Morphology in time and space: how does shape change with sequence stratigraphic architecture?

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Understanding stratigraphic architecture allows us to distinguish ecophenotypic variation from evolution.

Morphological change, modeled as a random walk (bottom), can appear as a dramatic jump when placed within sequence stratigraphic architecture (top).

This means that some evolutionary events might be simply an artifact of whether the environment a species lived in is preserved in a stratigraphic sequence.

Modified from Holland (2000).
To understand the effect of stratigraphic architecture on morphologic change, we need to collect a lot of data.

Typical geometric morphometric methods are lab-based and difficult to incorporate into stratigraphic field work.

Structure from Motion (SfM) is a photogrammetry tool that creates point-based 3D renders from overlapping 2D photographs. It is used by many stratigraphers in the field and by museums to digitize their fossil collections.
Can SfM be used to accurately quantify morphology in field-based stratigraphic studies?

The Cincinnati Arch, which has been extensively studied by Holland, Patzkowsky, and many others, is a great place to test this method.

Two early career researchers, J. Sclafani and M. Christie, led a team of undergraduate students to test this on brachiopods.
Our procedure:

1. Identify facies

2. Select and identify complete, well-exposed brachiopod fossils

3. Take photos from all angles
Results part 1: we can make some nice models!

Models are complete with good resolution of fine-scale detail. Specimens are digitally extracted from the rock for morphometric analysis.

Digital models that can be rotated for complete visualization are available at: https://sketchfab.com/mchristie09/models
Geometric morphometrics: 3D model point clouds are digitized as semi-landmarks over the shell surface.
Results part 2: *Rafinesquina* morphology changes between the C2 and C5 stratigraphic sequences, across the regional Richmondian biotic invasion.

Across this boundary, we see both the flattening of valves identified by Tyler and Leighton (2011) and the weakening of the environmental gradient identified by Holland and Patzkowsky (2007).

https://tinyurl.com/C5-raf-model
https://tinyurl.com/C2-raf-model

These results are being prepared for submission to Palaeo Electronica.
So let’s go to the field and collect more data!

“…the scarcity of attention that the analysis of morphological patterns has received makes it more likely that new investigations will reveal new insights. The goal is not merely cleaning up the record or simply removing stratigraphic overprints, but the recovery of interpretable patterns…that will offer new insights into the underlying process of evolution.”

– Holland and Patzkowsky, 2012
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