Carbon and Nutrient Cycling during the Late Devonian Frasnian-Famennian Stepwise Mass Extinction in Western Alberta, Canada*

Joshua H. Payne[1], Michael T. Whalen[1], and James E. Day[2]

Search and Discovery Article #30073 (2008)
Posted November 26, 2008

*Adapted from oral presentation at AAPG Annual Convention, San Antonio, Texas, April 20-23, 2008

[1]Geology and Geophysics Department, University of Alaska Fairbanks, Fairbanks, AK (ftjhp@uwf.edu)
[2]Geography-Geology, University of Illinois State, Normal, IL

Abstract

Well exposed Devonian rocks in the Rocky Mountains of western Alberta record a Late Givetian to early Fammenian 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 δ^{13}Corg and δ^{15}N during the Late Devonian that correlate biostratigraphically with the LKE and UKE. δ^{15}N and the δ^{13}Corg display positive excursions of ≥4‰ and the δ^{13}Corg lags behind the δ^{15}N during the events. An increase in δ^{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 δ^{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

Joshua H. Payne[1], Michael T. Whalen[1], and James E. Day[2]

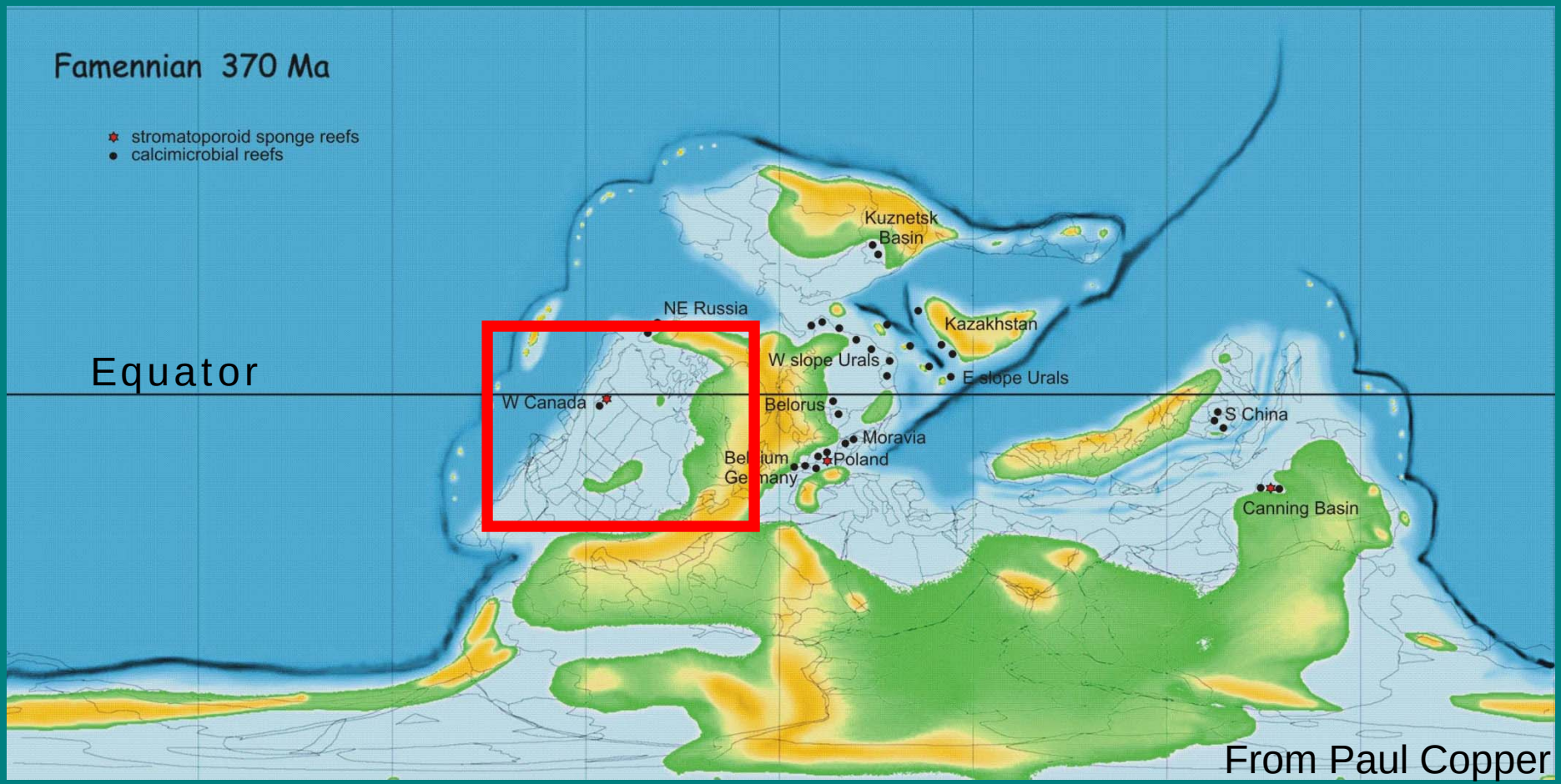
[1] University of Alaska Fairbanks

[2] Illinois State University

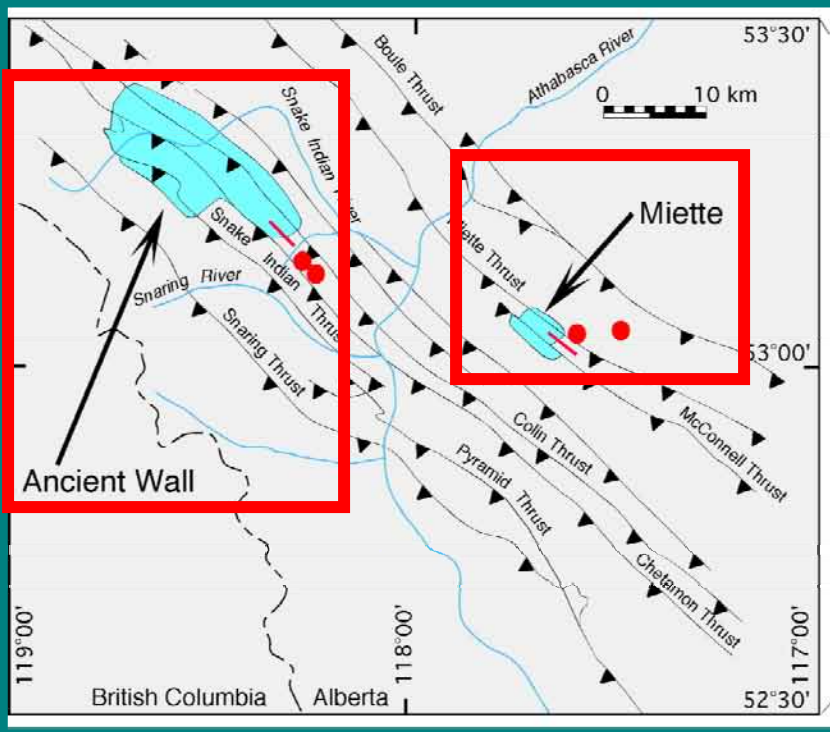
Photo taken by M. Whalen

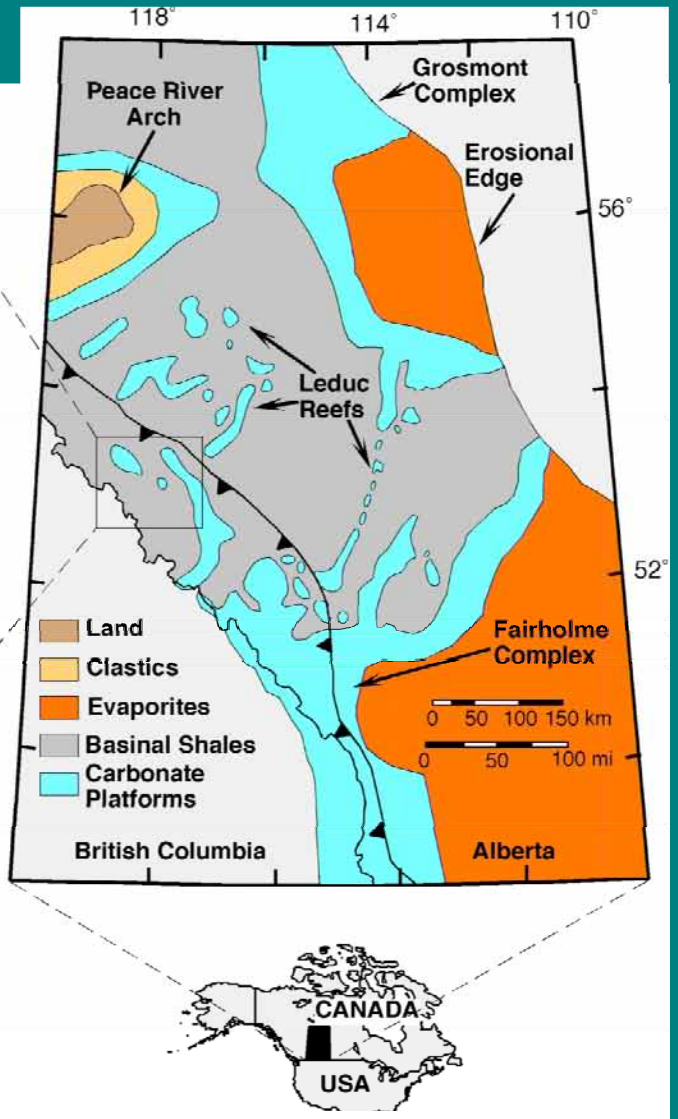
Paleogeography

- Western Canada was located under a shallow equatorial epieric sea and within the trade wind belt



Location: Rocky Mts., western Alberta

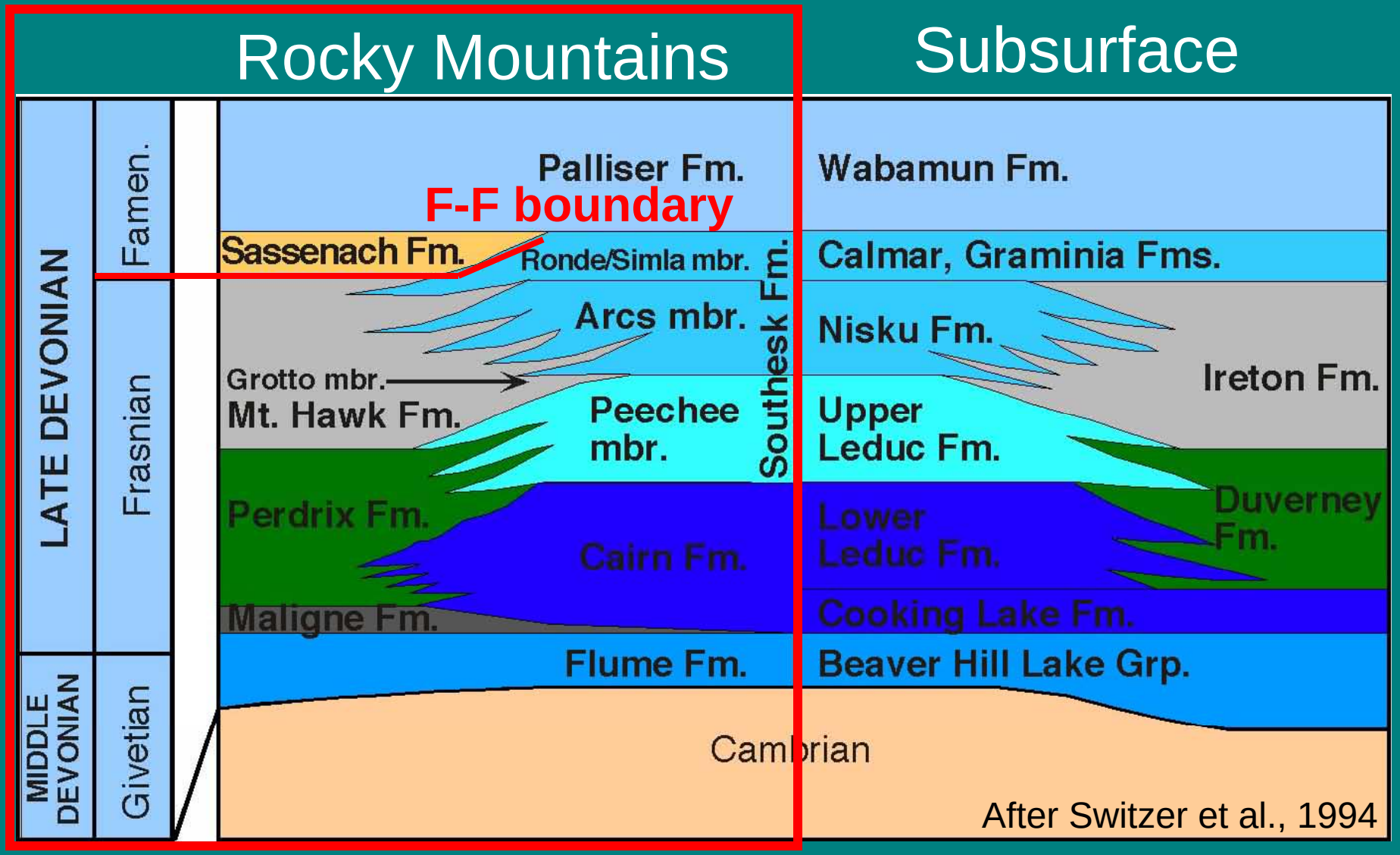




After Mountjoy, 1965

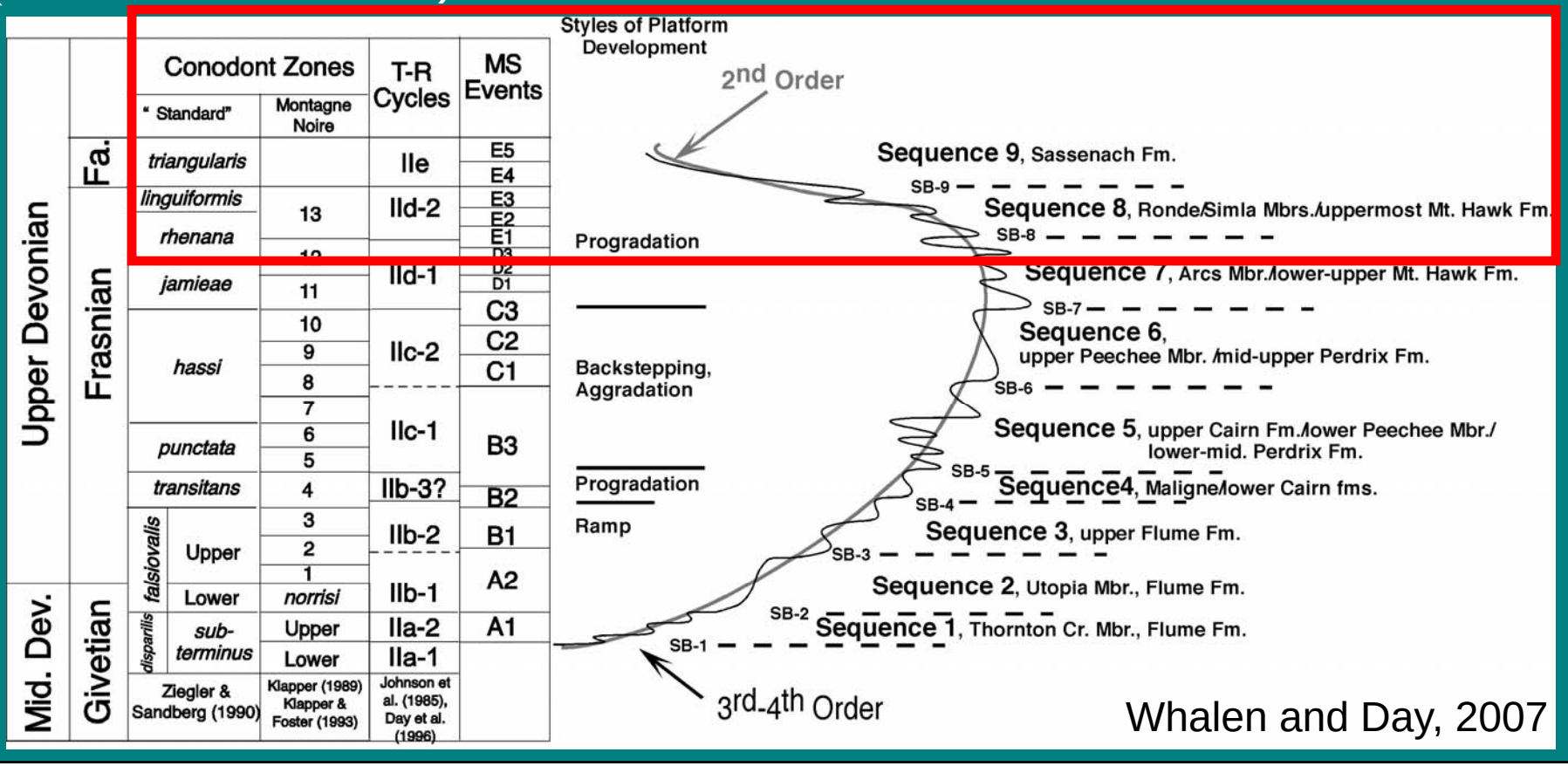
- 2 isolated carbonate platforms
- Ancient Wall and Miette, located in the Alberta Basin

Stratigraphic Nomenclature



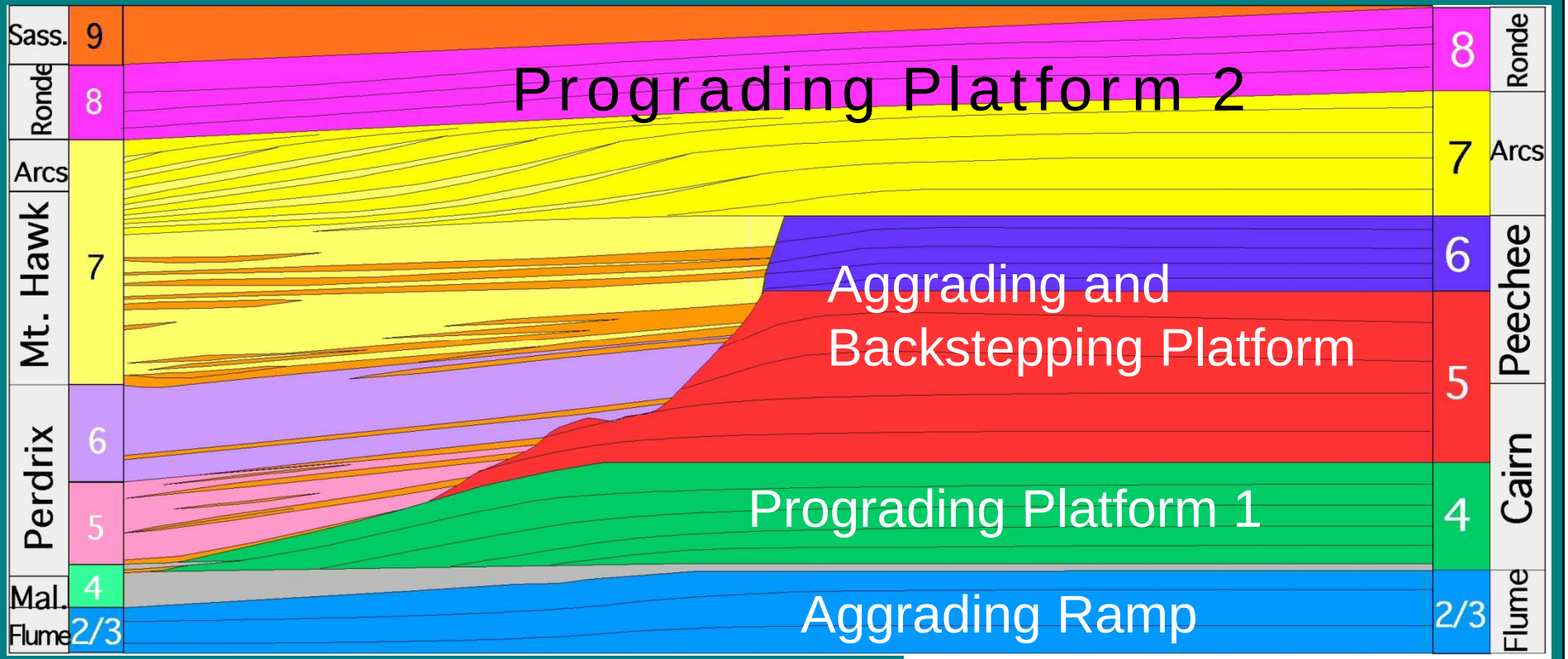
Sea Level and Biostratigraphy

- 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)



Whalen and Day, 2007

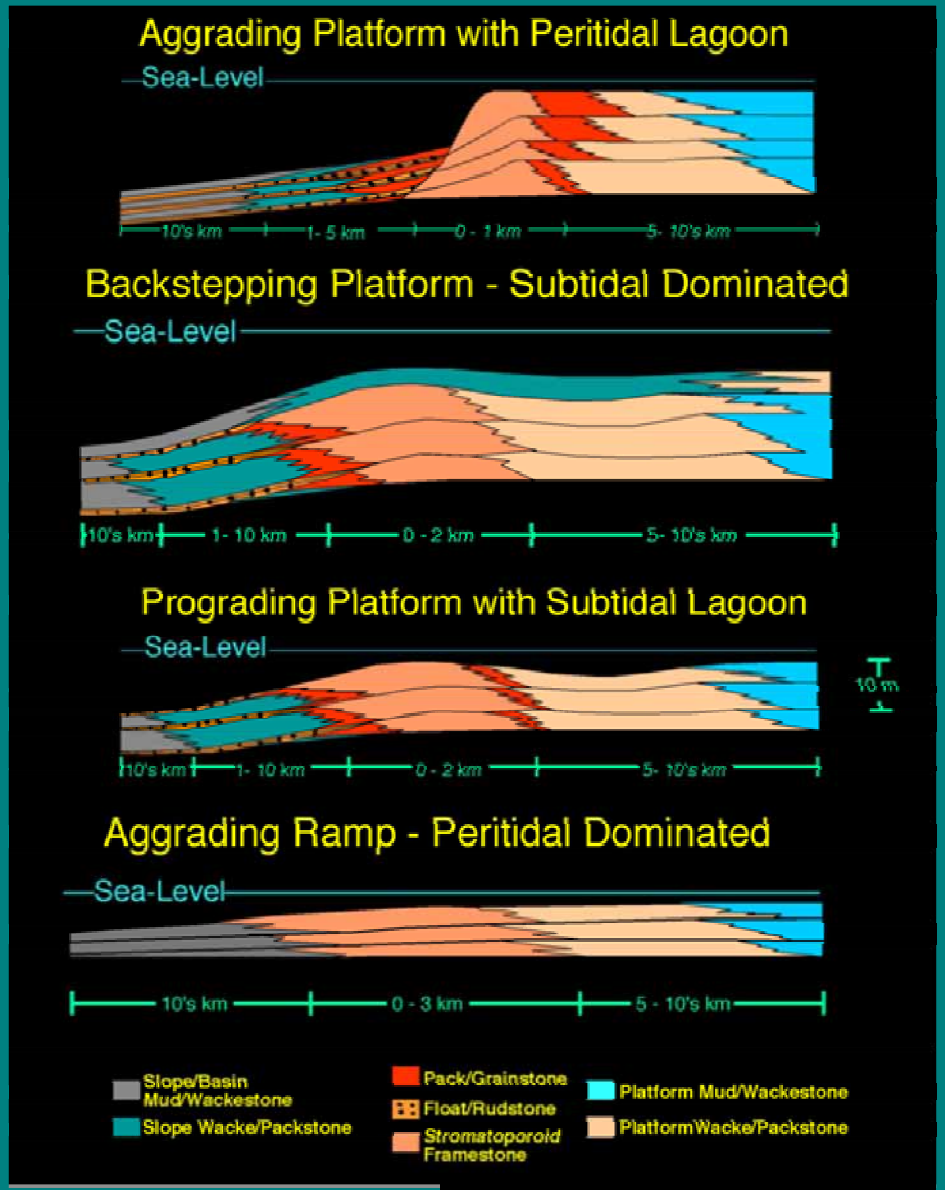
Carbonate Platform Development



Modified from Whalen et al., 2000

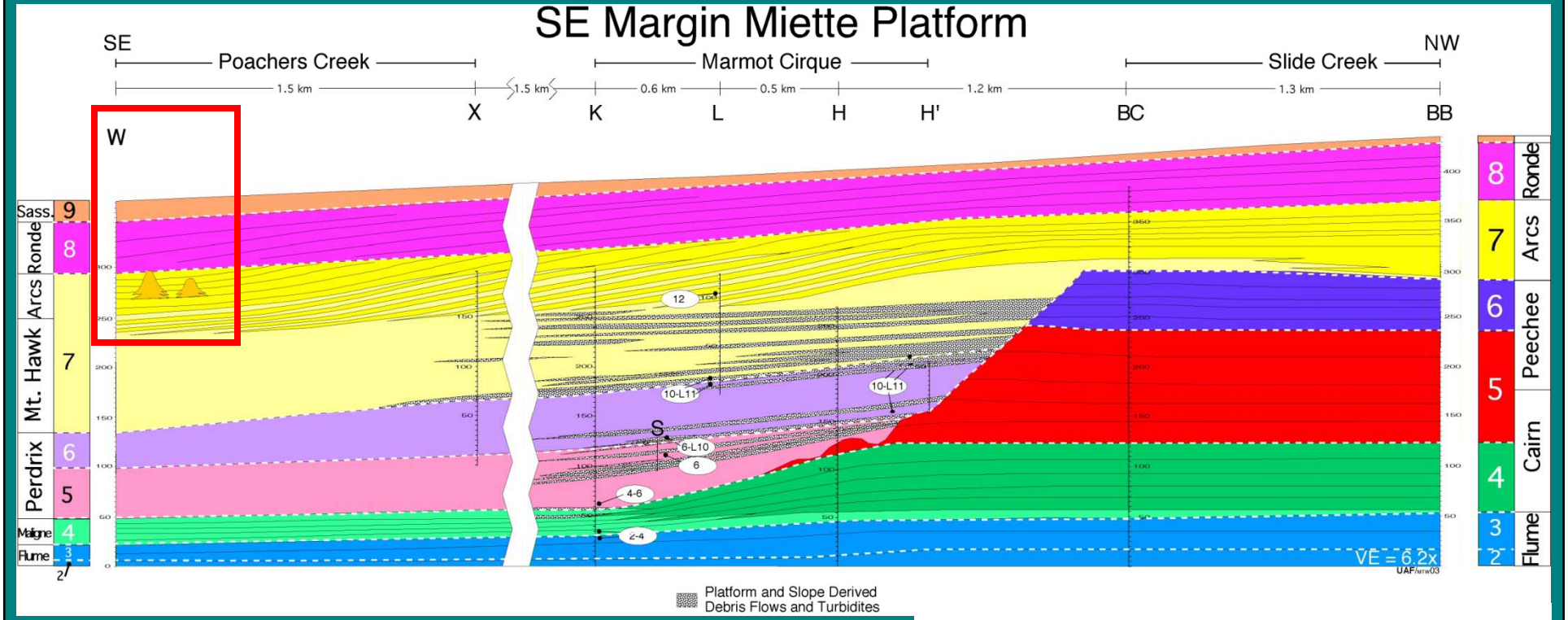
Depositional Environment

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



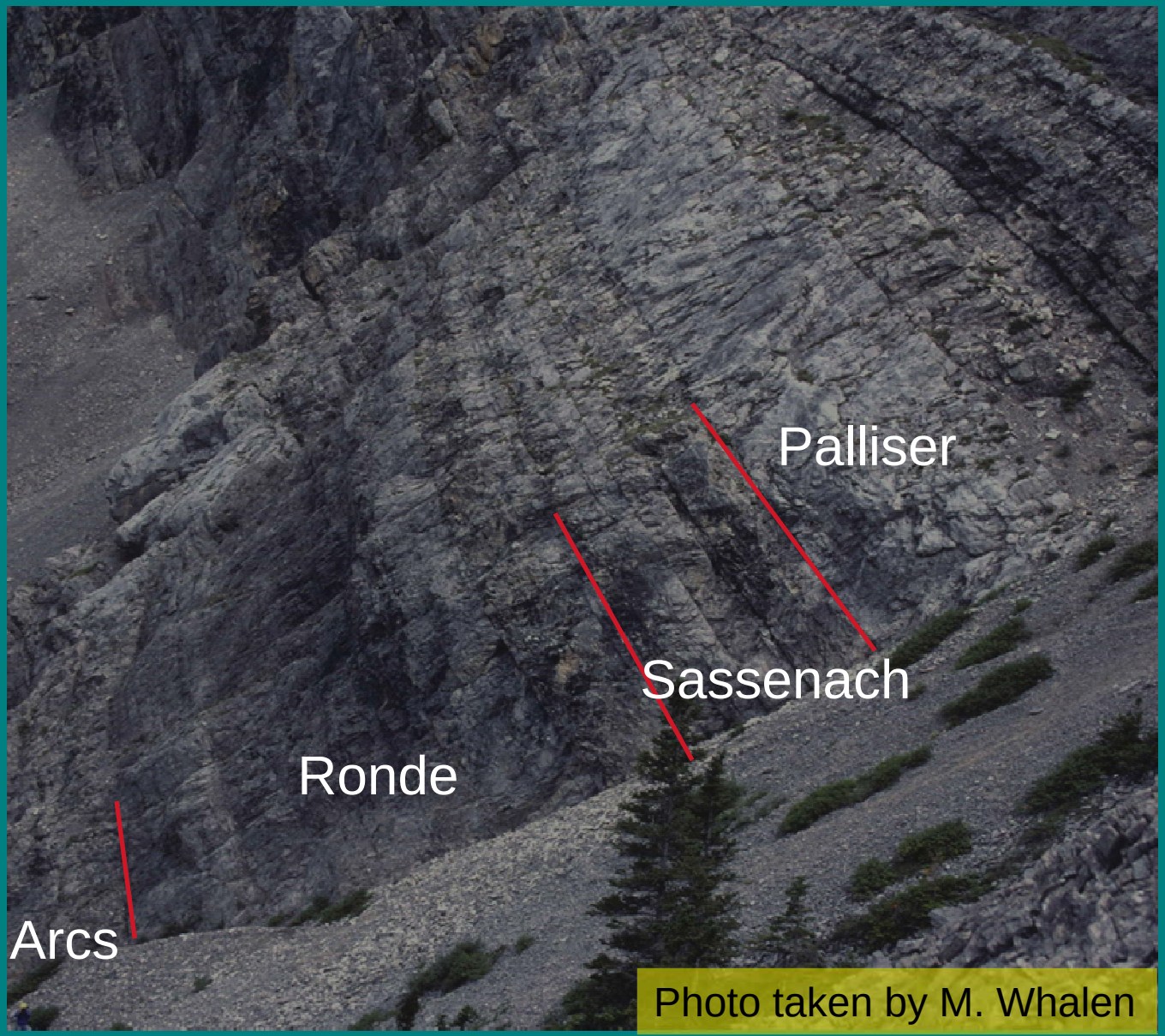
Whalen, et al.,2000

SE Miette Platform Margin

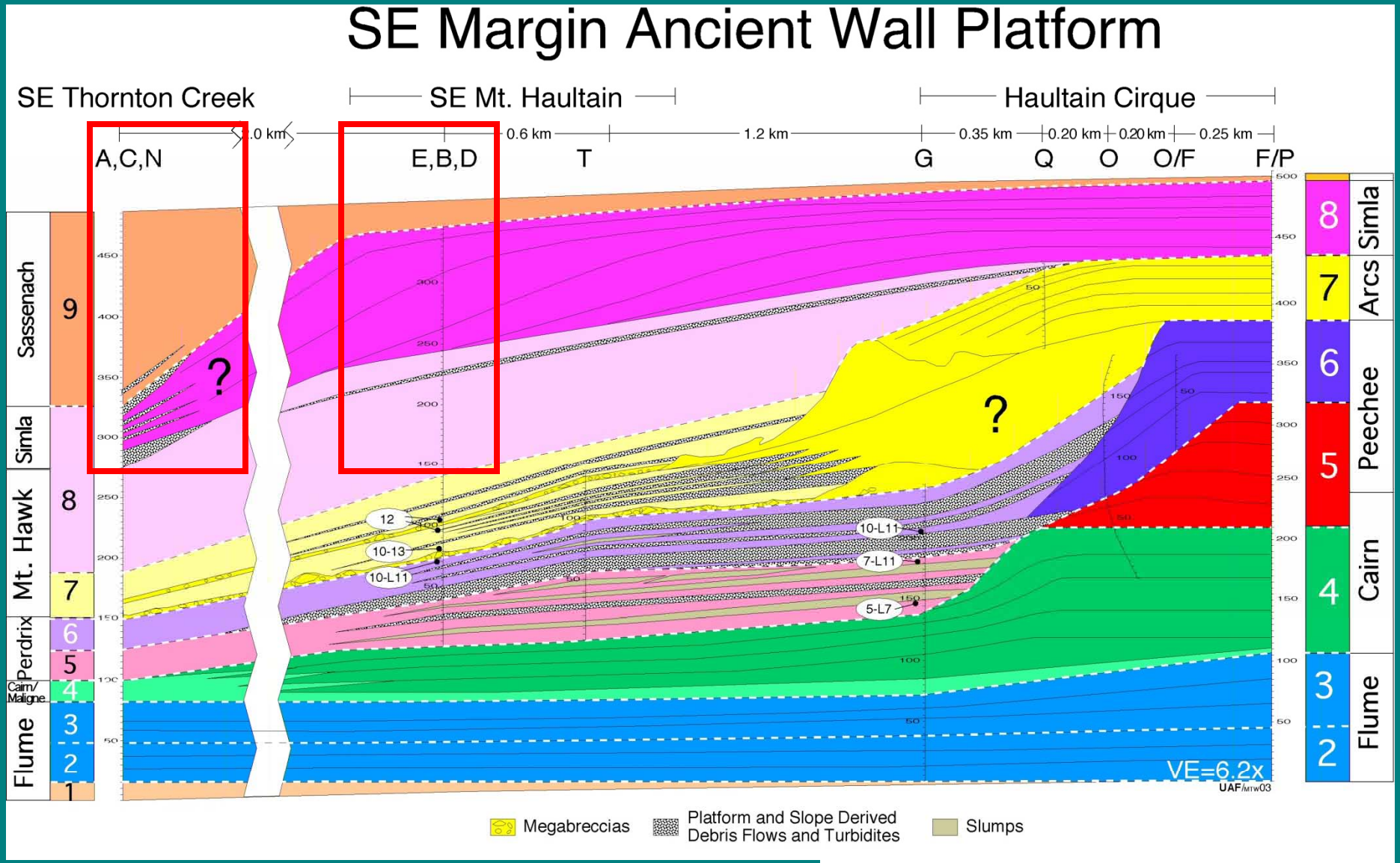


Modified from Whalen et al., 2000

SE Miette Margin:



Ancient Wall



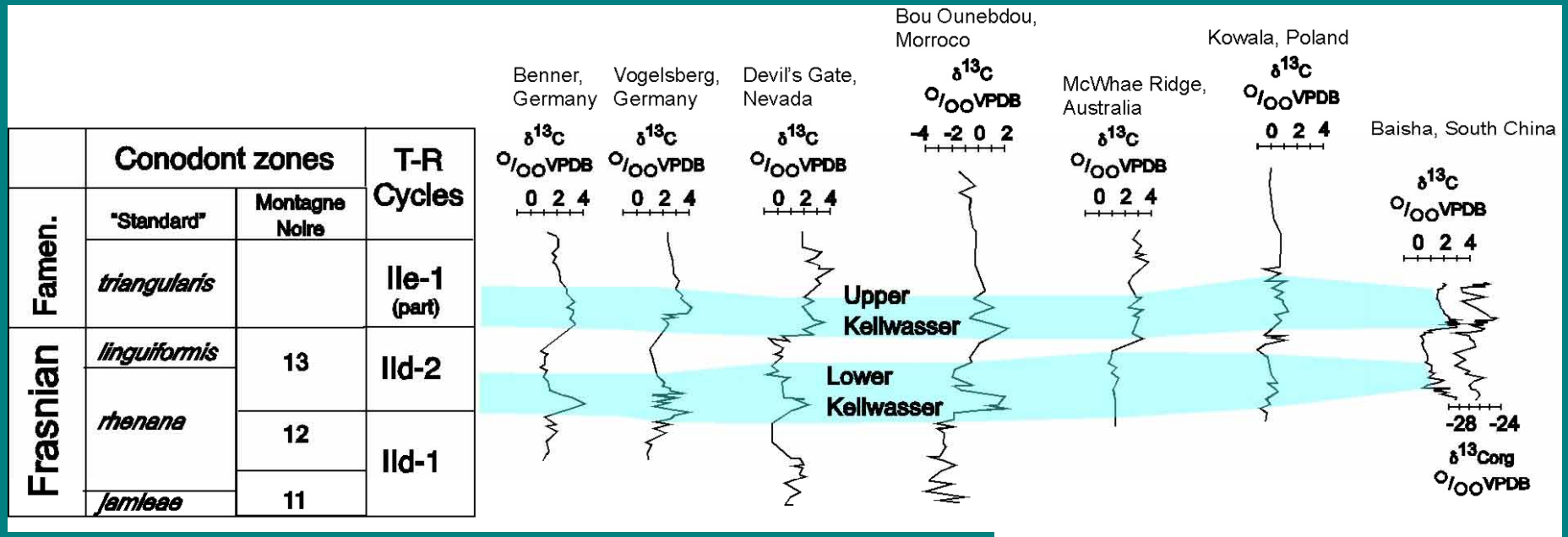
Modified from Whalen et al., 2000

SE Ancient Wall Margin

UKE and LKE Global Correlation

Anoxic event:

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

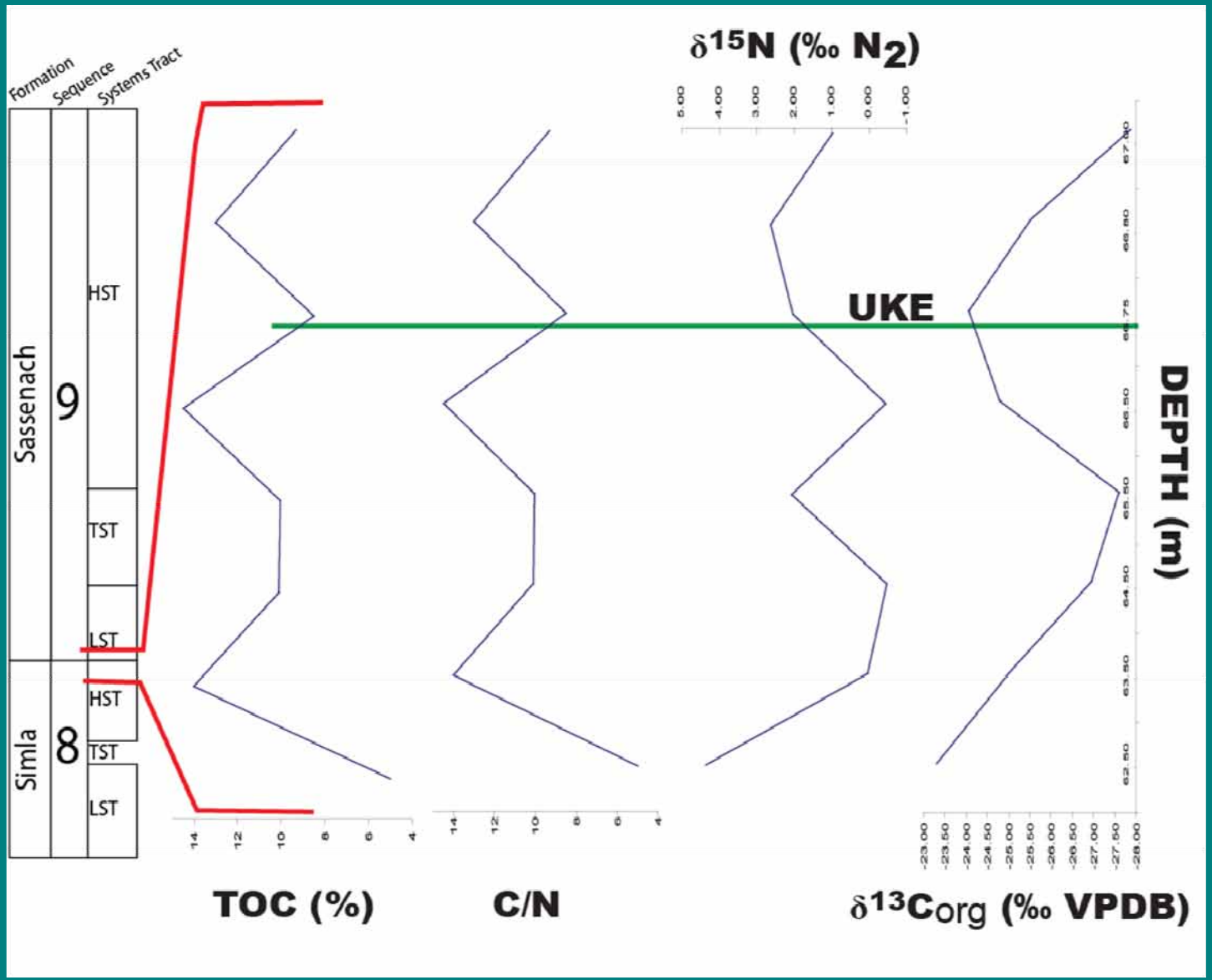


After Joachimski et al., 2002

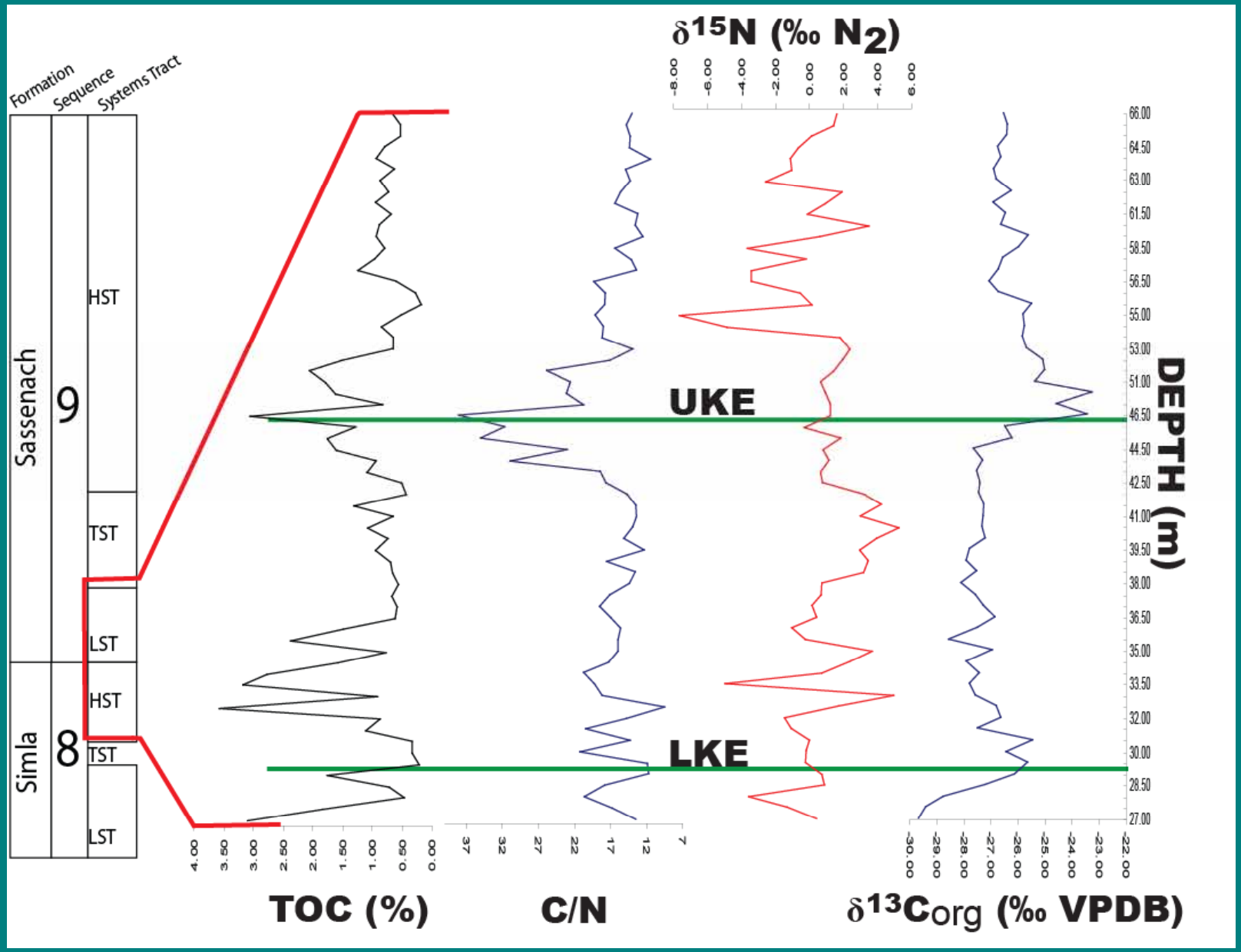
Stable Isotopes Excursions

- Globally recognized positive excursions 2‰ to 4‰ (VPDB) in the $\delta^{13}C_{inorg}$ and $\delta^{13}C_{org}$
- WHY?
- ↑ organic burial, ↑ primary production, and/or anoxic conditions

Miette Chemostratigraphy

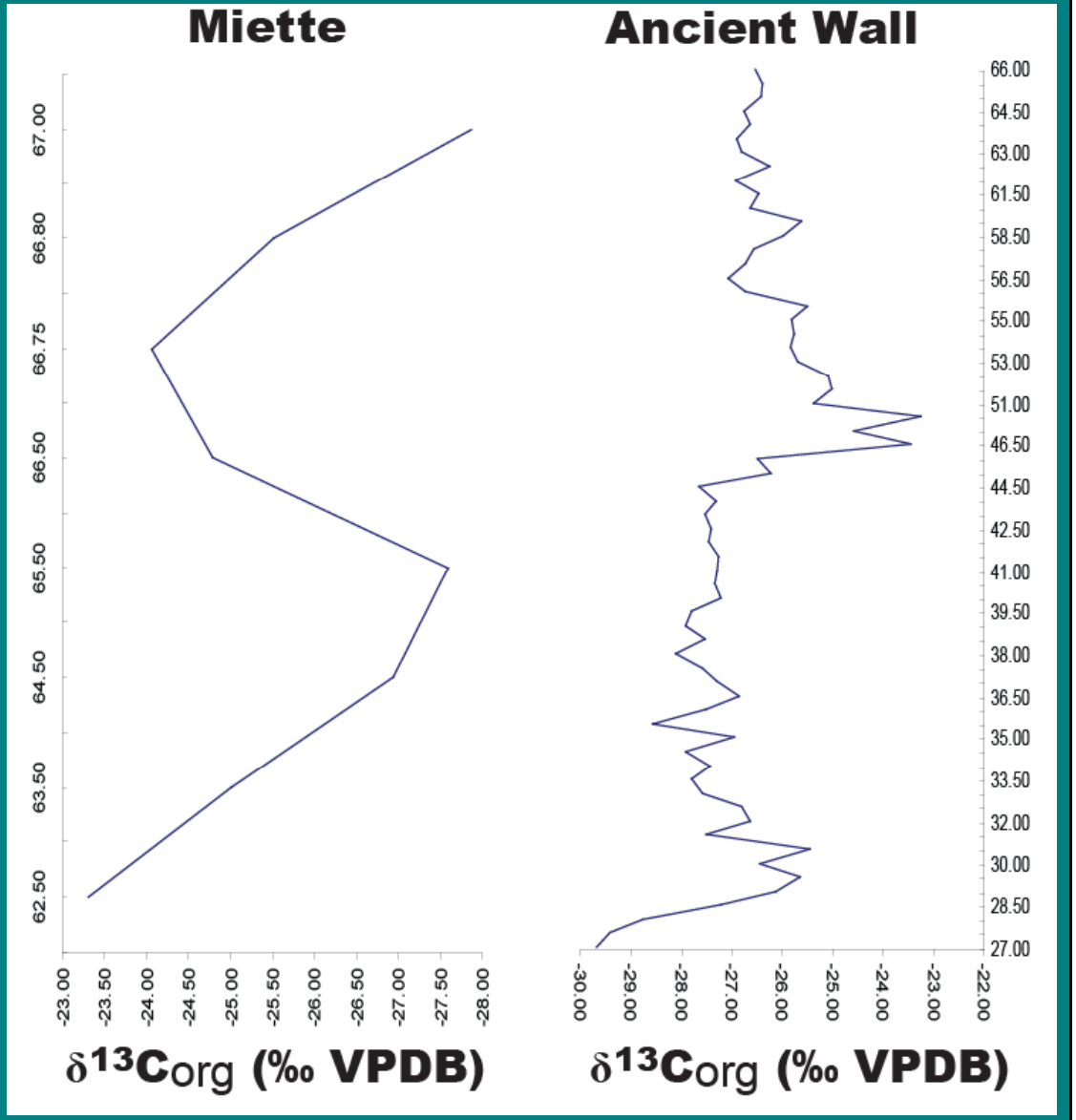


Ancient Wall Chemostratigraphy



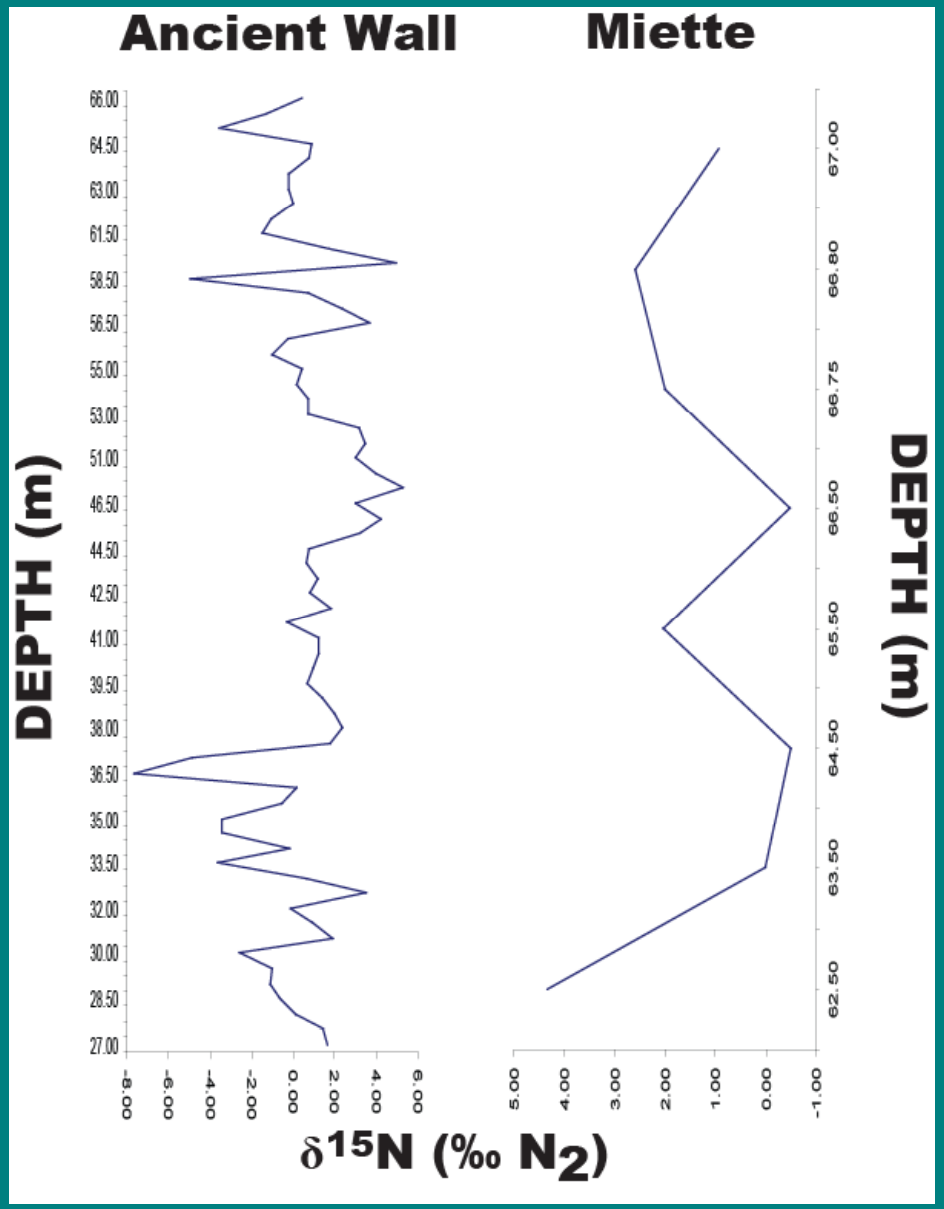
Local Variations in Cycling

- 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



Conclusions

- Have successfully seen the global excursion in the $\delta^{13}C_{org}$
- $\delta^{13}C_{inorg}$ and $\delta^{18}O$ data still needed
- XRF major and trace element data still needed

Acknowledgements

- I would like to thank my co-authors, the Geology and Geophysics Department at the University of Alaska Fairbanks, and the Alaska Stable Isotope Facility for their help and feedback.

- This project is supported by AGS Scholarship Program, GSA Grant in Aid, and University of Alaska Fairbanks Scholarships.

UAF™ UNIVERSITY OF ALASKA FAIRBANKS

Alaska Stable Isotope Facility
Water and Environmental Research Center

Selected References

Joachimski, M.M., R.D. Pancost, K.H. Freeman, C. Ostertag-Henning, and W. Buggisch, 2002, Carbon isotope geochemistry of the Frasnian-Famennian transition: Palaeogeography, Palaeoclimatology, Paleoecology, v. 181/1-3, p. 91-109.

Mountjoy, E.W., 1965, The Permo-Carboniferous succession of Mount Greenock and northern Jasper Park; discussion, translated title of paper by J.W. Hawryszko and R.s. Hamilton, 1964: Bulletin of Canadian Petroleum Geology, v. 13/2, p. 340-345.

Mountjoy, E.W., 1965, Stratigraphy of the Devonian Miette reef complex and associated strata, eastern Jasper National Park, Alberta: Bulletin Geological Survey of Canada, 132 p.

Switzer, S.B., W.G. Holland, D.S. Christie, G.C. Graf, A.S. Hedinger, R.J. McAuley, R.A. Wierzbicki, and J.J. Packard, 1994, Devonian Woodbend-Winterburn strata of the Western Canada sedimentary basin, *in* Geological atlas of the Western Canada sedimentary basin: p. 164-202.

Whalen, M.T., G.P. Eberli, F.S.P. van Buchem, E.W. Mountjoy, and P.W. Homewood, 2000, Bypass margins, basin-restricted wedges, and platform-to-basin correlation, Upper Devonian, Canadian Rocky Mountains; implications for sequence stratigraphy of carbonate platform systems: Journal of Sedimentary Research, v. 70/4, p. 913-936.


Questions???