



Analysis of Submandibular Salivary Calculus by External PIXE

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ABSTRACT

This work presents the study by external PIXE of two giant submandibular obtained from different individuals. The backscattered protons were detected to perform Rutherford Backscattering Spectrometry (RBS) simultaneously to PIXE. These calculi are rare and presented a layered structure; an elemental profile was obtained: P, Ca, O are commonly detected; Cl, Fe, Cu, Zn, Br and Sr are detected in particular layers. The ratios O/Ca and P/Ca were similar for the two calculi, but large differences for the other elemental contents were observed among the calculus. This analysis constitutes an indirect method to identify salivary components of particular cases.

Keywords: PIXE; RBS; saliva; salivary calculus; sialolith

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1. INTRODUCTION

The formation of salivary calculus in individuals is a common suffering among human beings. This illness called sialolithitasis is not dangerous, but it involves pain, malaise and feeding problems. In some cases, the origin of digestive system diseases is a consequence of this suffering. The exact calculus formation process is still unknown, but it is due to the obstruction of the salivary glands conduits and depends only in the saliva secretion. Other external elements do not take part in the process [1]. The salivary glands are found in the mouth and around throat. The major salivary glands are the parotid, the submandibular and the sublingual. The obstruction to the saliva flow by mineralized concretion in the conduits most commonly occurs in the submandibular glands. The structure of the concretion is a core continually coated by minerals contained in the saliva secretions, forming a layered arrangement around the core.

The whole saliva in the mouth is a complex biofluid mixture generated by the major and minor salivary glands. The saliva is a mineralized fluid which contains proteins and enzymes mixed with bacteria, leukocytes, sloughed epithelial cell and crevicular fluid. Its composition varies widely from individual to individual, from the secretion gland, and also from the same individual under different circumstances. Furthermore, the serum reference values published have to be regarded mainly as a general guide. Analytical methods developed for serum are often not directly applicable to saliva without modifications. The non-standardized methodology has partly contributed to the high variability in the data published for saliva parameters [2].

2. EXPERIMENTAL

The specimens consisted in two rare submandibular salivary calculus catalogued as giant or great size, denoted as A and B. Those specimens were extracted from the mouth of two different human beings in the Odontological Clinic at the Universidad Nacional Autónoma de México, (UNAM). The two samples have an ellipsoidal form and were cut carefully to half along the length axis with a diamond blade. PIXE and RBS in air were performed by protons using the external ion beam set up located at the 3 MV Pelletron tandem accelerator at the Instituto de Física, UNAM. The proton beam was collimated to 0.5 mm diameter using an anti-scattering cone and the incident beam energy at the sample surface was 3.1 MeV. An helium gas flux was used to reduce the beam dispersion. The X-rays generated in the target were registered by a LEGe detector and a Amptek Si detector. To reduce the Ca K X-ray intensity, an

absorber of 12 μm Ag evaporated on 3.5 μm Mylar was placed on the silicon detector window [3]. To enhance the X-ray emitted by heavy elements, a 76 μm aluminum absorber was placed at the LEGE detector window. The backscattered protons were registered simultaneously by a blind surface barrier detector placed inside a capsule under vacuum at 135° from the incident beam direction. The protons reach this detector passing through a 3.5 μm Mylar window along a cylindrical collimator with a 1.5 mm diameter aperture and 5 mm length. The X-ray peak counts in the PIXE spectra were obtained by the AXIL code [4]. The elemental concentrations in the calculus were determined using the computer code PIXEINT for thick target analysis. Using this code the X-ray emission intensity is simulated for a given sample composition. In this code, the results from RBS were taken as the first approximation for the main matrix composition. The uncertainties in elemental concentration were estimated to be 8 % to 12 %.

3. RESULTS

The calculus layered structure around a core was directly observed from the samples. These layers have inhomogeneous thickness and vary in tonalities of white (light) and gray (dark). The beam spots on the samples were selected on the core and on the different observable layers. These points were selected in places where the sample surface does not present roughness or high porosity density. Eight points were taken for sample A and six for sample B. The point 1 is corresponding to the core and the subsequent points were taken in order from the center. The elements detected using RBS in the two samples were O, P and Ca, indicating that the main composition is a kind of calcium phosphate [5]. The elemental concentrations detected in samples A and B are shown in the Tables 1 and 2 respectively. In those tables the color tonality of the corresponding layers is indicated as light and dark.

TABLE 1. Elemental concentration for calculus A.

Region from center	Color	Element							
		O % $\pm 12\%$	P % $\pm 8\%$	Ca % $\pm 8\%$	Cl $\mu\text{g/g}$ $\pm 8\%$	Fe $\mu\text{g/g}$ $\pm 8\%$	Cu $\mu\text{g/g}$ $\pm 8\%$	Zn $\mu\text{g/g}$ $\pm 8\%$	Sr $\mu\text{g/g}$ $\pm 8\%$
1	light	45.00	15.70	39.24	nd	350	33	23	64
2	light	44.19	16.02	39.65	936	352	29	29	68
3	light	42.93	15.68	41.35	nd	272	36	29	64
4	dark	43.25	15.79	40.56	877	2921	29	22	70
5	dark	39.92	16.04	42.69	1205	1703	59	37	71
6	dark	43.53	15.79	40.55	686	503	33	41	70
7	light	46.84	14.54	38.49	821	308	28	23	75
8	light	45.17	15.0	39.71	744	334	38	22	67

TABLE 2. Elemental concentration for calculus B.

Region from center	Color	Element							
		O % $\pm 12\%$	P % $\pm 8\%$	Ca % $\pm 8\%$	Fe $\mu\text{g/g}$ $\pm 8\%$	Cu $\mu\text{g/g}$ $\pm 8\%$	Zn $\mu\text{g/g}$ $\pm 8\%$	Br $\mu\text{g/g}$ $\pm 8\%$	Sr $\mu\text{g/g}$ $\pm 8\%$
1	dark	45.69	16.08	38.20	215	10	23	19	70
2	light	38.77	20.40	40.81	135	5	7	14	50
3	dark	47.24	17.32	35.43	nd	4	7	2	34
4	light	45.54	15.84	38.61	nd	8	6	nd	41
5	dark	48.48	18.18	33.33	122	6	3	nd	23
6	light	46.09	16.90	36.97	357	11	9	nd	53

The ratios O/Ca have variations up to 18% from point to point in calculus A, while for B the variation was up to 30%. For sample A the values for the ratio O/Ca were around 1.08 while for sample B were around 1.2. For the ratio P/Ca, a non significant variation was observed in both samples. For calculus A

and B, the mean values for that ratio were 0.39 and 0.45, respectively. These results are consistent with the published data.

The elements Fe, Cu, Zn and Sr were detected in both samples. Fe, Zn and Sr are not reported in saliva. The presence of Cl in calculus A was observed, while in calculus B, Br was detected. Figure 1 shows the concentration values for those elements Fe, Cu, Zn and Sr in the calculus A and B. A large difference in the elemental concentration is observed between those elements from one sample to the other. This is an indication of the wide variation in the saliva composition from individual to individual.

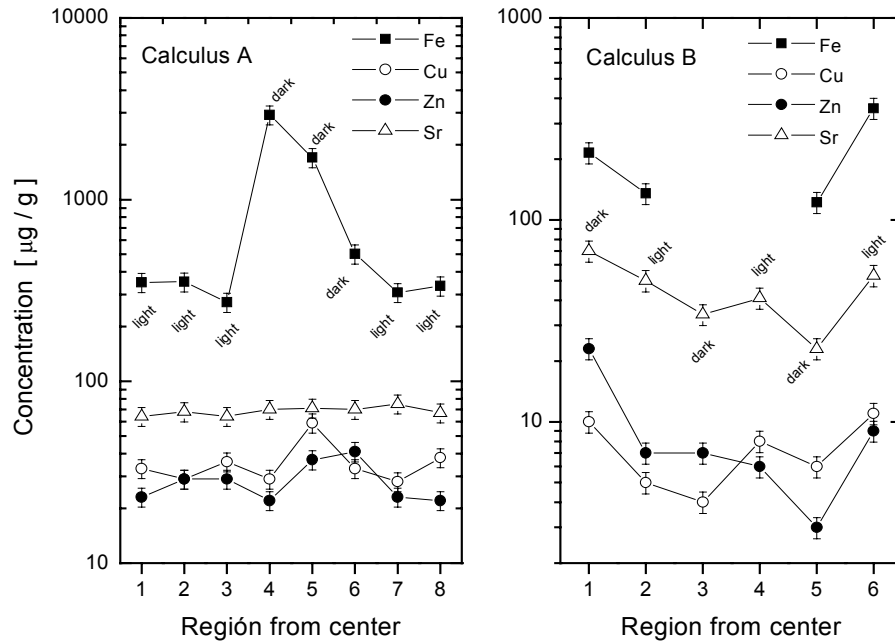


FIGURE 1. Elemental concentration for Fe, Cu, Zn and Sr for each point measured in the calculus A and B. The color tonality of the corresponding layer is indicated as light or dark.

From the results obtained, it was not possible to establish a relationship among the elemental concentration and the tonality light or dark in the different concretion layers. Only in the sample A for the dark regions a higher iron concentration was observed. Since this kind of giant calculus is non-common and the calculus formation depends on several factors in not possible to provide medical inquiries. Further studies in the calculus structure are required to obtain more conclusive results.

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