Multimethod analysis of apatites in sound human tooth enamel

MARIE J. BOTTERO*, JACQUES YVON** and JEAN VADOT*

*Université de Nancy I, UFR d’Odontologie, rue du Doyen Heydenreich, 54000 Nancy, France
** Laboratoire Environnement et Minéralurgie, UA 235 du CNRS, ENSG, INPL, BP 40, 54501 Vandoeuvre Cedex, France

Abstract: A multimethod analysis of mineral apatite of sound human tooth enamel was used to study the chemical variation and crystallinity of 20 samples originating from high-caries-activity mouths (HC), with impacted (HCl) or erupted teeth (HCE), and from mouths free of caries activity (FC), with impacted (FCI) or erupted (FCE) teeth. The different methods used are electron microprobe analysis to determine the concentration of Ca, P and Mg, infra-red spectroscopy to evaluate the relative concentration of CO$_3$ and PO$_4$ in the different samples. X-ray diffraction was used to calculate the lattice parameters and the coherent scattering thickness (Cs) deduced from (300), (002) and (004) reflections. All the data were analysed using Normalized Principal Component Analysis.

The chemical analyses show that FCI and FCE samples are affected by CO$_3$ substituting for PO$_4$, HCI and HCE samples by HPO$_4$ substituting for PO$_4$. The apparent coherent scattering thickness (Cs) along $c$ is lower for FCI and HCE than for FCE and HCl. There are more crystal defects along $c$ for the former two samples.

Data analysis shows that $a$, $c$ and packing order along $c$ are, in part, inversely correlated with CO$_3$ concentration. Packing order along $c$ (Cs(002)) plays a discriminant role; it is very high for FCE and very poor for HCE, moderate for FCI and HCl. Chemical substitutions and size of lattice parameters are not really discriminant either for the position (I or E) or for the origin (FC or HC) of the samples.

The caries susceptibility can be related to an increase of Cs(002) in erupted teeth and a decrease of Cs(002) in impacted teeth and also to an apparent excess of cationic charge. These observations seem to be indicative of the existence of a predisposition to caries correlated to chemical and structural (crystallographic) parameters of enamel.

Key-words: tooth, enamel, apatite, crystallinity, lattice parameters, coherent scattering, infrared.

Introduction

Calcium phosphates are by far the most dominant constituents of mature enamel (Montel, 1977). These are imperfect apatites, low in calcium (Ca/P $\approx$ 2.09) and hydroxide ions, but rich in substitutional impurities (Eanes, 1979). The main mineral components of teeth enamel are Ca$^{2+}$, PO$_4^{3-}$,CO$_3^{2-}$, with minor Cl$^-$, Na$^+$, K$^+$, Fe$^{2+}$, Zn$^{2+}$, Sr$^{2+}$ and citrates (Losee et al., 1974; Baud & Very, 1975; Bonel & Montel, 1964, 1972; Bonel, 1972). Under normal physiological conditions, tooth enamel mineral is stable. As the stability field of a given apatite depends on the medium characteristics (pH and chemical composition), phase variations may arise from differing equilibrium conditions (Francis, 1965).

The Ca and P contents of enamel decrease according to the Òpost eruptive effectÓ (Wolgens et al., 1981a and b); in all the teeth, they seem to decrease from the external side to the internal side or Ødentine/enamel junctionÓ (DEJ) as