Contribution of X-ray Microscopy to Bone Mineral Studies

EICHERT Diane, SALOME Murielle, COMBES Christèle*, BLEUET Pierre, BOHIC Sylvain, REY Christian*, SUSINI Jean

European Synchrotron Radiation Facility, ESRF, X-ray Micro spectroscopy Beamline ID21-22, BP220, 38043 GRENOBLE Cedex, FRANCE
**ENSIACET, Equipe Physico-chimie des Phosphates, 118 route de Narbonne, 31077 TOULOUSE Cedex, FRANCE*

Bone, which is formed by the infusion of an organic matrix, principally collagen, with calcium phosphate, performs two major functions in the body. This combination of about 20wt% collagen and 80wt% calcium phosphate provides the biomechanical properties needed for body support and movement. In addition, bone mineral is in metabolic interrelation with body fluids, serving principally as a reservoir for body minerals, storing or releasing them as the need arise, changing in size, distortion and chemical perfection with age, disease and chemical/medical treatment [1-2]. Trace elements have been shown to have a profound influence on the chemistry and solubility of bone as this latter is the accumulation "target" organ for many heavy metals. Consequently, many human diseases and pathological conditions result in changes in bone tissue that affect the rate of bone turnover and its physico-chemical properties. Bone mineral presents then a complex composition, and appears as a very sensitive, reactive and sophisticated material.

Several techniques may be used for the study of bone mineral but often allow a global measurement only without spatial information. However the study of the mineral content of bone at a microscopic scale is of particular interest, since it can give new insights into remodelling activities, mineralization processes, effect of drugs and related mechanical properties.

We report here applications of X-ray microprobe techniques to the analysis of bone and biomaterials (analogous to bone mineral and implants). In particular, we will present the studies carried out on bone mineralization and maturation processes using X-ray micro-fluorescence, micro-XANES and micro-diffraction and micro-infrared [3-4]. Secondly, examples of applications to more specific topics will be shown, namely the study of bone mineral in osteogenesis imperfecta pathology [5], the effect of Sr based drugs against osteoporosis and the integration of titanium implants in bone [6]. Last, recent developments in x-ray micro-tomography allowing in-situ dynamic follow up of the formation and propagation of micro cracks in bone under strain will be presented [7].

[1]: Posner A.S., In bone and Mineral Research, edited by W.A. Peck, Elsevier, New York (1987) : 65
[2]: Rey C. et al., Cells Mater. (1995) 5 : 345
[3]: Eichert et al., Spectrochimi. Acta B (2005), submitted
[4]: Eichert et al., J. Bone Miner. Res. (2005), submitted
[5]: Eichert et al., in preparation
[6]: Eichert et al., in preparation
[7]: Bleuet et al., SPIE Developments in X-Ray Tomography IV(2004) 5535 : 129