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Deformation and fracture mechanisms in bone and bone-like materials: inspiration for new engineering materials and biomaterials

Abstract: Bone is a high-performance material with a variety of functions, the primary of which is mechanical support. To fulfil this structural function bone is stiff and hard, but it is also surprisingly tough. These properties are attributed to a balanced content of minerals (calcium and phosphate), proteins (mostly collagen) and water, and also to a hierarchical structure which is often described as building blocks nested over several length scales. While composition and architecture are important for the performance of bone, recent studies have also highlighted the importance of the weak interfaces within this material. Here I will discuss how architecture and weak interfaces govern two key mechanisms in bone: the gliding of fibrils at the nanoscale, and the deflection of cracks along cement lines. Interestingly, similar mechanisms are exploited in other structural biological materials such as seashells and sponge spicules, and in engineering materials such as fiber reinforced composites, layered ceramics and architectured materials. In these materials the interplay of architecture and weak interfaces generates unique and attractive combinations of stiffness, strength, large deformations and toughness. I will present some examples of novel materials that we are developing based on these bio-inspired concepts, using bottom-up and top-down fabrication strategies. These materials are targeted at various engineering and biomedical applications including toughened ceramics and synthetic bone grafts.

Bio: Prof. Barthelat has been at McGill University since 2007, where he is now an Associate Professor and leads the Laboratory for Advanced Materials and Bioinspiration. His research interests include mechanics of deformation and fracture in biological materials, bioinspired materials and interfaces and architectured materials. He also develops novel experimental techniques for materials testing and solid mechanics.