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Chemistry of bone mineral, based on the hypermineralized rostrum of the beaked whale *Mesoplodon densirostris*

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Abstract

Carbonate-substituted hydroxylapatite is the inorganic component in bone. The nanometer size of bone crystallites and their interweaving with subequal volumes of collagen fibrils make the chemical analysis of the bone mineral extremely difficult. The few chemical analyses that are available commonly were made on ashed bone, which, in addition to mineral, also includes chemical residues of collagen. For the present study, we chose the rostrum of the whale *Mesoplodon densirostris*. Its mineral content of up to 96 wt% makes it an ideal material for pursuing the chemistry of bioapatite within bone. Both bulk (X-ray fluorescence, thermogravimetry, and carbon analysis) and point analyses and element mapping (electron microprobe) were applied to this densest of bone materials. Its bioapatite has an average carbonate content of ~8 wt% and an average Ca/P atomic ratio of 1.7. The rostrum shows extremely low-concentration trace elements (Al, Si, Fe, Ti, and Sr) and some minor elements (K and Cl) as in typical bone materials. Homogeneity of elemental distribution is demonstrated in typical mineral-dominated areas within the rostrum sections except around a few vascular holes and vessels. The very good correlation between electron microprobe point analyses and the XRF bulk analyses of the rostrum indicate the latter to be a useful chemical model of bone mineral. The bulk analysis shows that the bioapatite in the rostrum has an average composition of $(Ca_{8.40}Mg_{0.20}Na_{0.54})[(PO_4)_{4.87}(CO_3)_{1.13}](OH)_{0.87}$.

Keywords: Apatite, bone, whale rostrum, electron microprobe, X-ray fluorescence