[PS]Late Pennsylvanian (Virgilian) to Early Permian (Leonardian) Conodont Biostratigraphy of the "Wolfcamp Shale", Northern Midland Basin, Texas*

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Abstract

Analysis of Late Pennsylvanian (Virgilian) to Early Permian (Leonardian) conodonts from the northern Midland Basin, west Texas, has produced a biostratigraphic framework that enables correlation to surrounding regions, such as the Eastern Shelf and Midcontinent. Conodont specimens were obtained from organic-rich basinal shales from three cored intervals (8836–9020 ft, 9200–9502 ft, 9660–9840 ft) of the Shell Stephens L 1V well (Lynn County, Texas). The presence of conodonts within the deep-water basinal shale facies suggests that the specimens were deposited *in situ*, rather than transported by turbidite or debris flow. Core 1 was age-dated as latest Wolfcampian to early Leonardian based on the occurrence of species of *Neostreptognathodus* and *Sweetognathus*. Core 2 was age-dated as latest Virgilian to early-mid Wolfcampian based on occurrences of species of *Streptognathodus* and *Sweetognathus*. The Virgilian-Wolfcampian boundary was placed at 9740′ within Core 2 based on the presence of *Streptognathodus wabaunsensis*, *S. conjunctus*, and *S. invaginatus*. Core 3 was age-dated as Virgilian based on the occurrence of *Streptognathodus virgilicus* and *S. pawhuskaensis*. Barren to nearly barren intervals are present towards the mid to upper portion of Core 2 (9200′ – 9300′), and towards the base of Core 3 (below 9800′), while diverse clusters of conodonts occurred at the top of Core 1 (8841′–8970′), bottom half of Core 2 (9330′–9502′), and middle of Core 3 (9670′ – 9715′). Delineation of cyclothems using the gamma ray logs and core lithologies were used in association with the constructed conodont framework to aide in correlation to adjacent regions and wells. The success of this study will allow for conodonts to be utilized alongside the established fusulinid zonation to strengthen Pennsylvanian-Permian correlations throughout the Permian Basin and Midcontinent region, as well as globally.

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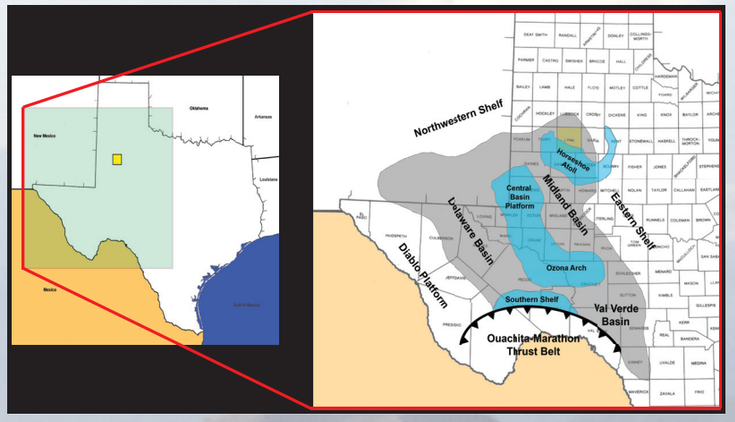


Figure 1: Overview map of southwest Texas and surrounding regions (left), Lynn County highlighted in yellow. Major basins, shelfs, and platforms highlighted on adjacent enhanced map (right). Reconstructed and modified from Hamlin and Baumgardner, 2012.

Introduction & Background

The "Wolfcamp Shale" is a series of calcareous and siliciclastic mudrock that has been a prime target for oil and gas exploration in the Midland basin (fig. 1). The thickness of the Wolfcamp ranges from 300-600 ft in the north and northeastern portion of the basin, to over 2000 ft in the southern portion and Val Verde Basin (Hamlin and Baumgardner, 2012). The "Wolfcamp Shale" of the Midland Basin has been commonly attributed as entirely Wolfcampian (Early Permian) in age. In the classic Adams et al. (1951) starved basin hypothesis paper, they suggested that the lowermost basinal shale section was Late Pennsylvanian in age, calling it the Penn Shale, but they did not provide biostratigraphic evidence for that age-date. The uppermost "Wolfcamp Shale" has been previously age-dated with fusulinids as early Leonardian (Wilde, 1975; Mazzullo and Reid, 1988). This study provides the first conclusive conodont biostratigraphic data demonstrating that the so-called "Wolfcamp Shale" in the Midland Basin includes strata that are Late Pennsylvanian (Virgilian), Wolfcampian, and early Leonardian in age.

The lower Permian has traditionally been defined using fusulinid and ammonoid zonations, with conodont zonations having only recently developed. Age-dates for the Wolfcamp vary, and have hindered accurate correlation of the strata to surrounding regions and to Lower Permian type sections in the Urals of Russia. The purpose of this study is to...

- better define the conodont biostratigraphy and age of the "Wolfcamp Shale" within the Midland basin.
- provide a means of accurate correlation to the surrounding regions and type sections using the constructed zonations in conjunction with the established fusulinid and cyclothem frameworks.

Conodont specimens were obtained from three cored basinal shale facies intervals of the Shell Stephens L 1V well (fig. 2), which were processed using standard bleach dissolution. Sample size was variable, ranging from 10 ft intervals to finer inch to half inch intervals. Associated gamma ray, resistivity logs, and core lithology were used in determination of cyclothems to aid in correlation.

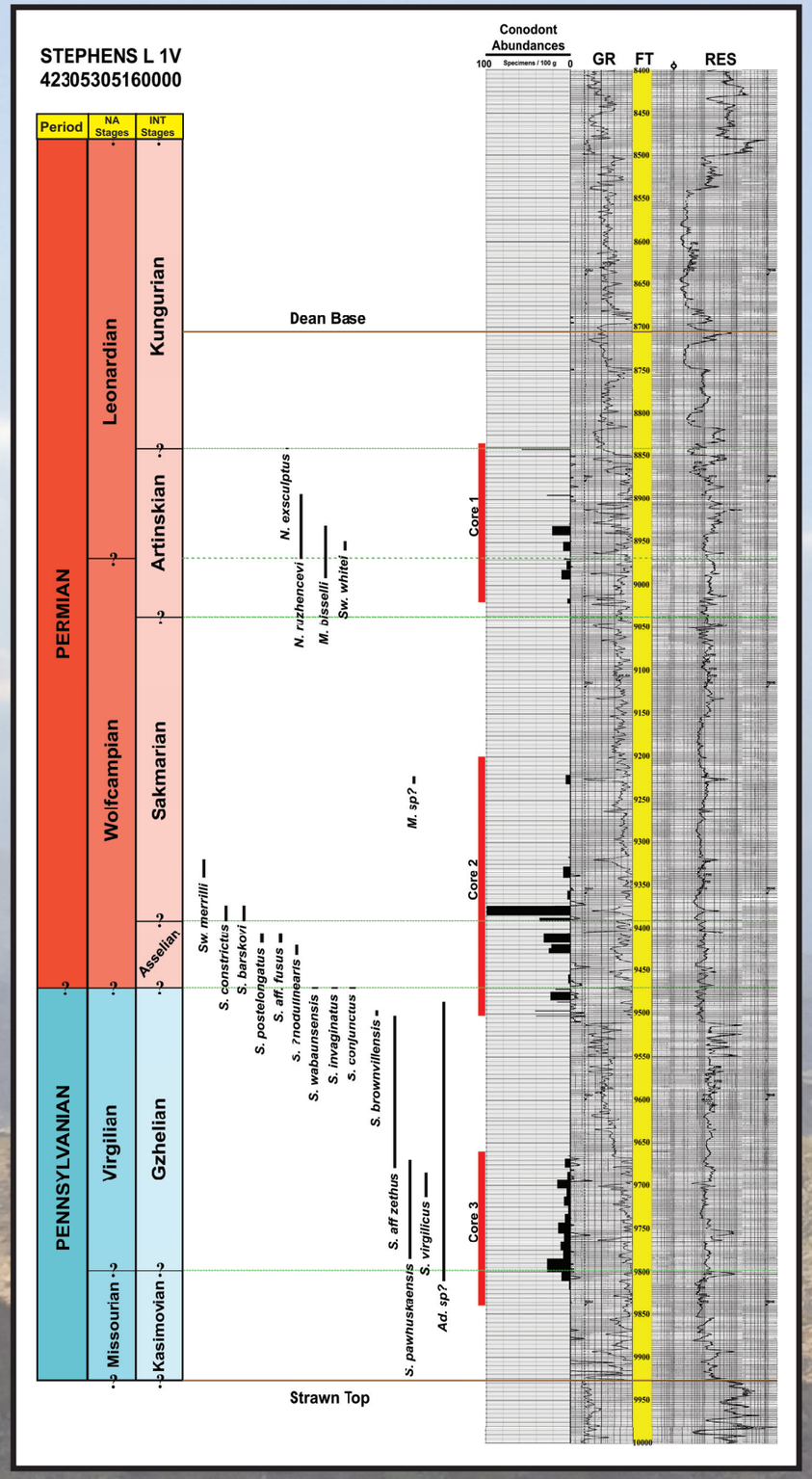
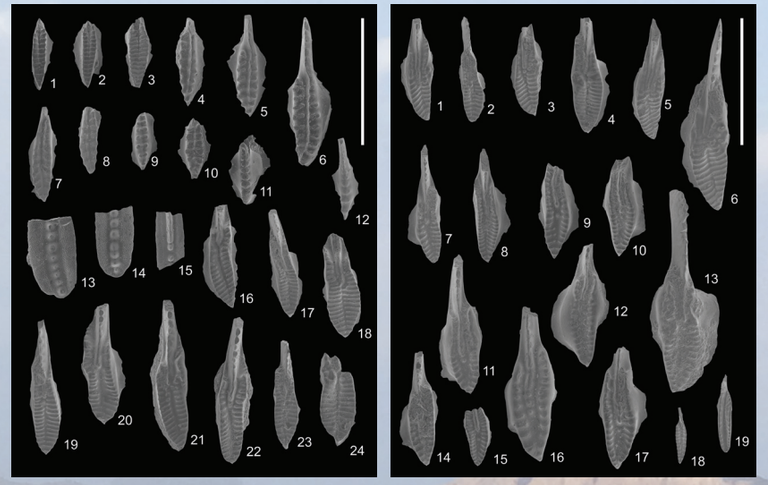


Figure 2: Gamma Ray and Resistivity logs of the Stephens L 1V well with conodont species, ranges, abundances, core intervals, and inferred ages. Conodont abundances are plotted adjacent to gamma ray as a log style histogram from 0 to 100 specimens per 100 g sample, increasing to the left. Cored intervals are highlighted in red. Conodont ranges are plotted adjacent to logs as black bars, with species names appearing immediately below each respective range. Inferred ages are shown on the far left with both North American (left) and International (right) stage names. Strawn top and Dean base horizons shown by brown marker. Stage boundaries identified by conodonts shown as green dashed lines.

Preliminary Results

A total of 19 species comprising 5 genera were identified (figs. 3-4) from three cored intervals (8836-9020 ft, 9200-9502 ft, 9660-9840 ft) of the Shell Stephens L 1V well within the Midland Basin. Species occurrences, ranges, and abundances were plotted adjacent to the Gamma Ray and Resistivity logs to determine patterns and trends in specimen appearance, and to identify the ages of the cored intervals. Conodonts were found primarily in black shale facies, indicating that specimens were likely deposited *in situ*. Increases in specimen abundances generally coincide with increasing gamma ray readings (fig. 2), and therefore with increasing fine grained material. This may suggest that conodont influxes occur with rising sea-level, while barren intervals occur during sea-level fall, and subsequently during periods of restricted water circulation.

Species of *Neostreptognathodus*, *Sweetognathus*, and *Mesogondolella* were identified within Core 1, giving it an age of latest Wolfcampian to earliest Leonardian (mid-late Artinskian to early Kungurian) (fig. 2), and tying it to the uppermost *Eoparafusulina linearis* and lowermost *Schwagerina crassitecroria* fusulinid zones. The Wolfcampian-Leonardian boundary was placed at 8969', at the first appearance of *N. ruzhencevi*, while the Artinskian-Kungurian boundary was placed at the appearance of *N. exsculptus*, 8842'. Within Core 2, species of *Mesogondolella*, *Sweetognathus*, *Streptognathodus*, and *Adetognathus* were identified, age-dating it as latest Virgilian (Gzhelian) to early Wolfcampian (Asselian to lower Sakmarian) (fig. 2), and tying it to the *Tritcites-Schwagerina* and *Pseudoschwagerina* fusulinid zones. The Virgilian-Wolfcampian boundary (Gzhelian-Asselian boundary) was placed at 9470' based on the occurrence of *S. invaginatus*, *S. conjunctus*, and *S. wabaunsensis*, while the Asselian-Sakmarian boundary was tentatively placed at the first appearance of *S. barskovi*. An indeterminate species of *Mesogondolella* was found between 9221' and 9231'. Core 3 was identified as Virgilian (Gzhelian) based on occurrences of species of *Streptognathodus* and *Adetognathus* (fig. 2).



Figs. 3, 4: Conodont plates showing specimens found. Scale bar represents 1 mm. Figure 3 (left): 3.1 - 3.3 *N. exsculptus*; 3.4 - 3.8 *N. ruzhencevi*; 3.9 - 3.10 *Sw. whitei*; 3.11 - 3.12 *Sw. merrilli*; 3.13 - 3.14 *M. bisselli*; 3.15 *M. sp?*; 3.16 - 3.17 *S. constrictus*; 3.18 - 3.19 *S. barskovi*; 3.20 *S.* aff. *fusus*; 3.21 - 3.22 *S. postelongatus*; 3.23 - 3.24 *S. ?nodulinearis*. Figure 4 (right): 4.1 - 4.2 *S. invaginatus*; 4.3 - 4.4 *S. wabaunsensis*; 4.5 - 4.6 *S. conjunctus*; 4.7 - 4.10 *S. brownvillensis*; 4.11 - 4.13 *S.* aff. *zethus*; 4.14 - 4.15 *S. virgilicus*; 4.16 - 4.17 *S. pawhuskaensis*; 4.18 - 4.19 *Ad. sp?*.

Conclusions & Future Work

- 18 species and 5 genera of conodonts were identified from the basinal shale facies of the "Wolfcamp Shale." The majority of these species occur regionally (Glass Mountains, Eastern Shelf, Midcontinent), and globally (Russia, China, Japan), and can be used with cyclothems and fusulinid ties for correlation.
- The Carboniferous - Permian boundary was identified at 9470', and the Wolfcampian - Leonardian boundary identified at 8969', age-dating the cored sections of the "Wolfcamp Shale" as latest Pennsylvanian to early Leonardian.
- Future work aims to correlate the Stephens L 1V well to the Eastern Shelf and Midcontinent using the constructed conodont framework and transgressive-regressive sequences identified from core and Gamma Ray log, and to compare the conodont picks for the Wolfcamp base and top to the log picks of adjacent wells within Lynn County, TX.

Acknowledgements

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