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Multiscale Analysis of Biomaterials: From Macro- to Nanoscale in Hen Bone Tissue

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A multiscale and multimodal analytical framework is introduced to elucidate the complex structural and compositional changes in bone tissue, taking the age-related deterioration of hen bone properties as a model system. Particularly, laying hens during the intensive egg production cycle experience significant physiological stress due to the need to mobilize large amounts of calcium for eggshell formation, often leading to severe skeletal deterioration [1]. By treating this biological phenomenon as a geochemical interface process, we demonstrate how high-resolution techniques can provide an understanding of the possible structural and compositional factors leading to bone integrity deterioration.

The research highlights the potential of a diverse tool-array for characterization across multiple resolutions:

- Macro to Microscale [1,2]: Thermogravimetry, X-Ray Diffraction (Powder & 2D), ATR-FT-Infrared & Synchrotron-base-FTIR, Computed Tomography.
- Micro to Nanoscale [3,4]: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atom Probe Tomography (APT).

The main findings of this multiscale analysis of hen bone properties indicate that aged-related skeletal changes are likely marked by alterations in the bone mineral crystallinity and the mineral-organic matrix ratio that may reflect specific metabolic adaptations to physiological stress. This methodology provides a robust approach for the broader analysis of biomaterials in environmental and health sciences, offering a path to identify quality biomarkers through advanced geochemical and physical characterization tools.

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