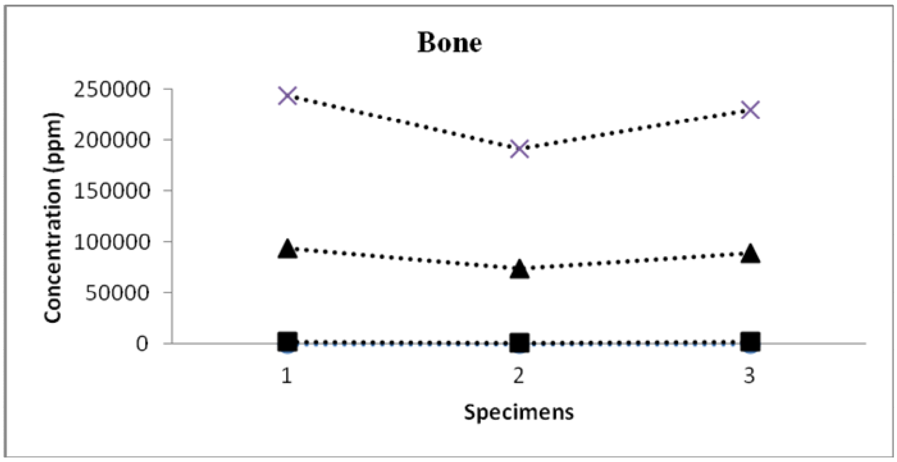

Figure3: PIXE concentration data (μgg^{-1}) as determined by GeoPIXE II for bone specimens showing the overall trend for the trace elements Ca, P and Mg

been a renewed interest in the application of nuclear microprobe in the biomedical field. The current output of this research is encouraging and further investigation in a wide range of materials and population is envisaged for the future. Dynamic Analysis has proved to be a strong combination for the determination of concentration and elemental mapping in camels hard tissues. However this is showing that the nuclear microprobe analytical technique is very powerful tool for the detection of the trace elements and elemental mapping in camels hard tissues.

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