

**Origin and Stratigraphy of Enigmatic Sandstones of the
Cretaceous Western Interior Seaway: The Late Turonian Wall
Creek-Turner System, Powder River Basin, WY.**

Patrick Sullivan

PhD. Student, anticipated Dec '2024

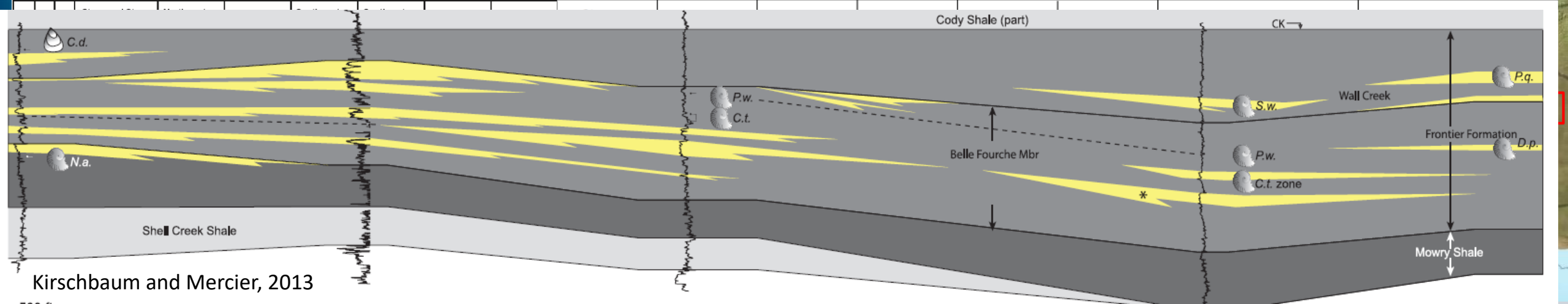


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MUDTOC**

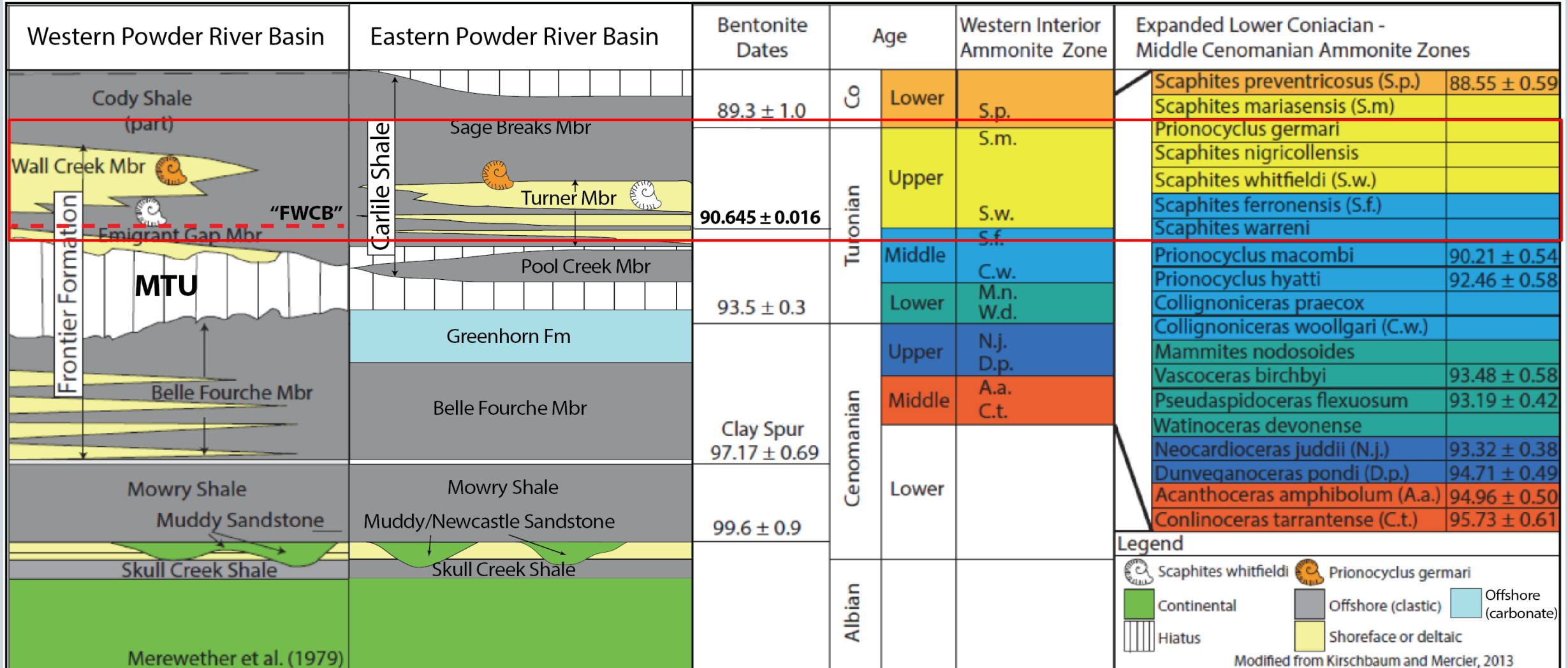
Outline

- **Introduction and Motivation**
 - Geologic context
 - Research Questions
- **Previous work**
 - Structural overview
 - Sediment Provenance
 - Depositional Models
 - Petroleum System
- **Research Roadmap and Preliminary Observations**
 - Cores and Outcrops
 - U/Pb Geochronology

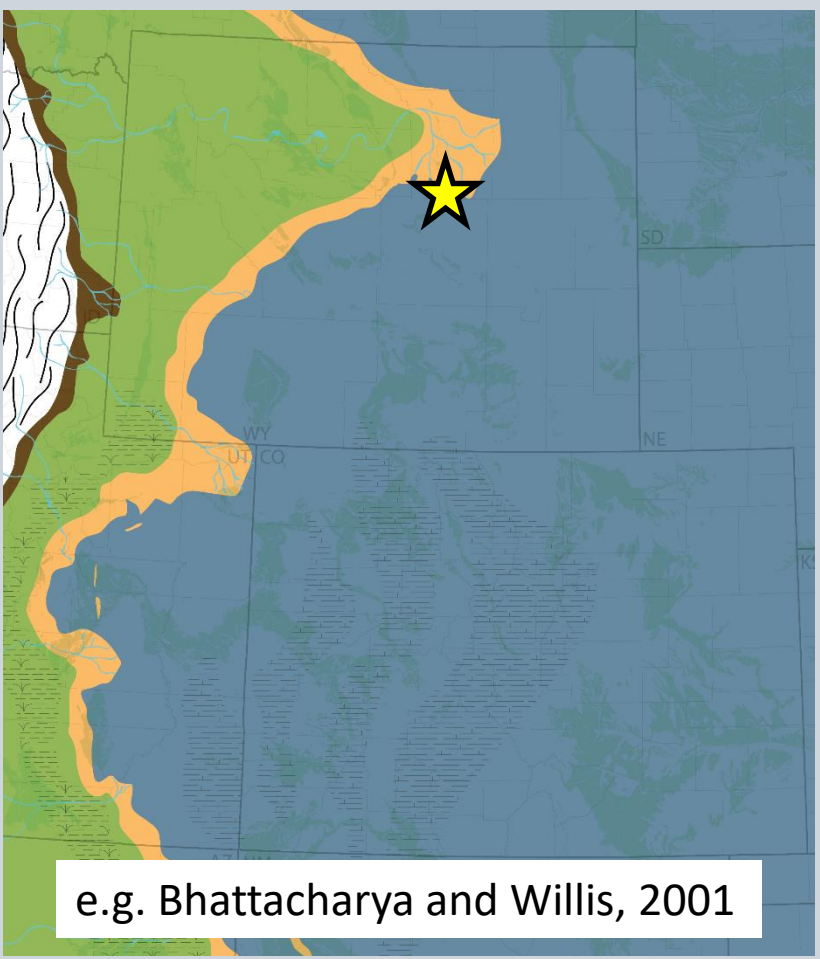
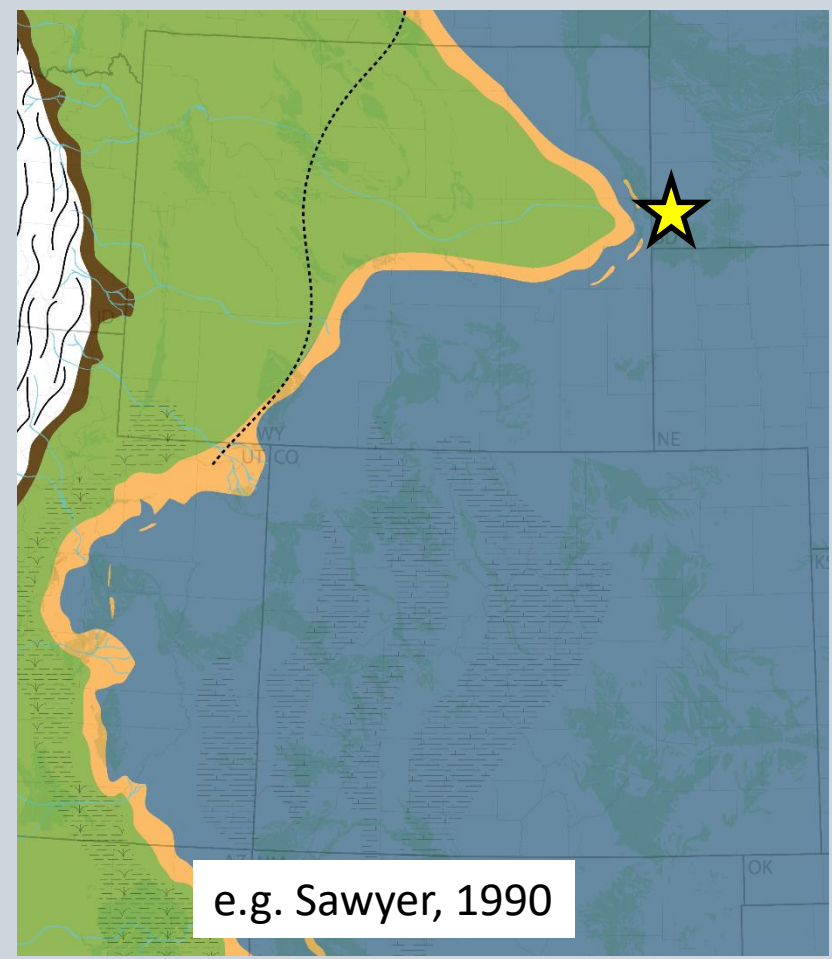
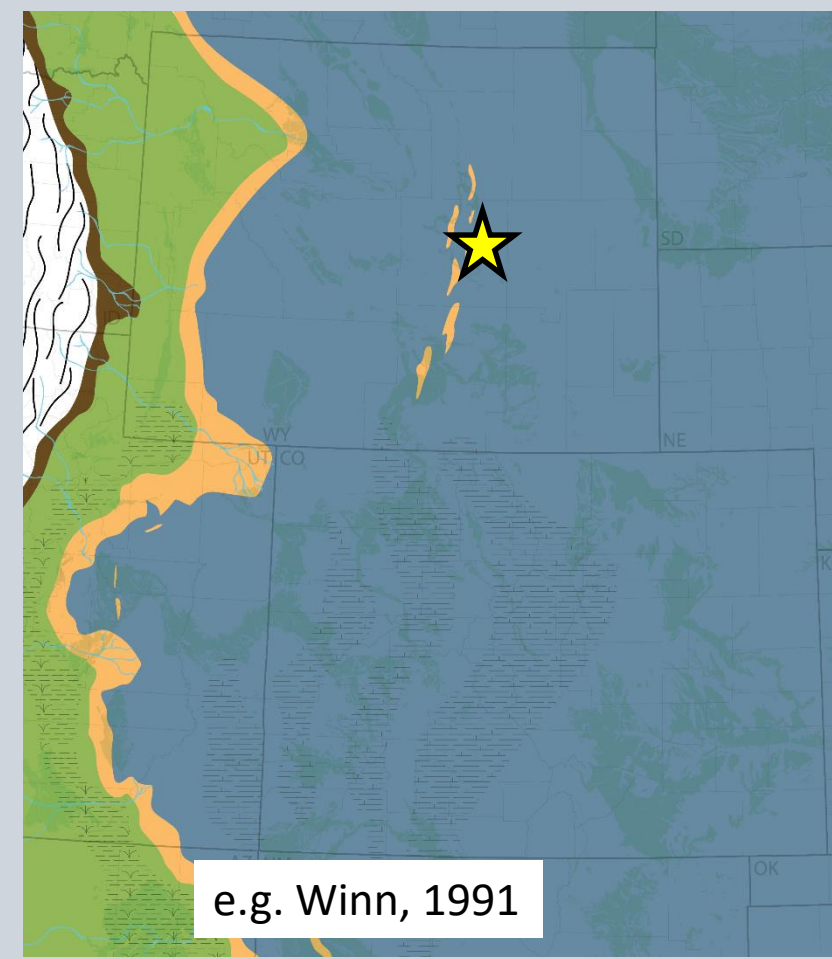
90 Million Years Ago...



The Wall Creek-Turner System

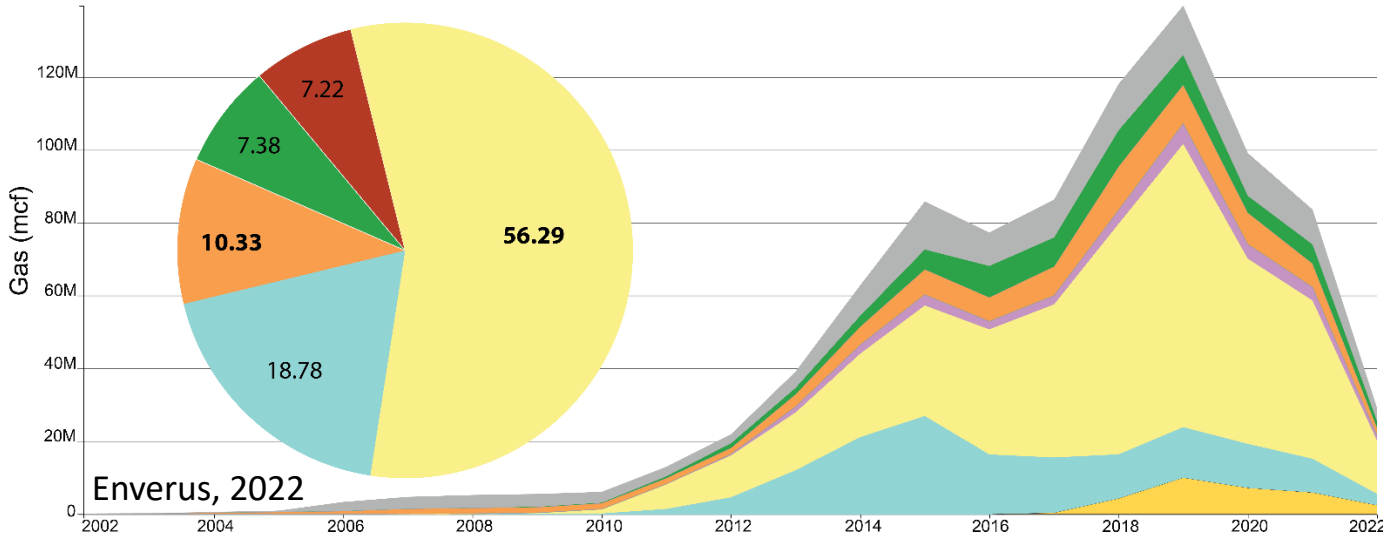
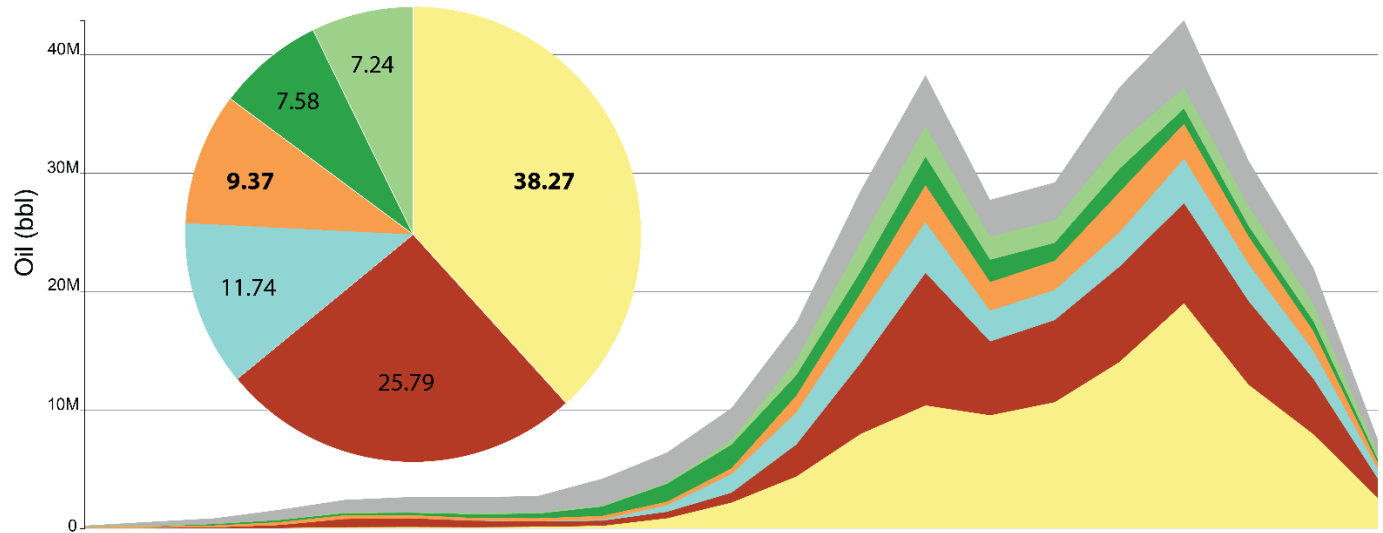


An Unresolved Map...



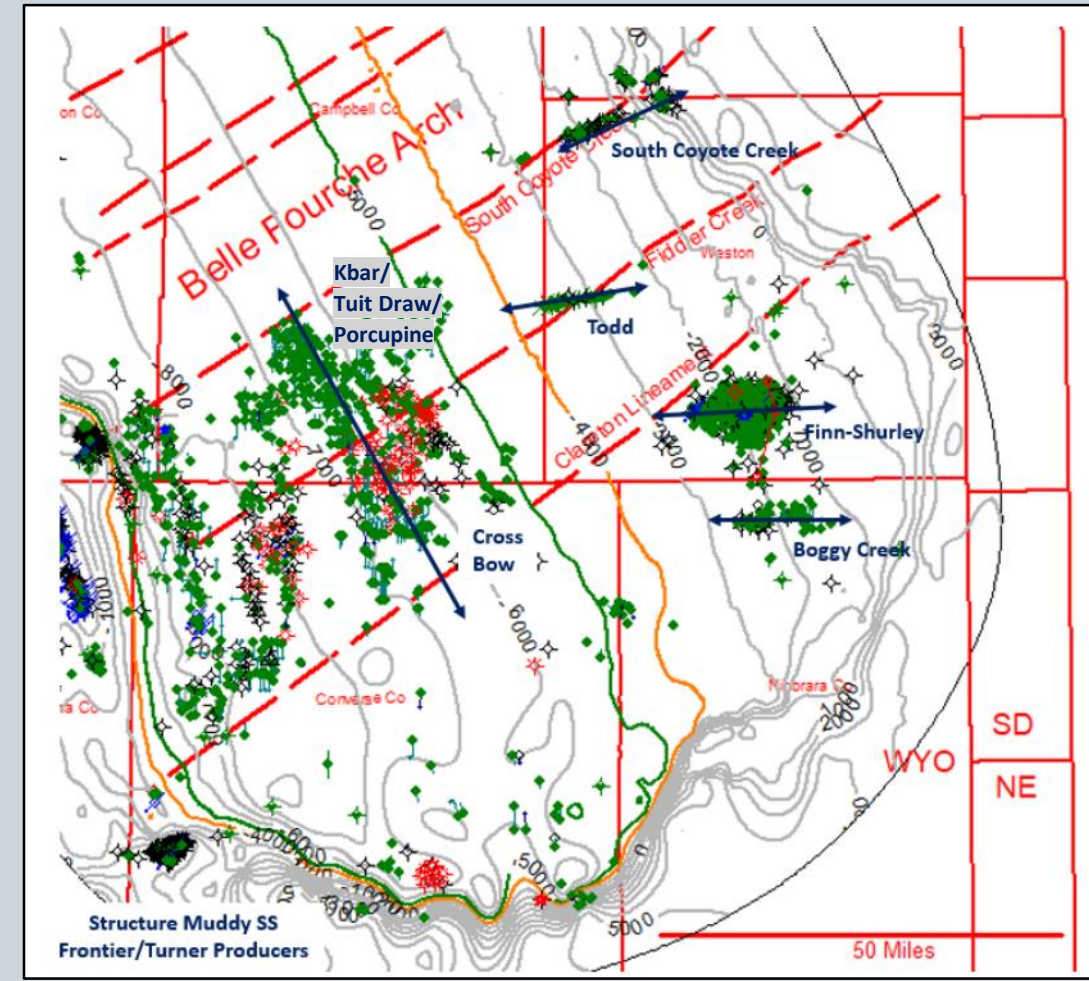
A Production Powerhouse

Powder River Basin: Top 6 Producing Units



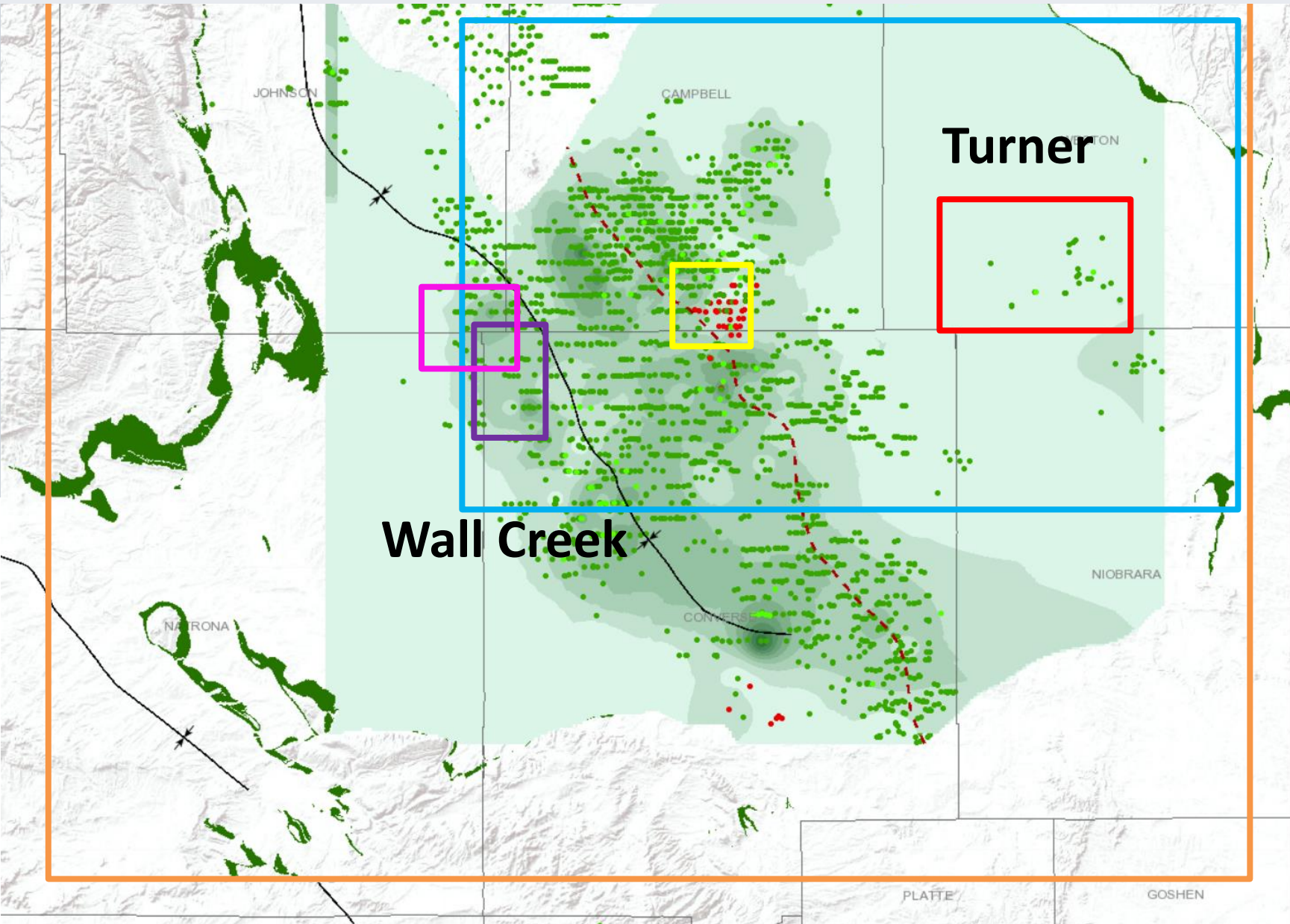
Enverus, 2022

- FRONTIER
- PARKMAN
- FRONTIER-TURNER
- NIOBRARA
- TURNER
- MOWRY
- SUSSEX
- SHANNON
- OTHERS



Sonnenberg et al., 2019

MUDTOC Efforts



BBL (18 mo)

- < 42,000
- 42,000 - 84,000
- 84,000 - 126,000
- 126,000 - 168,000
- 168,000 - 210,000
- 210,000 - 252,000
- 252,000 - 294,000
- 294,000 - 336,000
- 336,000 - 378,000
- 378,000 - 420,000

Payne, 2017

Heger, 2017

Dellenbach, 2019

Bone, 2020

Milar, 2020

Sullivan, 2024

WSGS, 2019

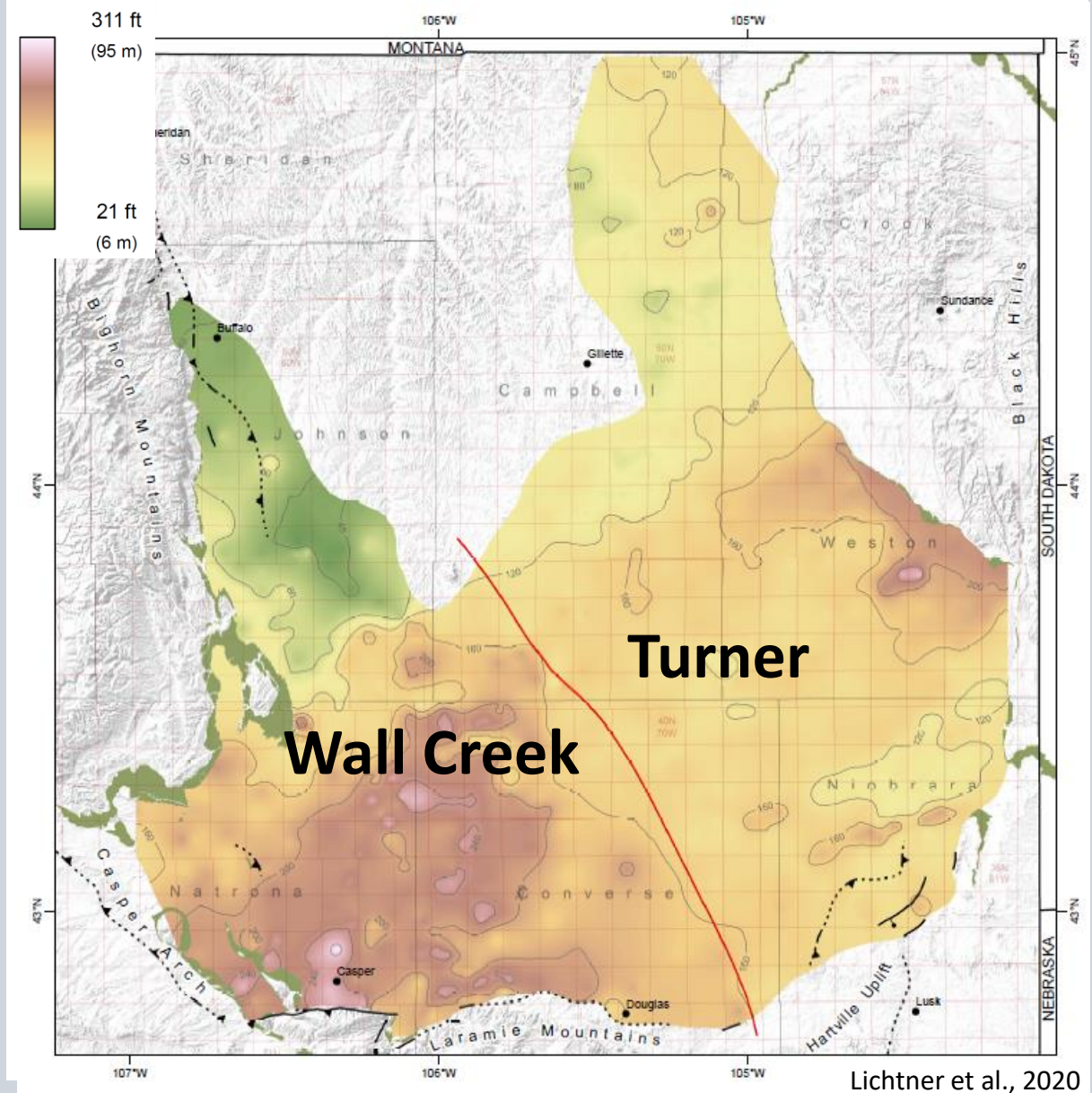
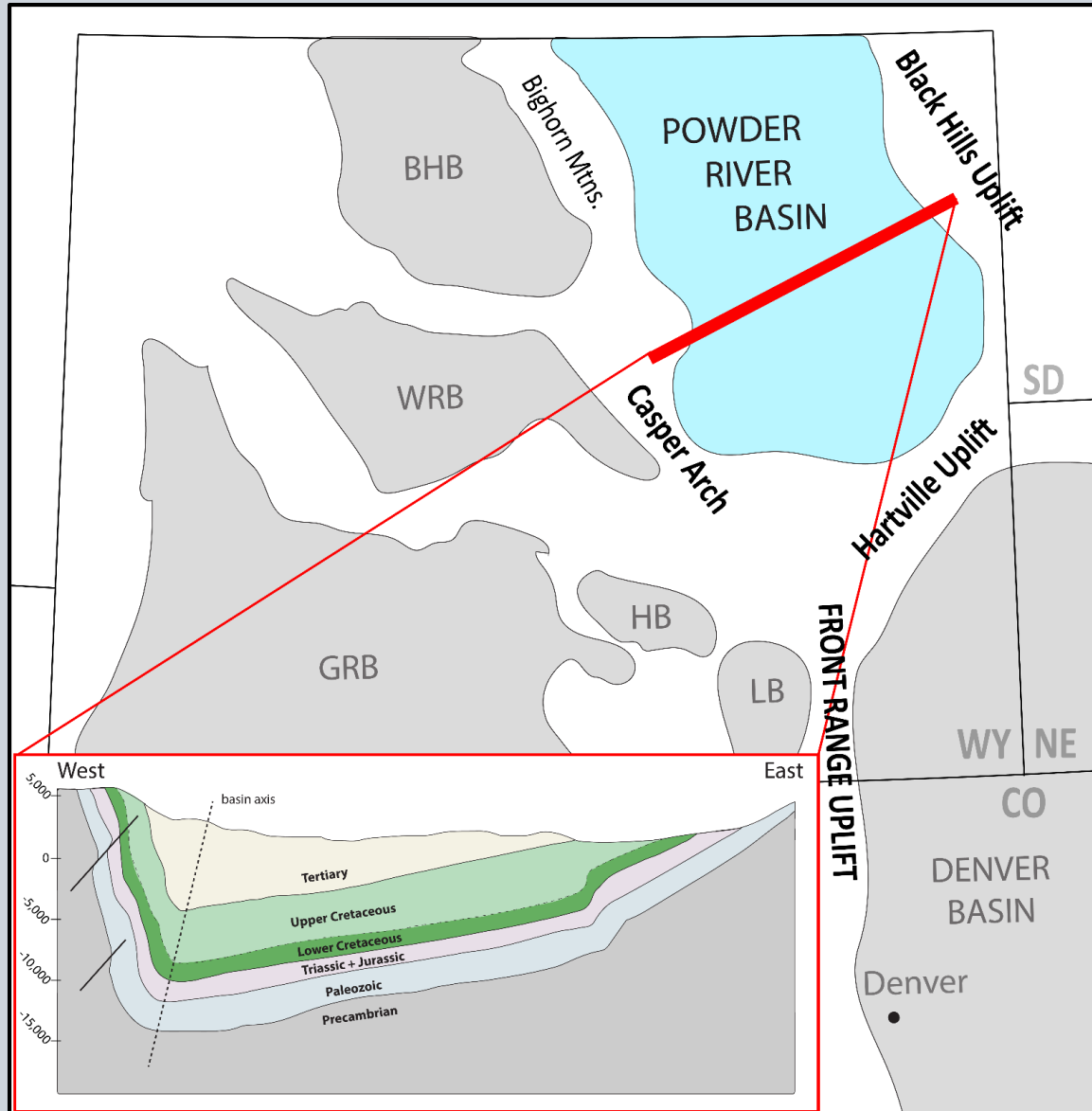
Research Questions

- 1. What are the primary controls on the distribution of sedimentary processes and depositional environments within the Wall Creek-Turner System?**
- 2. What is the depositional age and provenance of sediment in the Wall Creek Turner system, and can they shed insight into the evolution of Late Turonian shorelines in the Rocky Mountain Region?**
- 3. What are the structural, stratigraphic, and depositional controls on reservoir quality of the Wall Creek-Turner system?**

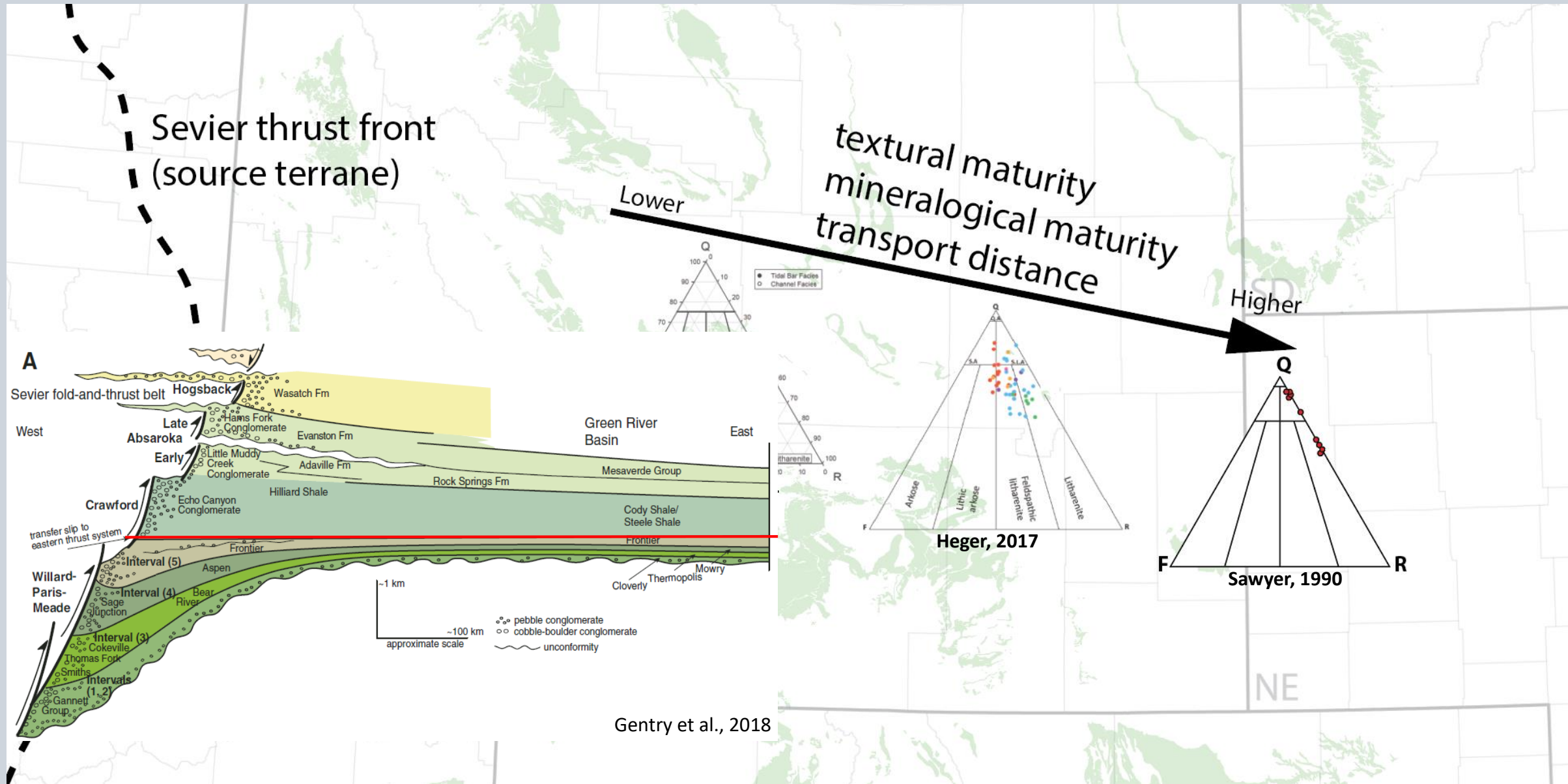
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Structural Overview



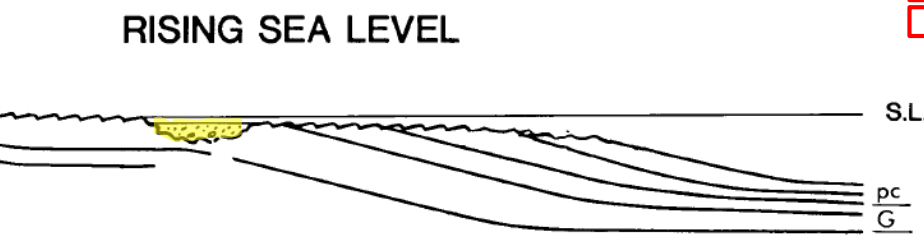
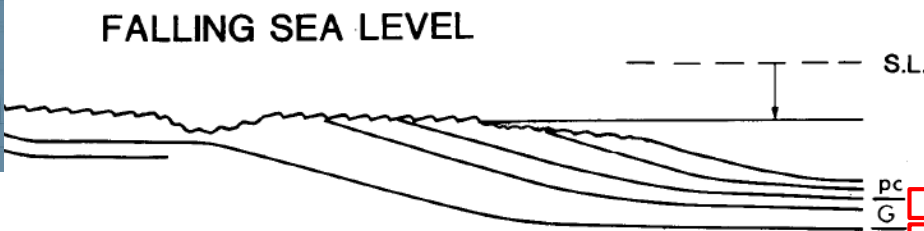
Sediment Provenance



Gentry et al., 2018

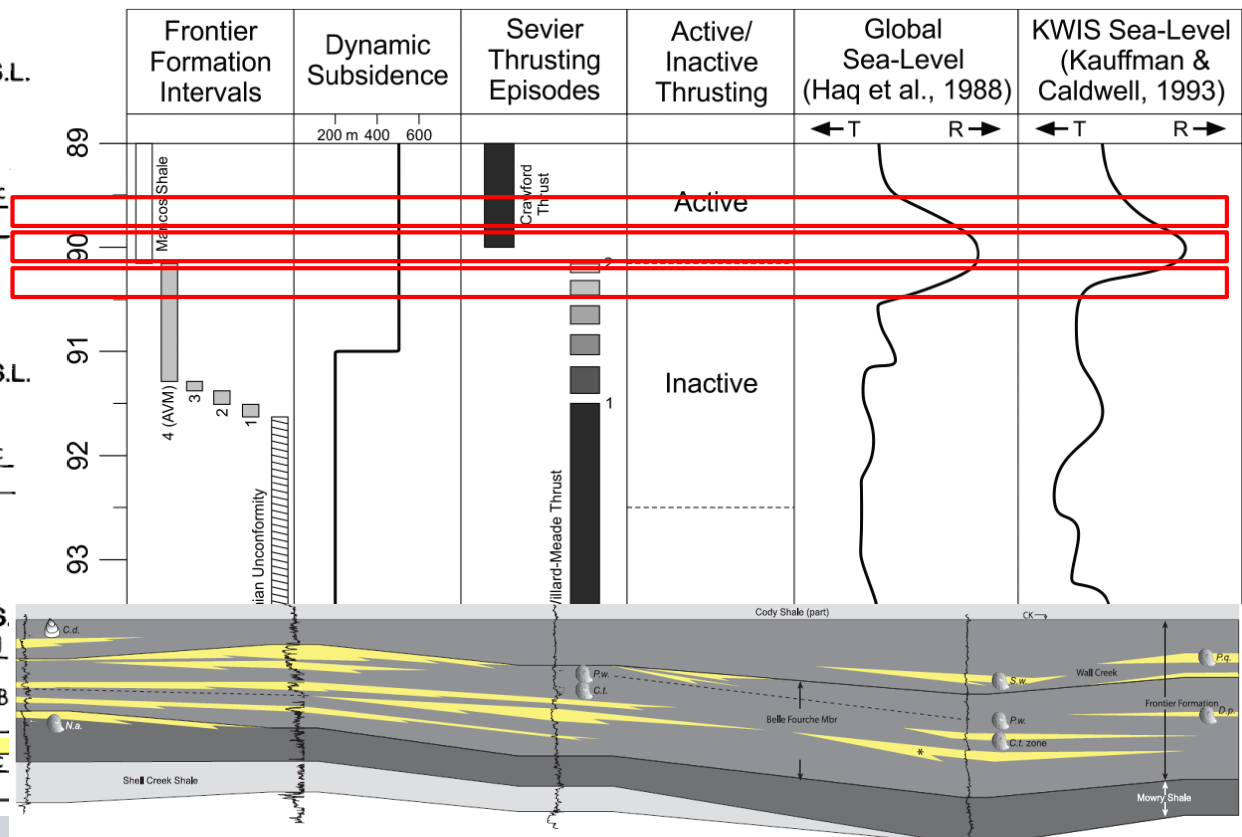
Depositional Models

Incised Valley Fills and Shoreface Sands



A.

B.

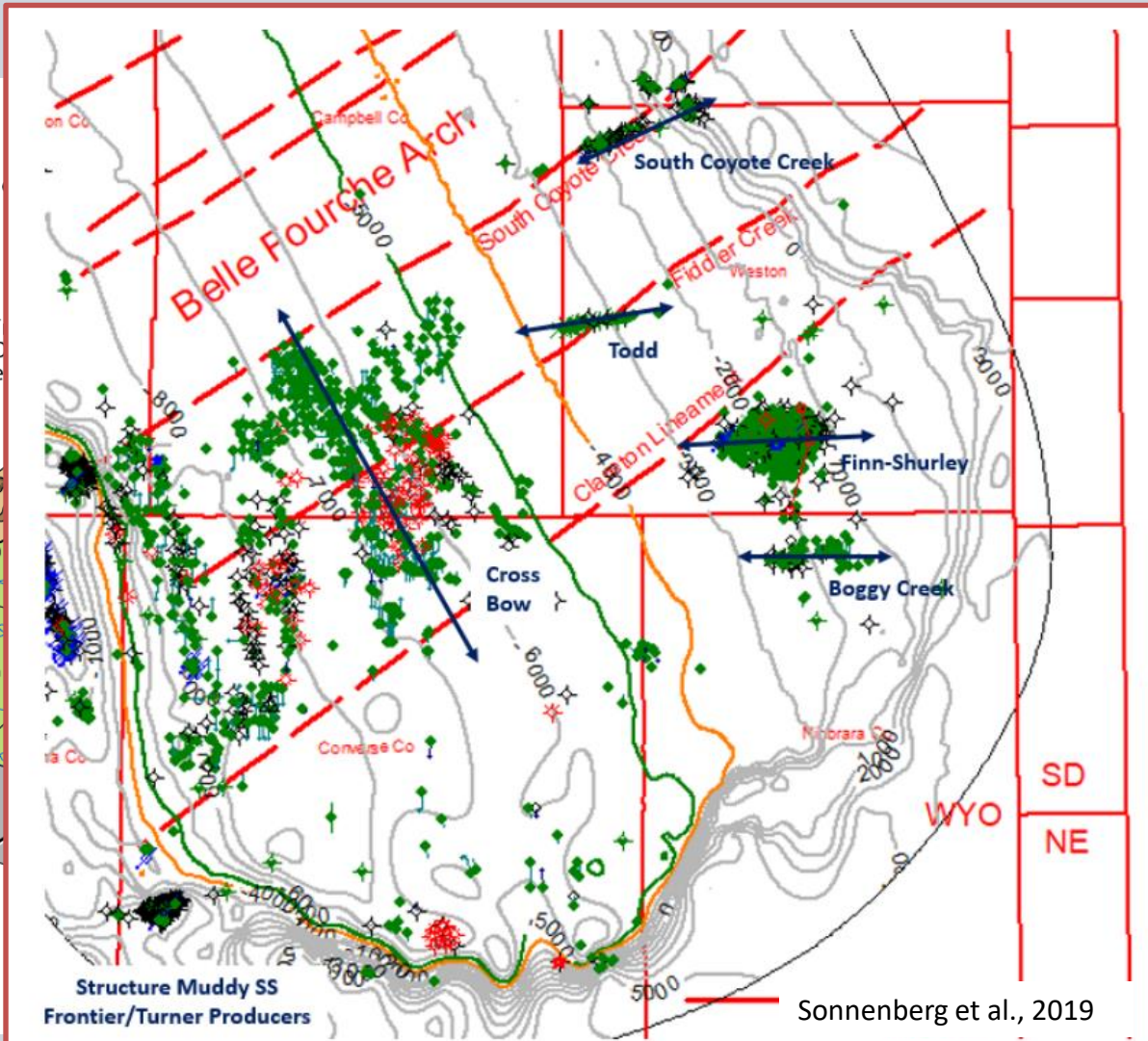
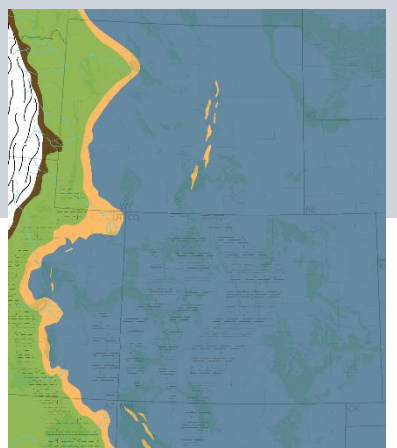


mod. Weimer and Flexer, 1985

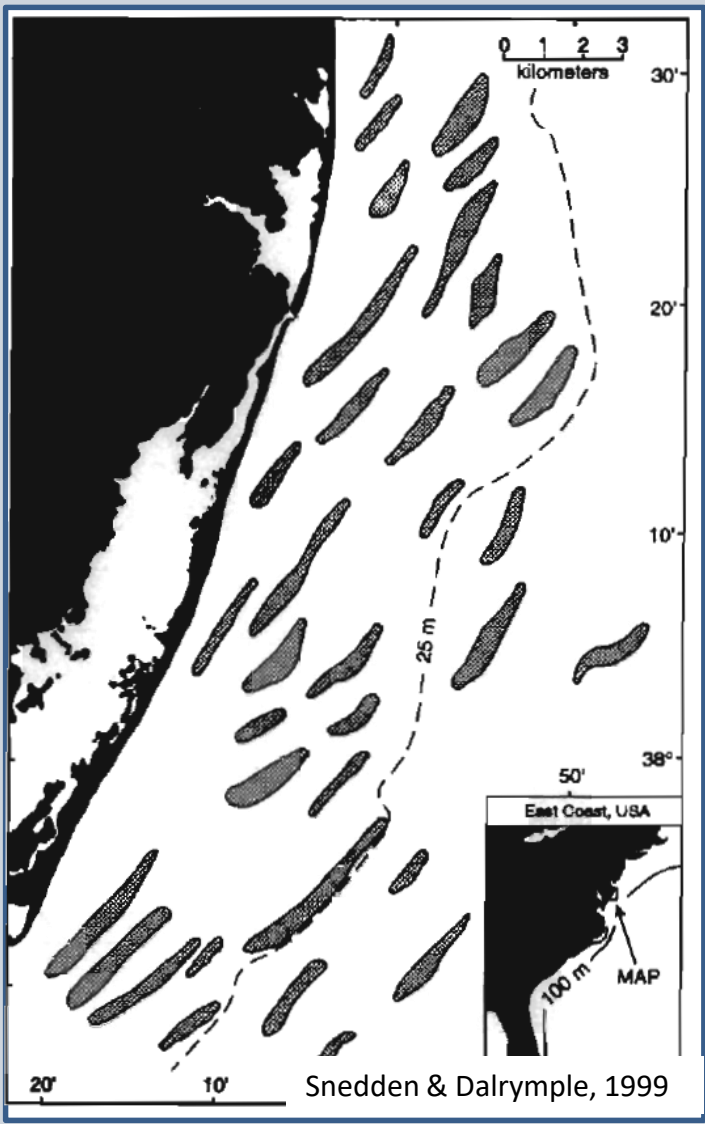
Hutsky and fielding, 2017

Depositional Models

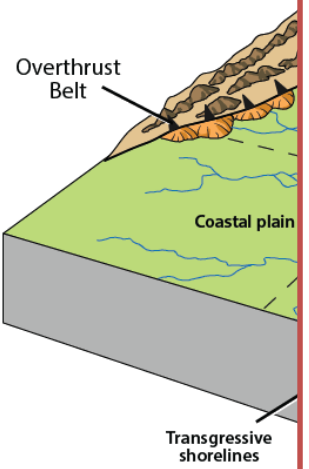
Shelf Sand Sheets and Bars



Sonnenberg et al., 2019

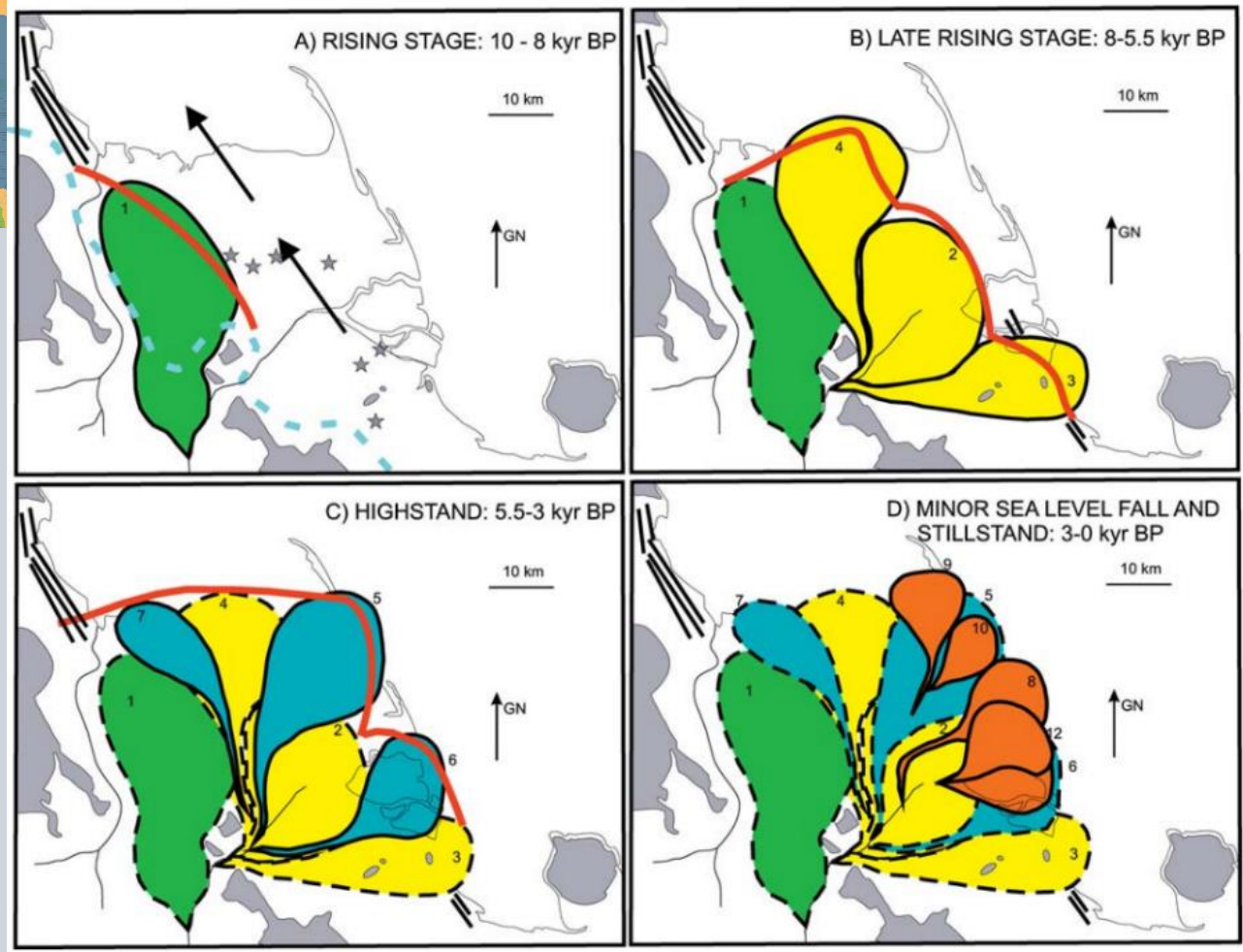
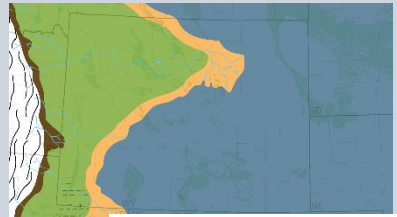


Snedden & Dalrymple, 1999



Depositional Models

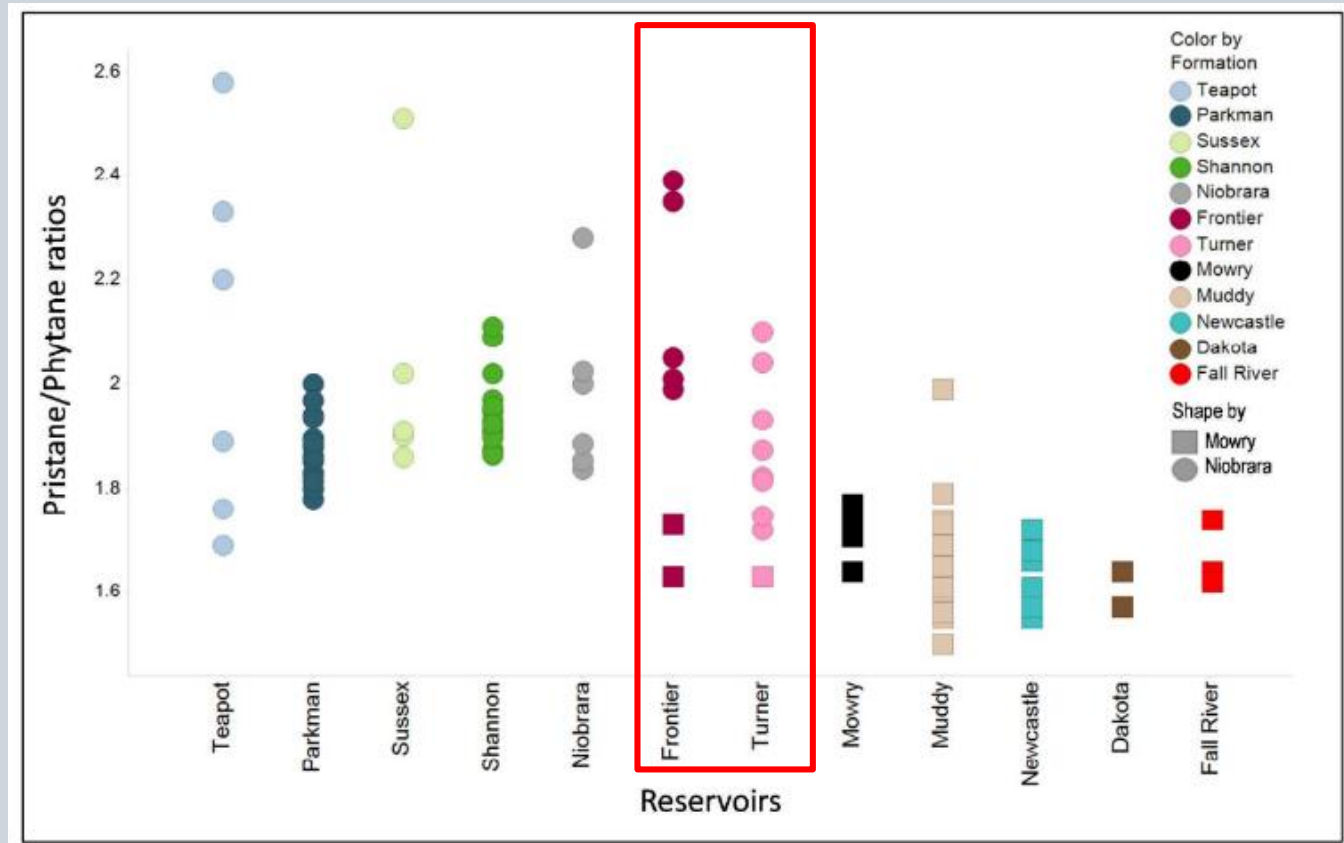
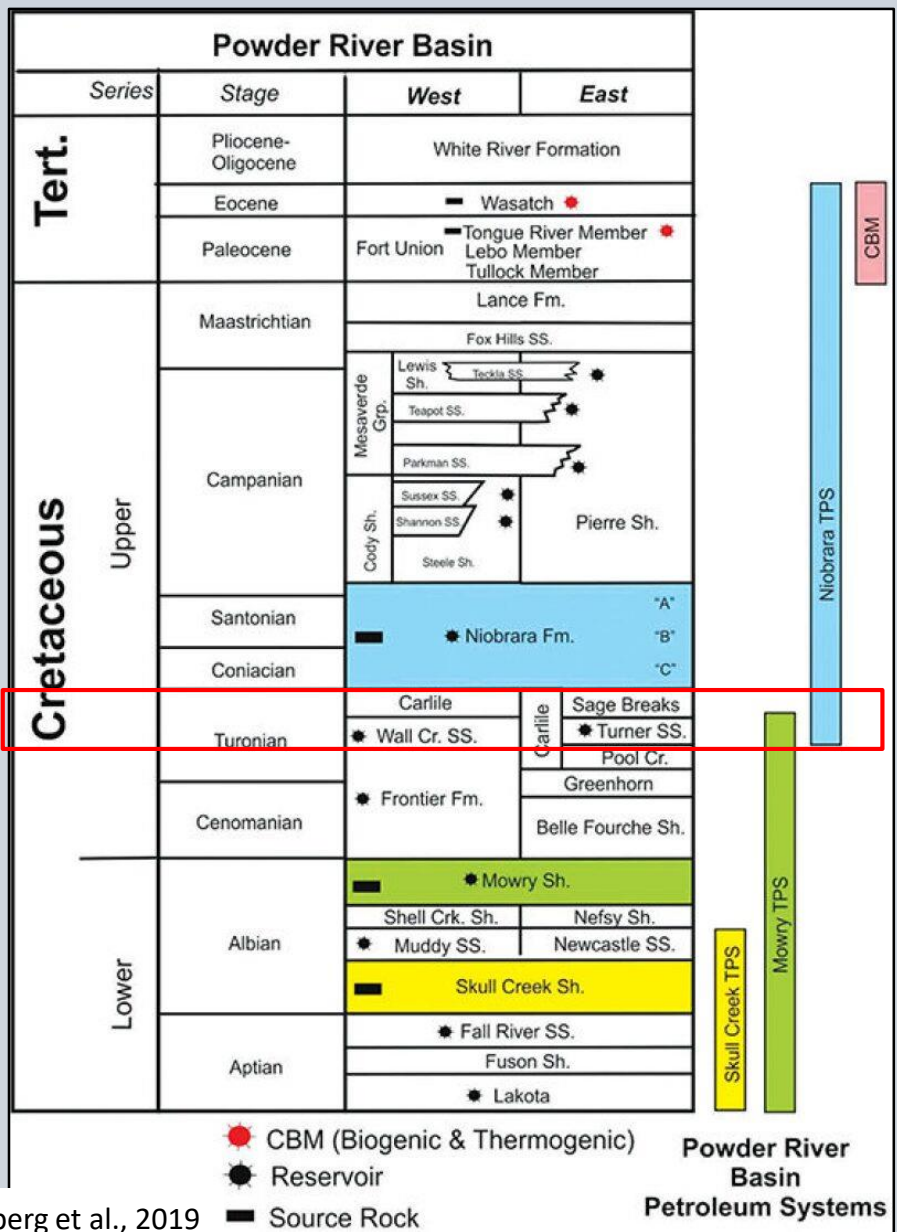
Mixed-Process Deltas



Fielding et al., 2006



Petroleum System



Rahman, 2016

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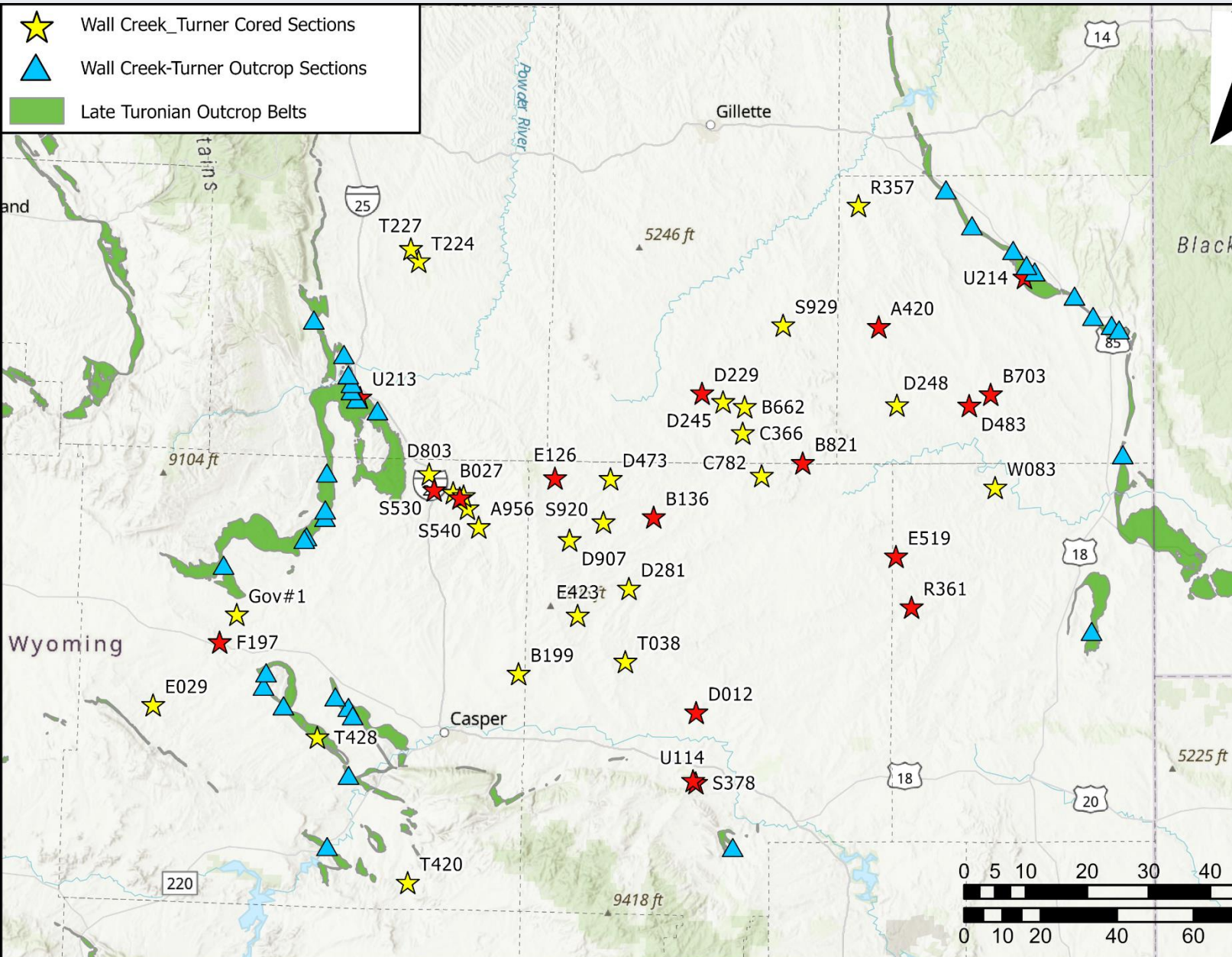
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Cores and Outcrops



Preliminary Core Observations: Processes

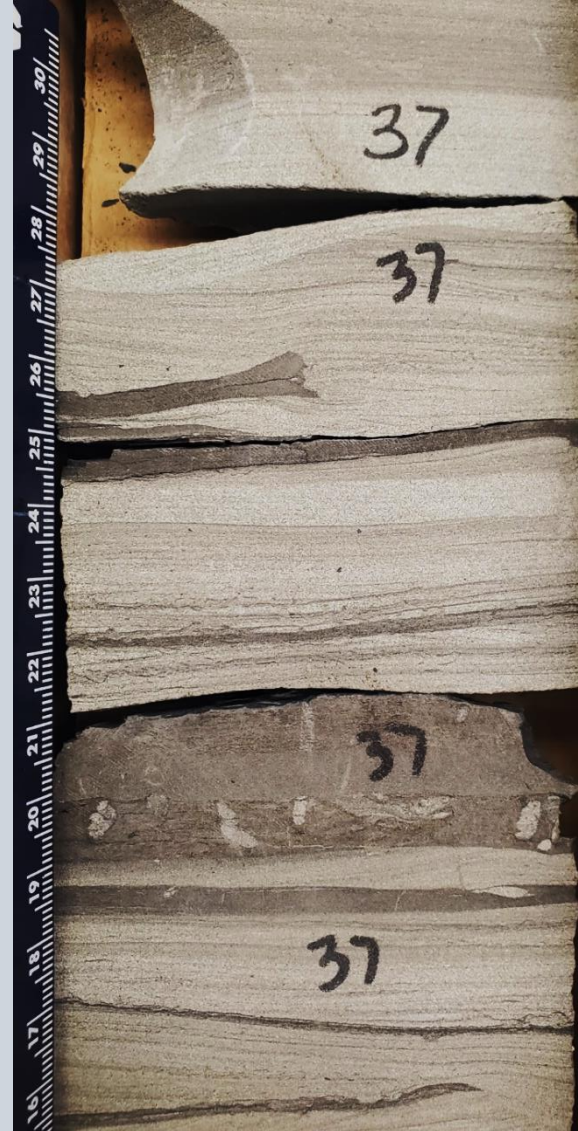
Tides



Waves



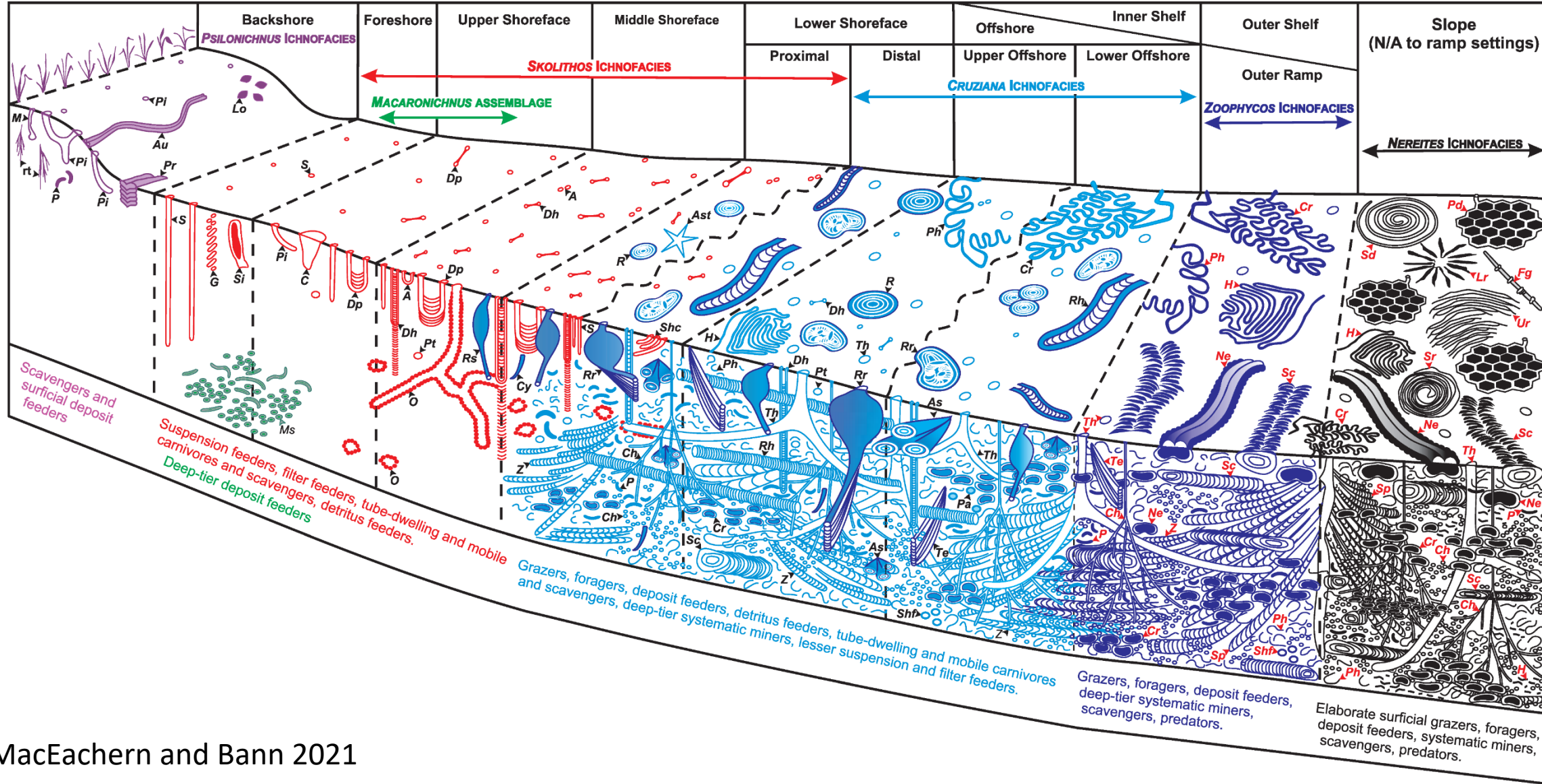
Storm currents



Rivers

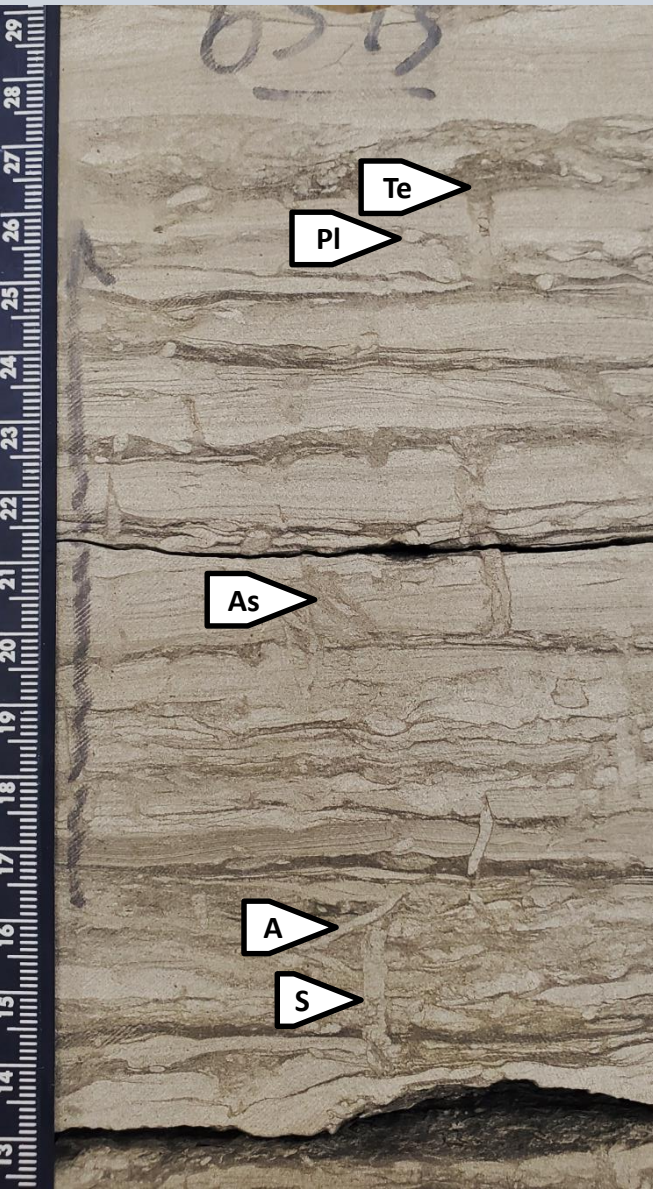


Preliminary Core Observations: Bioturbation

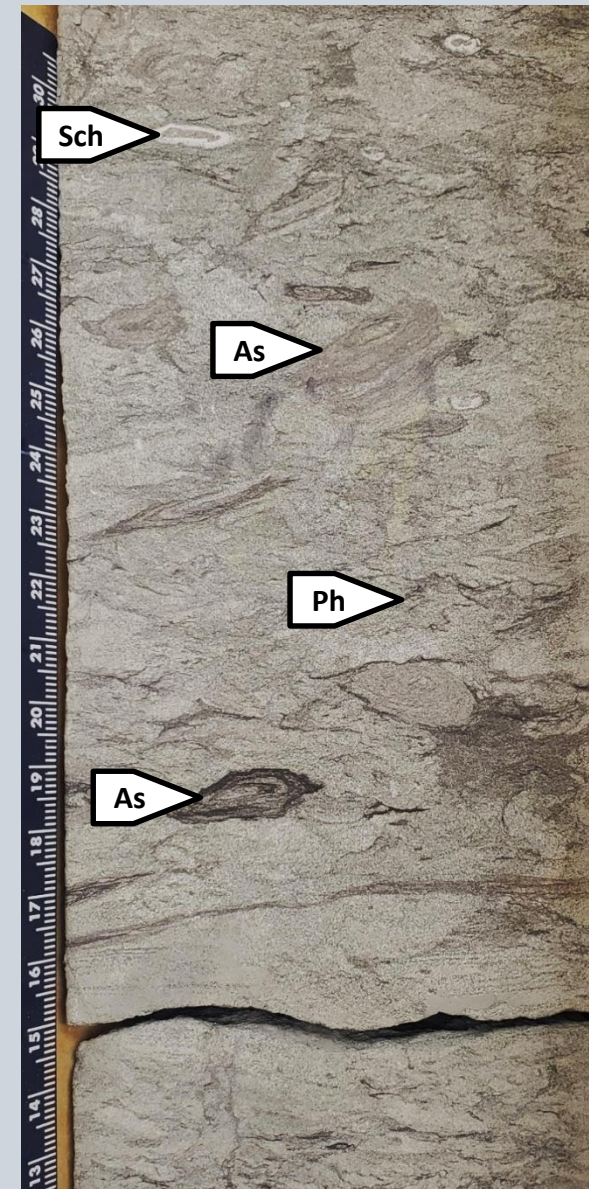


Preliminary Core Observations: Bioturbation

Skolithos Ichnofacies



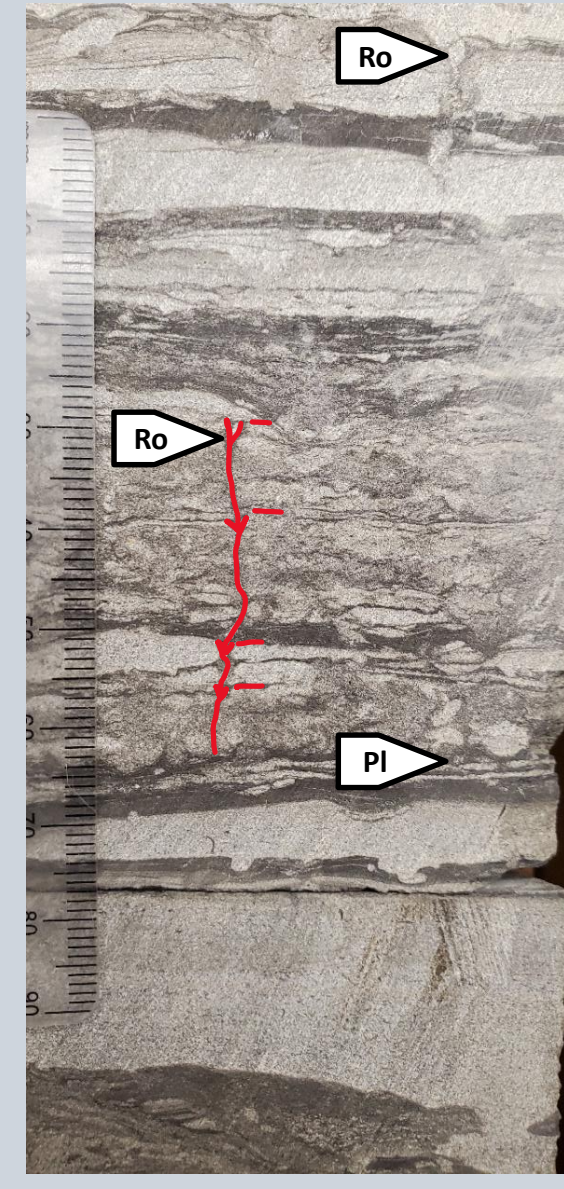
Cruziana Ichnofacies



Macaronichnus Ichnofacies

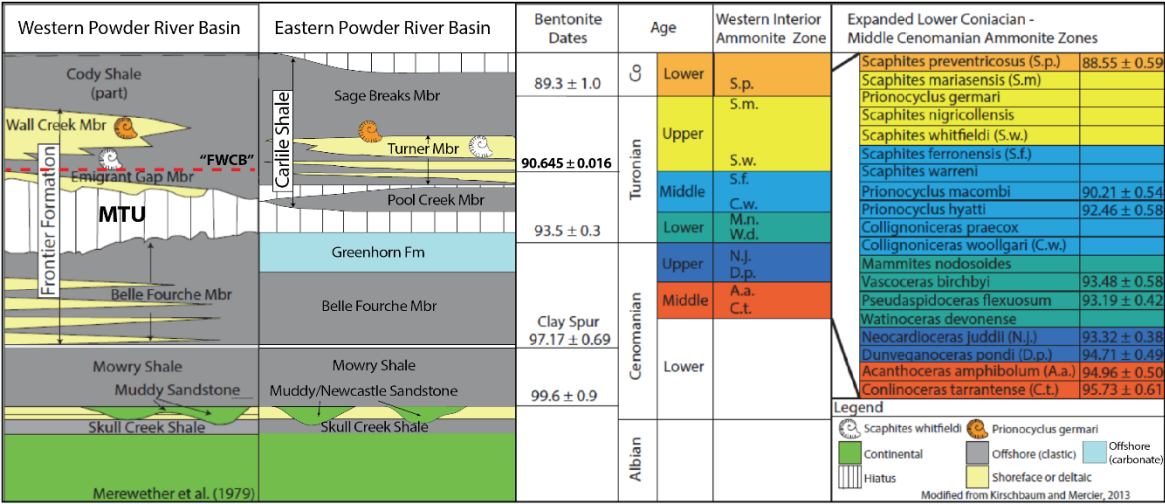


Rosselia Ichnofacies

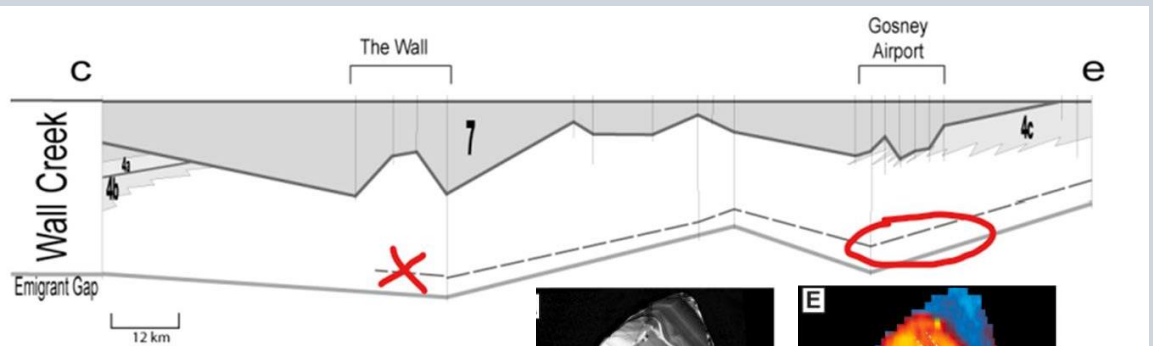


U/Pb Geochronology

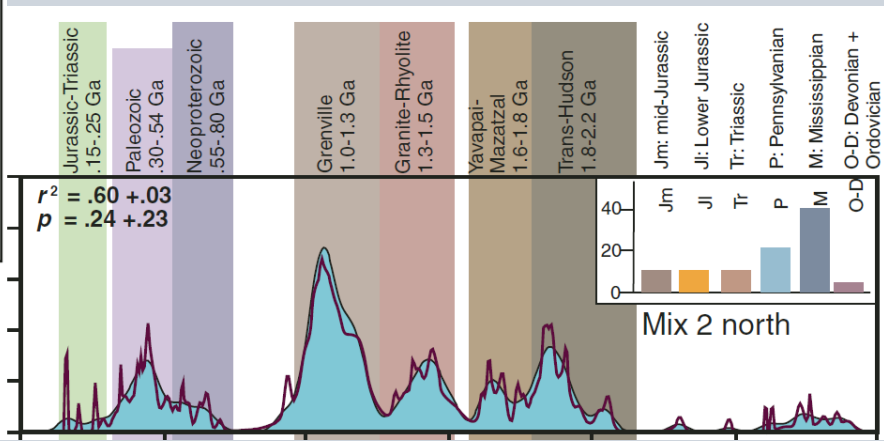
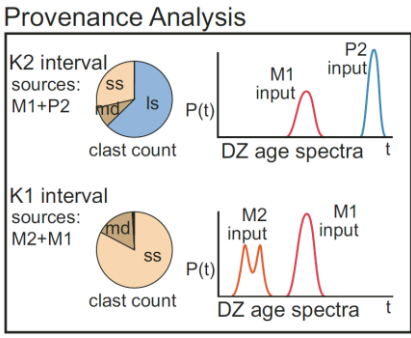
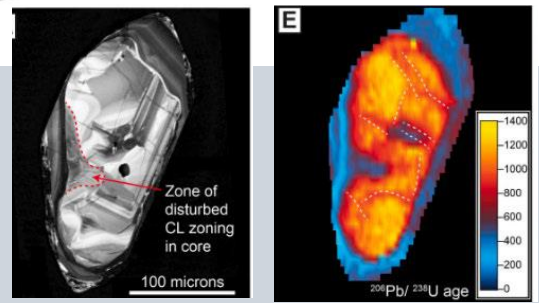
CA-ID-TIMS



LA-ICP-MS



Bhattacharya et al., 2003



Gentry et al., 2018

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Mike Johnson & Associates

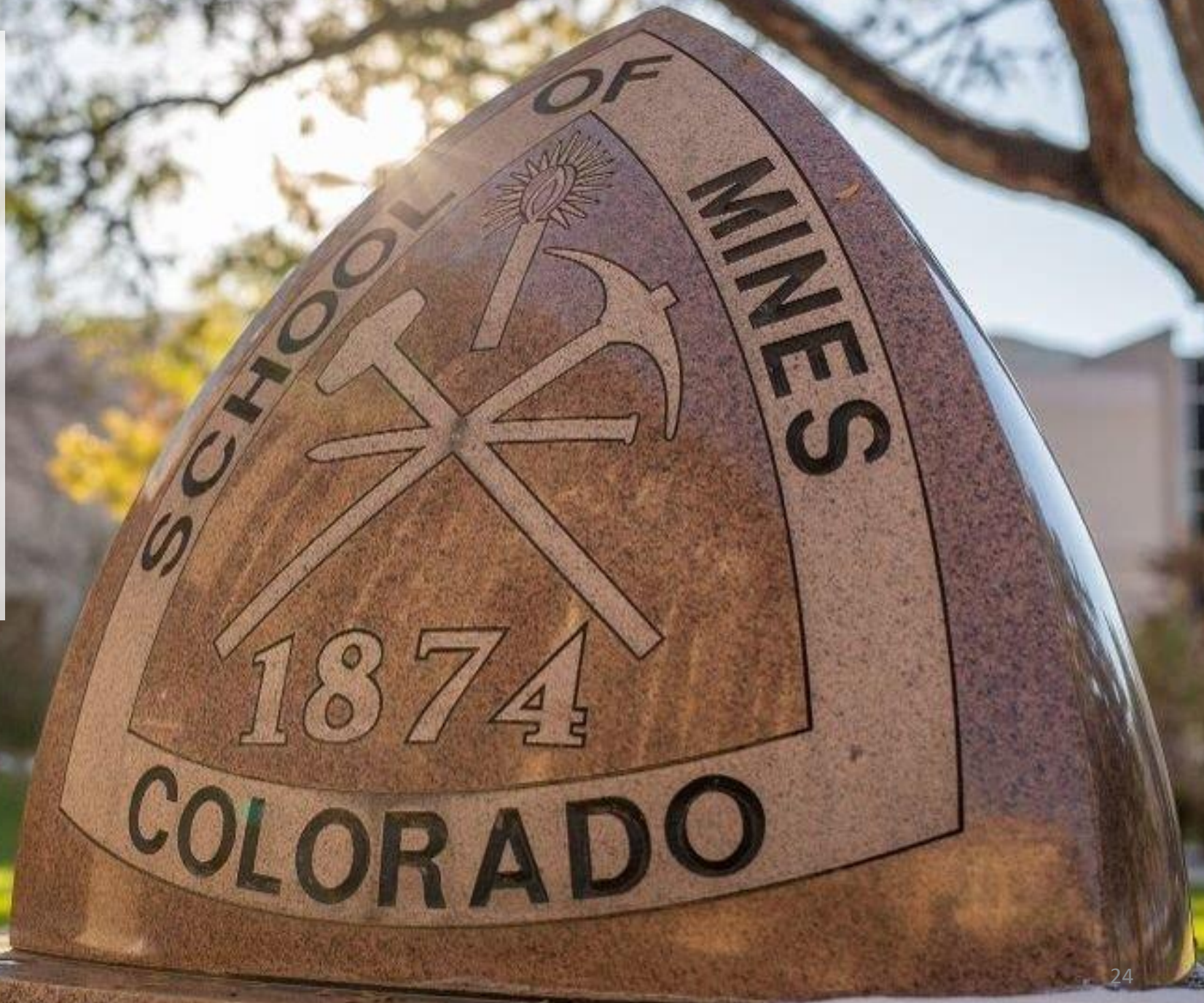


Questions?





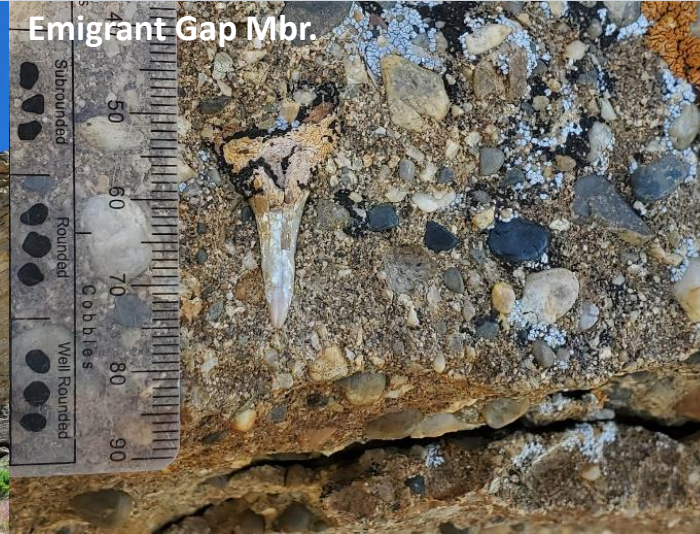
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Wall Creek Member



Pete's Draw

Turner Member

Osage Oil Field



Osage Oil Field



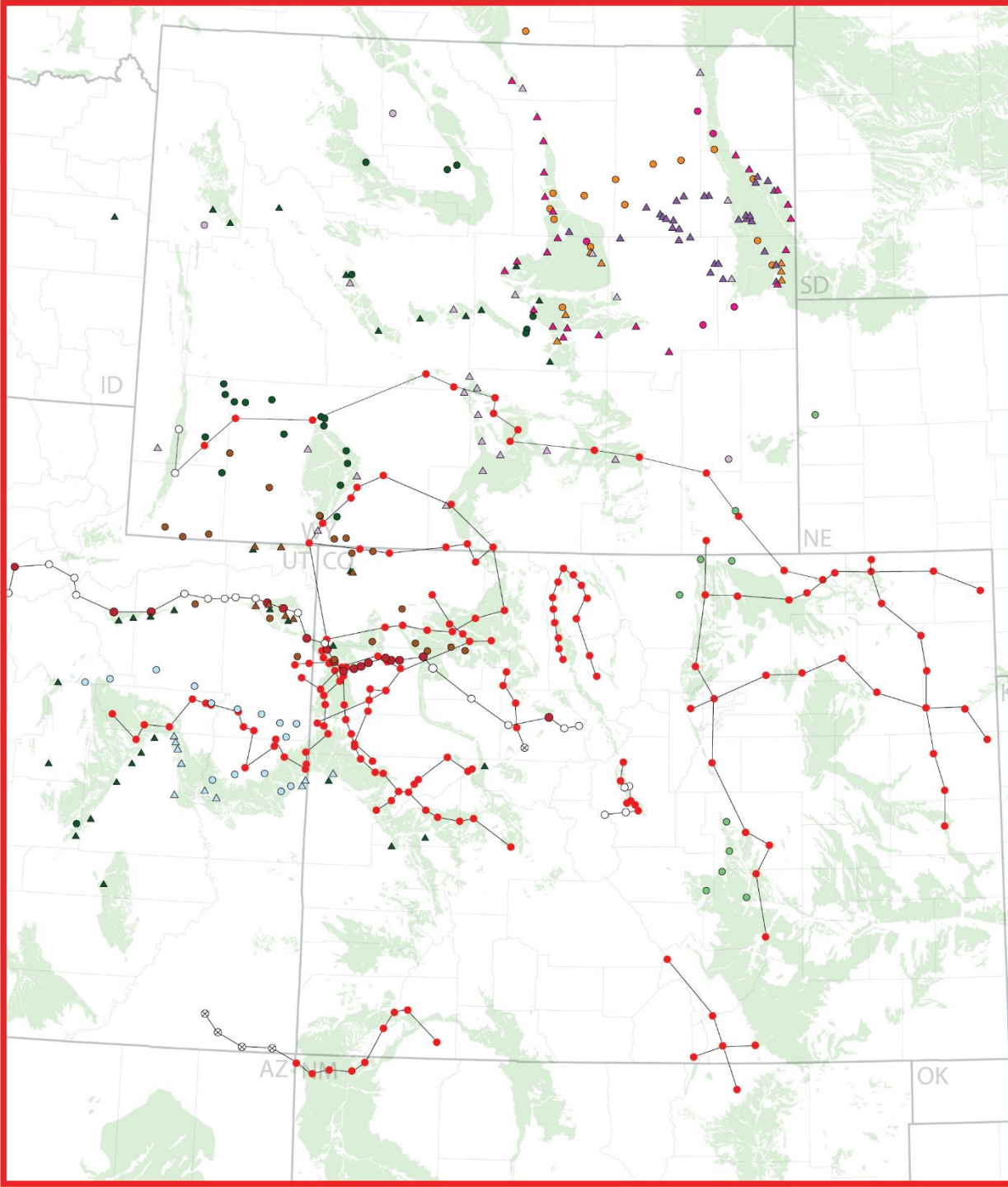
S. Douglas



Old Woman Anticline - South



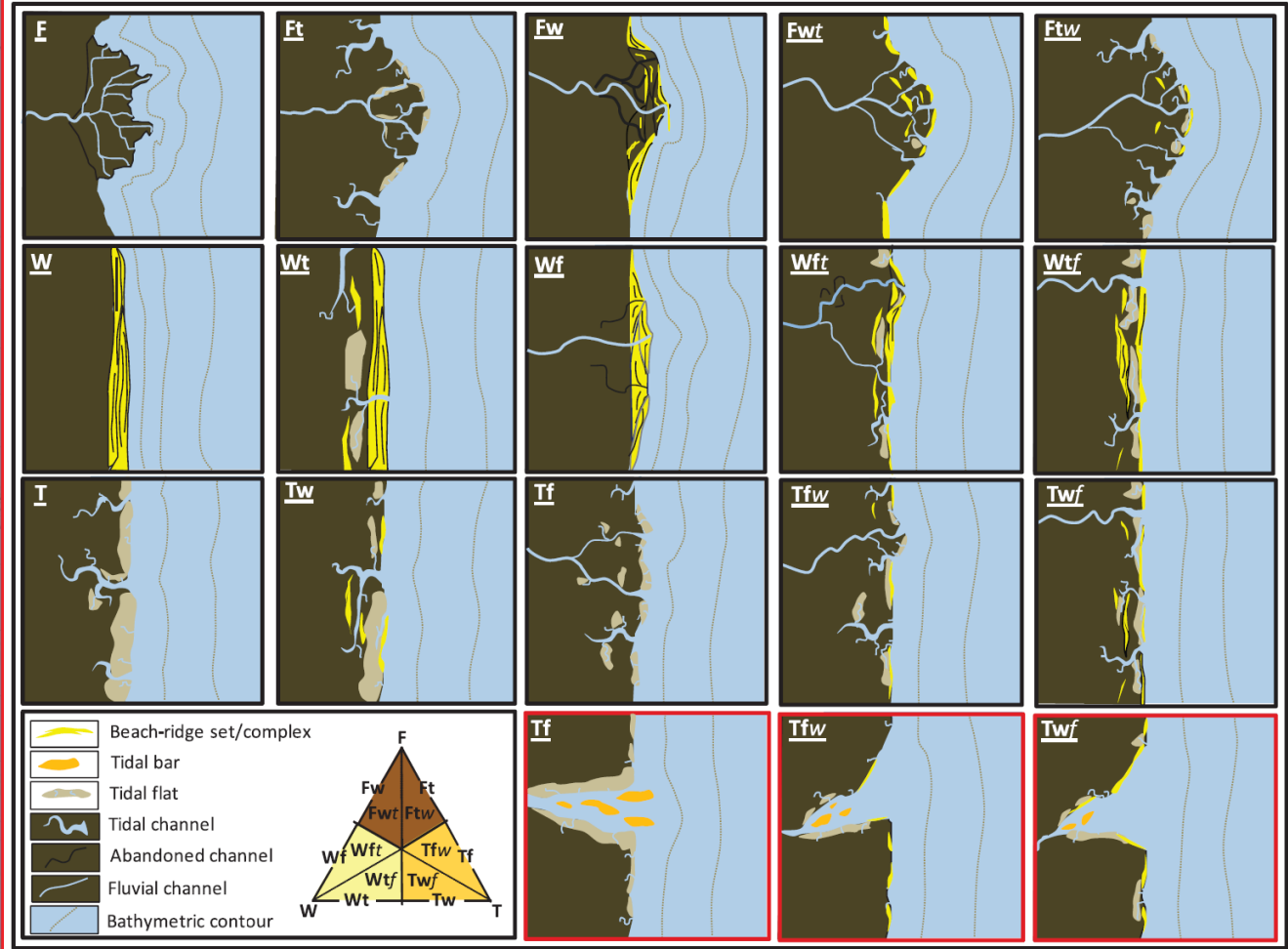
Paleogeography



- ▲ Outcrop data
- Subsurface - not deposited or eroded
- Subsurface - not deposited
- Subsurface - present
- ⊗ Subsurface - no data

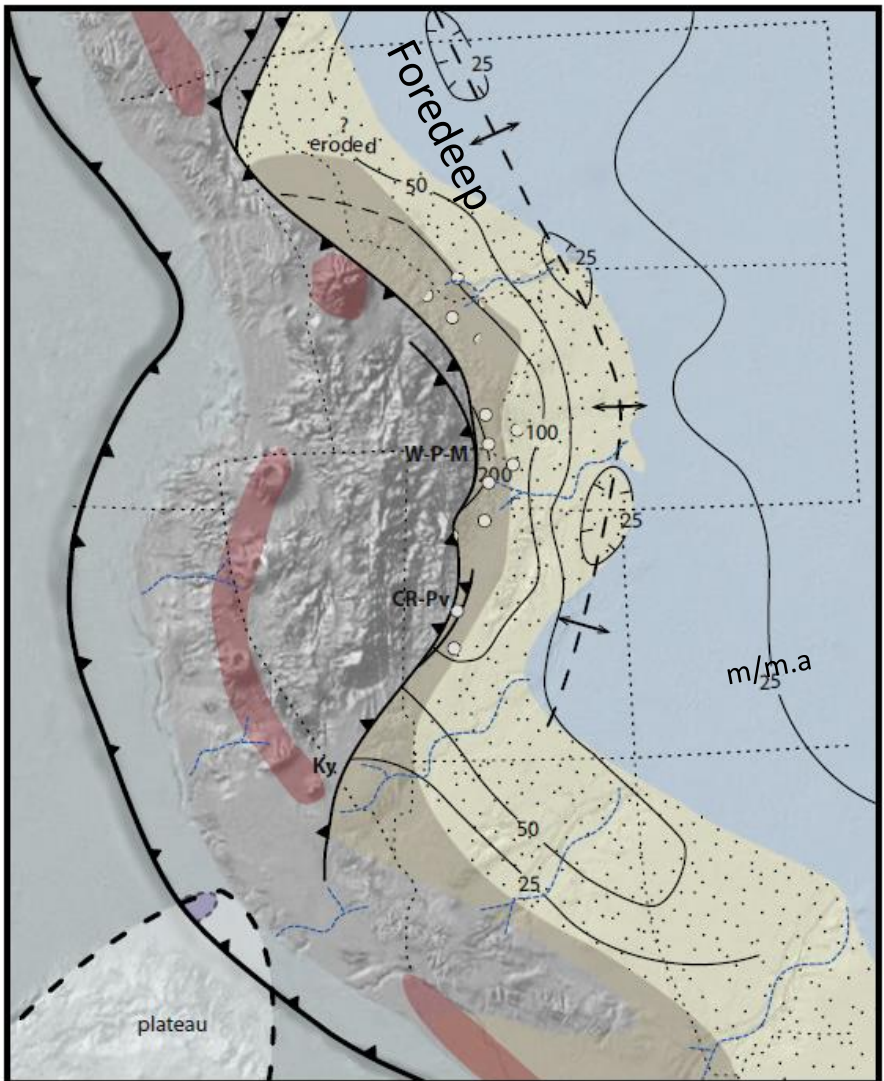
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Paleogeography

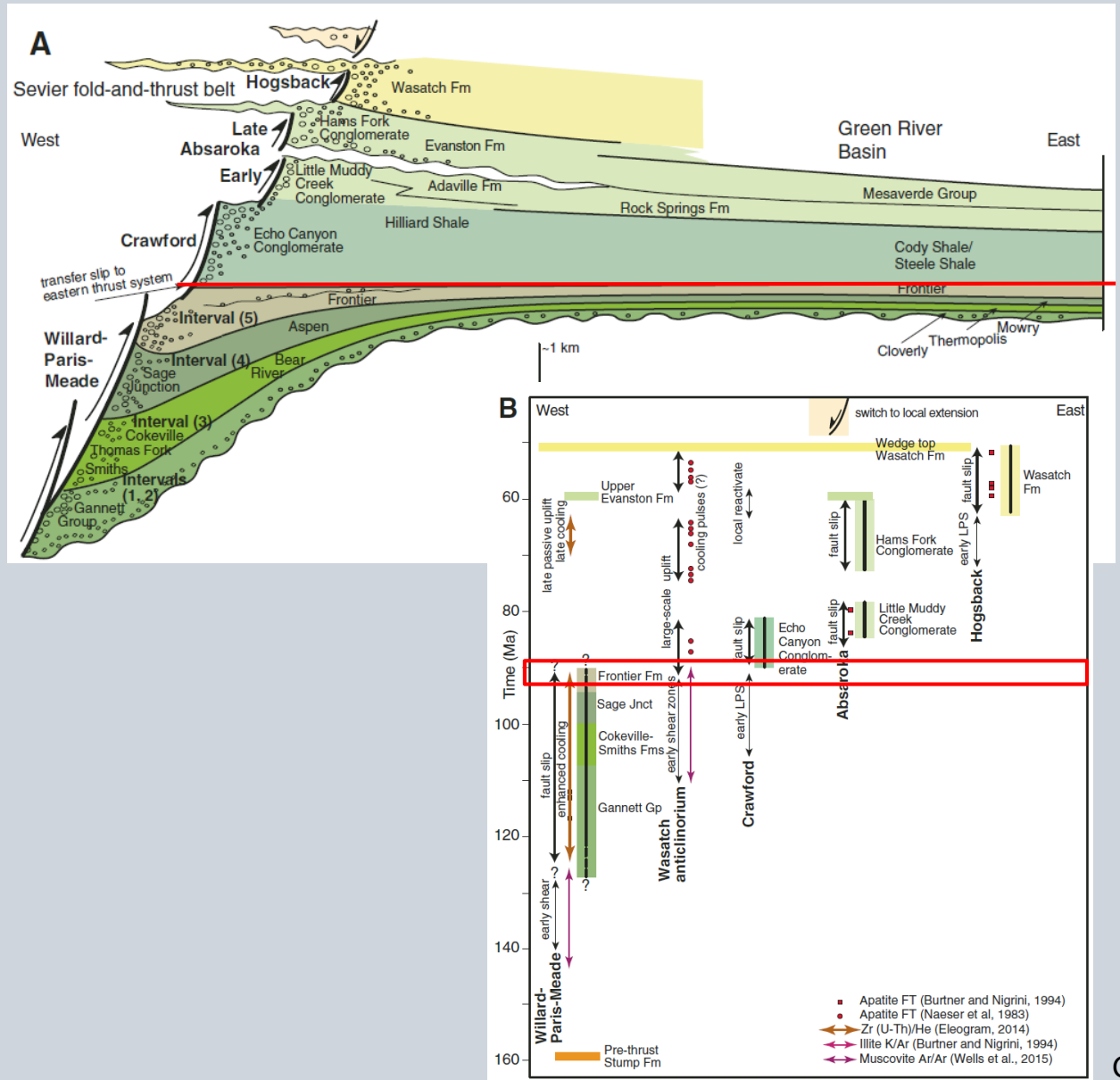


Sediment Provenance

Turonian ~ 94 - 89 Ma

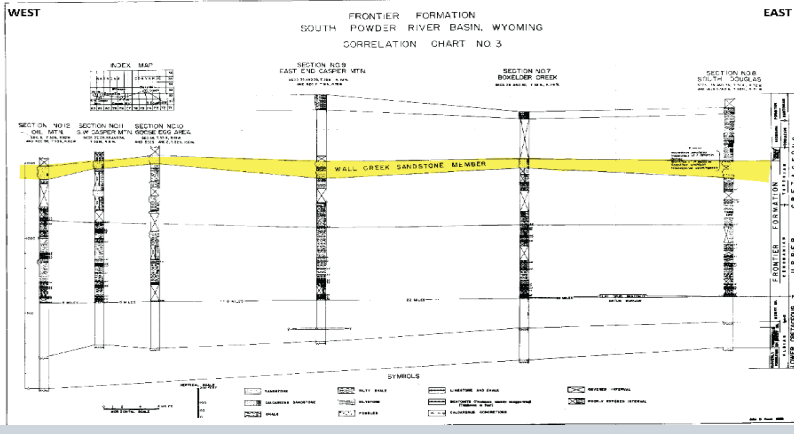
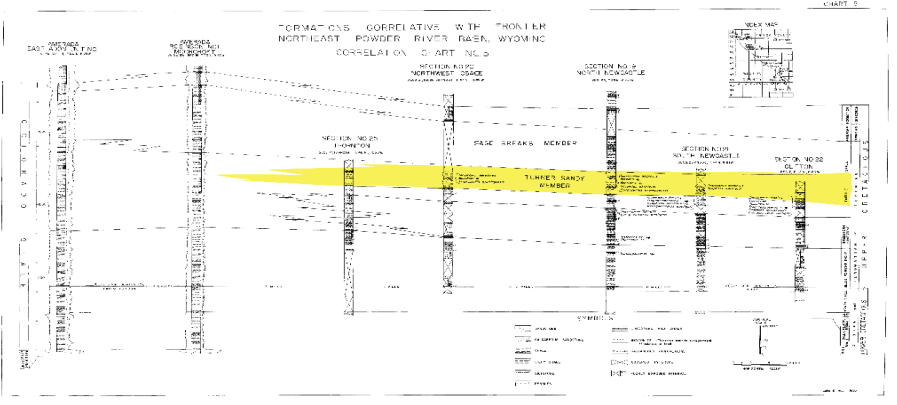
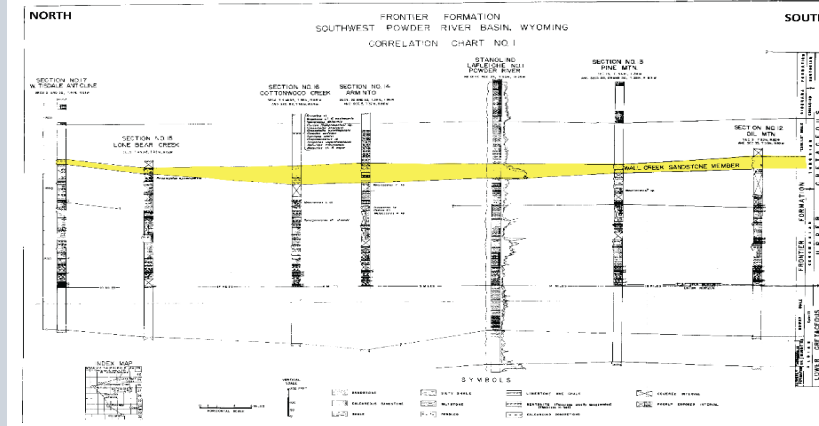
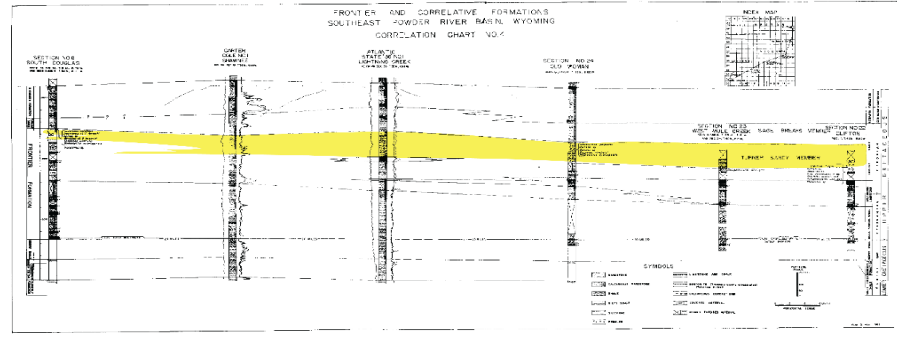
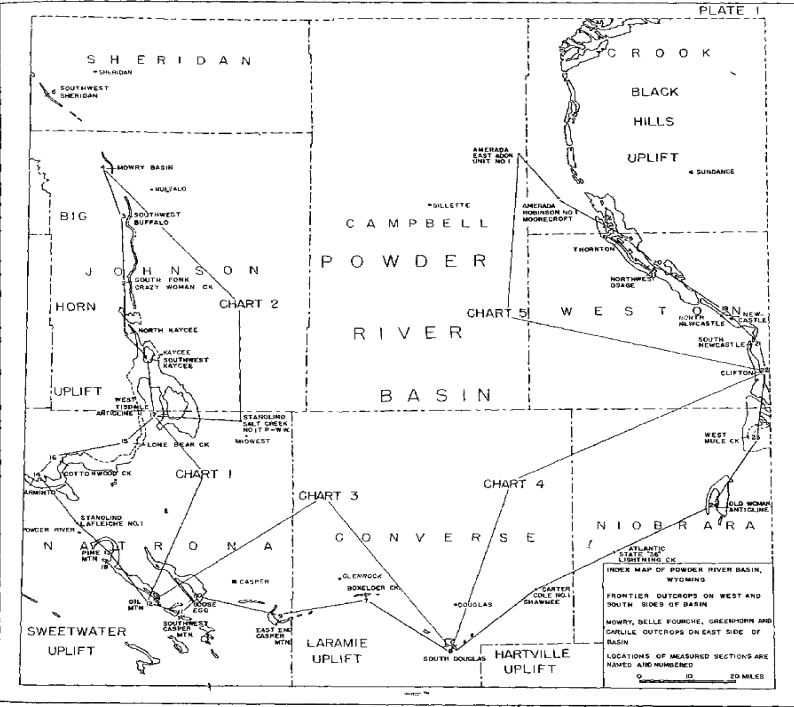
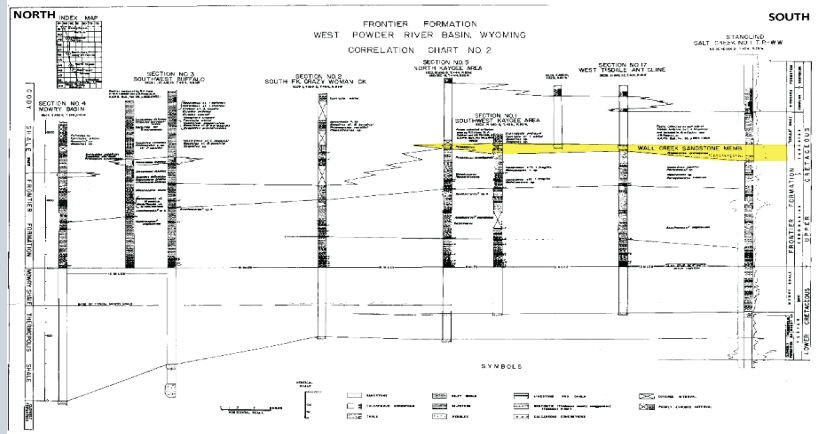


Yonkee and Weil, 2015

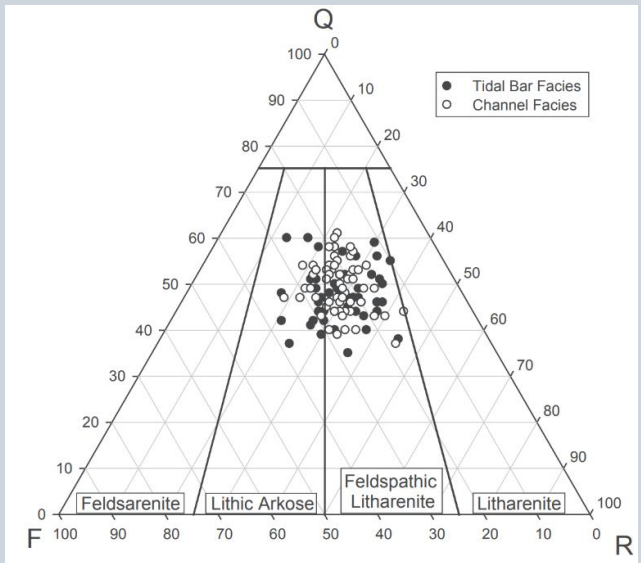


Gentry et al., 2018

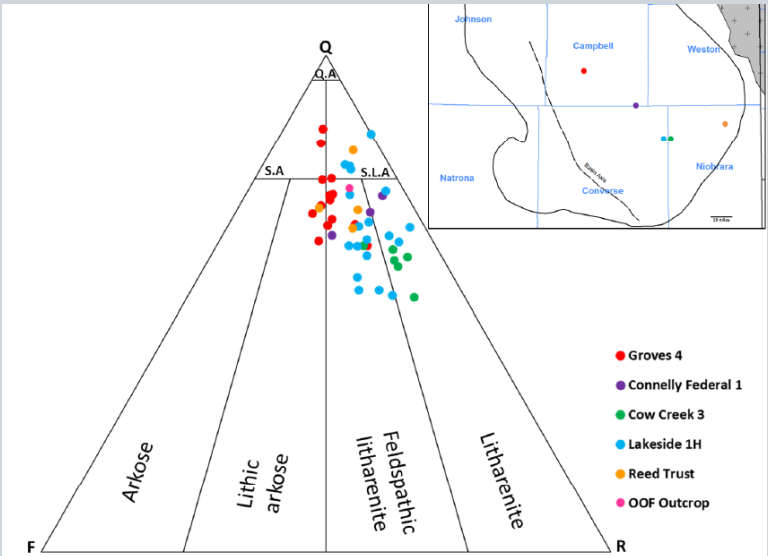
Regional Stratigraphy



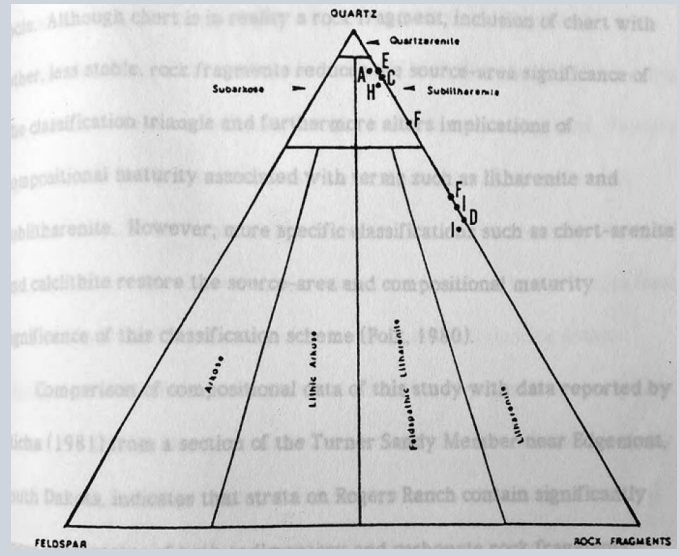
Mineralogy



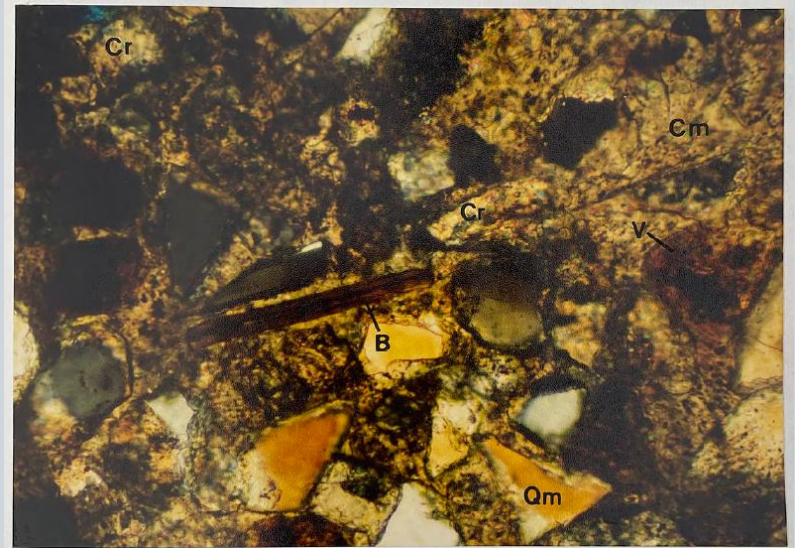
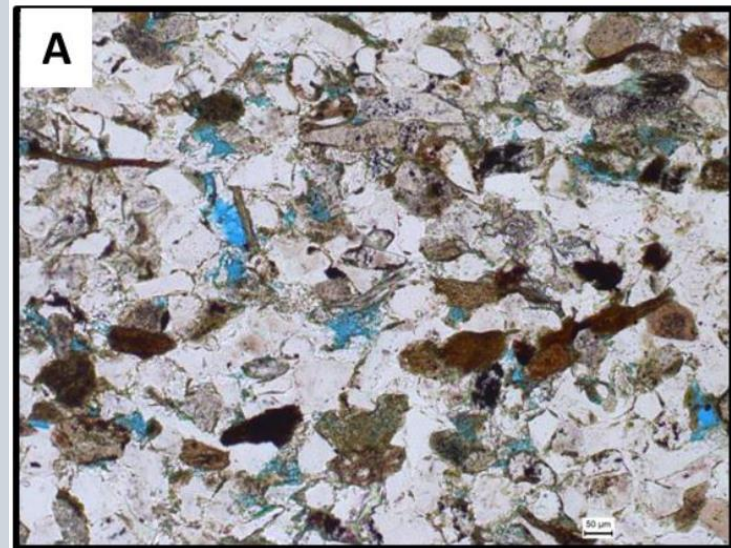
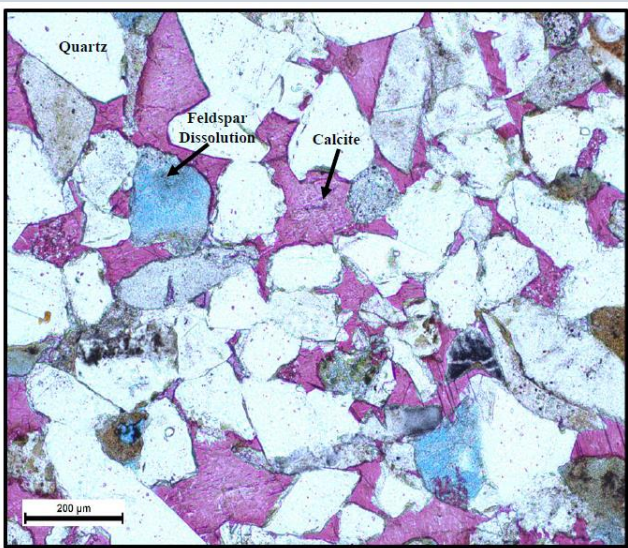
Nyman et al., 2014



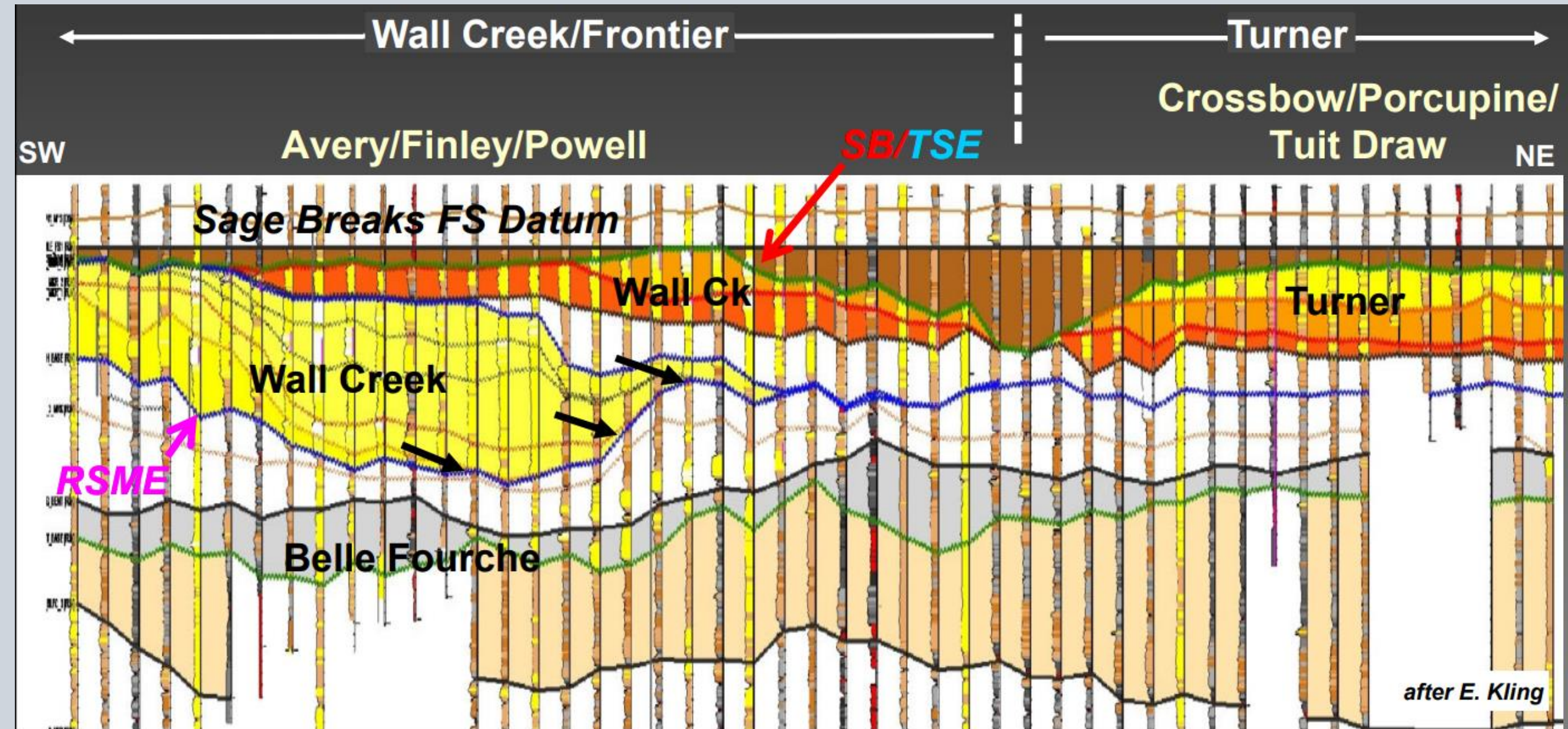
Heger, 2017



Sawyer, 1990

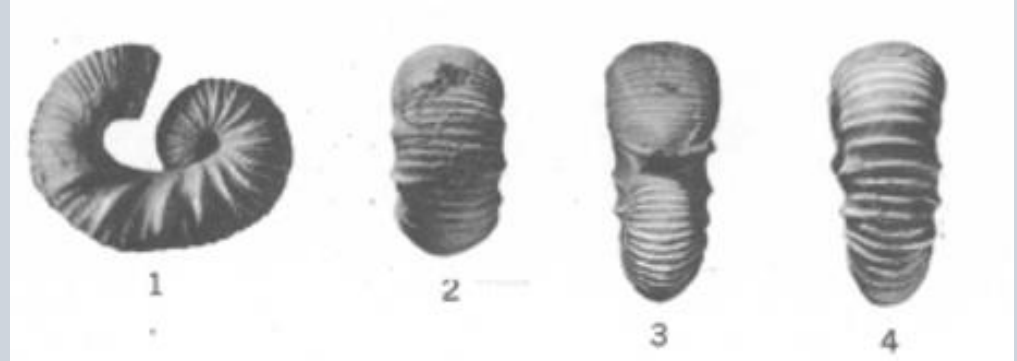


Log Correlations and Stratigraphic Model



Biostratigraphy

| SERIES | Stages | | Western In zones and | Intercalated radiometric ages (Ma) | 2 nd order sea-level fluctuations |
|---------------------|------------------|---------------------|----------------------|------------------------------------|--|
| | Informal | substage | | | |
| Cretaceous | Santonian (part) | Lower | <i>Clioscapites</i> | | Niobrata |
| | | Upper | <i>Scaphites de</i> | | |
| | Cretaceous | Middle | <i>Scaphites ve</i> | 87.61 88.08 | |
| | | Lower | <i>Scaphites pr</i> | 88.70 88.85 89.00 | |
| | Turonian | Upper | <i>Scaphites ni</i> | 89.15 | |
| | | | <i>Prionocylus</i> | 89.30 | |
| <i>Scaphites ni</i> | | | 89.45 | | |
| <i>Scaphites wi</i> | | | 89.60 | | |
| Turonian | Middle | <i>Scaphites fe</i> | 89.75 | | |
| | | <i>Scaphites wa</i> | 89.90 | | |
| | | <i>Prionocylus</i> | 90.05 | | |



FIGURES 1-15. *Scaphites warreni* var. *ubiquitosus* Cobban, n. var. 1-5, Side, rear, top, and bottom views, and second from last suture (composite) of holotype, an internal mold, U.S.N.M. 106751. From a thin sandstone bed in the Mancos shale about 150 feet below base of Tociito sandstone lentil at map locality 274. 6-11. Seventh from last suture, and top, bottom, rear, front, and side views of an internal mold, U.S.N.M. 106752, from same locality as figures 1-5. 12-15, Last suture, and bottom, rear, and side views of an internal mold of a small adult specimen, U.S.N.M. 106753. From the Mancos shale at map locality 273 (p. 23).



FIGURES 1-17. *Scaphites nigricollensis* Cobban, n. sp. From a bed of calcareous concretions 59 feet below top of Turner sandy member of Carlile shale at map locality 114. 1-6, Bottom, top, rear, front, and side views, and second from last suture of holotype, an internal mold, U.S.N.M. 106730. 7-12, Next to last suture, and front, rear, top, bottom, and side views of a paratype, an internal mold, U.S.N.M. 106731b. 13-17, Fifth from last suture, and side, rear, top and bottom views of a paratype, an internal mold, U.S.N.M. 106731a (p. 25).



30-40. *Scaphites whitfieldi* Cobban, n. sp. 30-34, Fifth from last suture, and side, rear, bottom, and top views of holotype, U.S.N.M. 106735. From a ferruginous concretion bed 251-264 feet above base of Carlile shale at map locality 112. 35-40, Side, front, rear, top, and bottom views and next to last suture of a specimen, an internal mold, U.S.N.M. 12258a, figured by Whitfield as *S. wyomingensis* Meek. From the Carlile shale on the western flank of the Black Hills (p. 24).

Cardium Formation

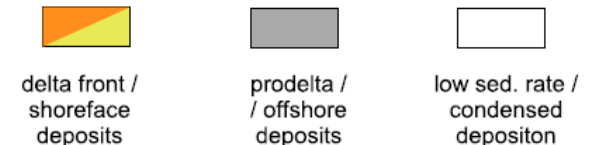
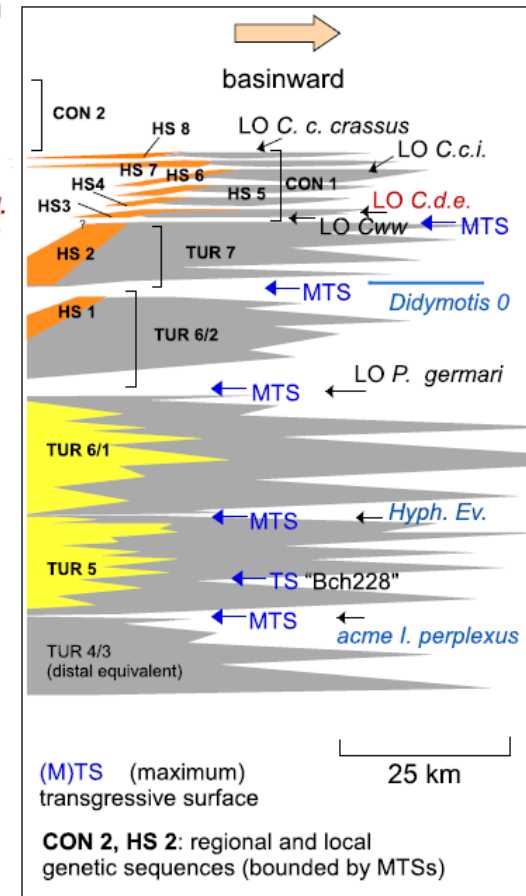
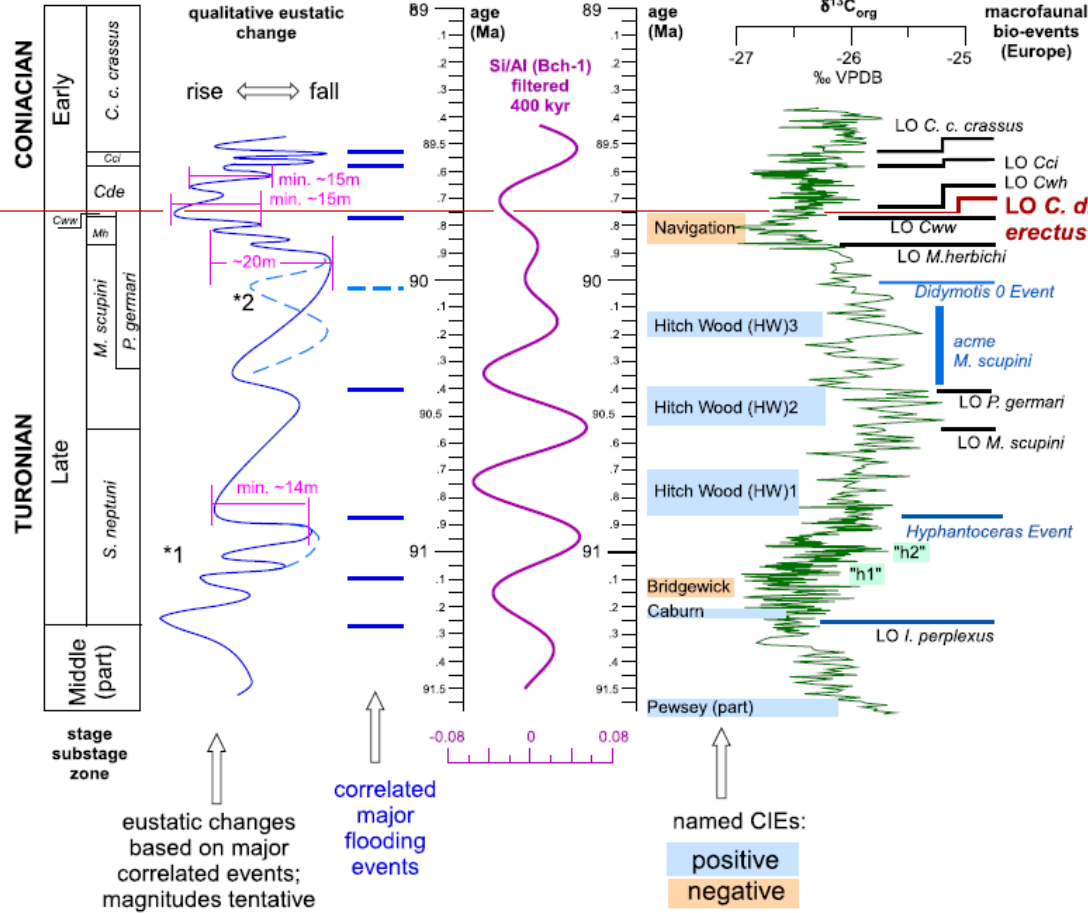
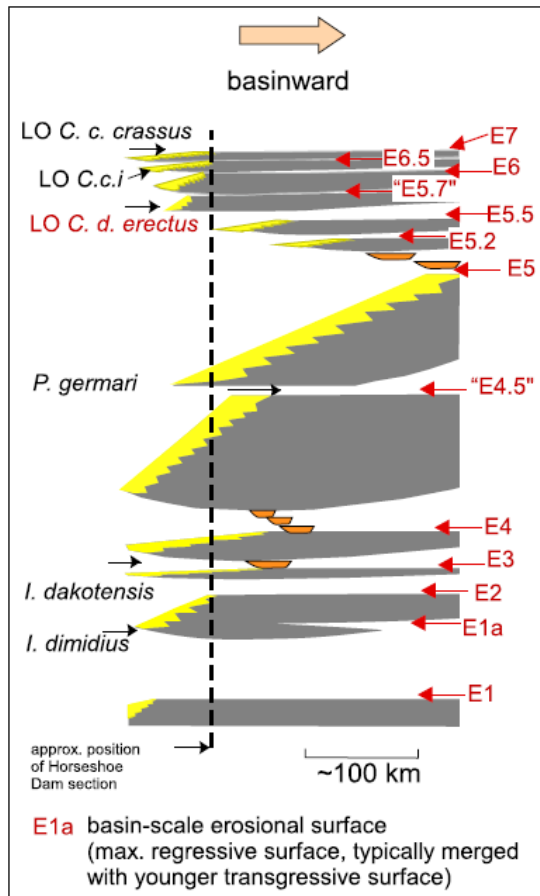
A.G. Plint, D. Uličný, S. Čech et al.

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WESTERN CANADA

TIME STRATIGRAPHY, SEA LEVEL, C-ISOTOPES

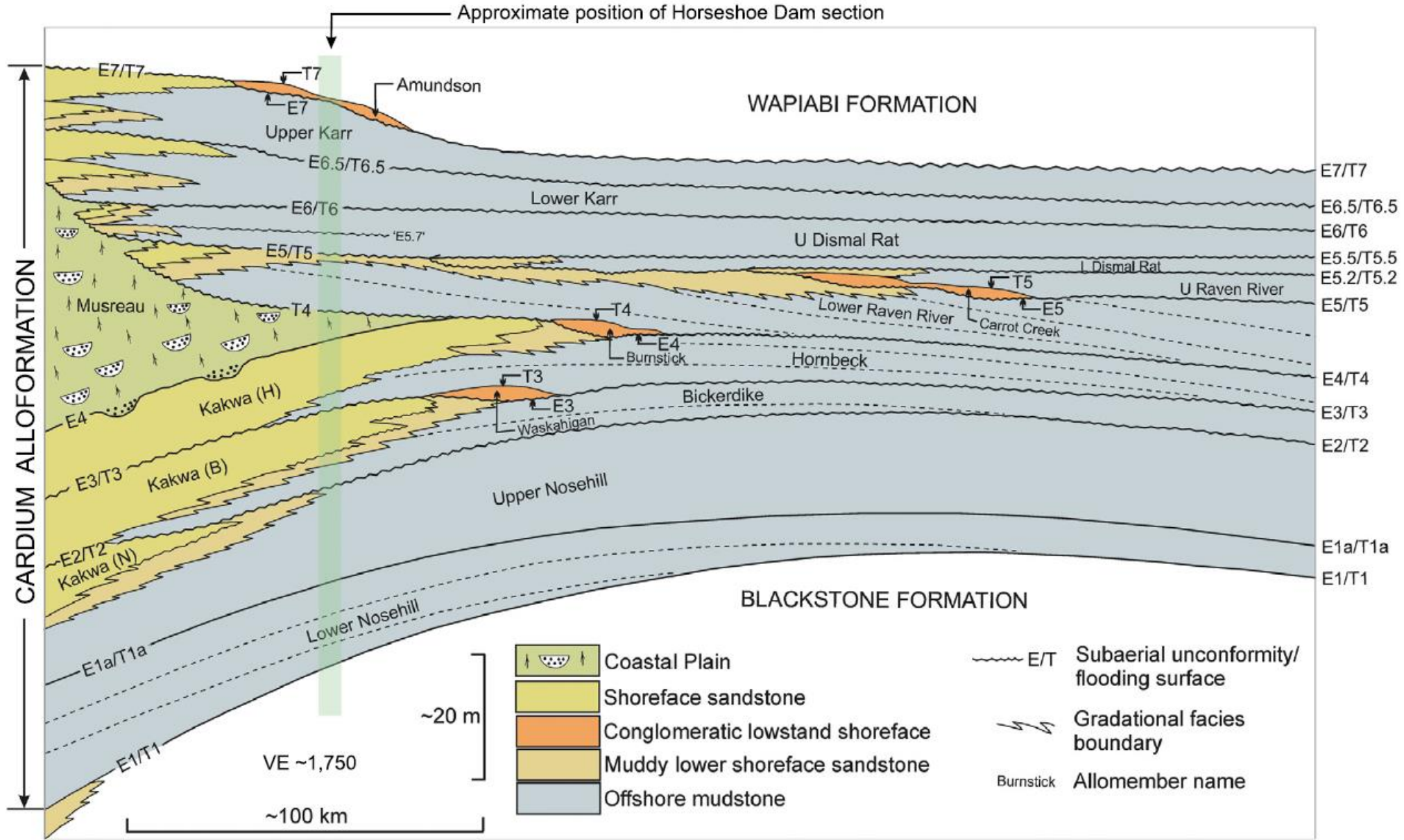
BOHEMIA



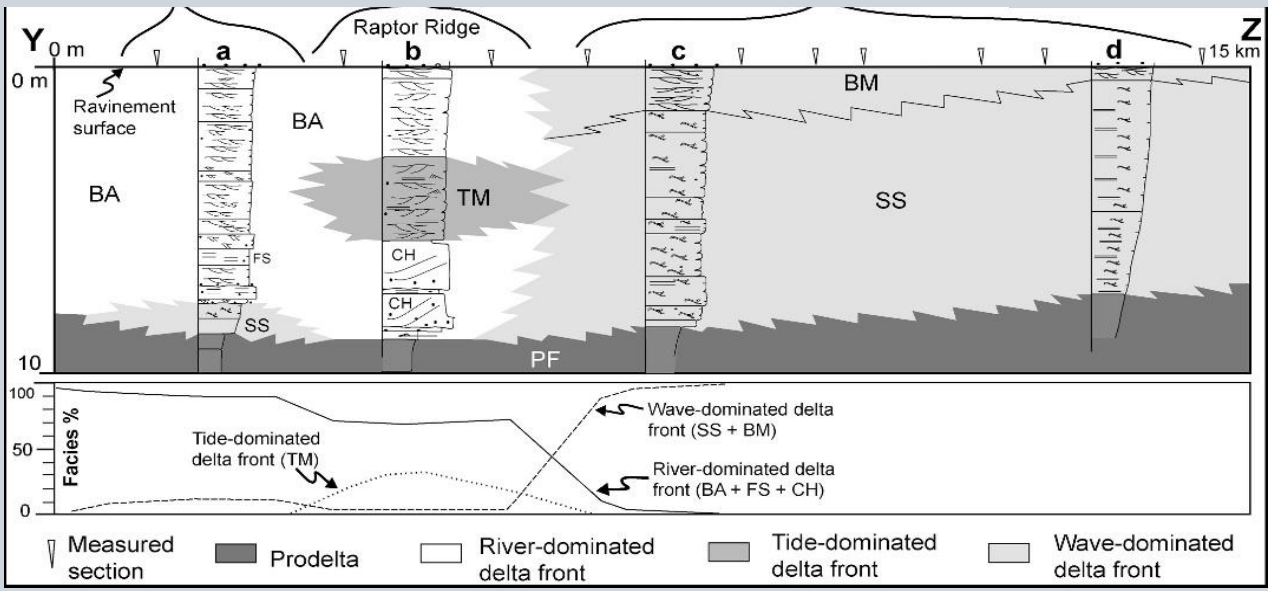
*1: E3 flooding marked in the WCFB only

*2: base TUR 7 flooding in the BCB, time-equivalent in the WCFB may be missing due to E5 erosion

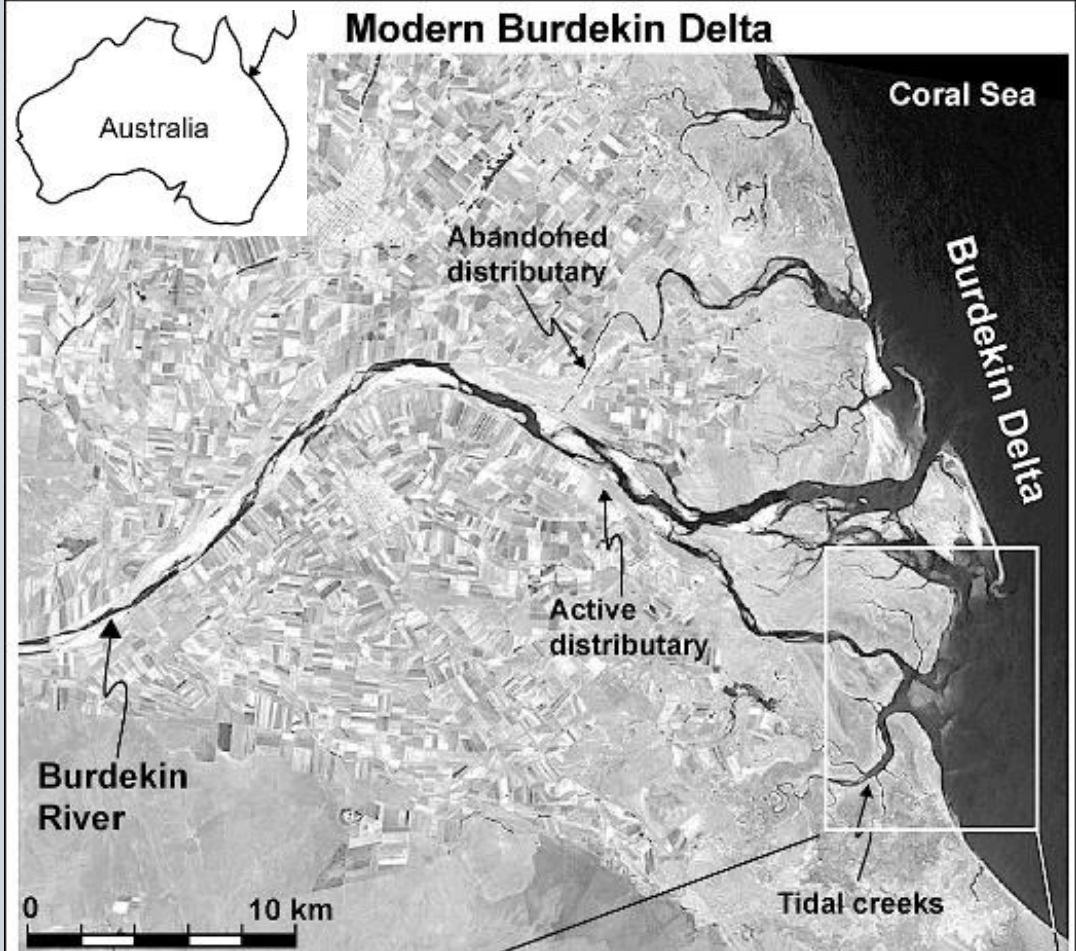
Cardium Formation



Modern Analogue: Wall Creek Mbr.



Sadeque et al., 2007



Fielding et al., 2006

Turonian Geochronology

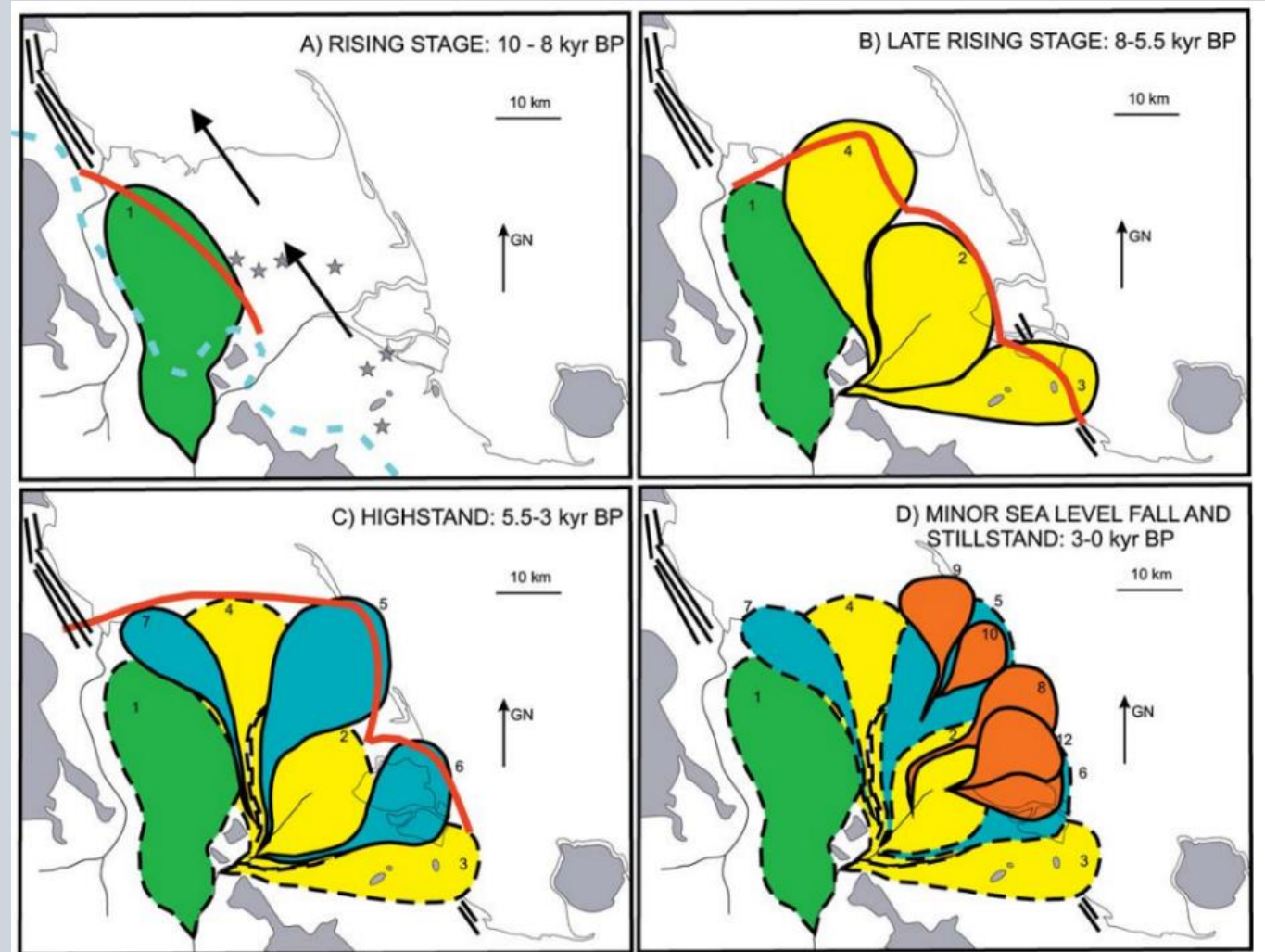
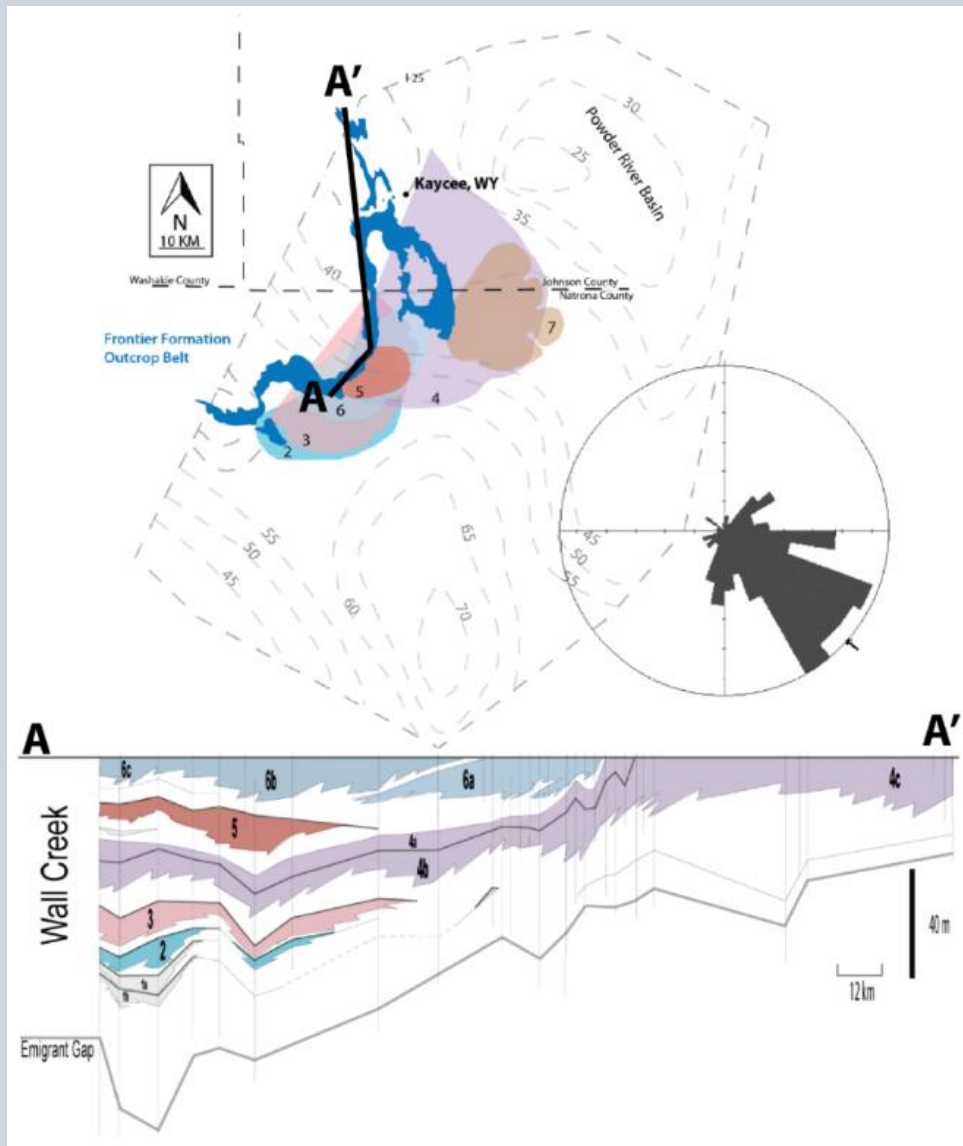
New, unpublished U-Pb CA-ID-TIMS dates, in stratigraphic order:

| | | |
|--------------------------|--------------------------|---------------------------------------|
| CO-BS-11140: | 87.985 +/- 0.014 Ma | (Niobrara Channel – Powder R. Basin) |
| CO-BS-11177: | 88.567 +/- 0.015 Ma | (Sage Breaks Sh – Powder River Basin) |
| CO-BS-11285.85: | 90.645 +/- 0.016 Ma | (Turner Ss – Powder River Basin) |
| WY-TA-1 (Janok Section): | Waiting on collection... | (Wall Creek Ss: Powder River Basin) |
| CO-NC-1-130' | 90.881 +/- 0.023 Ma | (Montezuma Valley Fm – Eagle Basin) |
| CO-TR-1: | 91.008 +/- 0.014 Ma | (Juana Lopez Mbr – Eagle Basin) |
| HQ-CB1-191107: | 91.639 +/- 0.024 Ma | (Codell Ss – Denver Basin) |
| CO-LP-1-U: | 92.682 +/- 0.015 Ma | (Blue Hill Sh – Denver Basin) |
| HQ-CB2-191107: | 93.513 +/- 0.021 Ma | (Fairport Chalky Sh – Denver Basin) |

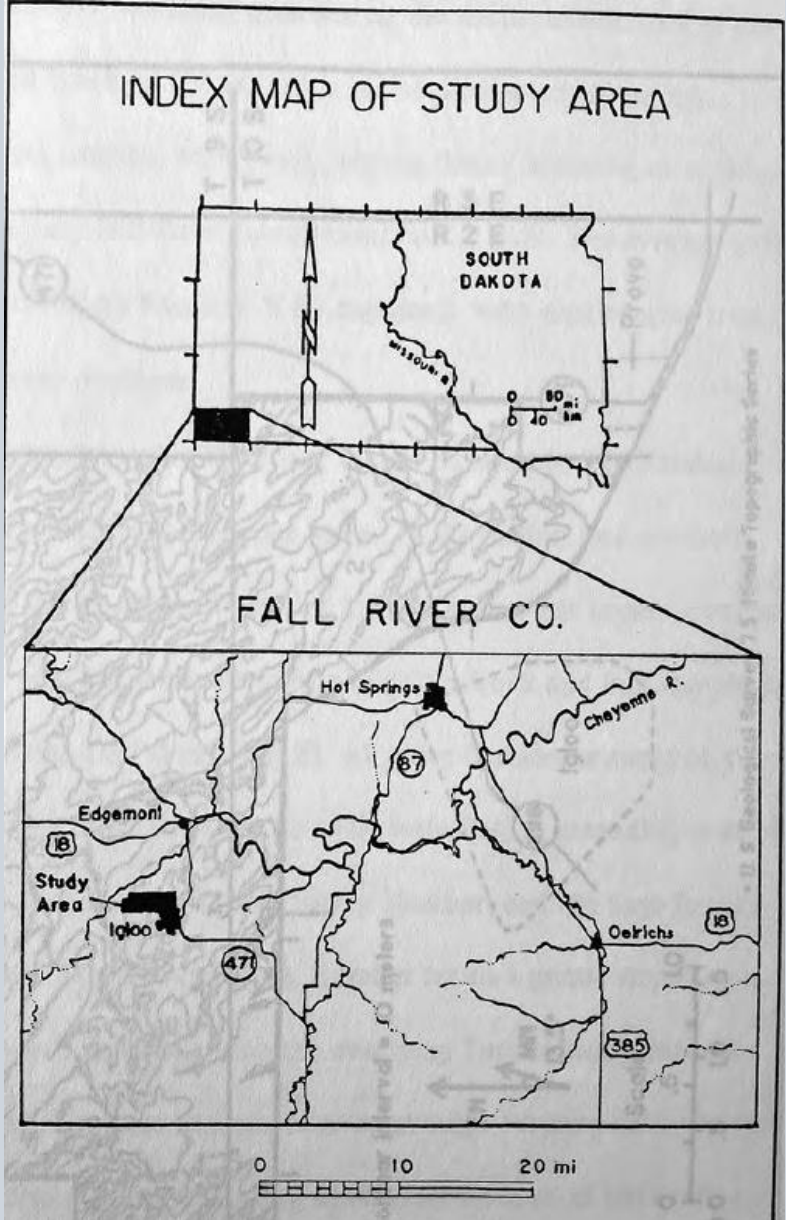
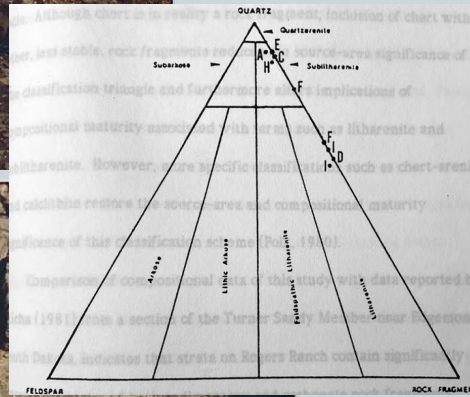
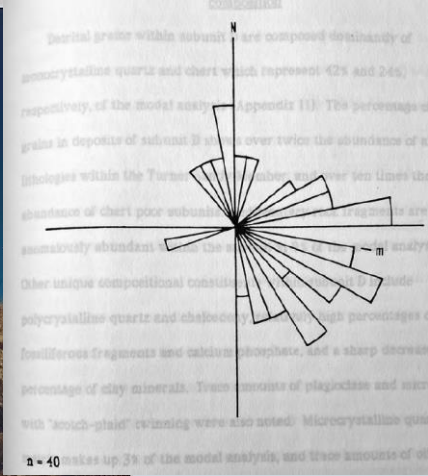
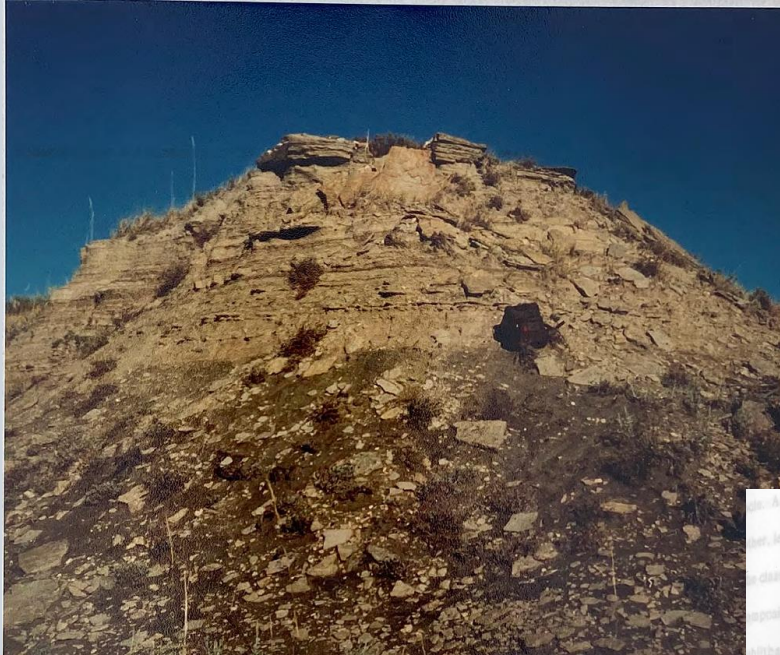
Sources of Detrital Zircons in the above rocks:

| | | |
|------------------|---------------------|--|
| GEA-UBB1-2008-01 | 94.136 +/- 0.013 Ma | (UBB Bentonite – Bighorn Basin) |
| CRC E099 - 569' | 96.004 +/- 0.016 Ma | ("X" Bentonite – Denver Basin) |
| GEA-XB1-200801 | 96.010 +/- 0.017 Ma | ("X" Bentonite – Bighorn Basin) |
| Case 11370' | 97.841 +/- 0.021 Ma | (Clay Spur Bent. – Powder River Basin) |
| AA-CSB-1-200801 | 97.849 +/- 0.019 Ma | (Clay Spur Bent. – Bighorn Basin) |
| GEA-ACB-2021 | 99.008 +/- 0.018 Ma | (Arrow Ck Bent. – Bighorn Basin) |
| Twig Fee 8790' | 99.013 +/- 0.013 Ma | (Arrow Ck Bent. – Powder River Basin) |

Modern Analogue: Wall Creek Mbr.



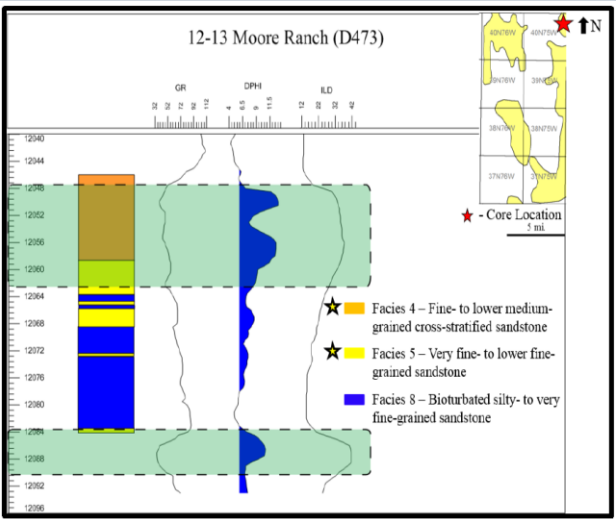
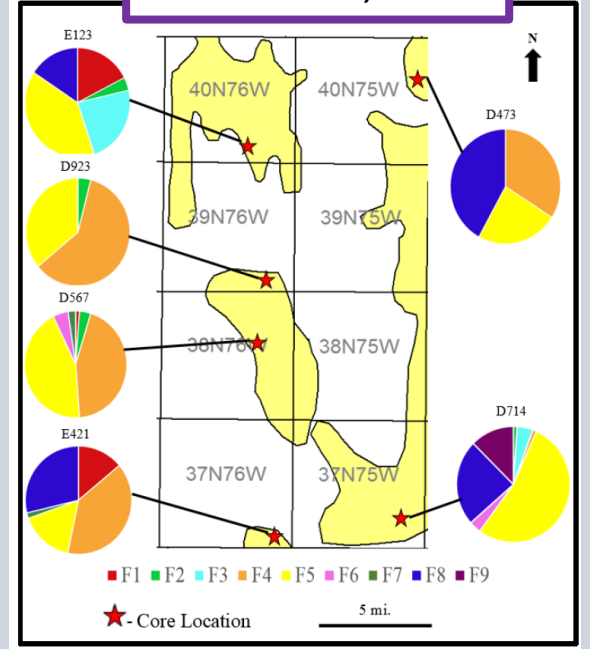
Sawyer, 1990 Thesis



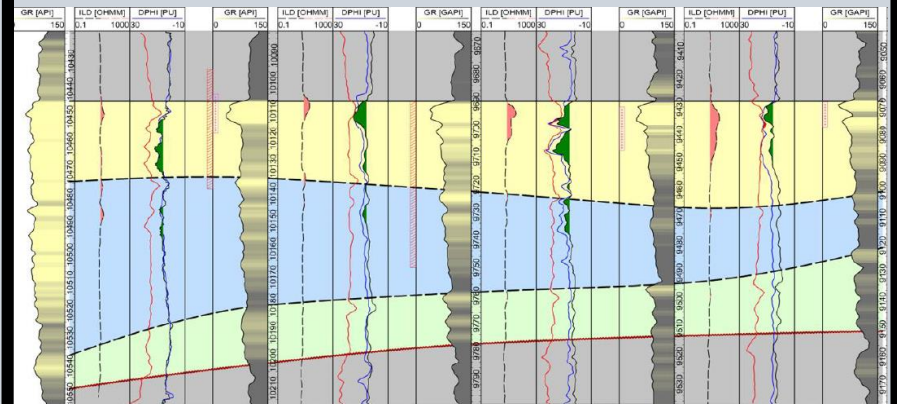
MUDTOC Efforts

WEST

Dellenbach, 2019



Milar, 2020



| BURROW TYPE | LINING | FILL MATERIAL | IMPACT ON RESERVOIR |
|---------------------|--|---|---------------------|
| <i>Asterosoma</i> | YES – linings packed with clay and/or fine organic matter | Actively filled with mud, silt and/or very fine sand | Negative |
| <i>Macronichnus</i> | NO | Actively filled with sediment that contrasts with the host sediment | Positive |
| <i>Ophiomorpha</i> | YES – linings packed with clay and/or fine organic matter | Passively filled – can be the same as the host strata or have an increased clay content | Positive/negative |
| <i>Palaephycus</i> | YES – margins lined with agglutinated sand, silt or organic matter | Passively filled with sediment that rarely contrast with the host sediment | Positive |

Bone, 2020

