A variety of Ca:P ratios are possible following the Carbonate Apatite Formulae. Several are often seen in one polished slice of lobster cuticle e.g. (Kunkel et al. 2012) where Ca:P 1:2, 2:1, 7:2 are seen, sometimes in adjacent sectors of a structure such as the organule wall, panel 2.

In canal sectors close to the environment the Ca:P ratio approaches that of apatite itself, 10:6. Furthest away from the environment, last to be deposited, it is also furthest from the apatite ratio at 7:1 Ca:P.

Kunkel, Nagel & Jercinovic 2012

A tangentially polished cuticle surface shows an organule canal perpendicular to its long axis. The Calcite collar is devoid of PO₄ and CAP lines the canal. (A) Phosphorous (Ka) X-ray map. (B) Calcium (Ka) X-ray map. (C) Rows top to bottom—raw: selected areas of Ca, P. PC1: Calcite PC used to choose calcite pixels. PC2: Wall PC used to choose wall pixels. (D) Calcite and Wall pixel Ca and P contents are plotted. Slopes extrapolated through zero show the Ca:P ratios relative to clam calcite (green, no P), HAP (red, Ca:P 1.67), and monocalcium phosphate (blue, Ca:P 0.49). The brightness of images (A), (B), and (C-raw) scales linearly with X-ray intensity.

3D-Xray-tomography of lobster shell carbonate apatite trabeculae. Fig 8 of Kunkel et al. 2016.

Placement of a trabecular structure (green in C and D) in the exocuticle of the lobster. One of these cuticle medallions (shown in C and D) has an ESD lesion which goes through the calcite and exocuticle layer dissolving them. The trabeculae (in green) are seen somewhat reorganized at the periphery of the lesion in the D tangential view, video link: http://www.bio.umass.edu/biology/kunkel/3D/Ha4_ESDlesion.avi

With Skyscan 1272 uCT 6 mm diameter medallion, ~0.5um pixel size.

Atomic force microscopy finds the trabeculae to be harder (h) than its surrounding matrix (s). The trabeculae seem to be composed of plates but need higher resolution to evaluate their properties (Kunkel 2013).

In Kunkel et al. (2018) these spectra show that the CaCO₃ is calcite not aragonite and that the carbonate apatite is a lower grade carbonate-apatite than vertebrate bone.

Fossil Thylocephalan organules.

Lobster, Homarus

Late Devonian Thylocephalan

Broda & Zatôń (2017)

References:

Broda K & M Zatôń (2017): A set of possible sensory system preserved in cuticle of Late Devonian thylocephalan arthropods from Poland. Historical Biology, DOI: 10.1080/08912963.2017.1284834


