Micro-CT and Holographic Imaging of Late Cretaceous Benthic Foraminifera in Saudi Arabia

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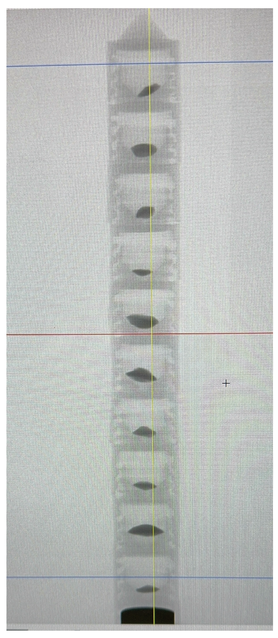
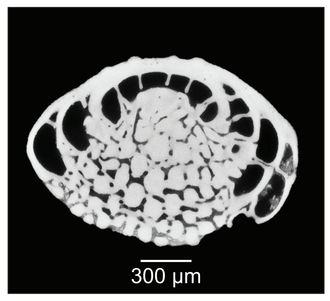
Abstract

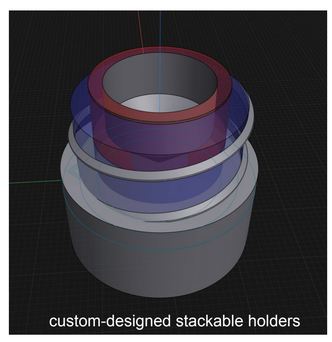
Taxonomic studies of foraminifera in thin sections have known limitations. Micro-Computed Tomography (Micro-CT) offers an alternative to study the internal and external structures of foraminifera but suffers from long acquisition time. We, therefore, customized a vertical holder which stacks up to 15 foraminiferal specimens for each circular scan. Our goal is to create a reference library of accurate 3D foraminiferal models to highlight morphological differences and similarities between different genera and enhance taxonomic identification. We generated digital models of many Cretaceous specimens including Omphalocyclus macroporous, Fissoelphidium operculiferum, Chrysalidina hensoni, and Fallotia sp. and produced cross sections at a variety of orientations. The combined database of 3D models and cross sections will assist micropaleontologists in the study and identification of foraminifera in thin section and eliminate ambiguities.

Holographic projection can be an even more effective tool for morphological studies of foraminifera. We have developed a new workflow to optimize 3D foraminiferal models for holographic displays. This workflow not only enables the holographic visualization of 3D foraminifera but also the intuitive creation of real-time cross-sections at any orientation.

(1) Introduction







Micro-CT analysis of microfauna offers significant insights in the internal and external structures essential for taxonomic analysis. However, the aquisition process can be time intensive and a standardized setup is yet to be developed for foraminifera.

Objective:

- Study Late Cretaceous benthic foraminifera of the Aruma Formation in Saudi Arabia using a refined micro-CT workflow. These specimens were documented locally but were not published or studied in detail since 1972.

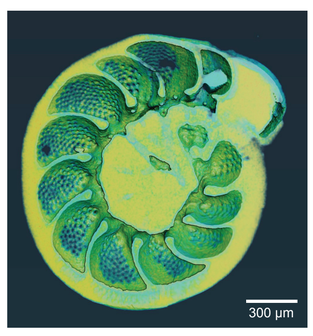
Methodology:

- Design a reusable vertical stack of sample holders.
- Develop a script to automate the acquisition targetting microfossils in the stack.
- Process data and build a catalogue with 3D models and cross-sections for taxonomic analysis.

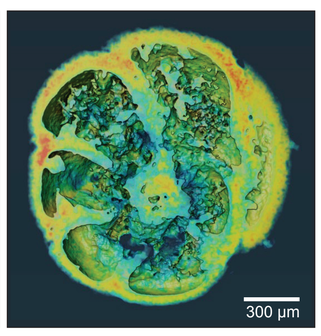
(2) Understanding Cross-Section Ambiguity

Radial slices of different benthic foraminifera show similar cross sections that mimic what a micropropaleontologist may find in a thin section. 3D models help improve the understanding of internal structures and minimize ambiguities in taxonomic identification .

Fissoelphidium operculiferum



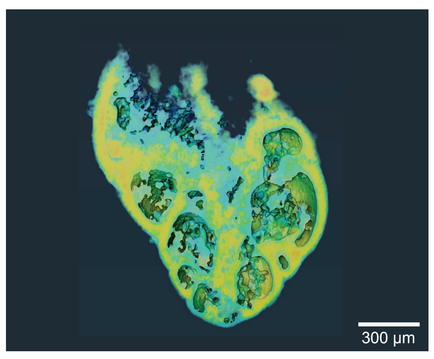
Rotalia trochidiformis

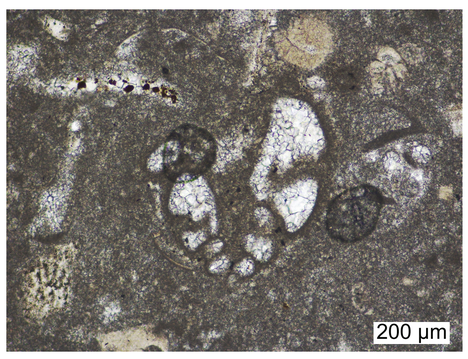


Ataxophragmium spp.

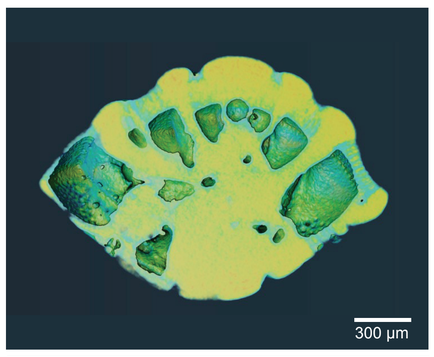
(3) Matching 3D Slices with Thin Sections

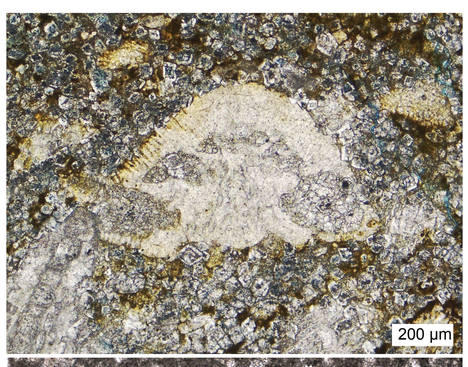
A database of foraminifera 3D models can be inspected and individual models can be virtually sectioned at any angle to match foraminifera in thin sections. This comparison offers a robust method for confirming identification and reducing analyst error.



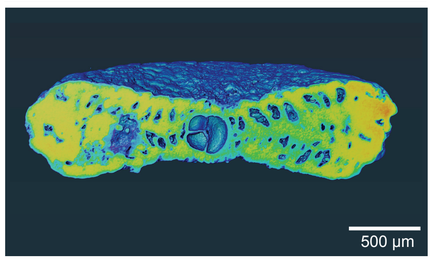


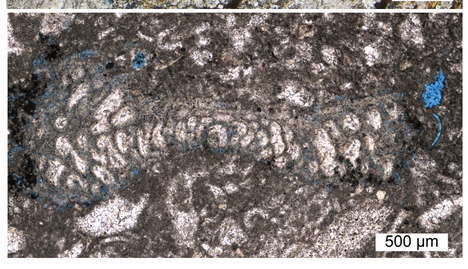
Ataxophragmium spp.





Rotalia trochidiformis

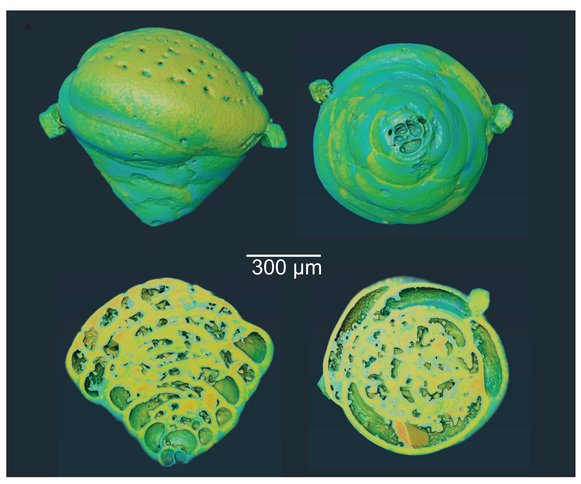


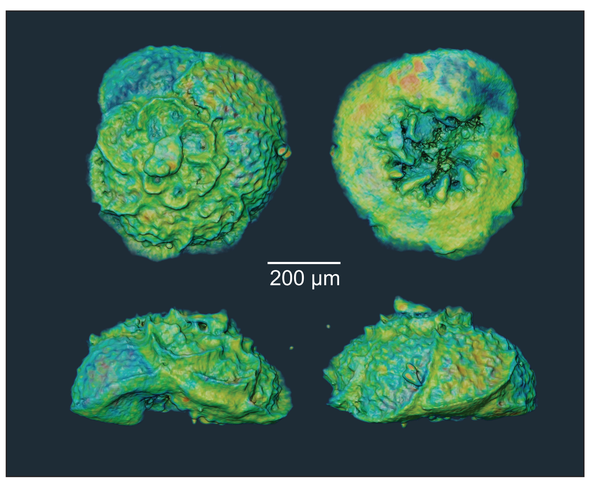


Omphalocyclus macroporous

(4) Unpublished Cretaceous Species of Redmond, 1972

In 1972, C.D. Redmond, described new species of Cretaceous benthic foraminifera from the Aruma Formation in Saudi Arabia. The following figure shows the first illustrations of some of the unpublished Cretaceous taxa using the latest developments in micro-CT imaging.





Chrysalidina hensoni (Redmond, 1972)

- Test High conical
- 4 Chambers per whorl, slightly inflated
- Apertures small, round and numerous
- Interseptal pillars numerous around the central axis
- **Age Range: ?Campanian - Maastrichtian**

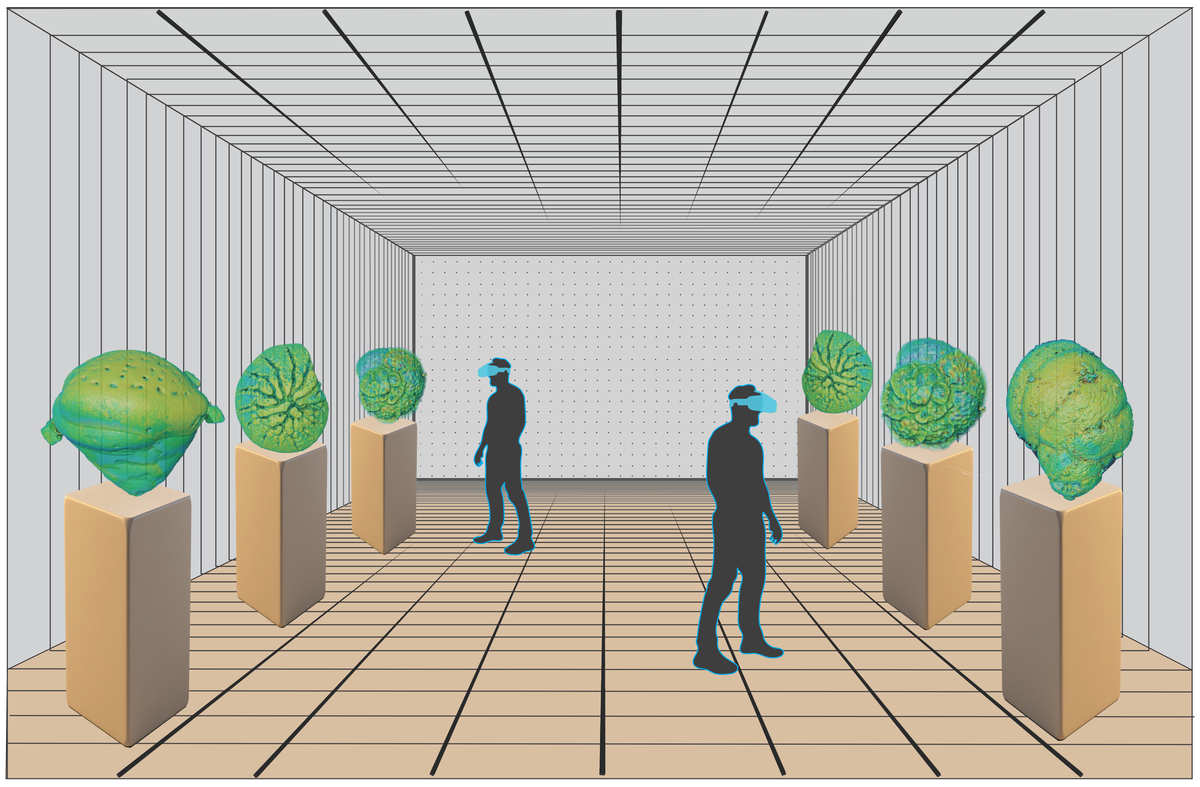
Arumella ornata (Redmond, 1972)

- Dorsal side strongly convex
- Ventral side concave to nearly flat
- Sutures sharply keeled and raised
- 5 - 6 chambers in the final whorl
- Periphery bluntly angled

Age Range: Maastrichtian

(5) Augmented Reality Holographic Projection

We developed a workflow to project micro-CT data into an augmented reality headset. This visualization technique allows the stereoscopic visualization and intuitive manipulation of 3D models of foraminifera in a mixed reality setting. A unique feature of this setup is the creations of real-time slices for studying the internal structures of foraminiferal models. This work takes a step towards improving the future of communication between specialists while also striving to inspire future generations of micropaleontologists and enthusiasts.



Acknowledgements

Domingo Lattanzi provided the training and support for the micro-CT work and suggested the development of a customized setup for the micro-CT of microfossils. Dr. Ronell Sicat programmed the Hololens to visualize the micro-CT data for this study. Dr. Abdulkader Afifi funded and supported the project as the principal supervisor of Ali Alibrahim's PhD project.