Stratigraphic Architecture of the Frasnian Cline Channel, Central Alberta Front Ranges*

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Abstract

A sequence stratigraphic interpretation for the Frasnian strata of the central Alberta Rocky Mountains is presented. Six third-order depositional sequences are recognized and correlated across the study area, comprising the middle of a second-order depositional sequence, spanning the latest Givetian to end Frasnian of the Alberta Basin. The base of the succession unconformably overlies Middle Cambrian strata, representing transgressive onlap of the West Alberta Ridge, an antecedent landmass. This transgression initiated two large carbonate complexes, from south to north, the Fairholme and the Southesk Cairn. In the Woodbend Sequence One (WD1), these complexes became separated by the marine Cline Channel, which connected the Alberta Basin with the Paleo-Pacific.

The WD1 platform south of the channel was characterized by open marine circulation and poorly developed margins. The basal Woodbend Sequence Two (WD2) displays well-developed in situ carbonate lowstands on both sides of the Channel (Kiska Creek, Wapiabi Gap). The WD2 margin at Cripple Creek formed following a significant southward retreat of the platform, while the Wapiabi Gap margin was aggradational. Time equivalent basinal sediment consisted of the organic-rich Duvernay Formation. Differing margin styles continued in the basal Woodbend Three, a widespread, ramp-style lowstand developed south of the channel – with an aggradational reefal margin in the north. Significant transgressive and highstand shrinking of the carbonate platforms and Ireton Formation illitic shale bank progradation occurred. Ramp-style deposition dominated the Winterburn Sequences One and Two. The former developed a notable lowstand with subsequent progradation over older shale banks south of the Channel, with limited progradation in the north. Significant erosional down-cutting occurred at the base of the Winterburn Sequence Two (Wapiabi Gap). The basal Winterburn Sequence Three (WI3) was a restricted platform carbonate and fine-grained siliciclastic coastal plain, filling and onlapping erosional surfaces (Wapiabi Gap). Salt casts and collapse breccia in WI 3 siltstone (Cripple Creek) indicate significant basinal restriction. Margin styles and third-order sequence stacking were controlled by shale bank distribution and relative sea level. Sequence and bounding surface correlations are well constrained and supported by biostratigraphy (conodonts).

Reference Cited

McIlreath, I.A. and B.D. Shade, 1992, Geometry and evolution of the Upper Devonian Fairholme carbonate complex, Front Ranges, Alberta. Calgary: American Association of Petroleum Geologists, 1992 Annual Convention Official Program, p. 85.

STRATIGRAPHIC ARCHITECTURE OF THE FRASNIAN CLINE CHANNEL, CENTRAL ALBERTA FRONT RANGES

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Objectives

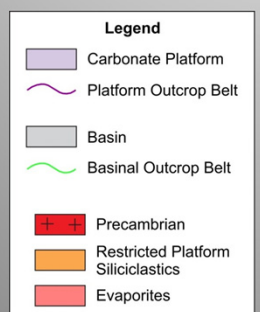
- Show outcrop data supporting our proposed Frasnian Physical Sequence Stratigraphic framework
- Show influence of extrabasinal fine-grained clastic basin fill (mainly clay) on stratal stacking patterns

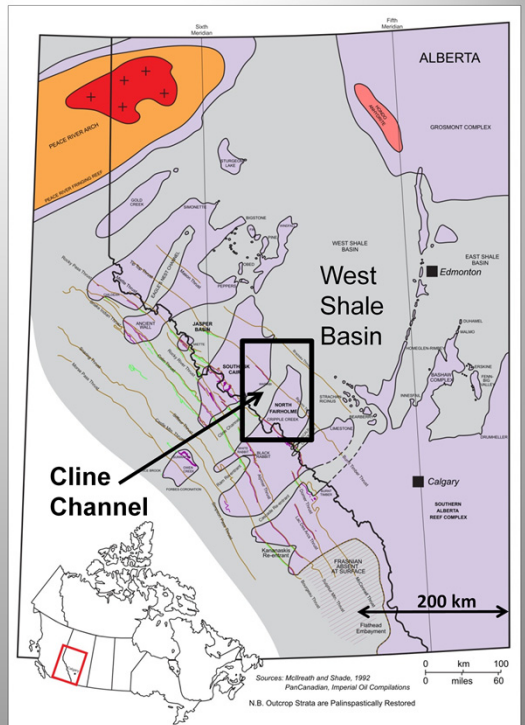
Outline

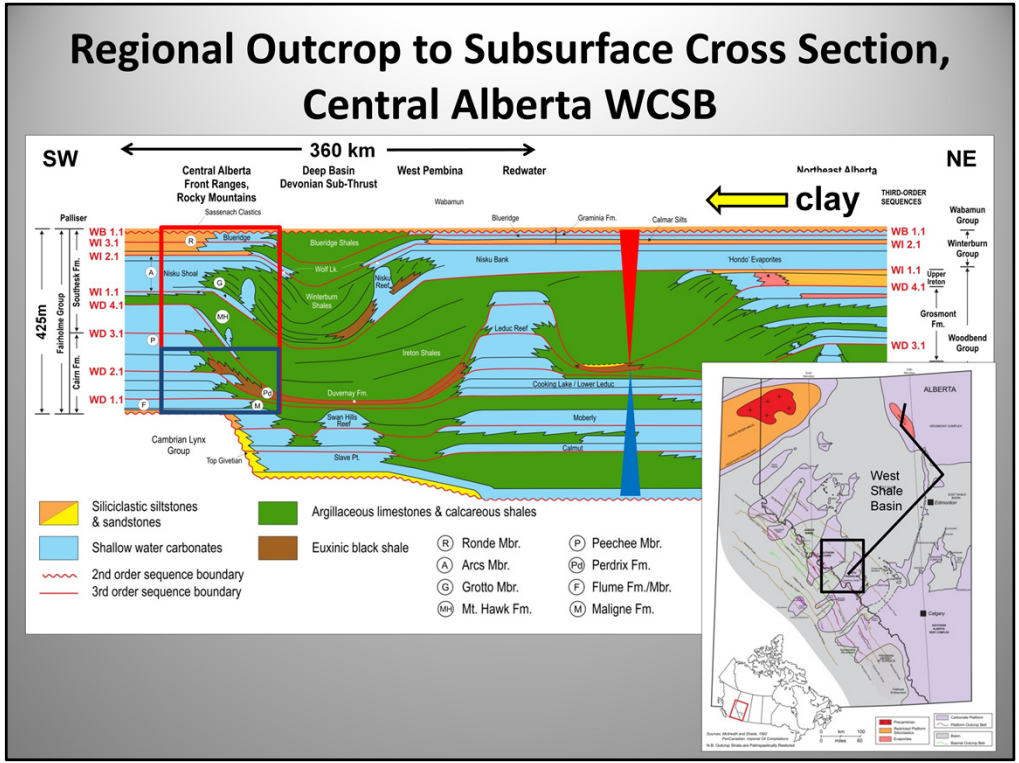
- Paleogeographic/stratigraphic setting
- Frasnian platform margin sequence stratigraphy on edges of the Cline Channel at Wapiabi gap and Cripple Creek
- Conclusions, acknowledgements

Regional Leduc Map

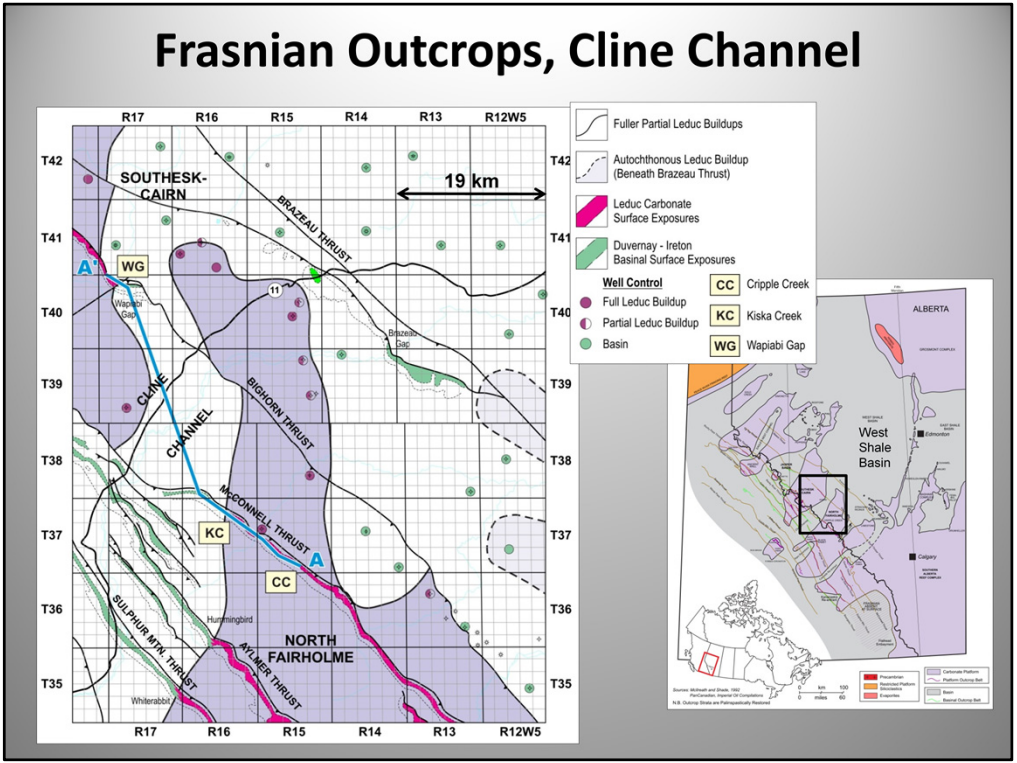
- Study area located in front ranges of west-central Alberta
- Areas of carbonate platform and basin shown
- Cline channel connects west shale basin to proto-Pacific



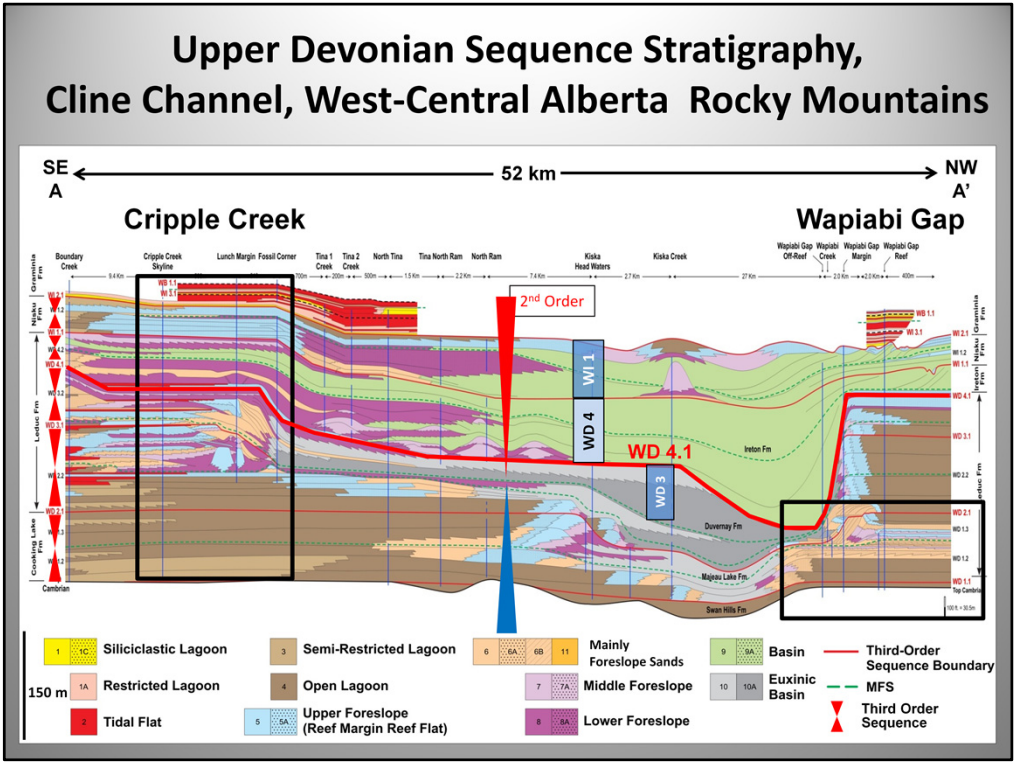




Presenter's notes: Section is 425 m thick, distance from Redwater to the Cline channel about 350 km.
2nd order Frasnian cycle from Watt mtn clastics to base Palliser.
Shallow water CO_3 in blue and basin fill in green.
Basin fill of mixed off bank carbonates and fine grained extra-basinal shale (argillaceous limestones and calcareuos shales).
Main source of extrabasinal clays from the east, basin unevenly filled.
Progradation of regional carbonate platforms mainly from the east, on a foundation of mixed shales and CO_3.
Time equivalent CO_3 in west mainly aggradation to backstepping until basin fill arrival, when progradation develops.
Lowstands overlie basin infill.
Outcrop stratigraphy in red box....upper part of 2nd order TST and entire HST in outcrops. Lower parts onlap against Cambrian.
Shallow water carbonate progradation limited by absence of basin fill (blue box).

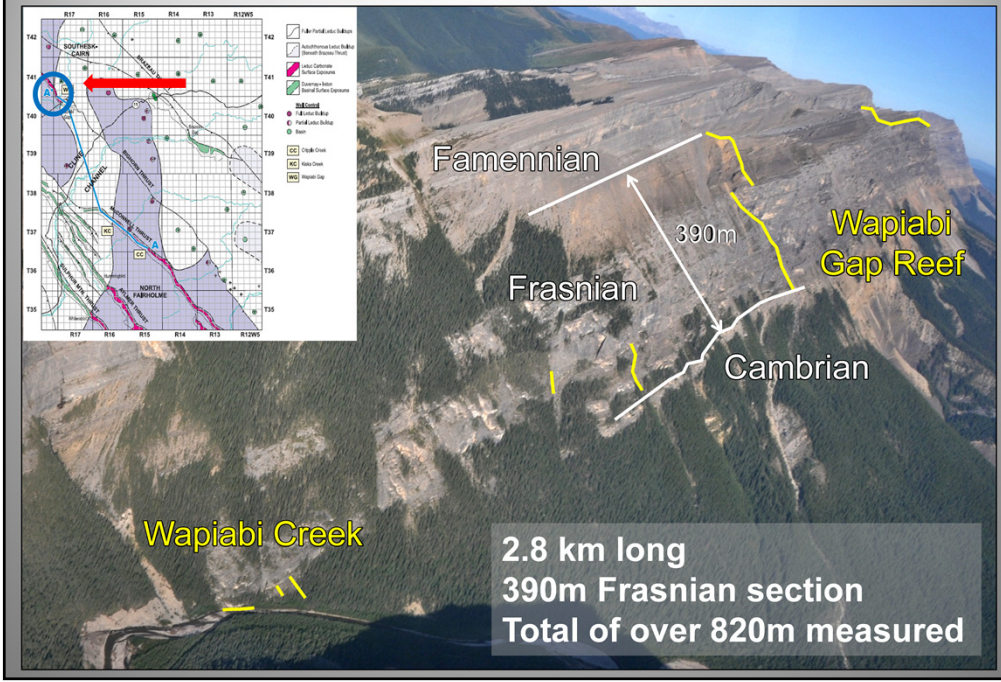


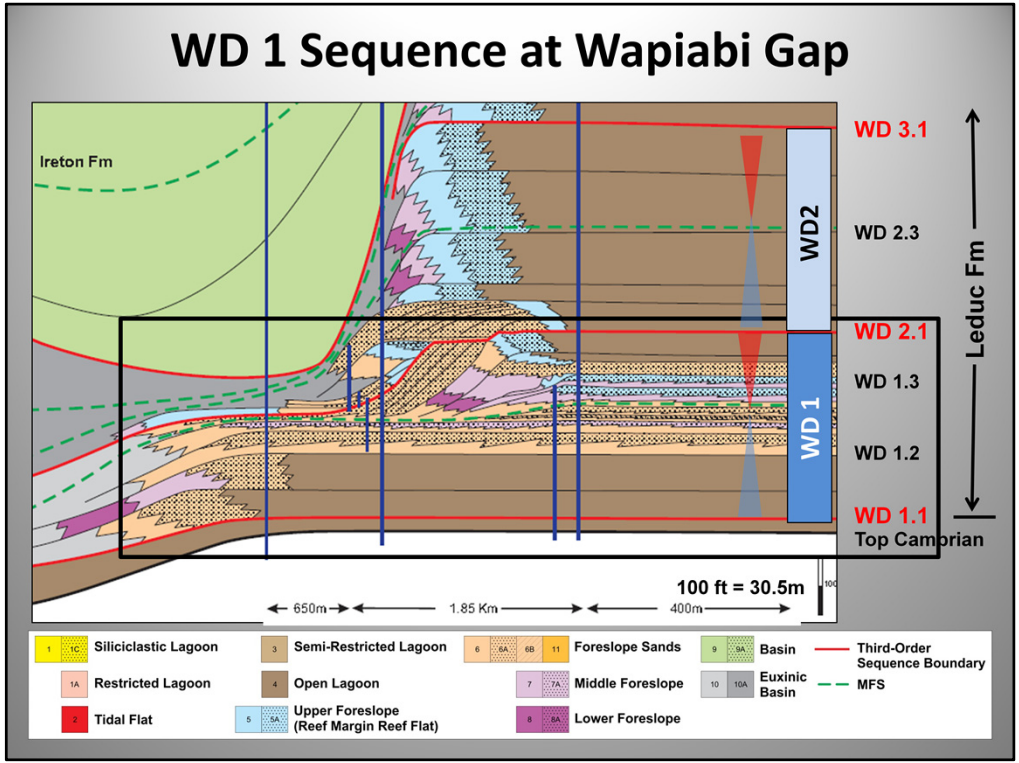
Presenter's notes: Location of studied outcrops on a palinspastically restored paleogeographic map.
On the NW and SE edges of the Cline channel.
WG, is on the Big Horn thrust and KC and CC the McConnell thrust.
52 km, 30 mi from CC to WG.
Note location of Xtion A'-A.



Presenter's notes: Section from CC to WG.
SE to NW section.
Legend, esp basin fill of limy shales and argillaceous carbonates distances, section 425 m thick at CC.
At WG Mainly backstepping to aggradational, until WD 4.1, when progradation of mixed shales/carbonates initiates.
At CC, Backstepping to aggradational until end of WD 2 time, when area was starved of extrabasinal clastics.
Progradation starts during sequence late WD 3.
At CC, progradation is one 3rd order sequence earlier.
Next
Outcrop study of WD1.1 and WD2.1 sequences, pre-clay shale influx sequence.

Wapiabi Gap Outcrop



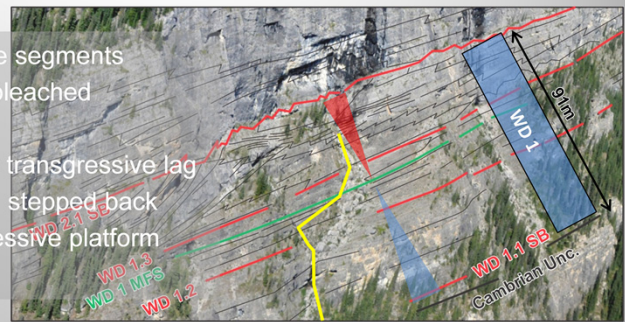


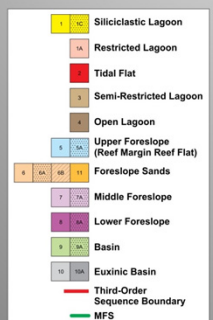
Presenter's notes: WD1 sequence

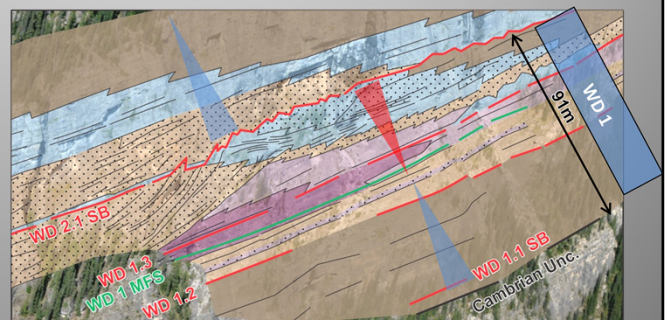
- Transgressive - regressive segments
- 3 component 4th order sequences

WD1 at Wapiabi Gap

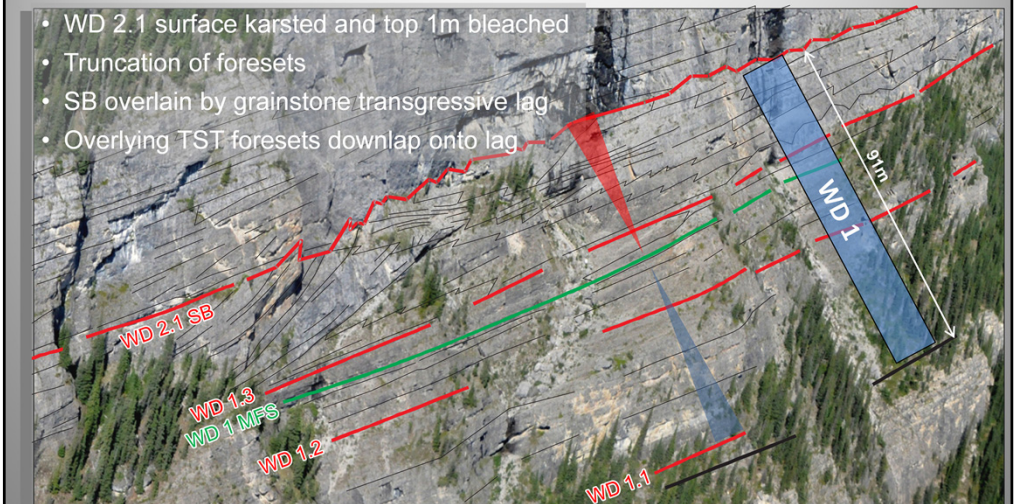
- Transgressive - regressive segments
- WD 2.1 surface karsted, bleached
- Truncation of foresets
- SB overlain by grainstone transgressive lag
- WD1 highstand margin is stepped back from the underlying transgressive platform margin





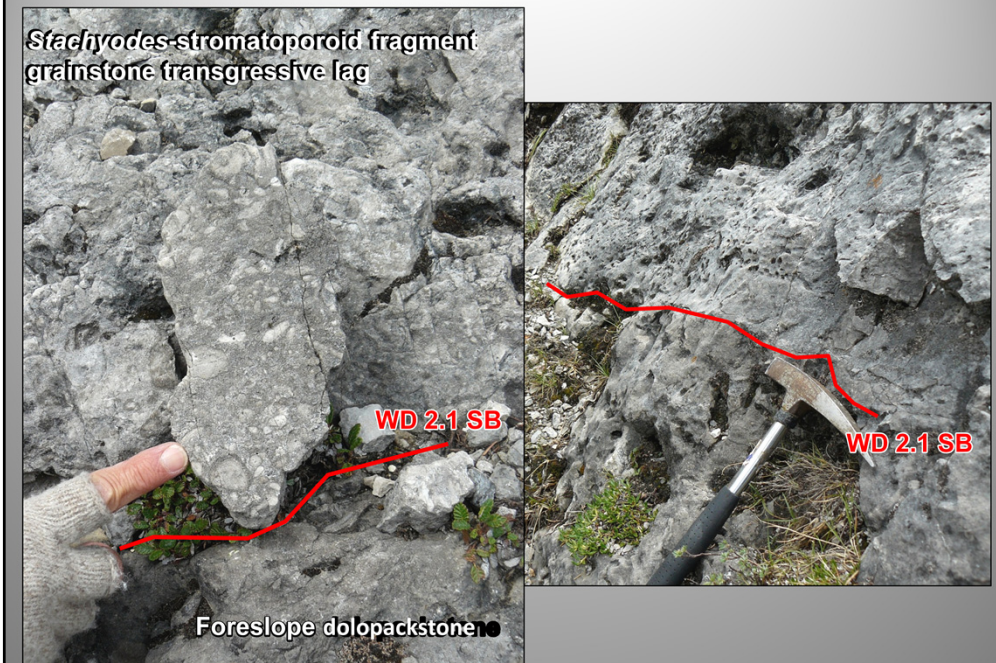


WD 1.1 & WD 2.1 at Wapiabi Gap

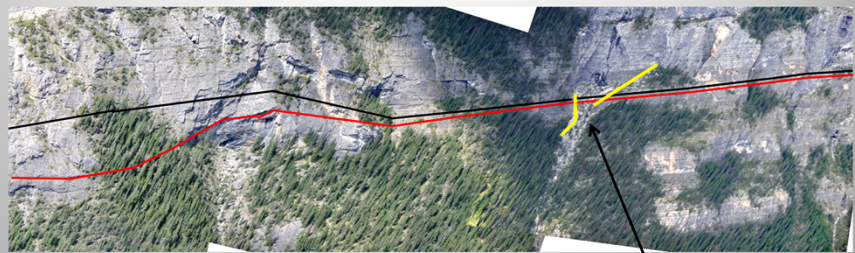


Presenter's notes: WD 1 TST is characterized by flat lying platform interior beds that grade up into the gently dipping foreslopes as we approach the mfs. Highstand foresets can be traced into the strom reef margin facies and onto the flat lying bedding of the reef flat and platform interior.

WD 2.1 Transgressive lag overlying WD 2.1 surface



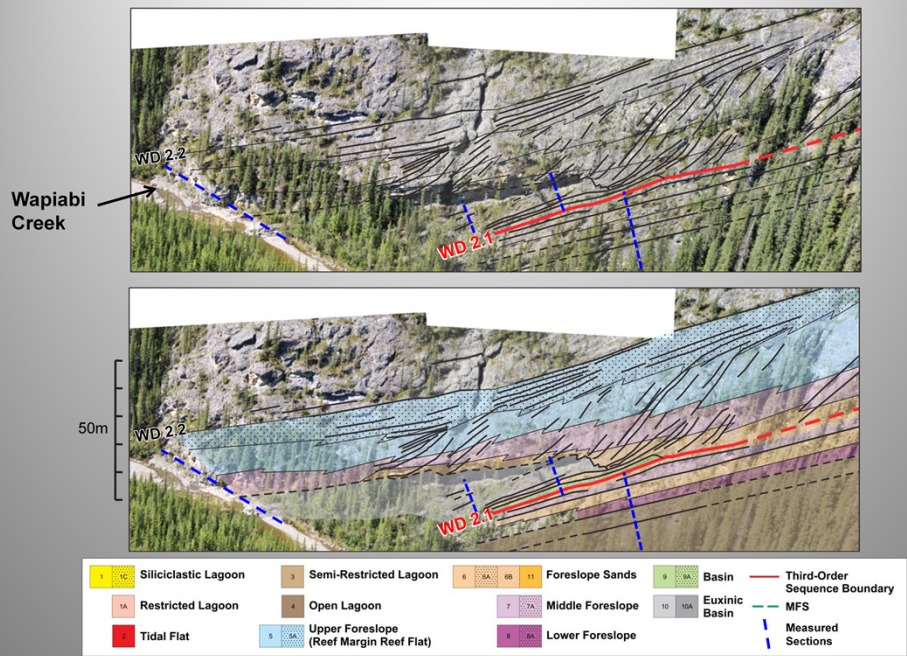
WD 2.1 Lowstand extent, Wapiabi Gap



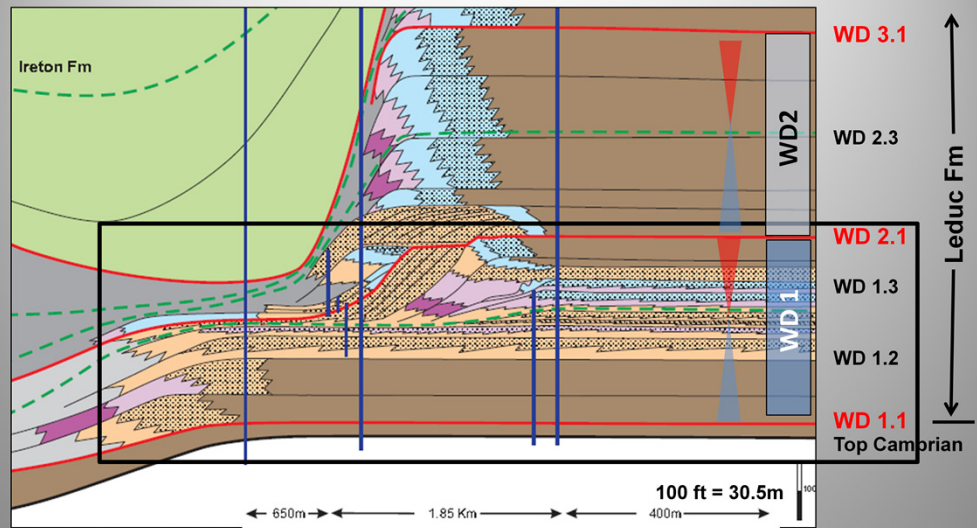
Lowstand

- 34m thick
- ~750m lateral extent

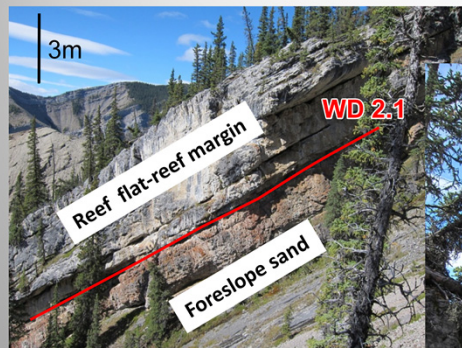
WD 2.1 Lowstand, Wapiabi Gap

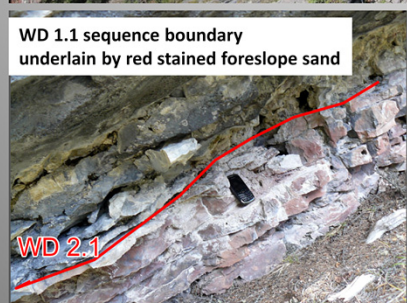


WD 1 Sequence at Wapiabi Gap



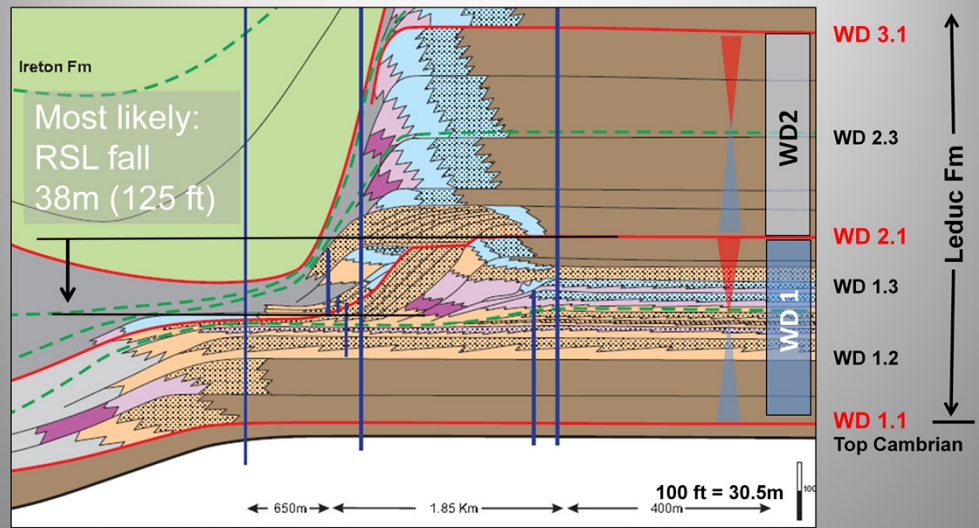
WD2.1 Lowstand, Wapiabi Gap





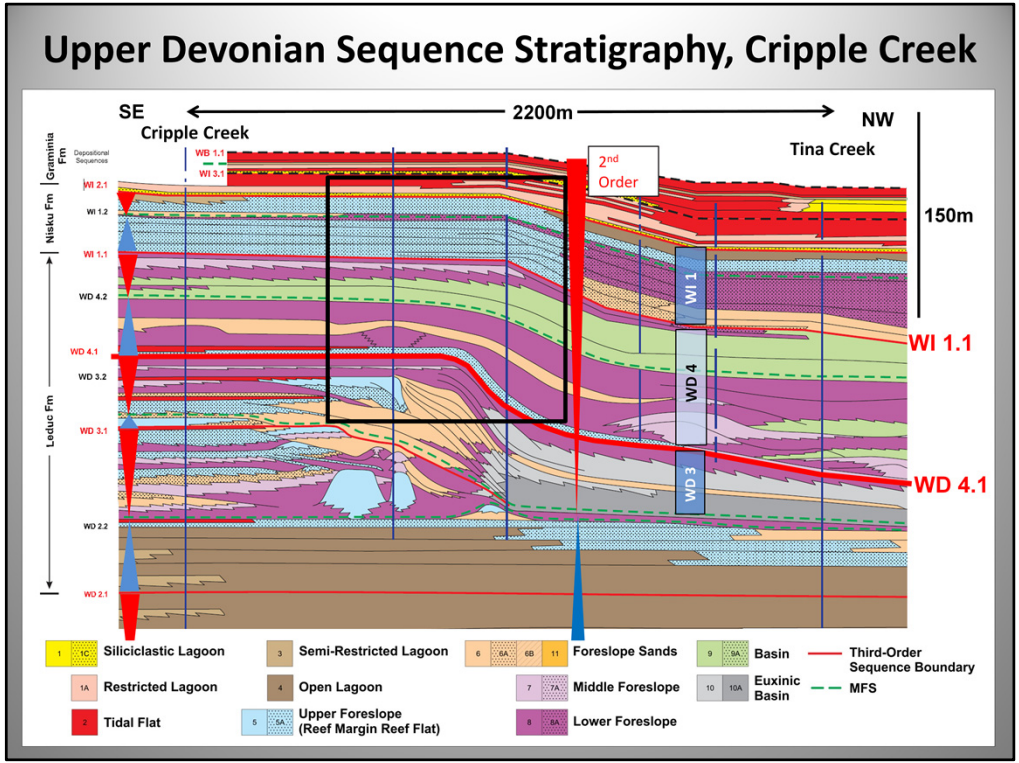
WD 2.1 Hemispherical stromatoporoid doloboundstone and overlying stromatoporoid fragment rudstone/grainstone

Magnitude of RSL Fall at WD 2.1 SB, Wapiabi Gap

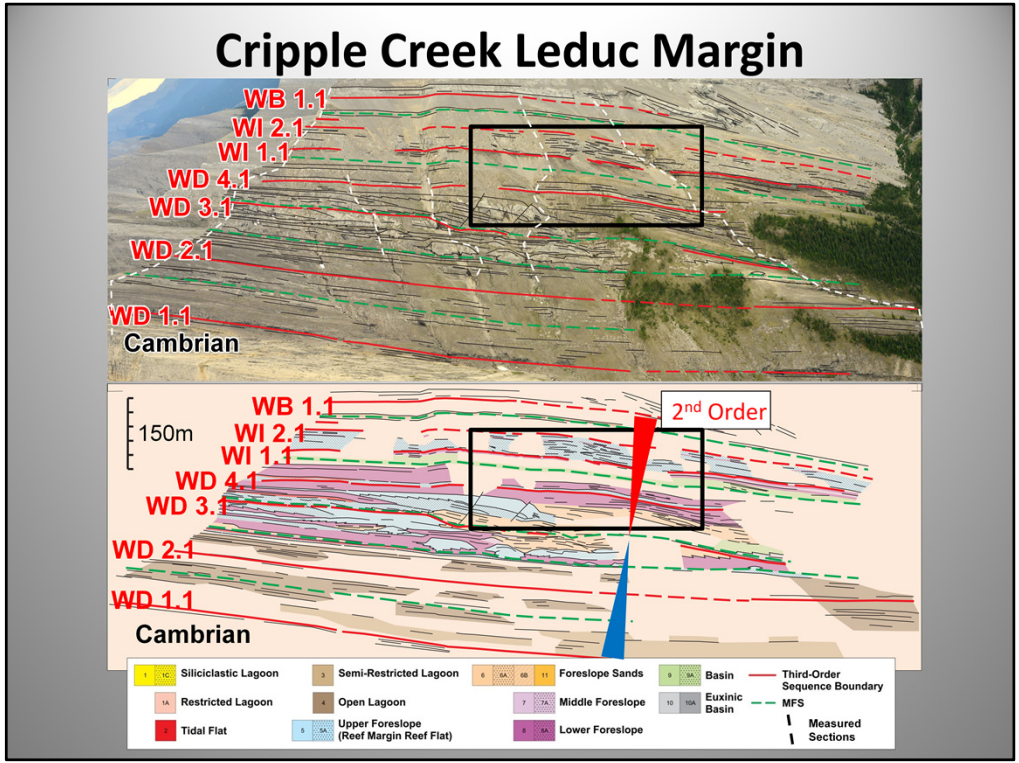


Road Map

- Have reviewed outcrop data documenting the WD 1 sequence and the WD 2 lowstand and associated surfaces . Both sequences are characterized by backstepping and aggradation
- Will review two sequences deposited after the onset of mixed shale/carbonate basin infill, sequences that are:
  1. more ramp-like
  2. have prograded beyond the older shelf margins



Presenter's notes: Section from CC.
SE to NW section.
Progradation starts during late WD 3, with the arrival of extrabasinal fine grained clastics.
WD 4 and WI 1 sequences documented at Cripple Creek are laterally extensive, kms to >10 km, easily recognized and useful for correlation.

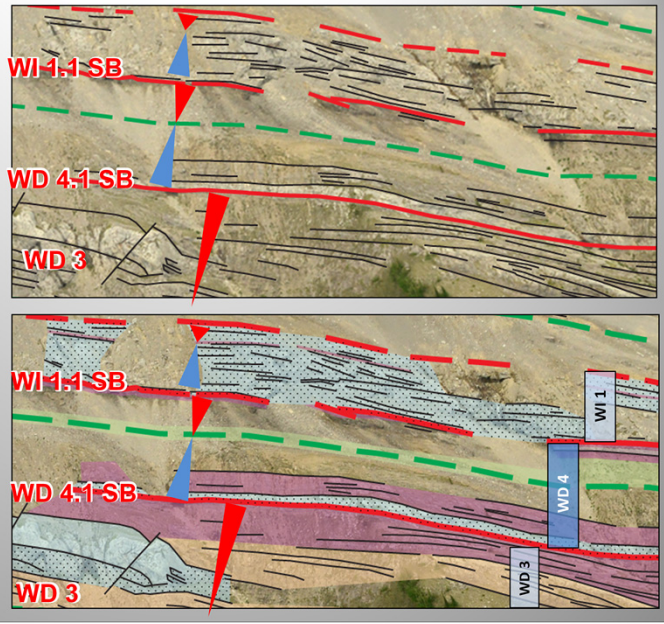


Presenter's notes: 425 m of vertical section.

Cripple Creek Leduc Margin

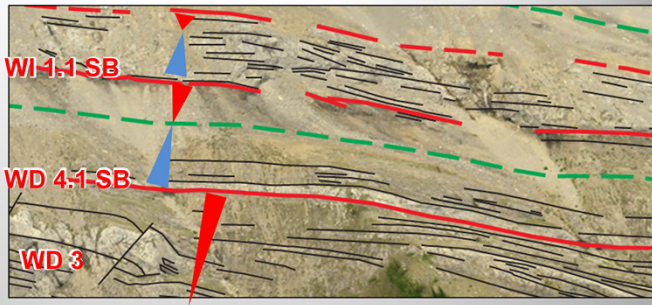
WD 4.1 and WI 1.1 sequence boundaries based on:

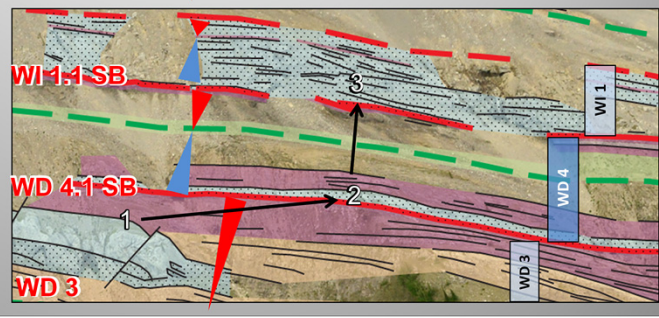
- grainstone margin abruptly overlying lower foreslope
- lowstand grainstone wedge onlaps W1.1 surface
- overlain by tidal flat facies at skyline, 1.1 km due south (left)

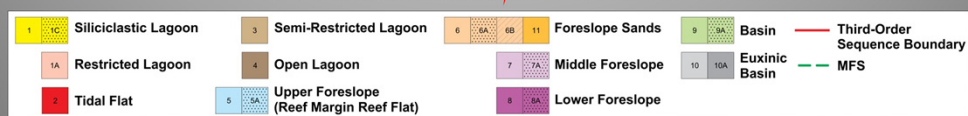


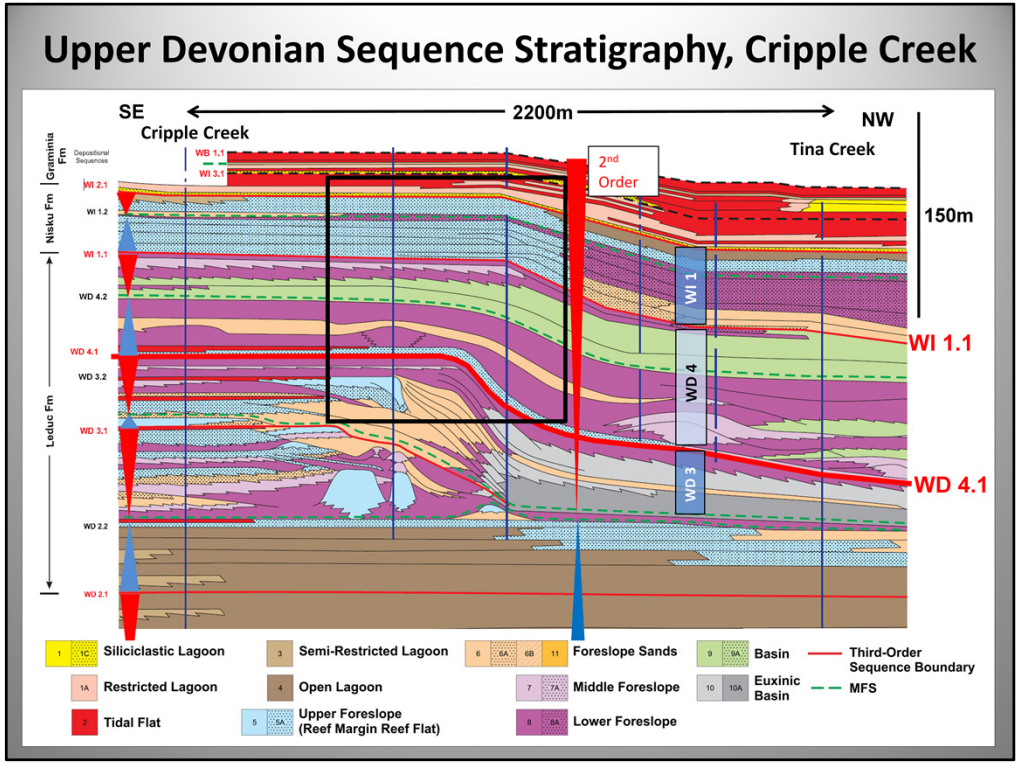
Cripple Creek Leduc Margin-Foreslope dip angle evolution

- Slope breaks numbered
- Foreslope dips decrease as basin infills (from approx. 35 degrees to <10 degrees)
- Mixed clastic-carbonate basin fill strata have low angled slopes
- Sequences (WD 4 & WI 1) developed over these low angled slopes are consequently laterally extensive: 10s of km in extent









Presenter's notes: WD 4 and WI 1 sequences at Cripple Creek have prograded beyond the older platform margins, are laterally extensive, kms to >10 km and easily recognized and correlated.

Conclusions

- Eight 3rd order Frasnian sequences are exposed in the Alberta Front ranges, four are described here
- Frasnian shallow water carbonates continuously backstep/aggrade with each RSL rise until the arrival of extrabasinal fine-grained clastic basin infill
- Sequences deposited after the influx of basin infill are laterally extensive and important for sequence recognition and for regional correlation

Acknowledgements

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- Many colleagues, including field assistants for their contribution to our research
- Phil Argatoff for drafting