Abstract

Well exposed Devonian rocks in the Rocky Mountains of western Alberta record a Late Givetian to early Famennian 2nd order eustatic sea level cycle and a series of nine 3rd order sea level changes. Two late Frasnian-earliest Famennian transgressive events are associated with a step-wise mass extinction represented by the Lower and Upper Kellwasser events (LKE & UKE). Tropical and subtropical carbonate platform organisms were preferentially affected by these events, and a variety of mechanisms have been implicated. C & N stable isotope stratigraphy provides insight into carbon and nutrient cycling and ecologic change associated with these events. Preliminary geochemical analysis of organic matter from a basinal section along the southeast margin of the Ancient Wall platform documents stepwise excursions of both $\delta^{13}$Corg and $\delta^{15}$N during the Late Devonian that correlate biostratigraphically with the LKE and UKE. $\delta^{15}$N and the $\delta^{13}$Corg display positive excursions of $\geq 4\%$ and the $\delta^{13}$Corg lags behind the $\delta^{15}$N during the events. An increase in $\delta^{15}$N may be associated with denitrification mediated by bacteria in sub-oxic to anoxic environments and implies increased primary production. Increased riverine input of nutrients associated with greater terrestrial weatherability due to the rise of rooted land plands and/or deepwater upwelling likely influenced productivity. Increased productivity, rapid burial, eutrophication, and development of oxygen-depleted conditions preserved organic matter and resulted in the positive $\delta^{13}$Corg excursion. Similar patterns are found in Upper Devonian sections worldwide confirming the global nature of these events.
Carbon and nutrient cycling during the Late Devonian Frasnian-Famennian stepwise mass extinction in western Alberta, Canada

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Paleogeography

- Western Canada was located under a shallow equatorial epieric sea and within the trade wind belt.
Location: Rocky Mts., western Alberta

- 2 isolated carbonate platforms
- Ancient Wall and Miette, located in the Alberta Basin

After Mountjoy, 1965
<table>
<thead>
<tr>
<th>Lower Devonian</th>
<th>Late Devonian</th>
<th>Subsurface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miguasha Fm.</td>
<td>Lismer Fm.</td>
<td>Wabamun Fm.</td>
</tr>
<tr>
<td>Maligne Fm.</td>
<td>Sassenach Fm. Rode/Simla mbr.</td>
<td>Calmar, Graminia Fms.</td>
</tr>
<tr>
<td>Grotto mbr.</td>
<td>Arcs mbr.</td>
<td>Nisku Fm.</td>
</tr>
<tr>
<td>Mt. Hawk Fm.</td>
<td>Peechee mbr.</td>
<td>Upper Leduc Fm.</td>
</tr>
<tr>
<td>Perdrix Fm.</td>
<td></td>
<td>Lower Leduc Fm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooking Lake Fm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beaver Hill Lake Grp.</td>
</tr>
</tbody>
</table>

After Switzer et al., 1994

**Stratigraphic Nomenclature**

Central Alberta Subsurface

Rocky Mountains

- **F-F boundary**
Sea Level and Biostratigraphy

- Conodont Zones, T-R cycles, and MS events in relation to sequences, platforms, and sea level
- Sequence 8 (Ronde and Simla Mbrs.) and 9 (Sassenach Fm)

### Table: Conodont Zones, T-R Cycles, and MS Events

<table>
<thead>
<tr>
<th>Conodont Zones</th>
<th>T-R Cycles</th>
<th>MS Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Standard*</td>
<td>Montagne Noire</td>
<td></td>
</tr>
<tr>
<td>* triangularis*</td>
<td>Ile</td>
<td>E5, E4</td>
</tr>
<tr>
<td>* linguliformis*</td>
<td>13</td>
<td>Ild-2</td>
</tr>
<tr>
<td>* rhenana*</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>jamiaeae</td>
<td>11</td>
<td>Ild-1</td>
</tr>
<tr>
<td>hassi</td>
<td>10, 9</td>
<td>Ilc-2</td>
</tr>
<tr>
<td>punctata</td>
<td>8</td>
<td>Ilc-1</td>
</tr>
<tr>
<td>transiens</td>
<td>7</td>
<td>Ilb-3?</td>
</tr>
<tr>
<td>Upper</td>
<td>6</td>
<td>Ilb-2</td>
</tr>
<tr>
<td>Lower</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sub-terminus</td>
<td>4</td>
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</tr>
<tr>
<td>Upper</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Lower</td>
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</tr>
<tr>
<td>Lower</td>
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</tr>
</tbody>
</table>

### Diagram: Styles of Platform Development

- Sequence 9, Sassenach Fm.
- Sequence 8, Ronde/Simla Mbrs./Uppermost Mt. Hawk Fm
- Sequence 7, Arcs Mbr./Lower-upper Mt. Hawk Fm
- Sequence 6, Upper Peechee Mbr./Mid-upper Perdrix Fm.
- Sequence 5, Upper Cairn Fm./Lower Peechee Mbr./Lower-mid Perdrix Fm.
- Sequence 4, Maligne/Lower Cairn Fms.
- Sequence 3, Upper Flume Fm.
- Sequence 2, Utopia Mbr., Flume Fm.
- Sequence 1, Thornton Cr. Mbr., Flume Fm.

Whalen and Day, 2007
<table>
<thead>
<tr>
<th>Layer</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sass.</td>
<td>Prograding Platform 2</td>
</tr>
<tr>
<td>Ronde</td>
<td>Aggrading and Backstepping Platform</td>
</tr>
<tr>
<td>Arcs</td>
<td>Prograding Platform 1</td>
</tr>
<tr>
<td>Mt. Hawk</td>
<td>Aggrading Ramp</td>
</tr>
<tr>
<td>Perdrix</td>
<td>Modified from Whalen et al., 2000</td>
</tr>
</tbody>
</table>
Depositional Environment

• Carbonate Platform Facies:
  • Basin facies
  • Slope facies
  • Platform margin facies
  • Lagoon facies

Whalen, et al., 2000
SE Miette Platform Margin

Modified from Whalen et al., 2000
SE Miette Margin:

Photo taken by M. Whalen
Ancient Wall

Modified from Whalen et al., 2000
Anoxic event:

• Upper Kellwasser Event (UKE)
• Lower Kellwasser Event (LKE)

After Joachimski et al., 2002
Stable Isotopes Excursions

- Globally recognized positive excursions 2‰ to 4‰ (VPDB) in the $\delta^{13}C_{\text{inorg}}$ and $\delta^{13}C_{\text{org}}$

- WHY?

- $\uparrow$ organic burial, $\uparrow$ primary production, and/or anoxicic conditions
Miette Chemostratigraphy

Diagram showing chemostratigraphy with depth (m) on the y-axis and various geochemical parameters on the x-axis, including TOC (%), C/N, $\delta^{15}$N (‰ N$_2$), and $\delta^{13}$C$_{org}$ (‰ VPDB). The diagram includes divisions for different sequences and stages (HST, TST, LST) within the formations of Sassenach and Simla.
Ancient Wall Chemostratigraphy

Diagram showing changes in TOC (%), C/N, and δ¹³Corg (% VPDB) with depth for the Sassenach and Simla formations. The δ¹⁵N (%N₂) is also depicted. Key stratigraphic levels include HST, TST, and LST, with specific depth markers for UKE and LKE.
Local Variations in Cycling

- Sea level changes: LOWSTANDS or HIGHSTANDS
- Weathering (carbonate and silicates): PLANTS
- Depositional Environment: OCEAN or EPIERIC SEA
- Carbon Burial: ?
Nitrogen as a Stratigraphic Tool

- Nitrogen cycle is complex and part of the marine biogeochemical cycle.
- $\delta^{15}N$ has not been used in previous studies.
- Biotic processes control $\delta^{15}N$.
- Denitrification or Nitrogen Fixation.

![Graph showing historical nitrogen depth data with labels for Ancient Wall and Miette.](image)
Conclusions

• Have successfully seen the global excursion in the $\delta^{13}C_{\text{org}}$

• $\delta^{13}C_{\text{inorg}}$ and $\delta^{18}O$ data still needed

• XRF major and trace element data still needed
Acknowledgements

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Selected References


Questions???