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Thermal behavior of dental enamel and geologic apatite: An infrared spectroscopic study

JIANMIN SHI,[1,*] ARNDT KLOCKE,[2] MING ZHANG,[3] AND ULRICH BISMAYER[1]

[1]Mineralogisch-Petrographisches Institut, Universität Hamburg, Grindelallee 48, 20146 Hamburg, Germany
[2]Klinik und Poliklinik für Zahn-, Mund- und Kieferheilkunde, Universität Hamburg, Martinistrasse 52, 20246 Hamburg, Germany
[3]Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3 EQ, U.K.

ABSTRACT

Teeth and bones consist of an apatite-type structure and such biogenic apatites usually occur in nano-crystalline form. Because of the small particle size in biological tissues, local structural details of biogenic apatite have still not been resolved in detail. Comparison of the phonon spectra of enamel apatite with those of inorganically formed apatite was carried out to improve our understanding of the vibrational behavior of biogenic apatite. In situ mid-infrared absorption spectra of dental enamel and geologic fluorapatite were recorded from 300 K to ca. 750 K. Lattice vibration modes were studied at low temperature in the infrared region of 150 to 650 cm^{-1}. The IR excitations indicate that geologic apatite undergoes heavier thermal changes than enamel apatite at temperatures between 60 K and 300 K. In situ high-temperature IR spectra confirm the different thermal evolution of dental enamel and geologic fluorapatite. The P-O overtones or combinational vibrations and hydrous species of enamel apatite show two different thermal regions below and above 600 K. The thermal behavior in the region below 600 K corresponds to the loss of adsorbed and part of the lattice water, combined with an increase of structural OH groups. In the second thermal region (above 600 K), the similarity of thermal response of dental enamel to that of the geologic apatite from 300 K suggests the existence of a highly ordered system. This result may be explained by the dehydration and atomic rearrangements in the channels of enamel apatite structure below 600 K.