

Flexible Dermal Armor Inspired by Nature Designs

MOTIVATION

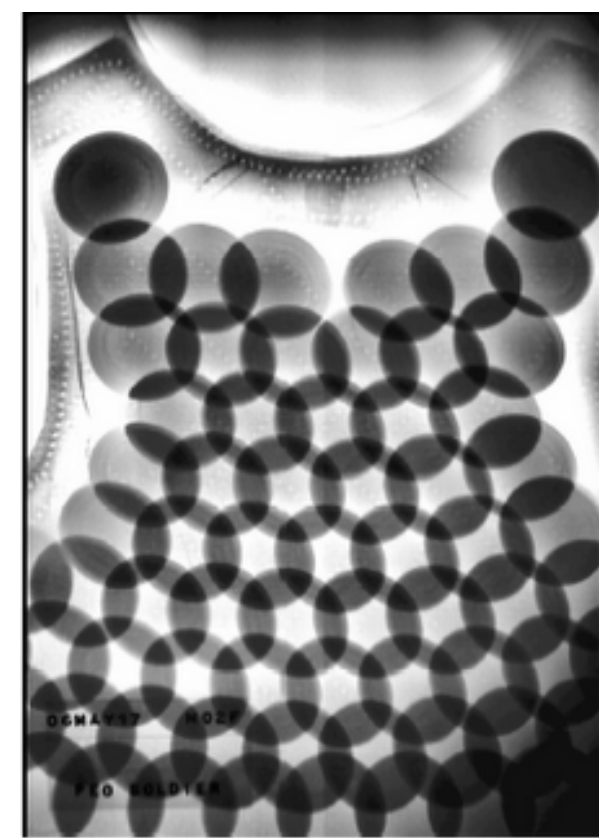
- Develop flexible dermal armor (bulletproof ballistic vest)
- Offers more flexibility and maneuverability
- Interlocking and compliant mechanisms
- Revolutionizes traditional rigid ballistic vest designs (too stiff, too rigid and too heavy)
- Acts as an impact absorbent materials
- Hierarchical designs: layered by layered makes nature materials stronger
- Optimal strength (strong) with less material (lightweight)

BACKGROUND

- Dragon skin failed! Why?
- After ballistic testing, plates clustered together
- Dragon skin wasn't able to sustain ballistic testing

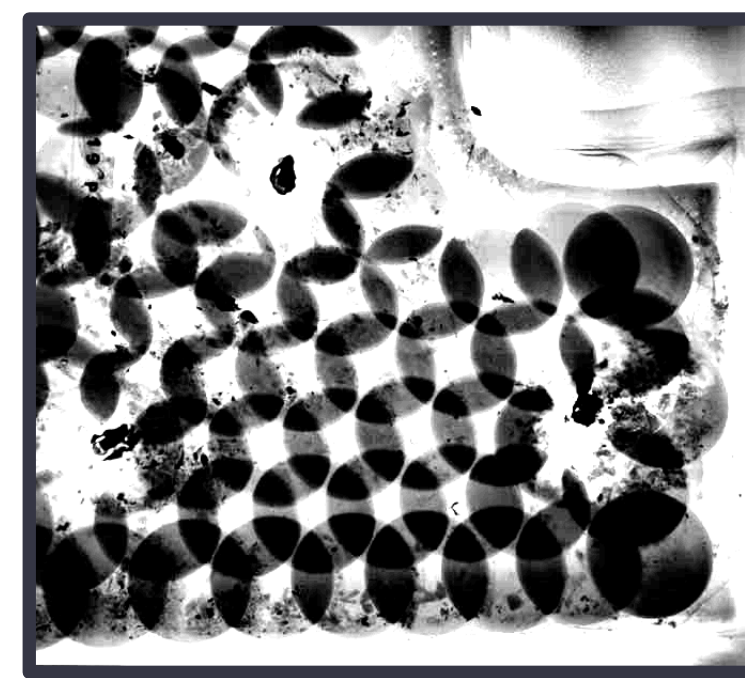


Before Testing



<http://www.pinnaclearmor.com/images/mar-ciras.jpg>

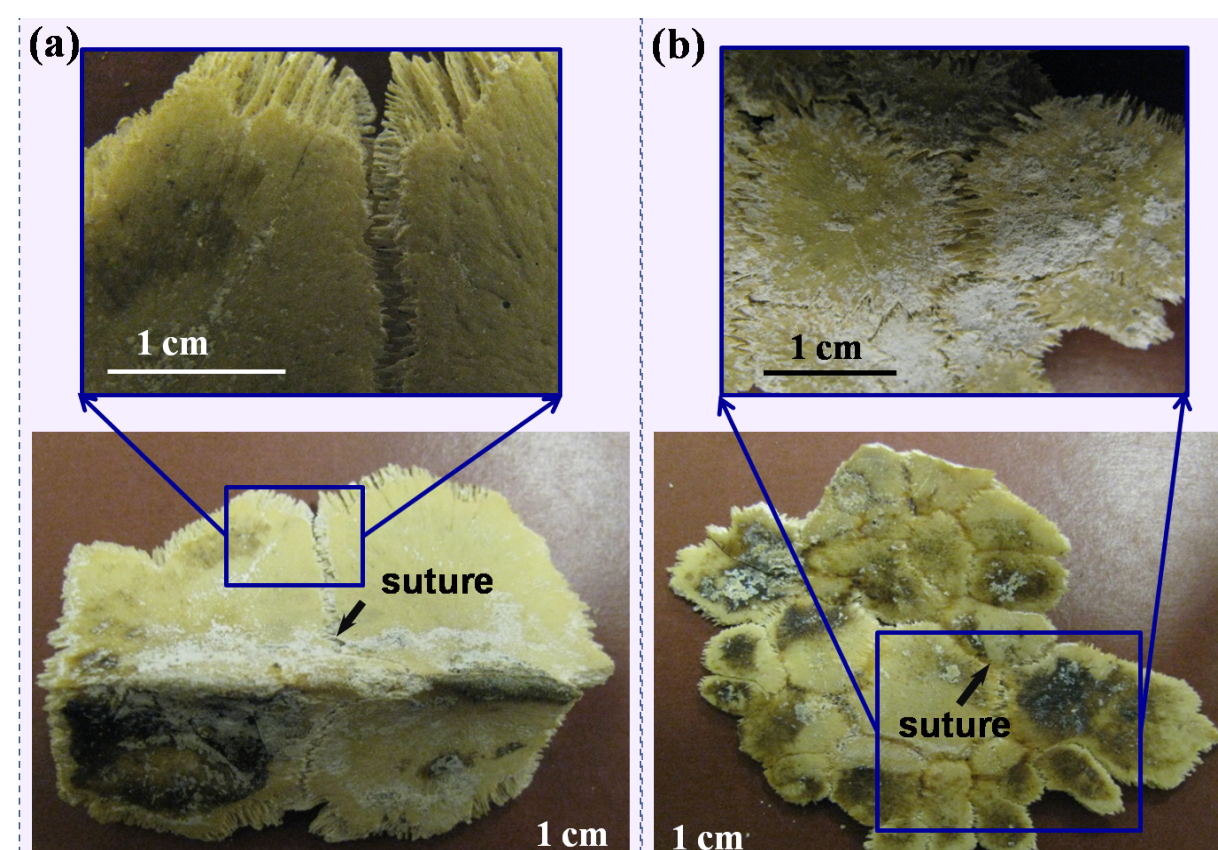
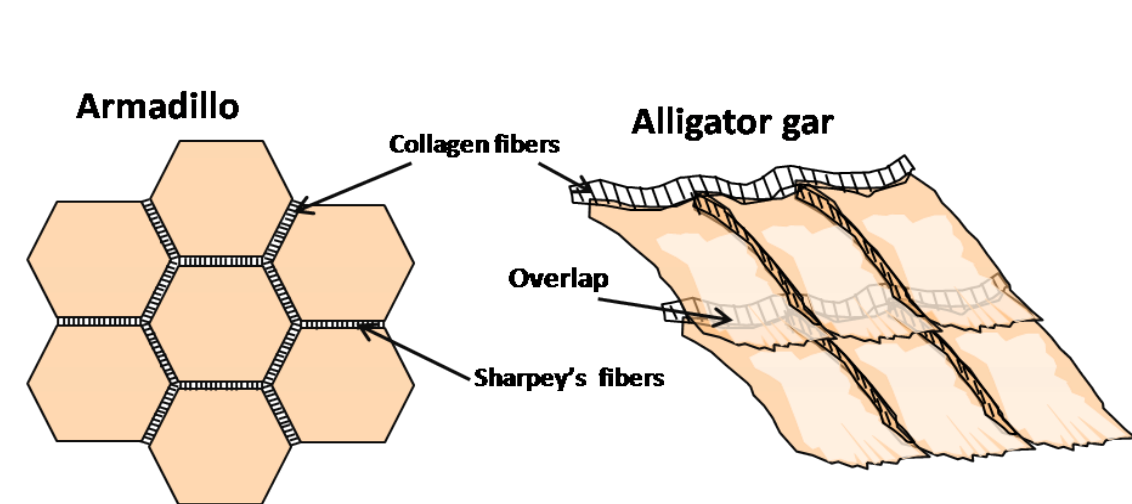
After Testing



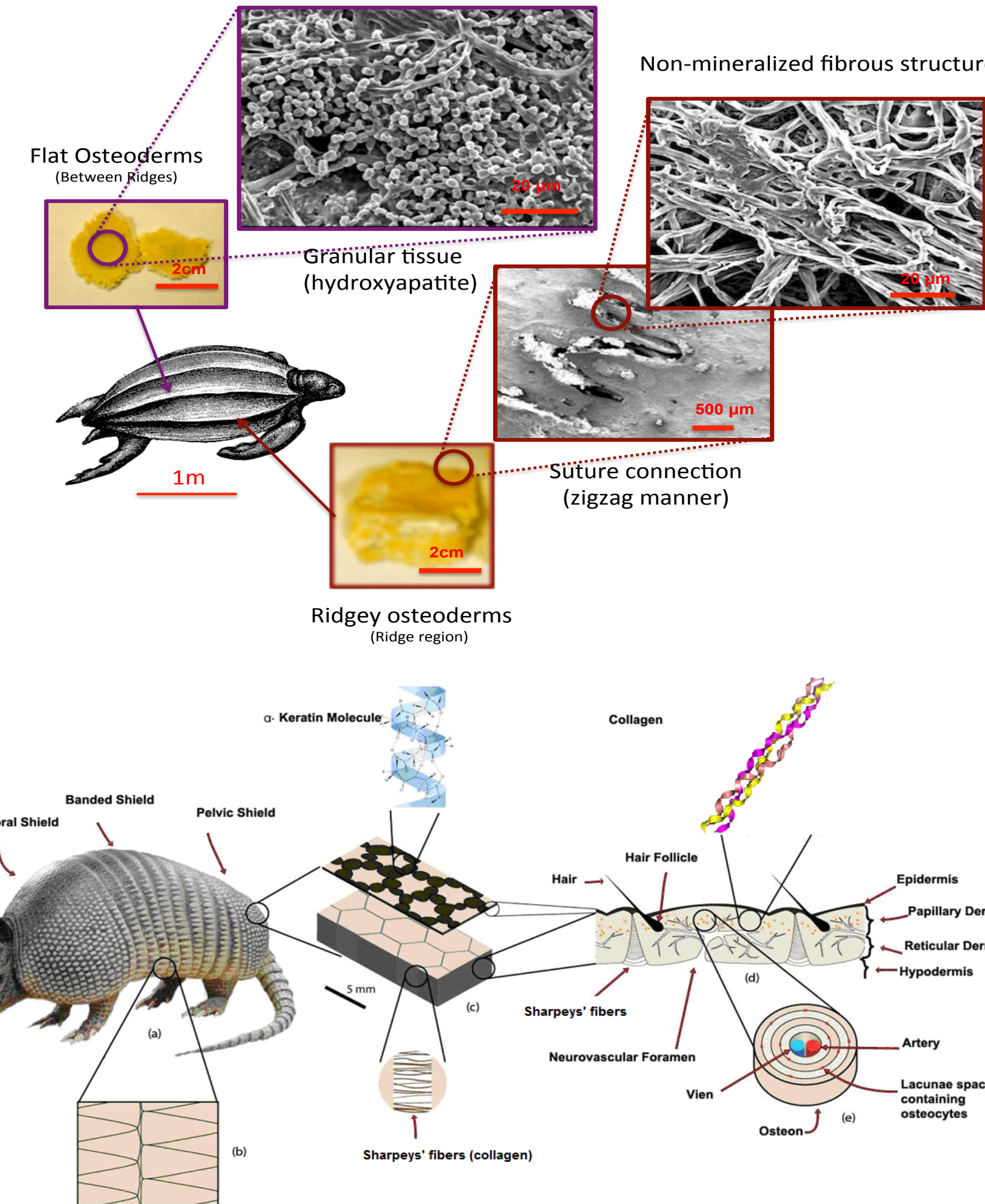
<http://www.pinnaclearmor.com/images/tac-nsg-front.jpg>

SUTURE DESIGN

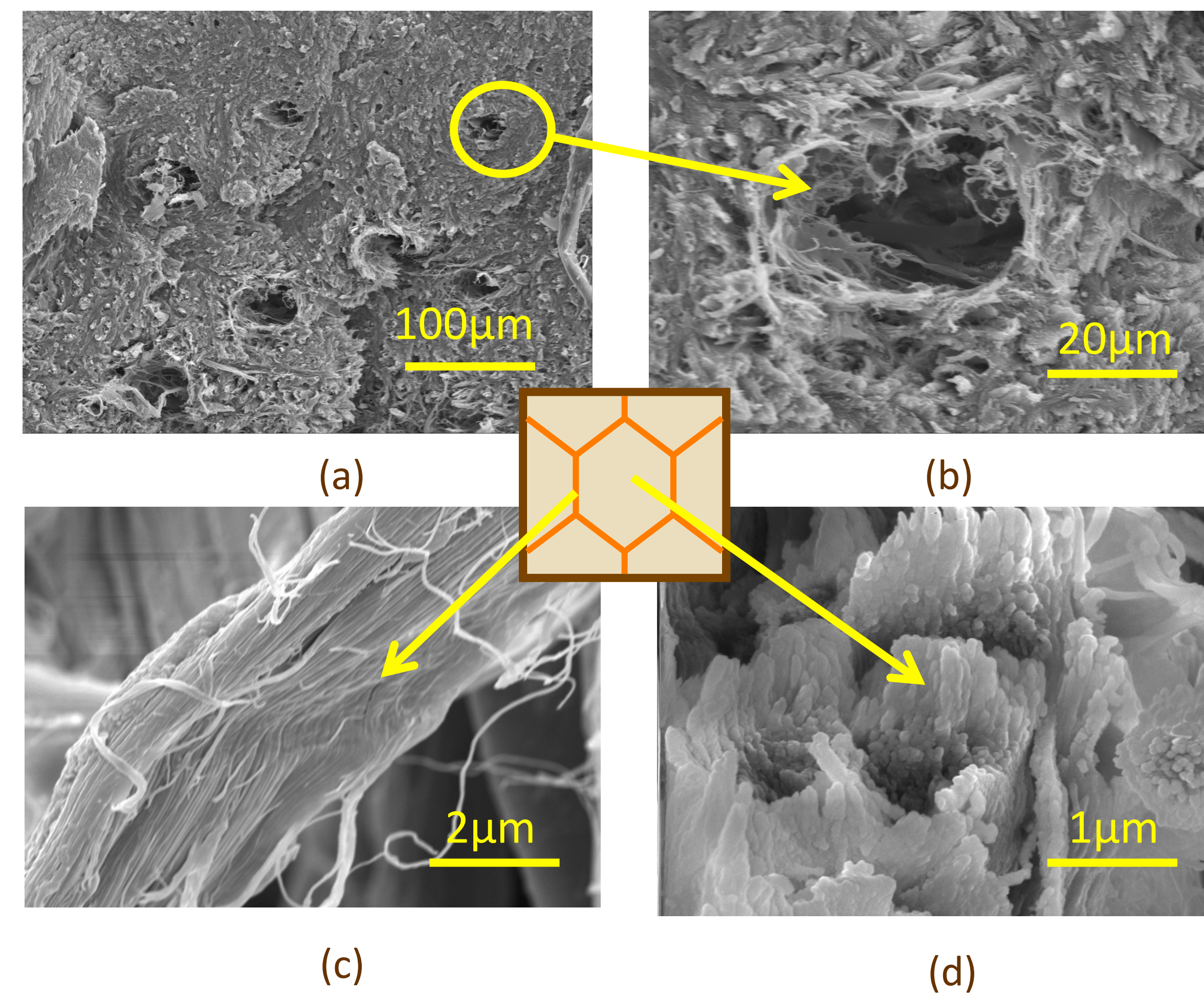
- Interlocking and compliant mechanism
- Yields more degrees of freedom
- Sharpey fibers proposes flexible connectivity



HIERARCHICAL STRUCTURE

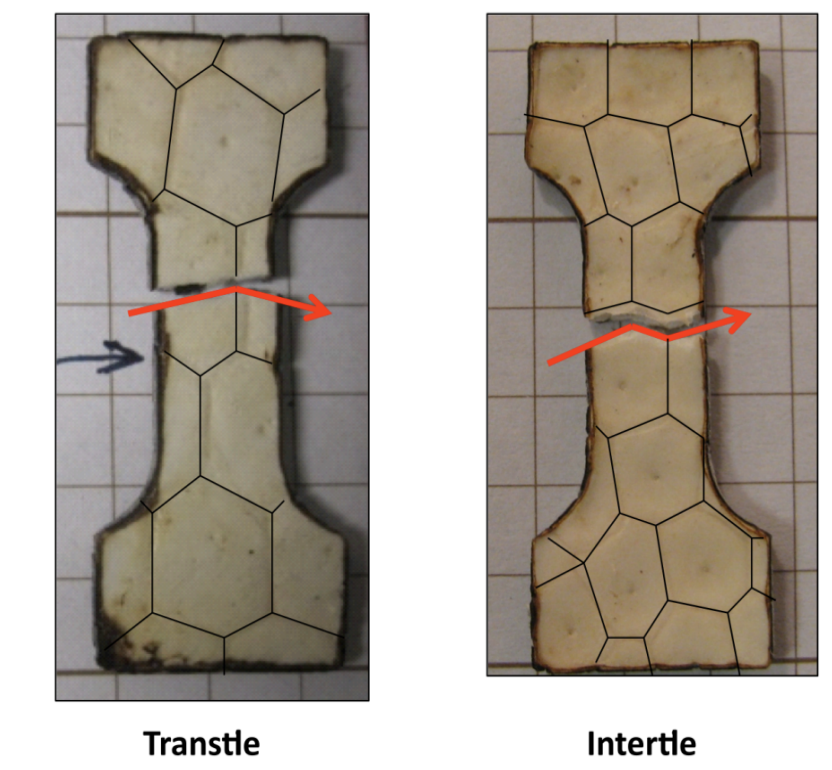
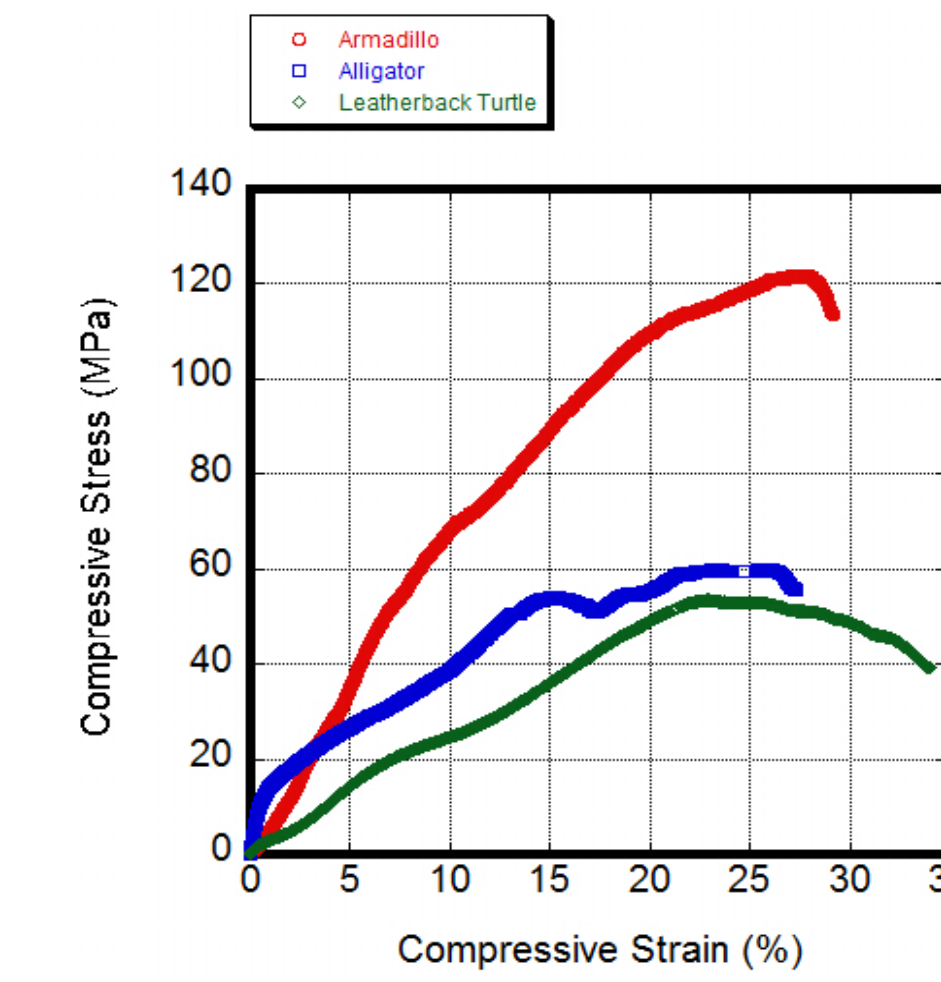


STRUCTURAL CHARACTERIZATION

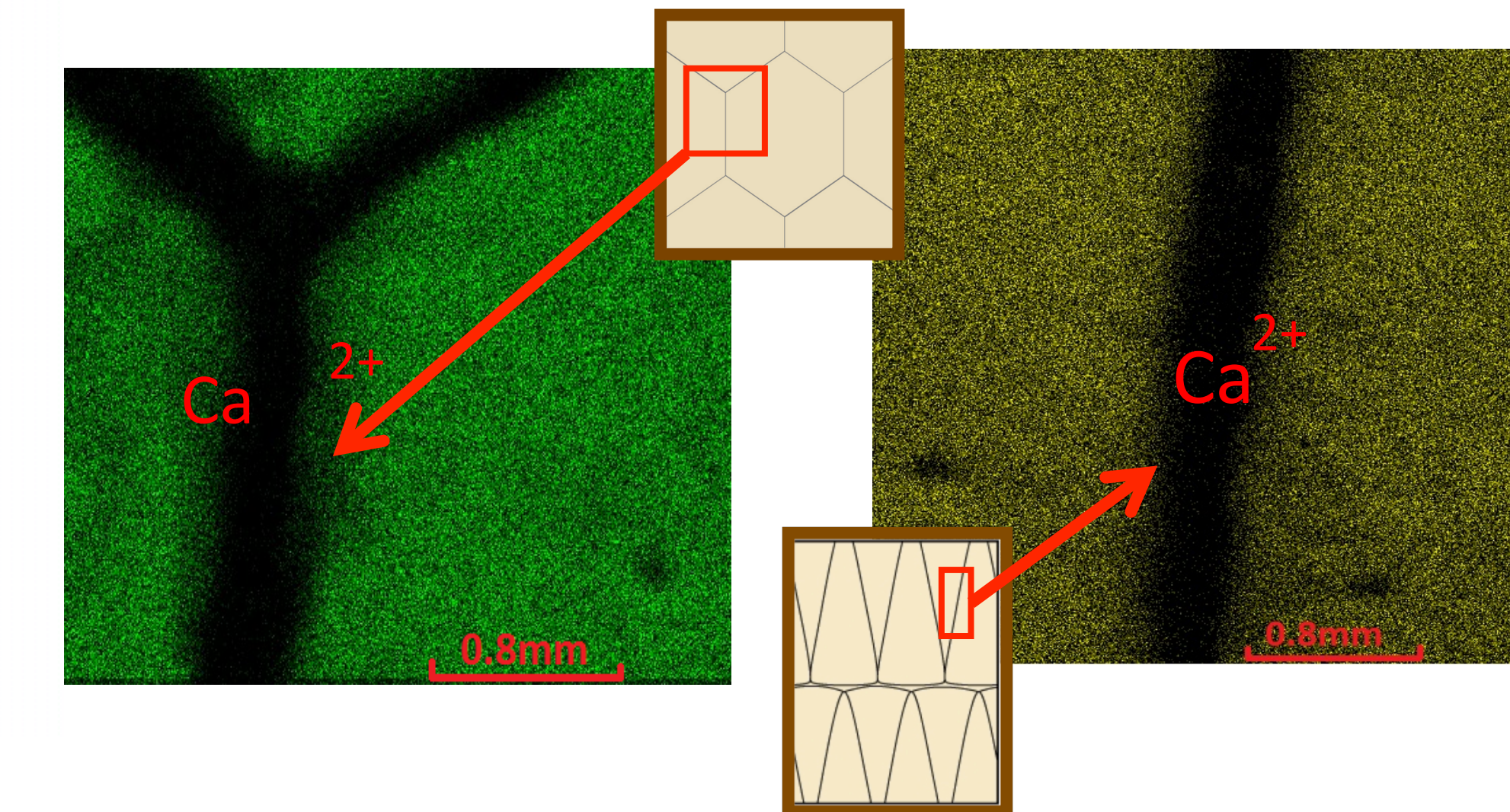
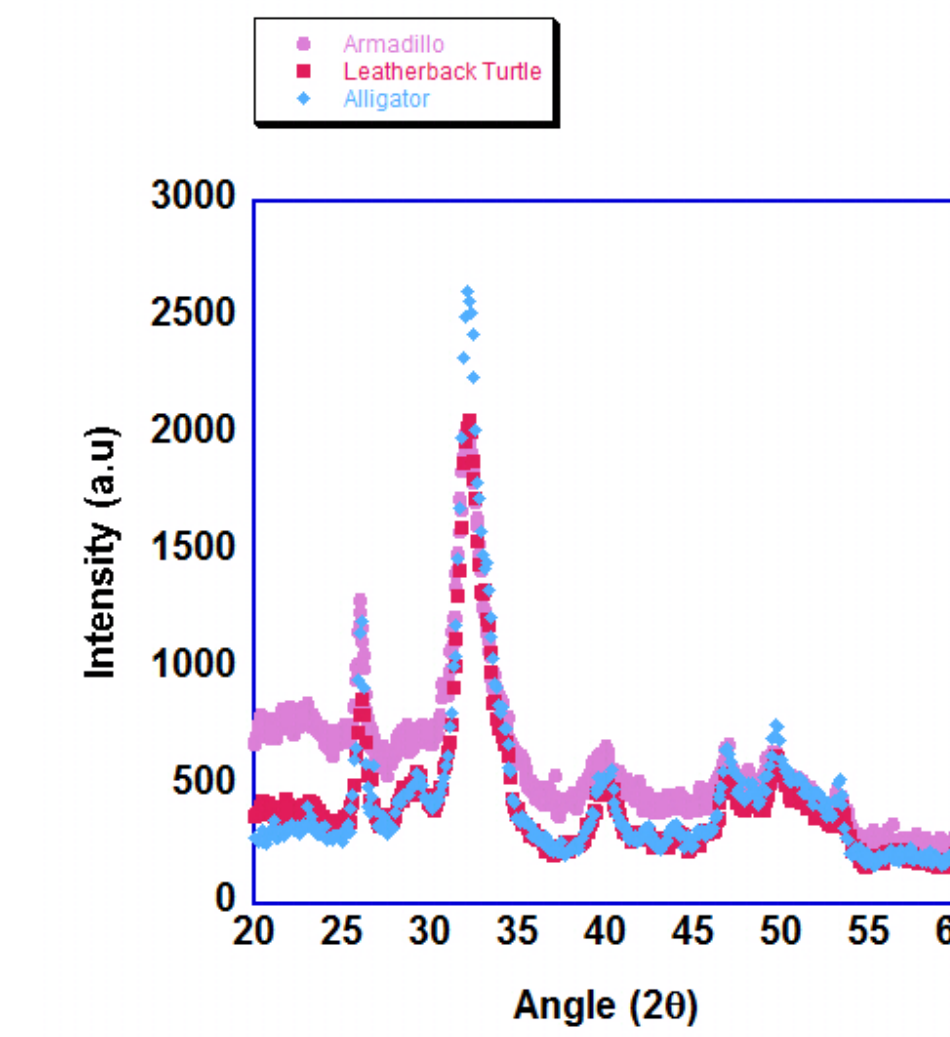


- (a) Cross sectional view of the carapace showing laterally oriented osteons (in the papillary dermis layer)
- (b) 2000X view of the osteon with approximately 150-200 µm in diameter which includes a dense collagen network in its surroundings
- (c) Non-mineralized Sharpey fiber of 4µm in diameter found between the tiles
- (d) Mineralized collagen fibers found on the tiles

MECHANICAL PROPERTIES



- The dried armadillo carapace (Jernigan's Taxidermy, Texas) specimens were cut into a dumbbell shape using laser cam. Each specimen was tested in a 500N universal testing system (Instron 3342, Norwood, MA) with a strain rate 10-3 s-1. Ten of each hydrated (in distilled water for 24 hrs) and dry samples were performed under tensile load.
- Two types of failure modes were observed: (1) transtile; (2) intertile; Transtile failure is where the fracture failure occurred through the tile. Intertile is where fracture failure occurred between the tiles. Hydrated samples have the tendency to have intertile failure.



- XRD: Hydroxyapatite (Strong bone minerals)-found in all osteoderms (image on left)
- X-ray fluorescence images taken on (a) the hexagonal tiles. The bright green color corresponds to calcium. Calcium is not found between the tiles, indicating that the Sharpey fibers are not mineralized and (b) the rectangular tiles. The yellow is an indication of calcium on the tiles. (images on right)

CONCLUSIONS

