Evaluating the Viability of Carboniferous Conodont and Brachiopod $^{87}Sr/^{86}Sr$ Values from the Santa Fe Mountains, New Mexico

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Abstract

The present study aims to assess the viability of conodont and brachiopod samples for use in strontium (Sr) geochemical analysis. The preassessment involved both the creation of thin sections from potentially unaltered brachiopods and the extraction of conodont elements from the host rock. As both specimens were preserved within the same matrix, the brachiopods were removed first with a tile saw before the remaining material was subjected to an acid bath to begin the process of removing the conodont elements. The remaining insoluble residue was then picked by hand under a stereo microscope to collect any ideal samples. Once procured, we observed the completed thin sections of our brachiopod samples under a petrographic microscope utilizing cathodoluminescence capabilities and took photomicrographs of the conodont element's texture using a scanning electron microscope.

Background Information

The Pennsylvanian Subperiod of the Carboniferous is the interval of geologic time between 323 and 299 million years ago. During this time, present day New Mexico (figure 3), was part of the western portion of Laurentia situated within the Taos Trough (figure 2). This waterway supported prehistoric marine faunas such as foraminifera, brachiopods, and conodonts. Conodonts are an extinct type of jawless chordate with tooth-like structures called elements that predate the evolution of true teeth (figure 1). Brachiopods are an extant group, meaning there are still taxa alive today; however, brachiopod diversity has greatly diminished since the end of the Paleozoic Era. The brachiopods found in this study were identified as *Anthracospirifer* cf. *newberryi* Sutherland and Harlow, 1973.

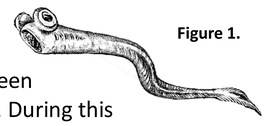

Figure 1.

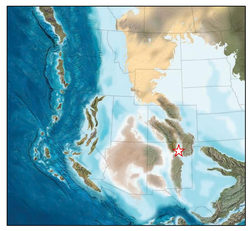

Figure 2. Location of the studied section within the late Paleozoic Taos Trough region of the Ancestral Rockies (modified from Blakey, 2011).

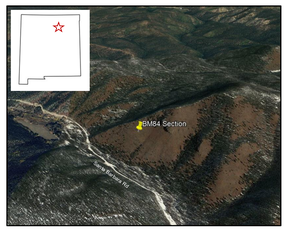

Figure 3. Northward view of the Bear Mountain Section near the crossing of Santa Barbara Road and Rio Santa Barbara (modified from Google Earth).

Scanning Electron Microscopy (SEM) of Conodont Sample

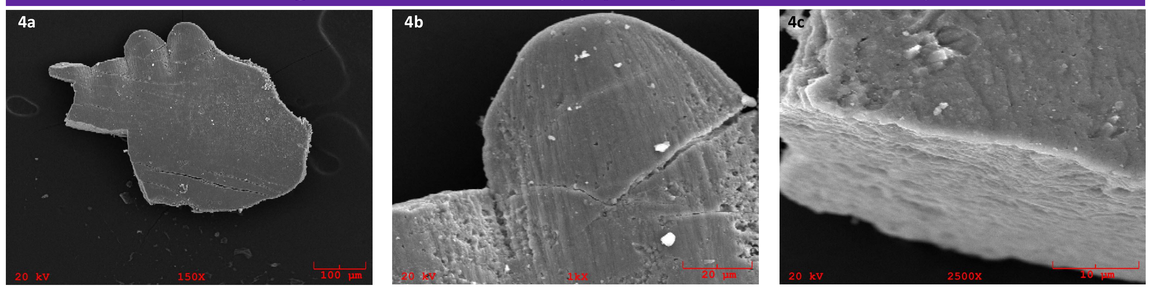

Figure 4. The above three images are photomicrographs of the conodont fragment picked from sample BM 84–1. Figure 4a depicts the lateral view of the free blade from a conodont element of *Idiognathodus* sp. Figure 4b is focused on one of the element's denticles (i.e., serrations of the free blade). The smooth, domed shape is a consequence of wear and reveals the advanced age this specimen reached before death. Figure 4c was captured along one of the broken edges of the element. This image, along with the other two, show a relatively smooth surface indicative of a well preserved, unaltered microfossil without recrystallization.

Cathodoluminescence of Brachiopod Thin Sections

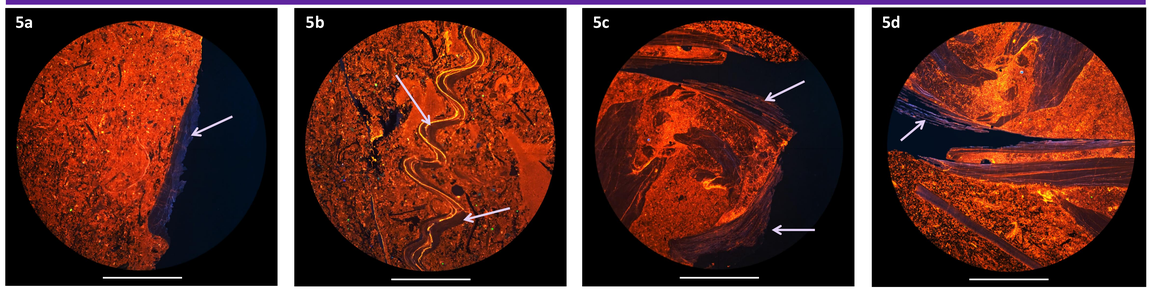

Figure 5. Figures 5a through 5d are images taken of the brachiopod thin section samples during cathodoluminescence analysis preformed at the University of Texas at Arlington. Cathodoluminescence spectrometry refers to the use of a concentrated electron beam fired within a pressurized chamber prompting luminescent-activating ions to glow. This process was used to determine if the brachiopod shell material was altered during diagenesis (i.e., post-burial processes). This is possible due to the low concentrations of luminescing Mn2+ ions present in oxygenated marine carbonates during the Early Pennsylvanian (Armendariz et al., 2007). If the calcium carbonate present within the brachiopod shells is unaffected during the diagenetic processes, it will not react when subjected to a concentrated cathode beam. The arrows point to the non-luminescent portions of brachiopod shells within these samples.

Thin Section Creation

The preparation of thin sections begins with the selection of ideal samples based on the quality of their preservation and size. Once selected, the specimens are removed from the matrix using a tile saw. The samples are then sanded flat perpendicular to the hinge and adhered to a frosted glass slide with UV adhesive. Using a thin section machine, the sample is cut and sanded down to 70 microns before it is frosted by hand to the ideal thickness of roughly 30 microns. Slides are then polished with a MiniMet and .05 micron abrasive powder. The sections were then stored for travel to UT Arlington for cathodoluminescence analysis.

Conodont Extraction

Because the conodonts occur in the same limestone matrix as the brachiopods, the process for extracting them begins once the brachiopod samples have been removed. Conodont elements are composed of the mineral apatite, whereas the brachiopods and surrounding matrix contain calcium carbonate. This means that when soaked in a dilute mixture of formic acid, buffer solution, and water, the matrix will dissolve and the conodont elements remain insoluble. From this point forward, each remaining insoluble grain is picked through under a microscope where individual conodont elements are identified and removed for study.

The Strontium Curve

The strontium (Sr) curve refers to the fluctuating quantities of strontium-87/86 within the world's oceans. When values are plotted, a well-defined curve is shown throughout the Carboniferous Period. Paired with biostratigraphy, it can be used to procure an approximate age of the strata through the processing of Sr indices such as brachiopods and conodonts. Strontium substitutes the calcium in the calcium carbonate of calcite and the calcium in calcium phosphate of apatite (McArthur and Howarth, 2005). Both organisms incorporate strontium in equilibrium with seawater. Therefore, both fossils accurately record the chemical signature of their surroundings. This Sr-Ca substitution occurs because strontium and calcium are similar elements with comparable charge and ionic radii.

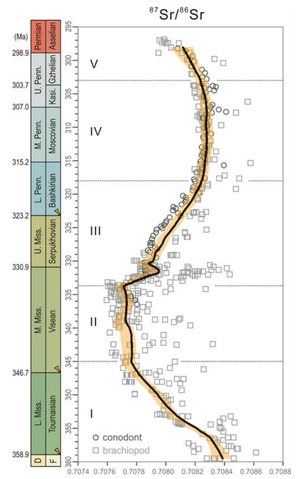

Figure 6. Carboniferous strontium curve with conodont and brachiopod values plotted (from Chen et al., 2021).

Results

The photomicrographs taken of the conodont fragment reveal the smooth, uncrystallized texture along the surface and interior edges of the fossil. The lack of crystalline structures shows that the conodont elements collected from sample BM 84–1 are good candidates for strontium analysis. Similarly, the minimally luminescing brachiopod shells from sample BM 84–3 will also be ideal for further testing once the outermost layer of shell is acid etched.

Significance

Although the Carboniferous-age rocks of the Bear Mountain area have been preliminarily mapped, the mixed carbonate-siliciclastic exposures remain undifferentiated and lack lithostratigraphic, biostratigraphic, and consequently, chronostratigraphic detail. With sufficient biostratigraphic control (provided by conodont elements) and original seawater $^{87}Sr/^{86}Sr$ values, precise correlations can be made with more well-defined lithostratigraphic units in the Taos Trough region and beyond.

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