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GAMMA-RAY SPECTROMETRIC ANALYSIS OF THE CONCENTRATIONS OF Cr, Ag, Fe, Co, Rb, and Pt IN NORMAL HUMAN ENAMEL

by

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In prosthetics, it is important to know the influence of dental restorations on the concentrations of the inorganic constituents of the teeth (*Söremark et al.*, 1962). Before studying the possible uptake and penetration of elements present in various restorative materials in contact with teeth, we have to know the "normal" concentration of the elements in question. The concentration of Ca, P, Na, Cl, Zn, Sr, Mn, Br, Cu, W, and Au in intact dental enamel has been the subject of investigation by means of thermal neutron activation in combination with gamma-ray spectrometric analysis (*Söremark & Samsahl*, 1961).

The purpose of the present investigation was to follow up the previous studies by means of a similar experimental procedure using a relatively high thermal neutron flux of about 6.5×10^{13} neutrons \times cm $^{-2}$ \times sec $^{-1}$. This higher neutron flux made it possible to study the concentrations of additional elements, with lower activation cross-sections, which could not be studied using the previous neutron flux of about 1.7×10^{12} neutrons \times cm $^{-2}$ \times sec $^{-1}$.

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MATERIALS AND METHODS

Fifteen intact first bicuspids from humans between 14 and 16 years old were used in the present investigation. Eight girls and seven boys were selected on characteristics of good general health. They engaged in normal activity and enjoyed a normally varied diet. The teeth were extracted for orthodontic reasons and were prepared for activation within 48 hours after being extracted. Only amalgam and silicate fillings appeared in the teeth of the subjects. However, the teeth to be analysed had no restorations, and no fillings were present in the neighbouring teeth. Nearly all of the enamel was separated from the dentine mechanically by chipping and breaking, using glass and polythene-covered instruments in order to avoid contamination. The samples were allowed to dry in an electric oven for 48 hours at 105° C. The enamel samples were then weighed and sealed in quartz tubes. The enamel samples were never in contact with materials other than polythene and quartz. Standards of the elements to be studied were inserted in known amounts into quartz tubes and placed in the same aluminium can as the sample. Thus, the standards and the samples were irradiated simultaneously. The aluminium can was sent to a neutron reactor for irradiation by thermal neutron beams for six days. The neutron flux was about 6.5×10^{13} neutrons \times cm⁻² \times sec.⁻¹.

After irradiation and when the period of two months of decay of short-lived nuclides had elapsed, the samples were dissolved in 1N HCl to which 0.3 % H₂O₂ was added. Chemical group separation took place according to a procedure described by *Samsahl & Söremark* (1962).

The activity was measured in a 3" \times 3" well-type scintillation NaI (Tl) crystal operating in combination with a 256-channel gamma-spectrometer. Quantitative data on the basis of the dry weight of the samples were calculated after comparison of the intensities of the identified elements with those of the appropriate standards. These measurements were repeated three times at intervals of two months.

In order to avoid contamination, the water used for the dissolution of the various standards to be sent for irradiation as well as for rinsing of instruments and glassware was purified according to the following process: Ordinary tap water was ionically

purified, and, in order to oxidize organic compounds, 1 ml 1N NaOH and about 2 ml 0.1N KMnO_4 per liter of water were added. This solution was subjected to distillation in a quartz apparatus. Again 1 ml 1N NaOH and 2 ml 0.1N KMnO_4 were added per liter of water obtained, and another distillation followed. The water thus obtained was again distilled, and was then collected in a polythene bottle. After the standards had been irradiated they were diluted 1000 times before chemical group separation and measuring took place.

RESULTS

The results obtained from neutron activation and gamma-ray spectrometric analysis of the enamel of fifteen intact first bicuspid teeth from 14- to 16-year old boys and girls on the basis of dry weight are tabulated in Table 1.

No significant difference was found with respect to sex. Neither were any significant differences found between the teeth from upper and lower jaws.

Table 1

The mean concentrations expressed in parts per million of Rb, Cr, Ag, Fe, Co, and Pt in normal enamel of fifteen first bicuspids from 14- to 16-year old humans. The values are based on the dry weight. The standard deviations are also tabulated.

Rb	Cr	Ag	Fe	Co	Pt
4.90	0.0037	0.0049	338	0.00024	0
± 2.2	± 0.0016	± 0.0012	± 109	± 0.00011	

DISCUSSION

Biological significances and the chemistry of some micro-elements in the enamel have been discussed, *e.g.* by *Brudevold & Söremark* (1964). The concentrations have been determined on a dry weight basis, meaning that density as well as water content of the enamel have not been taken into account.

The surface layer of enamel is more calcified than inner enamel and differs in composition in some respects (*Brudevold & Söremark*, 1964). Nearly the entire enamel was subjected to

neutron activation and gamma-ray spectrometric analysis in the present study. This means that the values obtained for the concentrations of the element in question are those for the entire enamel from each tooth. Consequently, the present study does not show the concentration of the element in various layers of the enamel. With the instruments at present available, we have not succeeded in grinding off layers of the hard tissues without contaminating the samples.

The methods used in the present investigation and errors due to the methods and sampling technique have previously been discussed (*Samsahl & Söremark, 1962*).

SUMMARY

The concentrations, on the basis of dry weight, of Rb, Cr, Ag, Fe, Co, and Pt in "normal" human enamel were studied. The values were obtained from fifteen intact first bicuspids from 14- to 16-year old boys and girls. The concentrations were studied by means of thermal neutron activation analysis of the individual enamel samples.

RÉSUMÉ

ANALYSE SPECTROMÉTRIQUE PAR RAYONS GAMMA DES CONCENTRATIONS DE Cr, Ag, Fe, Co, Rb, ET Pt DANS L'ÉMAIL HUMAIN NORMAL

Les concentrations, en se basant sur le poids à l'état sec, de Rb, Cr, Ag, Fe, Co et Pt dans l'émail humain "normal" ont été étudiées. Les valeurs ont été obtenues à partir de quinze prémolaires intactes provenant de sujets des deux sexes âgés de 14 à 16 ans. Les concentrations ont été étudiées par analyse par activation thermique neutronique de chaque spécimen d'émail.

ZUSAMMENFASSUNG

GAMMASTRAHLEN-SPEKTROMETRISCHE ANALYSEN DER KONZENTRATIONEN VON Cr, Ag, Fe, Co, Rb UND Pt IM NORMALEN MENSCHLICHEN ZAHNSCHMELZ

Es wurde die Konzentration von Cr, Ag, Fe, Co, Rb, und Pt in normalen Schmelz bestimmt. Die quantitativen Werte und ihre Standardabweichungen an 15 gesunden Zähnen von 14—16 J. alten Mädchen und Knaben wurden festgestellt.

Die Konzentrationen wurden mit Hilfe der Neutronenbestrahlung der Zahnschmelzproben, die mit bekannten Substanzen verglichen wurden, untersucht.

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