

AND FOSSIL LAQUEUS (BRACHIOPODA, TEREBRATULIDA) THROUGH THE QUANTITATIVE ANALYSIS OF SHELL OUTLINES AND MACHINE LEARNING

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Since morphology plays a critical role in species recognition in the fossil record, analyzing morphological characters in a quantitative manner in fossils and comparing ranges of variability with living close relatives is essential. The aim of our research is to determine if shell shape, specifically valve outline, can be used to accurately distinguish among extant brachiopod species, and if outline shape parameters in extant specimens can be applied as a guideline to test and differentiate fossil species. Furthermore, given the assumption that external morphology offers little resolution for classification of terebratulide brachiopods, we aim to test if outlines are good proxies for more taxonomically informative characters such as long loops—the calcareous structures supporting the lophophore. Given how complex and fragile these structures are, long loops are rarely preserved in the fossil record. Therefore, finding good proxies for these internal features is a fundamental goal.

To approach our research questions, we focused on the genus *Laqueus* Dall, 1870. *Laqueus*, compared to other terebratulide brachiopods, displays low levels of shell variability; its planar commissure makes it an ideal candidate for 2D outline analysis: and long loop morphology has been shown to reliably discriminate species within the genus. We analyzed and compared two datasets: 1) outlines and long loop landmarks and semilandmarks from extant specimens imaged using CT and 2) outlines of photographed extant and fossil specimens. Outline analysis was performed for both datasets using elliptical Fourier analysis (EFA). To quantify variation in shell shape, the resulting elliptical Fourier coefficients were then used as variables for a Principal Component Analysis (PCA) and a Canonical Variate Analysis (CVA) with leave-one-out cross-validation to test classification accuracy. To examine morphological integration between long loops and outlines, we used our CT dataset and performed a partial least squares analysis (PLS) on Procrustes-fitted coordinates of two blocks: 3D landmark and semilandmarks for long loops, and outline coordinates for the same set of specimens. Finally, to test fossil species assignments, we trained a model using the outline

of extant specimens, described by elliptical Fourier coefficients, under the Random Forests algorithm. Our results demonstrate that, even though outlines are not considered to be the most diagnostic characters, they provide enough morphological information to distinguish among extant named *Laqueus* species, validating current taxonomic assignments. Furthermore, there is a high correlation ($r=0.77$) between long loop shape and shell outlines, proving that, in the absence of taxonomically informative internal features, outlines offer sufficient resolution to classify *Laqueus* specimens. Our prediction model, based on extant shell shape variables, accurately categorized 81% of the fossil specimens to their previously assigned species.

TAPHONOMY OF THE PHACOPID TRILOBITES CERAUSUS PLEUREXANTHEMUS AND FLEXICALYMENE SENARIA FROM THE WALCOTT-RUST QUARRY (UPPER ORDOVICIAN)

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Trilobites are a dominant group of euarthropods throughout the Paleozoic, and are known primarily from their biomineralized dorsal exoskeleton. Despite their impressive diversity estimated to reach some 20,000 described species, the appendicular ventral anatomy of trilobites is only known from 31 taxa. In 1879 Charles Doolittle Walcott reported the preservation of trilobite appendages from the Rust Formation of the Trenton Group in Herkimer County, New York. Although trilobites are common throughout this group, appendages are only known from the partially enrolled individuals in Layer 3 of the Spillway Member. Shortly after deposition, calcite crystals formed inside these specimens, consisting mainly of the phacopids *Ceraurus pleurexanthemus* and *Flexicalymene senaria*, preserving aspects of the ventral anatomy in three dimensions with little compaction and a spectacular degree of fidelity. Despite the preservation quality, the taphonomic pathway leading to calcification of soft tissue in the Rust Formation trilobites remains poorly understood. Brett *et al.* (1999) suggested that the partially enrolled individuals created a microenvironment conducive to the precipitation of calcite thanks to anaerobic conditions where sulfate-reducing bacteria created a high concentration of bicarbonate and sulfide as waste leading to localized precipitation of calcite. Examination of hundreds of prepared thin sections of Walcott-Rust trilobites demonstrate