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Report:

Comparative textural analysis of Pleistocene hominid and actual human bone

Bone has been extensively investigated with respect to the orientation of mineral components at different scales in order to decipher its mechanical function and genetic processes. It is recognized a distinct evolution among bones and macroscopic features have been used to discriminate evolutionary trends. However little is known about the nanostructural level. Here we investigate the texture of the mineral component (apatite) in a fossil hominid bone in order to compare with modern one. Small fragments of *Homo antecessor* and *Homo sapiens* radii were analyzed with hard X-rays (λ= 0.141542 Å; 500μm beam size) at ID15B. A complete coverage (+60/0/-60º) was acquired. Tissue degradation in fossil sample was observed to be concentrated into the first mm of the frontal part; An amorphous signal is obtained there. Inner and internal faces mostly show common osteon microstructural details (Haversian channels, lamellae, lacunae…). A comparison of modern (left) and fossil (right) maps (2D images, azimuthally integrated) are shown in Fig.1 were (002) Apatite plane is indicated:

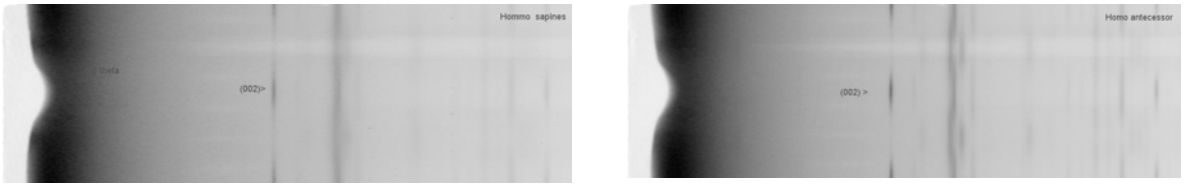

Fig. 1: *azimuthally integrated maps for modern (left) ad fossil (right) bone. (002) apatite peak is marked. Density variations along the lines reflect a strong preferred orientation of crystallites.*

Data were processed with Rietveld code MAUD [1] to obtain orientation distribution of apatite crystallites. Results reveal important correlations about tissue nanostructure: A strong (002) preferred orientation parallel

to bone axis in both samples with similar patterns. However fossil tissue (right) displays a higher preferred orientation in comparison with modern bone (left) (Fig.2).

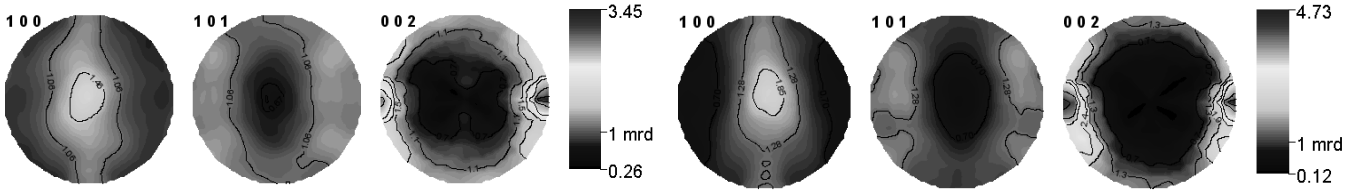

Fig. 2*: Pole figures of modern (left) and fossil (right). Scale in multiples of a random distribution (m.r.d.)*

Previous studies of bone microstructure suggest that crystallite size could be considered age-dependent parameters (e.g. [2]) We have refined microstructural parameters following the Popa model [3]. Prismatic crystallite shapes are found in both samples although differences in the long dimension arise. These results suggest that apatite crystal platelets are composed by coherent prismatic domains in shape. Differences in size between samples have to be explored in more detail in more samples to derive conclusions. Our results clearly demonstrate that both samples share a common nanostructure and support the idea that biological processes leading to the space distribution of mineral nano-particles in bone tissue are essentially the same in spite of macroscopic differences.

Analysis of nanostructed materials

The experimental device consists of an electro-thermal furnace incorporated in the 3 KN electro-thermo-mechanical tester. During the experiment the beam passed through the sample in the general transmission diffraction geometry (Fig.1), while the sample was heated at a rate of 5°C/s in steps of 25°C from room temperature (RT) to 600°C. The measurements were performed with the sample inside an environmental chamber with an N2/Ar flux where the X-rays entered and exited through Kapton windows. The temperature was recorded with a Platinum-Rodium thermocouple. Transmission diffraction patterns were recorded using a MAR345 image plate detector, mounted perpendicular to the incident beam behind the sample. Each diffraction pattern was collected over an exposure of 60 second during the isothermal steps. A Silicon powder standard was used to calibrate the sample to detector distance and refine instrumental parameters.

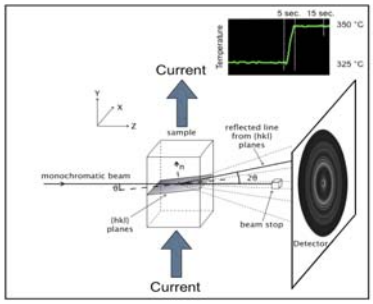

Fig. 1 *experimental set-up*

Sintered and not sintered Ti-Hidroxilapatite and Al-BN alloys were explored under load/thermal cycles in order to characterize microstructural and phase evolution (Fig. 2). Diffraction data were processed with MAUD [1]. Crystallite size evolution and lattice expansion were quantified. Results are very important to improve sintering procedure in the design of bone-like materials.

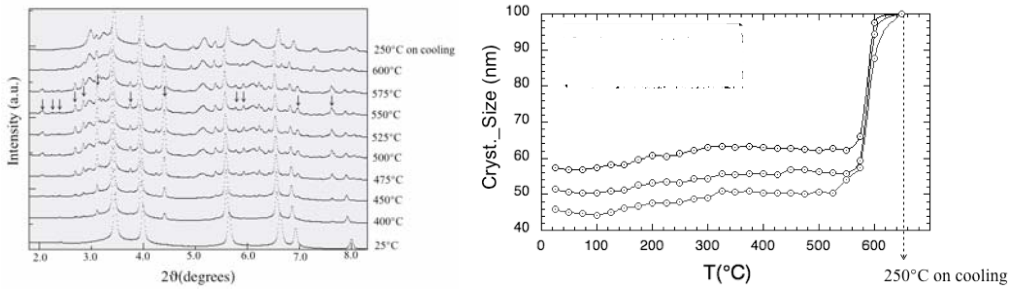

Fig. 2: *Integrated spectra at different temperatures showing phase transition with temperature (left) and crystal growth as a function of temperature (right).*

[1] Lutterotti, L., Matthies, S., Wenk, H.-R., 1999. International Union of Crystallography Committee Powder Diffraction Newsletter 21, 14-15.

[2] Nuzzo, S., Meneghini, C., Braillon, P., Bouvier, P., Mobilio, S., Peyrin, F., (2003) Journal of Bone and Mineral Research 18(4), 760-768.

[3] Popa, N. C., (1998). J. Appl. Cryst. 31, 176-180.