geoconvention
Calgary • Canada • May 11-13 2026

The Lower Triassic Montney Formation in western Canada: A Global Perspective

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Introduction

The Montney Formation is one of North America's most prolific and expansive conventional and unconventional resource plays and the produced natural gas, natural gas liquids and oil will generate considerable wealth. The thousands of publicly available well logs and hundreds of cores within west-central Alberta and northeastern British Columbia provide a rich playground for sedimentologists, stratigraphers, and a few biostratigraphers. The Montney Formation also provides a vast amount of knowledge regarding Earth's greatest extinction event, the end-Permian Mass Extinction (EPME), as well as the recovery of life afterward. The Montney Formation comprises three depositional sequences that are recognized around the world suggesting a global perspective might provide new insights into this extraordinary time interval. Sequence boundaries and internal marine flooding surfaces provide a means for correlation. Conodont biostratigraphy increases confidence and allows global correlation.

Biostratigraphy of the Montney Formation

Lower Triassic biostratigraphy has historically involved the distribution of ammonoids. Tozer (1967) recognized four stages correlated with ten ammonoid zones for the Lower Triassic of western and arctic Canada. They include Griesbachian, Dienerian, Smithian and Spathian and are now recognized as informal substages. The Geological Time Scale now recognizes two stages including Induan (most of Griesbachian and Dienerian) and Olenekian (Smithian and Spathian). Only a few ammonoid molds have been revealed from Montney cores, but the small size of conodonts (~1mm) makes them ideal index fossils to study Montney core and even cuttings (Henderson et al., 2018). Because of the predominantly siltstone lithology, standard processing techniques are not ideal; the best results have come from a study using core that was ground into pseudocuttings – it seems numerous elements popped out by physical disaggregation. Up to 20 conodont biozones are now recognized for the 4.9 Myrs of Montney deposition. We have even discovered an unusual way for shallow water conodonts to occur in deeper water samples; the animal had big eyes but was unable to avoid fishes looking for food.

Base-Montney and EPME Chronostratigraphy

Montney deposition begins with an uppermost Permian transgression that can be dated to between 252 and 252.3 Ma based on geochronologic ages at the Penglaitan section in South China (Shen et al., 2018). The base of the Griesbachian coincides with the onset of the latest Permian transgression. In western Canada the Montney transgresses across a structurally complex landscape during the latest Permian and unconformably overlies different units including the Mississippian Debolt, the Pennsylvanian Ksituan Member, and different levels in the Permian Belloy Formation. In the outcrop belt to the west the contact between the Grayling (Montney equivalent) and the Upper Permian Fantasque Formation is likely conformable. Late Permian conodonts recovered from uppermost Fantasque include cool-water species like *Mesogondolella*

sheni and from the lowermost Grayling Formation species of *Clarkina* including *C*. cf. *changxingensis*, *C*. *hauschkei*, *C. meishanensis* and *C. zhejiangensis*. The Permian-Triassic boundary is marked by *Clarkina taylorae* and rare occurrences of *Hindeodus parvus.* These mysterious conodont names reveal a fundamental shift in our habitable world. The EPME occurs during this interval and is sedimentologically unremarkable, characterized by the demise of the last benthic survivors - a low-diversity, demosponge-dominated community. The genus *Clarkina*, a warm water conodont genus, flourished in the Tethys Ocean during the Late Permian and earliest Triassic. Before the EPME, the world included a warm equatorial province and a northern cool-water province (Mei and Henderson, 2001). That world changed quickly with global warming associated with immense introduction of CO_2 associated with eruption of Siberian traps and ignition of vast coal deposits. *Clarkina* conodonts migrated into the Montney Basin as well as other basins along northwest Pangea, including the Sverdrup Basin in the Canadian Arctic, seeking slightly cooler conditions. The extinction interval in the Tethys Ocean is limited to an interval of 31 ± 31 kyrs (Shen et al., 2018) whereas in NW Pangea it may have occurred over an interval as long as 300 kyrs (Algeo et al., 2012).

Chronostratigraphy of the Recovery interval

The recovery from the EPME began in the Griesbachian with some diverse ichnofossil communities (Beatty et al., 2008). Recovery continued with the sudden appearance of planktic calcispheres in earliest Dienerian. The flat clam *Claraia* became abundant in latest Dienerian in the Pocketknife Member whereas bivalves and brachiopods are common in the upper Smithian Altares Member (Zonneveld and Moslow, 2018). A trophically complex modern-type ecosystem of diverse fishes and malacostrachans occurs in earliest Smithian. Ichthyosaurs were common and diversified during the mid-late Smithian. Many of these recovery events coincide with carbon isotopic positive peaks (Zhu et al., 2025) and 1.2 Myr obliquity modulation cycles that appear to be global signals. A high resolution XRF dataset (~1.1 million geochemical measurements) from the c-65-F/94-B-8 core (Moslow et al., 2018) has constrained redox conditions and other environmental indicators (Schoepfer et al., 2024). A time series analysis has been performed on the same dataset allowing the development of an astronomically tuned time scale anchored to 252 Ma (base-Montney transgression) (Chen et al., under review). This time model differs from the current model in the Geologic Time Scale (https://stratigraphy.org/chart/). This is important to finally resolve since it affects understanding of recovery and depositional rates. These various geochemical and astronomical analyses demonstrate that many recovery events are global in extent.

Top Montney Chronostratigraphy

The top of the Montney Formation is dated as latest Spathian and potentially earliest Anisian. The Montney Formation is overlain unconformably by the Sunset Prairie Formation, but it is possible that the Sunset Prairie is a member of the Montney Formation in which the erosional surfaces represent regressive surfaces of marine erosion during relative sea-level fall. Conodont biostratigraphy may resolve this stratigraphic issue.

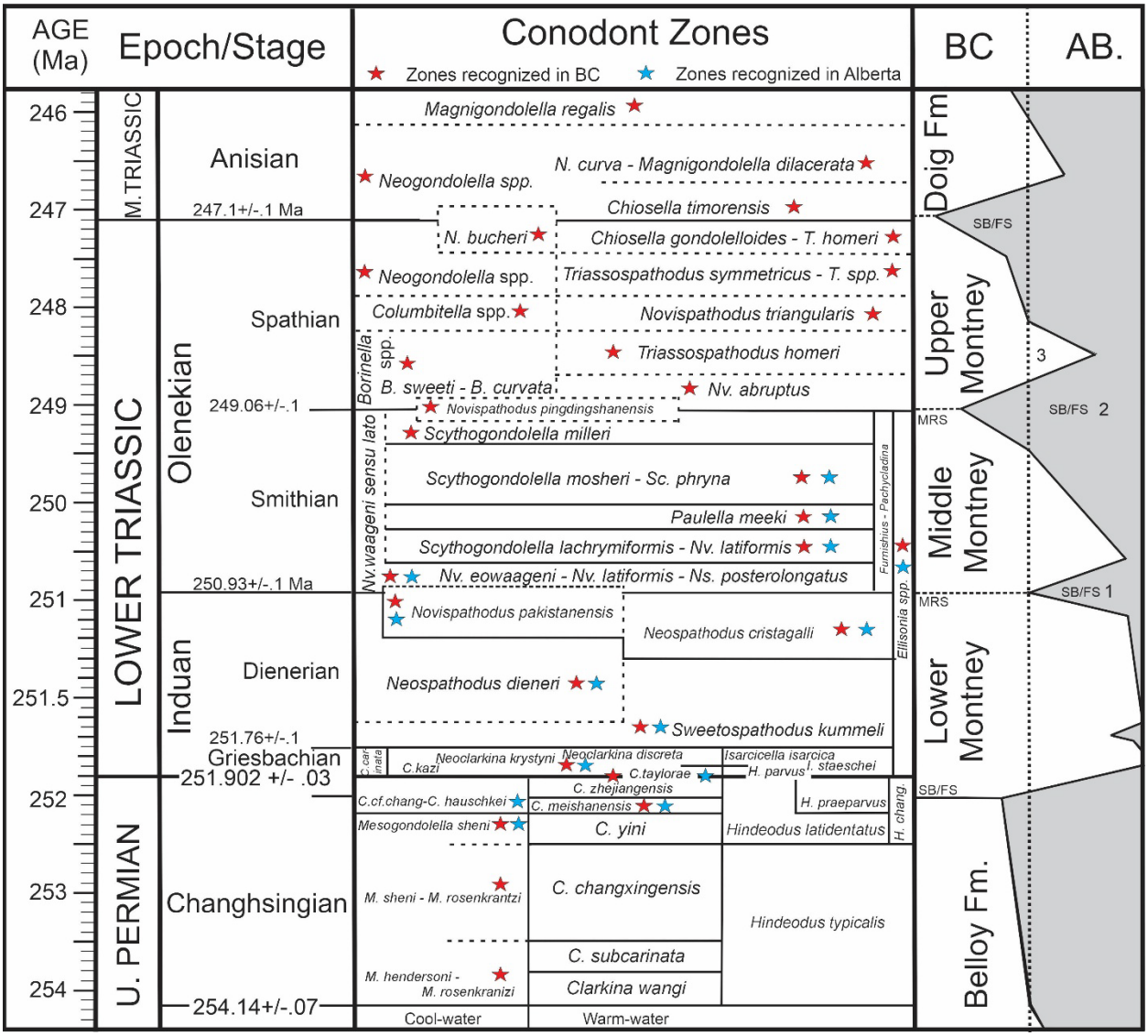
Conclusions

The Montney Formation is a tremendous resource play that will provide energy and generate wealth for years to come. The scientific studies on the Montney Formation have provided a global perspective and priceless new insights into extinction and recovery processes.

Acknowledgements

The research of CMH and students was supported by NSERC and by many oil&gas industry companies in Calgary in the forms of research sponsorship. All these companies are gratefully thanked for supporting scientific research and the education of highly qualified personnel – many are still working in industry or at universities today. Shane Schoepfer is thanked for his contributions, started during his post-doc, developing a dataset generously provided by Petronas Canada Ltd (formerly Progress Energy Canada Ltd.) that led to the high-resolution geochemical study published in 2024 and the time series analysis for c-65-F under review by Chen Shen. Finally, Tom Moslow has encouraged me to keep searching for conodonts in the Montney.

Figure 1. Correlation of the Montney includes Triassic stages, conodont biozones, sequence stratigraphy, and an astronomically tuned time model. Note that the base of Griesbachian is at 252 Ma or latest Permian. Note scale change between 251 and 252 Ma.



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