SHIMADZU
Excellence in Science

Application News

Electron Probe Microanalyzer EPMA-1720HT

Analysis of Deciduous Molar Surface by EPMA

T. Ono

User Benefits

- Enables highly sensitive measurement of the distributions of fluorine, magnesium, and other trace elements on the tooth surface.
- Possible to analyze the irregularly shaped, extremely uneven tooth surface without sample preparation.
- Can be used in research on the tooth growth process and prevention of tooth decay.

■ Introduction

Human teeth can be divided into the crown, which is visible in the mouth, and the root, which is hidden by the gingiva. The crown is covered with enamel and is the hardest tissue in the human body. Approximately 95 % of enamel is an inorganic substance consisting mainly of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$). Cavities (dental caries) occur when the amount of decalcification of the enamel caused by acids produced by caries-causing bacteria exceeds the amount of recalcification. It is known that coating teeth with fluoride or use of the artificial sweetener xylitol is effective for promoting recalcification. Analysis of trace elements is extremely important in research on this tooth growth process and prevention of tooth decay.

This article introduces an example of an analysis of the surface of a deciduous molar that was regularly coated with fluoride by a dentist, in which a mapping analysis was conducted using a Shimadzu EPMA-1720HT EPMA™ electron probe microanalyzer with stage height correction (trace mapping analysis function of the EPMA) following the uneven surface topography of the tooth.

■ Mapping of Deciduous Molar Side Surface

Dental caries (tooth decay) progresses in a biofilm called dental plaque. First, caries-causing bacteria such as *Streptococcus mutans* decompose the sucrose in foods and synthesize glucan, which has an adhesive property and forms plaque by adhering firmly to the teeth. Next, the caries-causing bacteria produce organic acids in the plaque, and tooth decay proceeds by decalcification of the enamel. Regular coating with fluoride is considered to be effective for preventing this decay process and promoting recalcification.

Fig. 1 shows the results of a mapping analysis of the entire side surface of a deciduous molar. Here, "COMPO" is a backscattered electron image in which differences in composition are emphasized by contrast. Similarly, "TOPO" shows the topographical information. It can be understood that the main components O, P, and Ca, and the F due to fluoride coating, are distributed uniformly over the entire surface. C and N were detected in the central valley and at the right and left edges, and are presumed to be components of the dental calculus (tartar) formed by calcification of plaque. In addition, the trace components Na, Mg, and Cl have also been detected with high sensitivity.

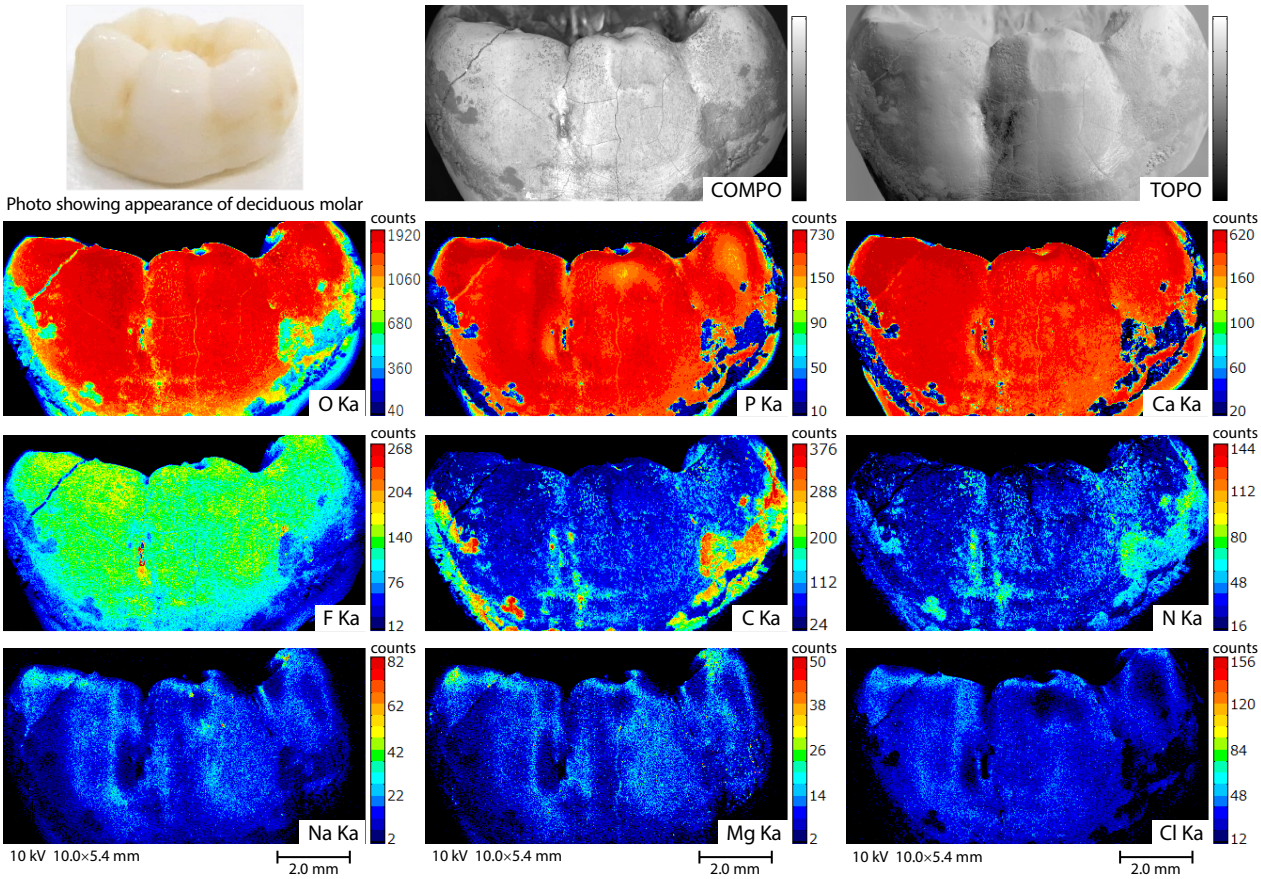

Fig. 1 Appearance of Deciduous Molar and Results of Mapping Analysis of Whole Side Surface

■ Mapping of Cusp and Side of Deciduous Molar

The main components of the inorganic substance which makes up the composition of teeth exist in a hydroxyapatite structure ($Ca_{10}(PO_4)_6(OH)_2$). OH^- is unstable, and if substituted with ions of F or Cl, $Ca_{10}(PO_4)_6F_2$ or $Ca_{10}(PO_4)_6Cl_2$ will form. In young persons, it is generally said that the concentration of fluoride ions in the surface layer of the enamel is high around the cusp part of teeth and low on the side of the dental cervix (the neck of the tooth between the crown and root). The highest concentration of Cl is found in the surface layer of the enamel, and the concentration tends to decrease in deeper parts (boundary with the dentin of the tooth). In the inorganic material of teeth, Mg is also a main component element of the enamel, after Ca and P, but because Mg has the effect of suppressing calcification, its concentration tends to increase from the surface layer of the enamel toward the dentin in the deeper tooth.

Fig. 2 shows the results of a mapping analysis of the boundary between the cusp and the side of a deciduous molar. Here, the distributions of the main component elements O, P, and Ca, the elements C and N, which are components of plaque and tartar, and the other trace components F, Na, Mg, and Cl were measured. F is distributed uniformly over the entire tooth, showing that regular fluoride coating is effective. Above the boundary between the cusp and the side, the intensity of Mg is high and the intensities of Ca and Cl are low, suggesting the possibility that the enamel layer has become thin in the cusp part.

■ Conclusion

A mapping analysis of the entire side surface of a deciduous molar and the boundary between the cusp and the side of the tooth was carried out using an EPMA. It was found that F was uniformly distributed by fluoride coating and trace components such as Mg and Cl could also be measured with high sensitivity, demonstrating that EPMA is an effective tool for research on the tooth growth process and prevention of tooth decay. In particular, although teeth have an irregular shape and an extremely uneven topography, because the Shimadzu EPMA has a high X-ray take-off angle, the tooth surface can be analyzed with high accuracy without sample preparation, by highly precise stage control utilizing the trace mapping analysis function of the EPMA.

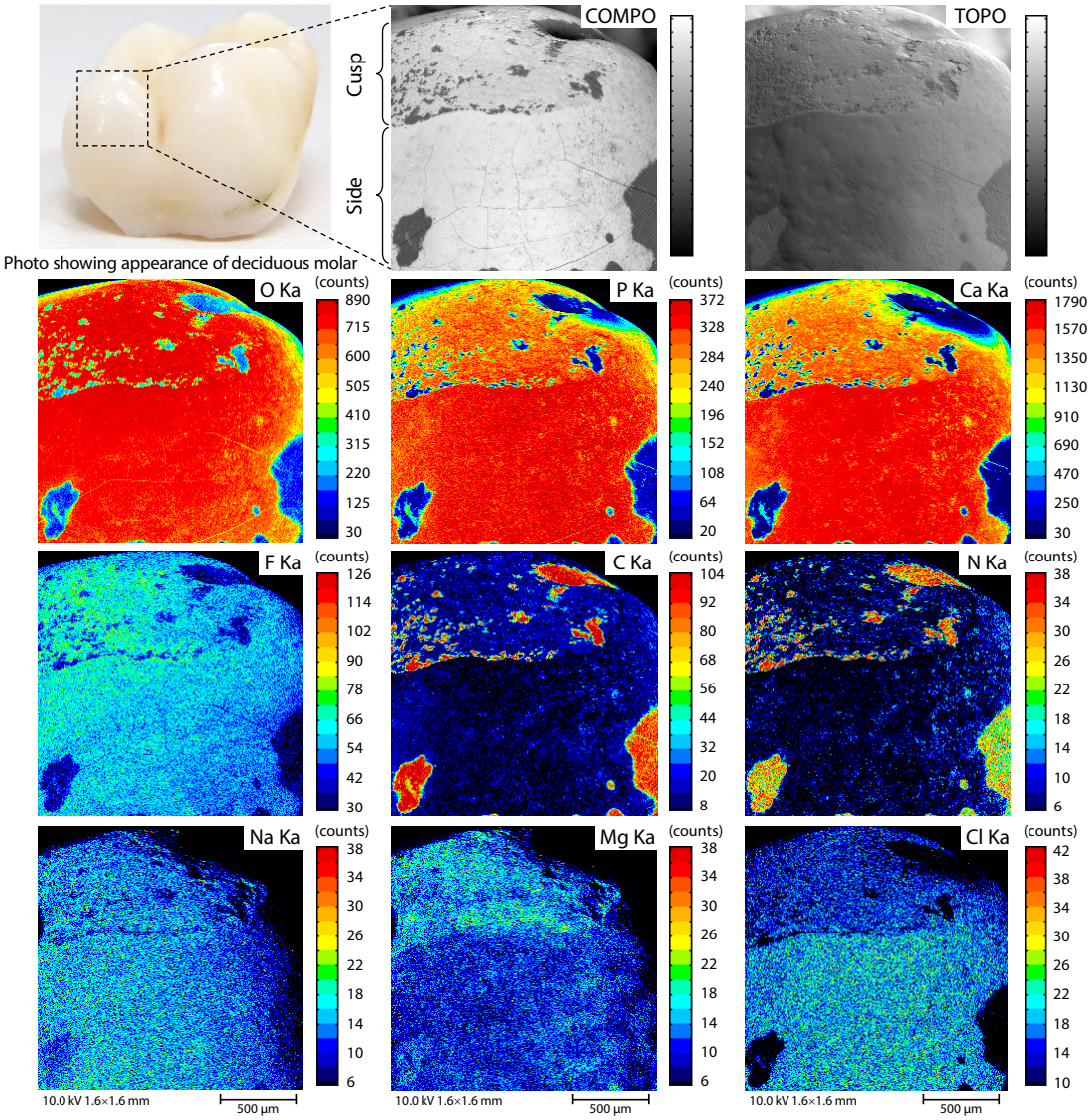

Fig. 2 Appearance of Deciduous Molar and Results of Mapping Analysis of Boundary of Tooth Cusp and Side

<Reference>
Haruo Nakagaki et al., Prophylactic Methods in Dental Caries Prevention for Dental Hygienists, 2nd Ed., Ishiyaku Publishers, Inc.

01-00285-EN First Edition: Feb. 2022

SHIMADZU

Shimadzu Corporation
Analytical & Measuring Instruments Division
Global Application Development Center

www.shimadzu.com/an/