Beyond the Uteland Butte Part I: If it's Not Red, Is It Even the Wasatch?

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Abstract

Horizontal wells targeting deep-lacustrine deposits have been a primary driver of oil production growth in Utah's Uinta Basin over the past 10 years, with Estimated Ultimate Recoveries (EURs) that rank among the most prolific shale oil basins in the United States. The most well-known development target is the Uteland Butte member (UB) of the Eocene Green River Formation. The UB represents a large-scale transgression of Lake Uinta and exhibits a remarkably similar gamma-ray character from outcrop to basin center, allowing it to be easily mapped over a large area. The UB lacustrine depositional phase is underlain by the Wasatch Formation, interchangeably called the Colton or Castle Peak by previous authors. In outcrop, the Wasatch classically presents as a succession of distinctly red channel sandstones and mudstones which commonly contain pedogenic features, indicating a fluvial-deltaic depositional environment with periodic surface exposure and occasional intervening lacustrine phases.

Utilizing public and proprietary whole-rock core, this study documents the multitude of depositional environments that can be identified within Wasatch Formation in the deepest parts of the Uinta Basin. Within the span of 10 miles, the same chronostratigraphic interval of the Wasatch Formation includes 1) black, organic-rich shales; 2) dark gray micritic limestones; 3) organic-lean gray shales with root structures and pedogenic surfaces; 3) fine-grained salt-and-pepper lithic gray sandstones; and 4) red-beds and medium-grain alluvial sandstones. This collection of lithologies indicates that deep lacustrine depositional systems and proximal alluvial systems existed contemporaneously in different parts of the basin during the time of Wasatch deposition. The depositional period of the Wasatch was clearly a dynamic time and requires detailed study for resource evaluation.

Keywords:

Uinta Basin, Green River Formation, Wasatch Formation, unconventional, lacustrine

Conclusions

The Wasatch Formation will continue to be an important horizontal target in the Uinta Basin but is more complex than the Uteland Butte

The Wasatch is more than just red beds and contains a wide range of facies depending on location and depositional water depth

The best horizontal production results are concentrated in areas of deep lake deposition, similar to the Uteland Butte

Supply-generated sequence stratigraphic concepts are helpful in the interpretation of stacking patterns in various water depths

Acknowledgments

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Utah Core Research Center

Riley Brinkerhoff

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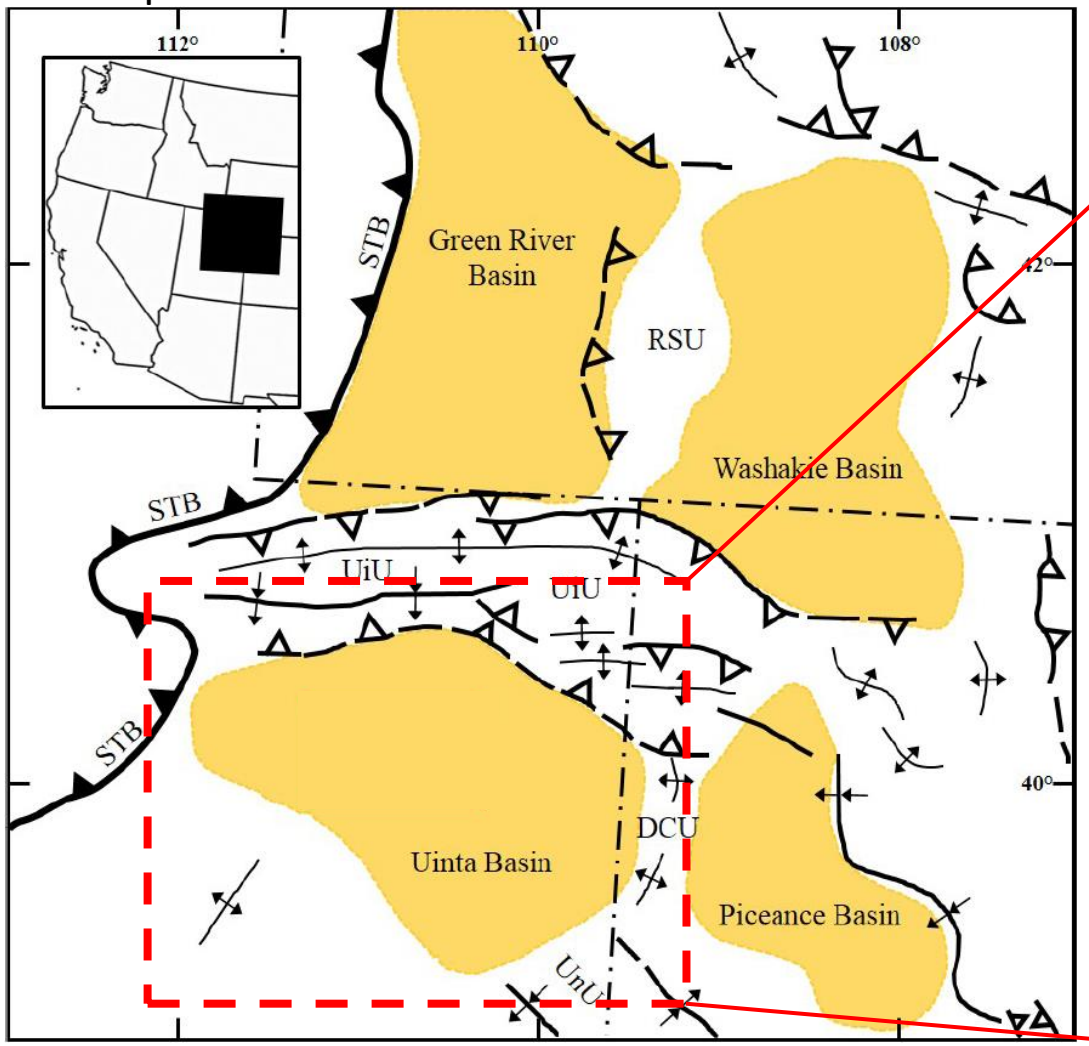
AGENDA

1. Geologic Background
2. Review of Wasatch Horizontal Production Trends
3. Lake Uinta Evolution
4. Lacustrine Sequence Stratigraphy
5. Wasatch in Outcrop
6. Core Facies Descriptions
7. Stacking Patterns in Different Water Depths
8. Extent of Wasatch Lake
9. Conclusions
10. Acknowledgments and References

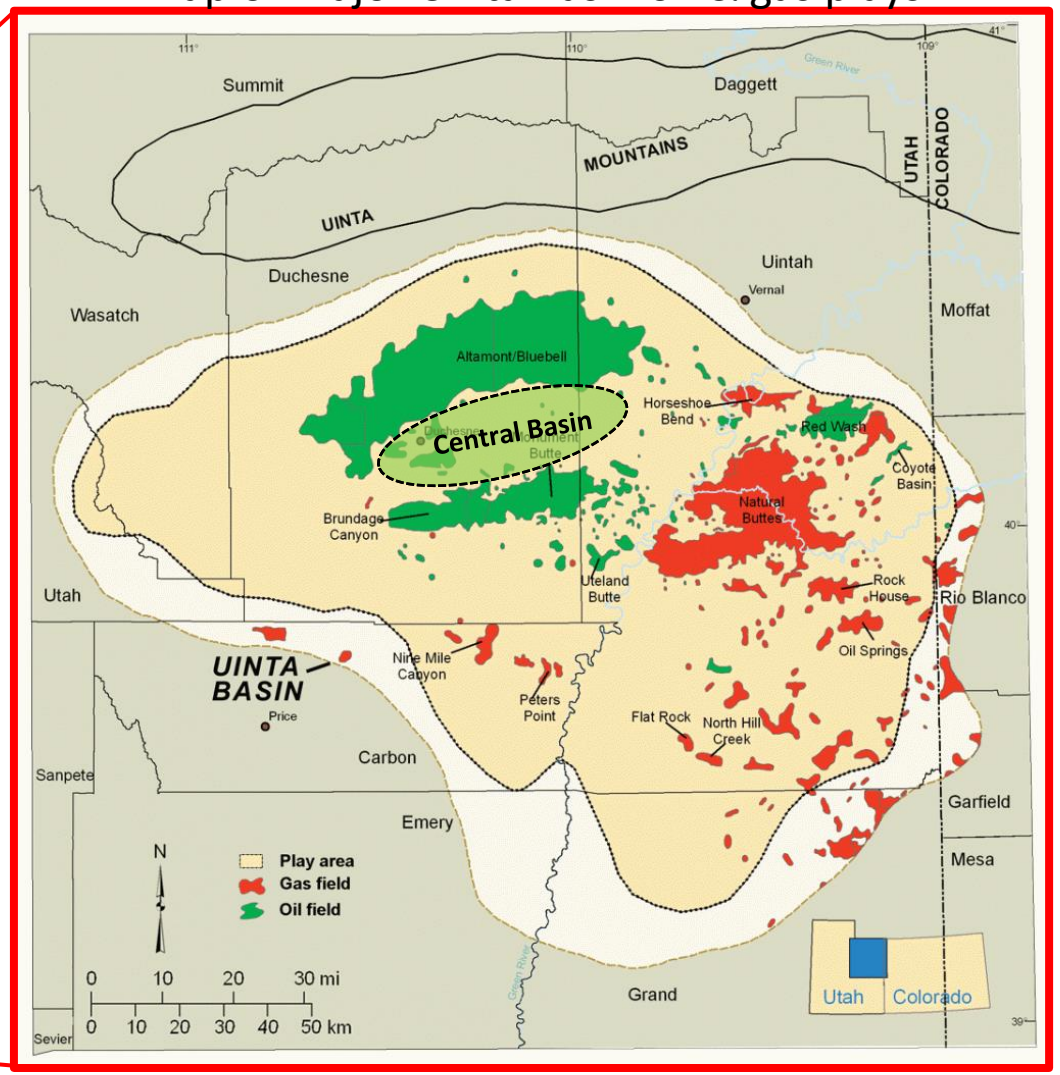
Uinta Basin Locator Slide

Map of western U.S. Laramide lacustrine basins



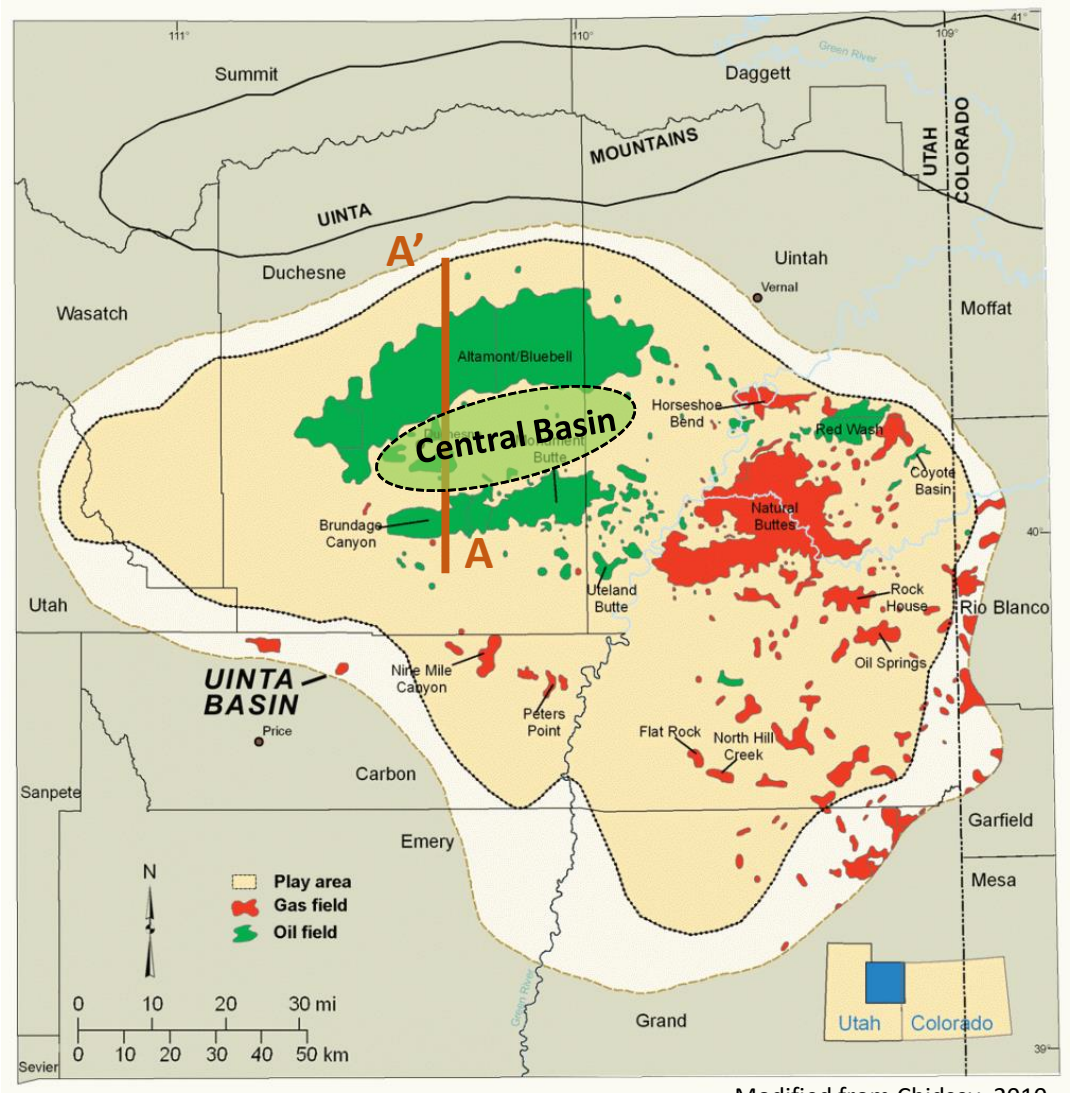
Modified from Rueda Chaparro 2019

Map of major Uinta Basin oil & gas plays



Modified from Chidsey 2010

Uinta Basin Overview



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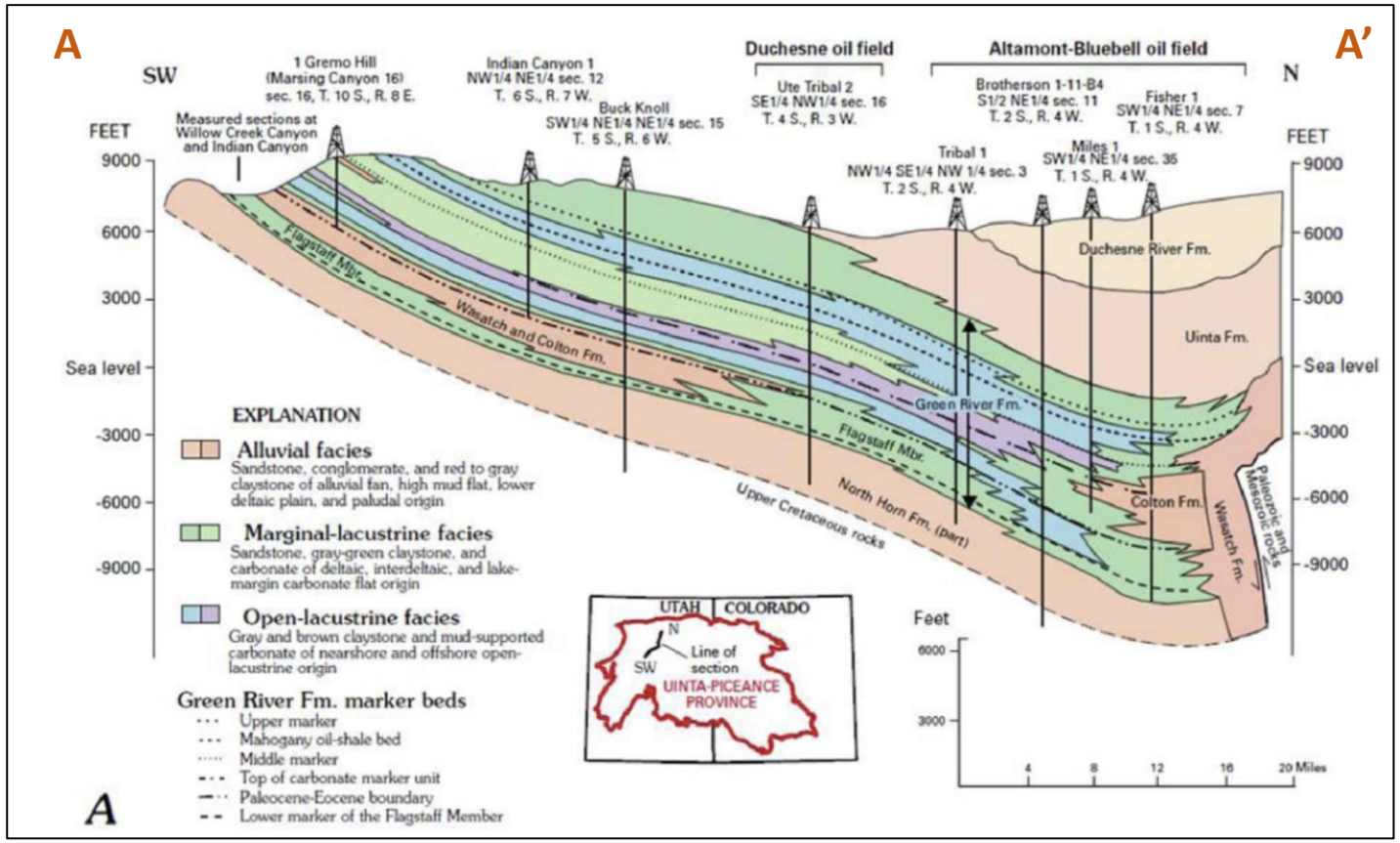
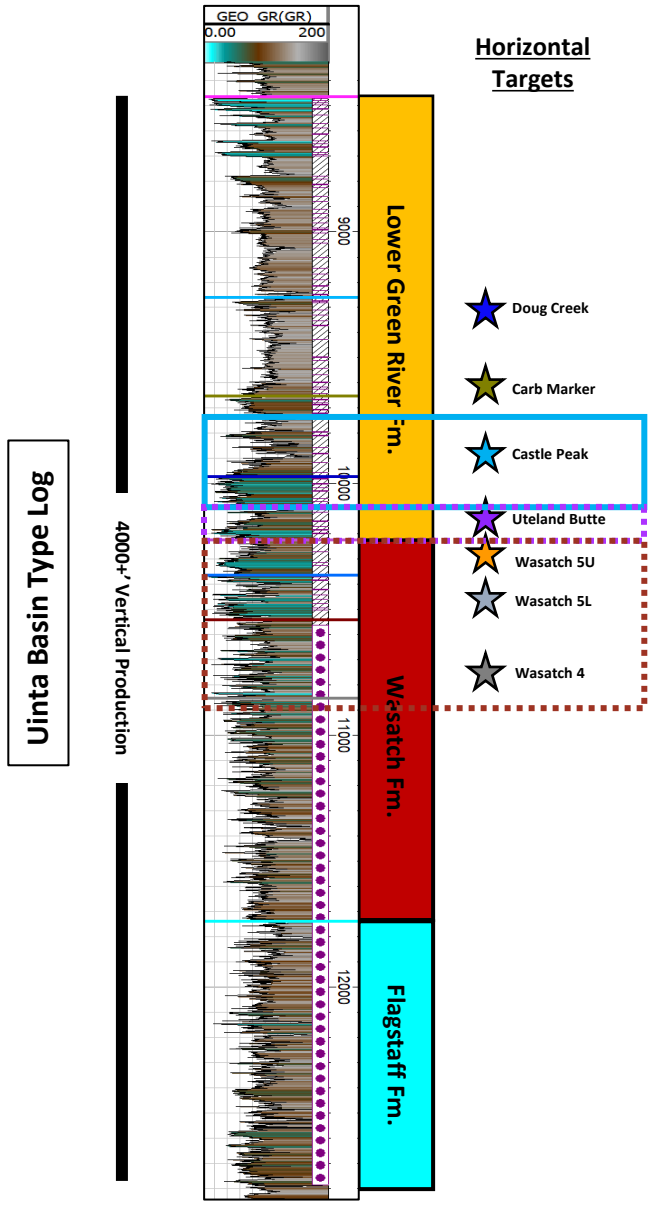


Modified from Schamel, 2015
See also Ryder et al, 1975

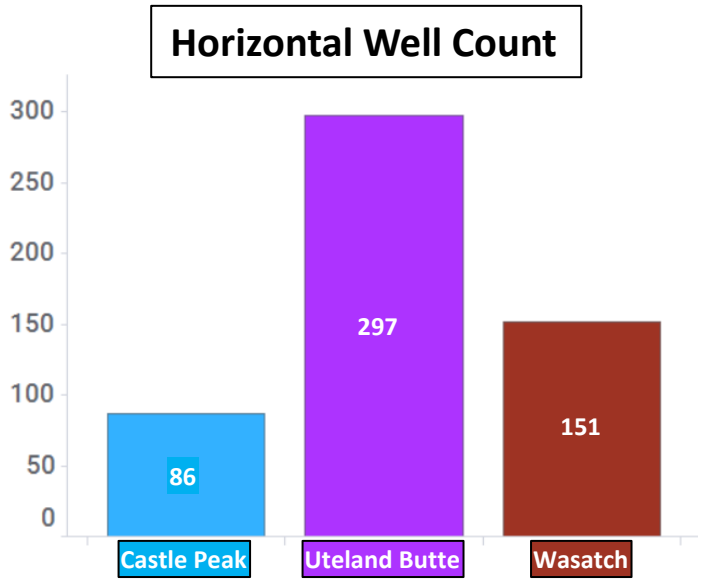
- Asymmetric basin geometry with thickest deposits south of the Uinta Mountains
- **Terminology note**: "Wasatch" will be used to refer to all deposits above the Flagstaff and below the Green River Fm

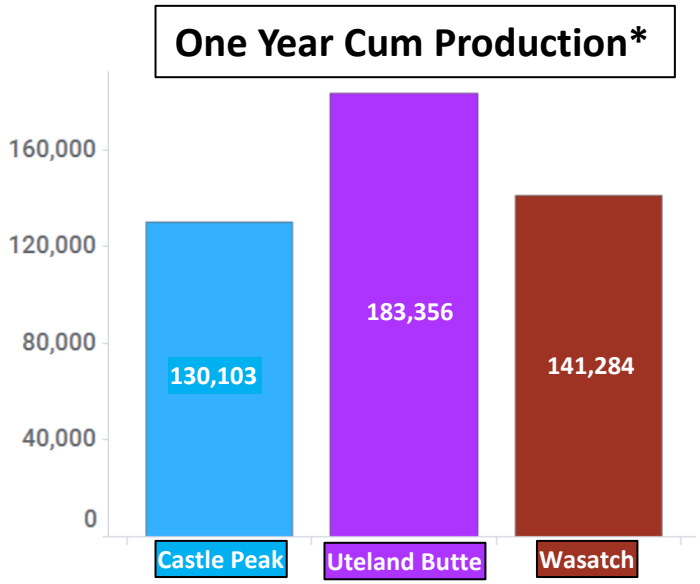
Uinta Basin Horizontal Production

It's Not Just the Uteland Butte



- Stable Eocene lacustrine system results in multiple stacked horizontal development benches
- ~78 MMBO produced from horizontal wells in the Uinta Basin since 2012
- The horizontally-productive section of the Wasatch is 5x as thick as the Uteland Butte but has 50% fewer wells targeted in it
- The resource is present but the story is more complex than the Uteland Butte

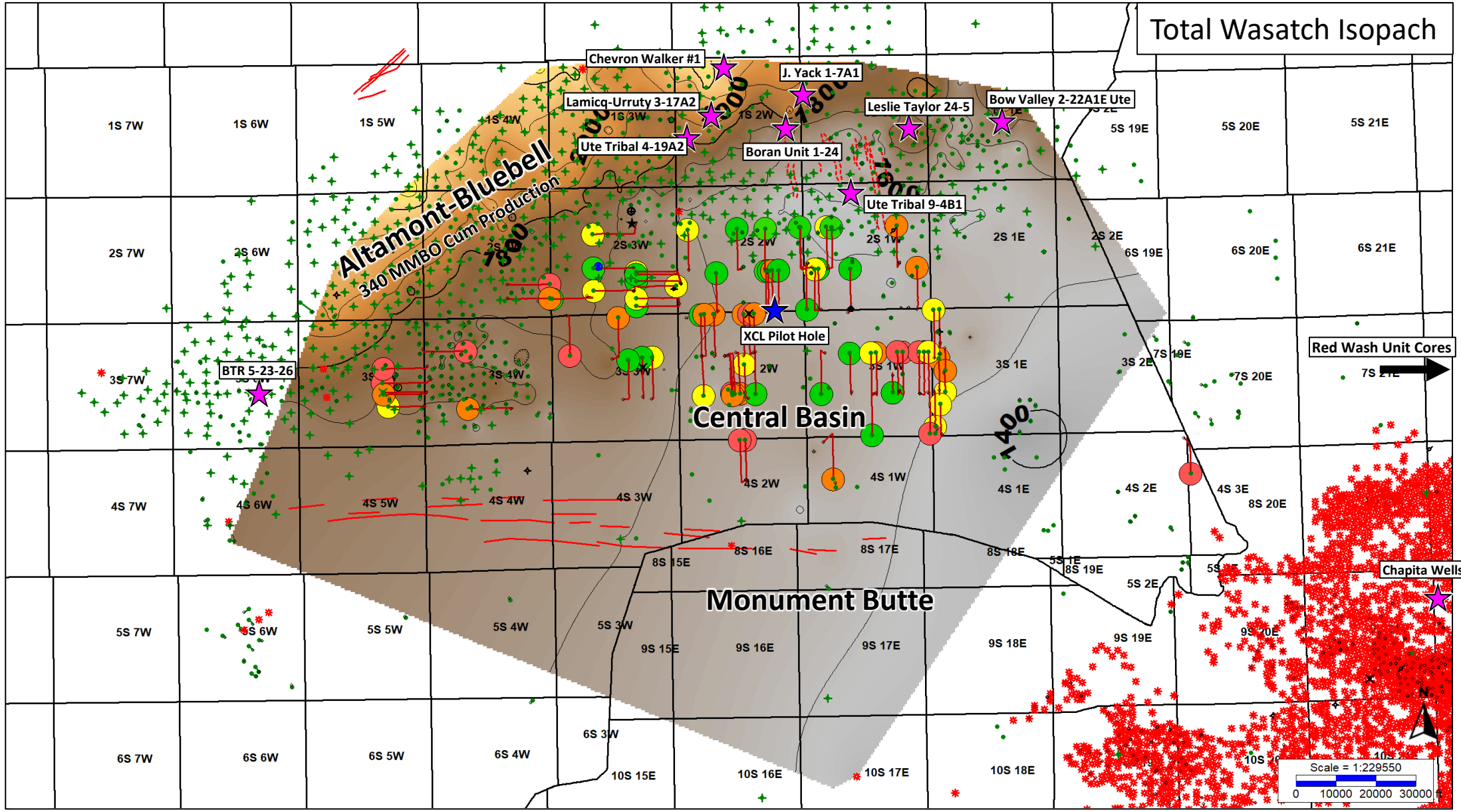




*Data Filtered to Horizontal Completions since 2018

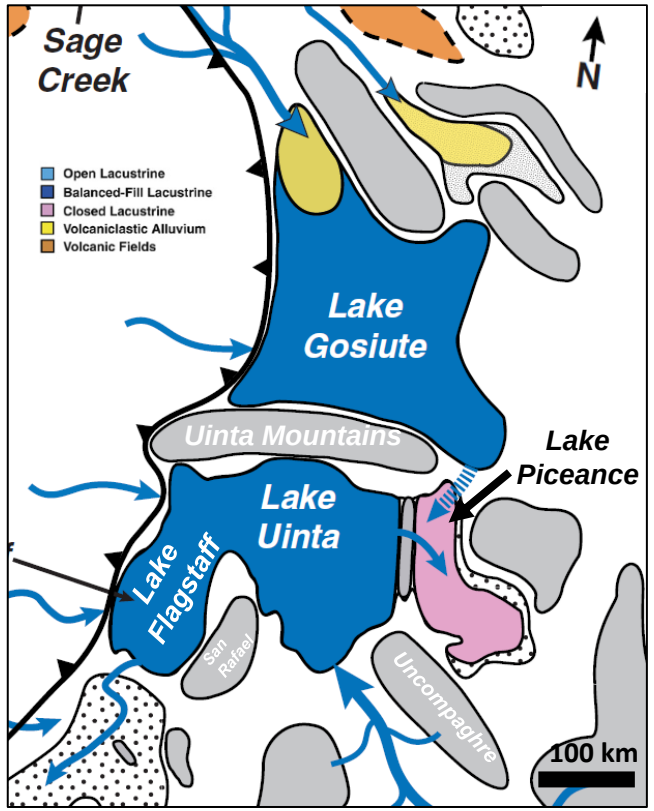
Wasatch Horizontal Production

10,000’ Laterals with 12 Months of Production



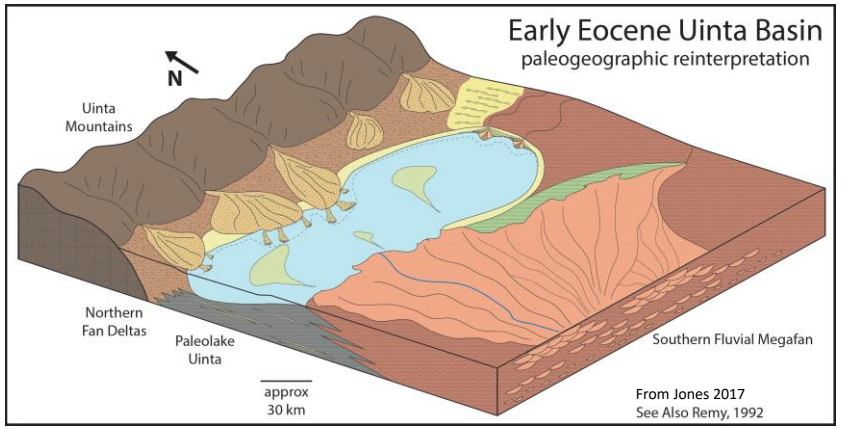
Uinta Basin Lake Evolution

Flagstaff

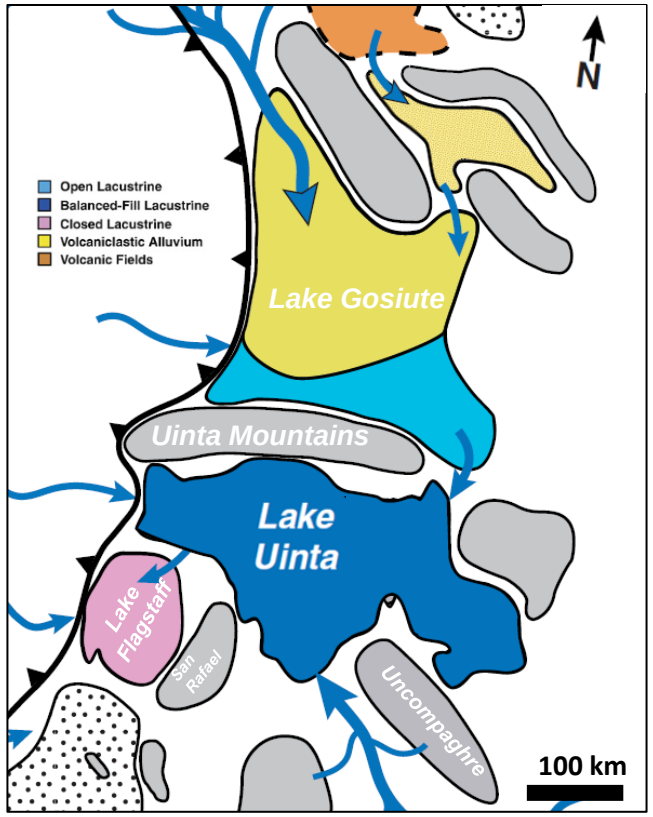


Modified from Davis et al 2009

Wasatch



Lower Green River

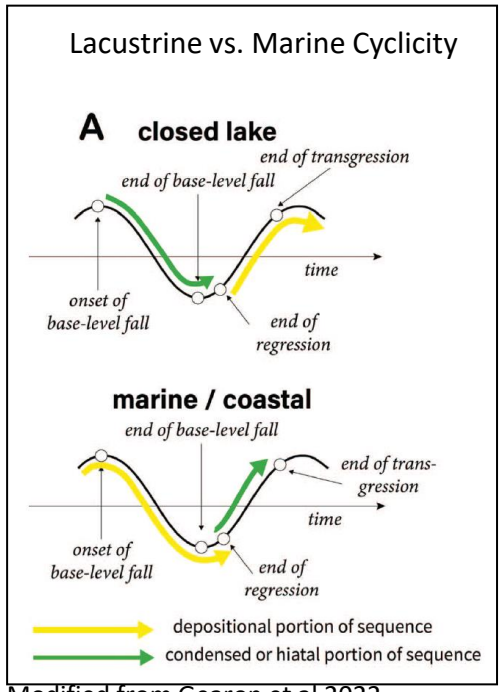


Modified from Davis et al 2009

- The Uinta Basin hosted large, relatively stable lakes during the time of deposition of the Flagstaff and Lower Green River Formations
- The Wasatch Formation was deposited during the Paleocene-Eocene Thermal Maximum
  - The environment was more arid overall with stronger storms and monsoons
  - Lake Uinta was smaller with more varied depositional environments during this time

Supply-Generated Sequence Stratigraphy

- **Key Point:** In lacustrine environments, sediment supply is directly related to water influx and deposition predominantly occurs during transgressions and highstands
- Gearon et al (2022) describes an idealized supply-generated sequence using outcrops of the middle Green River Formation
- Previous authors (Gall et al 2017, Birgenheier 2020) have demonstrated a link between climate and depositional facies in the Green River



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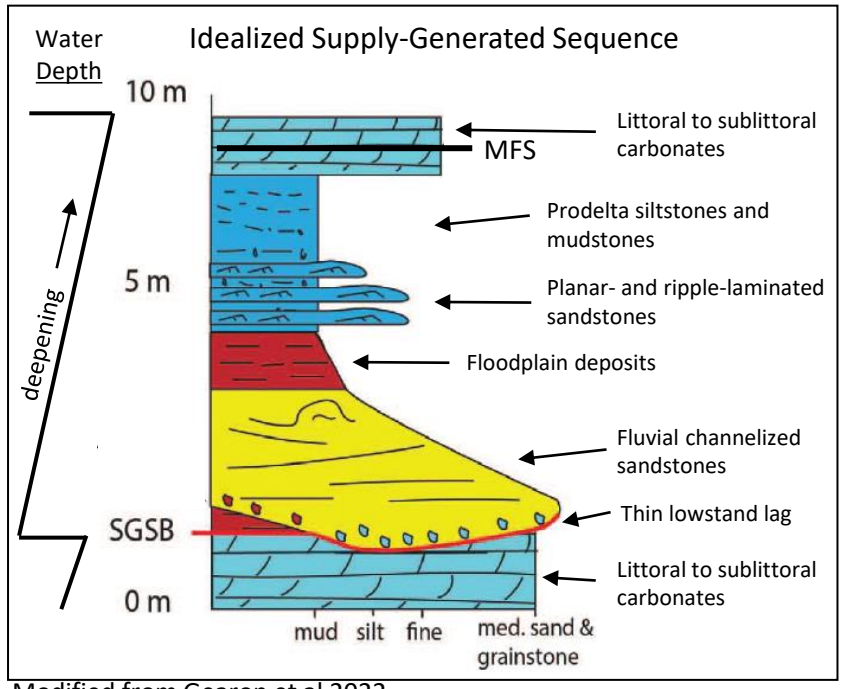

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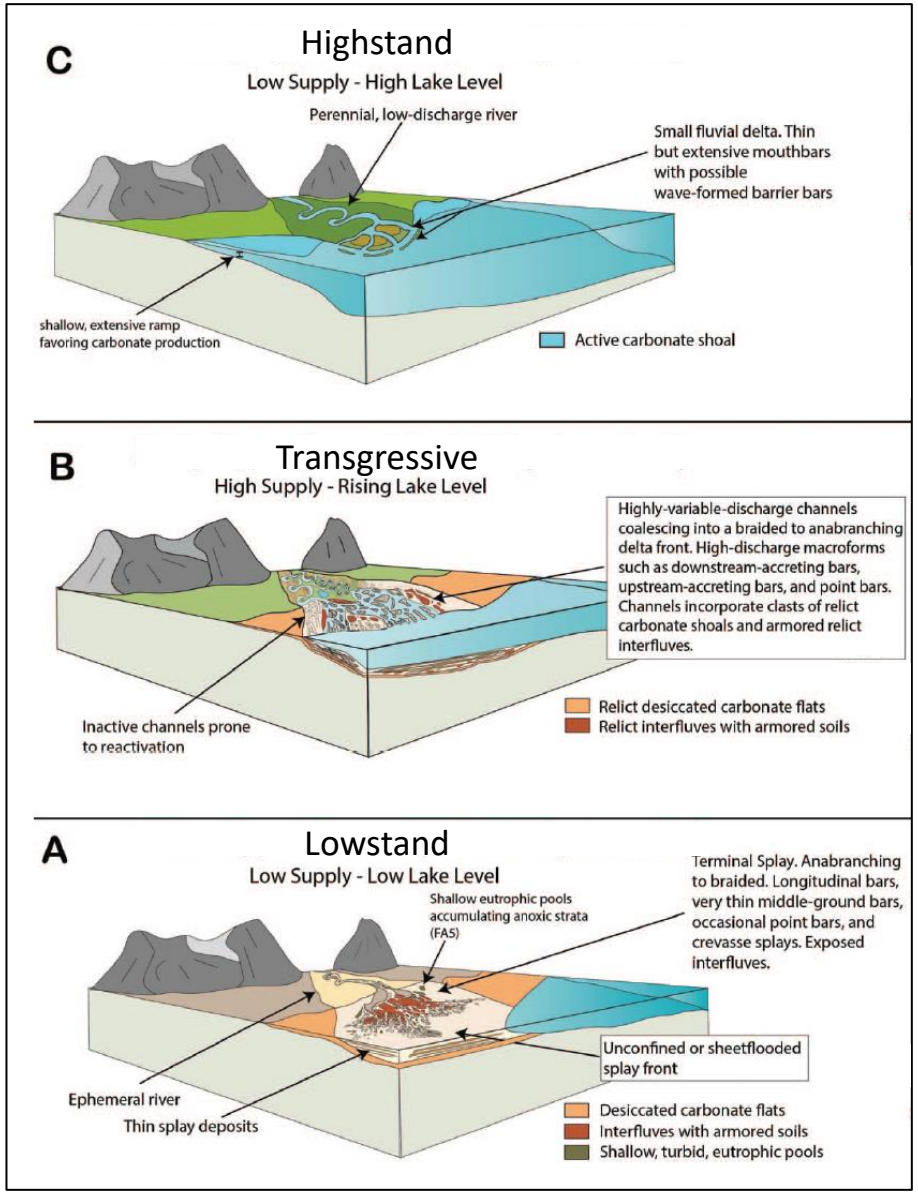


Modified from Gearon et al 2022

Wasatch in Outcrop

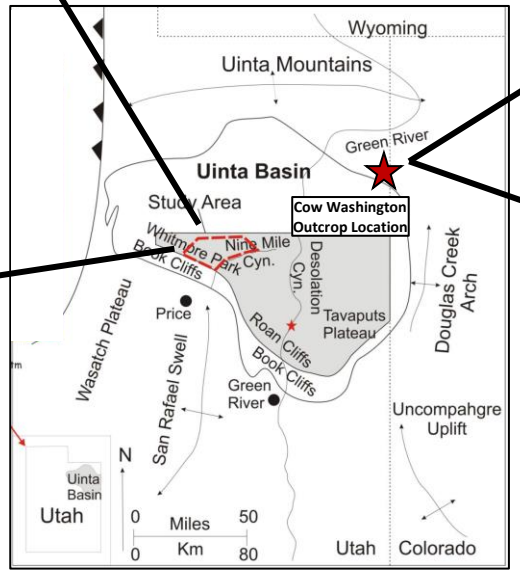
Stacked Wasatch Channel Sands
Fluvial-Deltaic Environment

Thin Amalgamated Wasatch Channel
Well-Drained Floodplain Environment

Southern Basin Margin

Paleosol with root casts

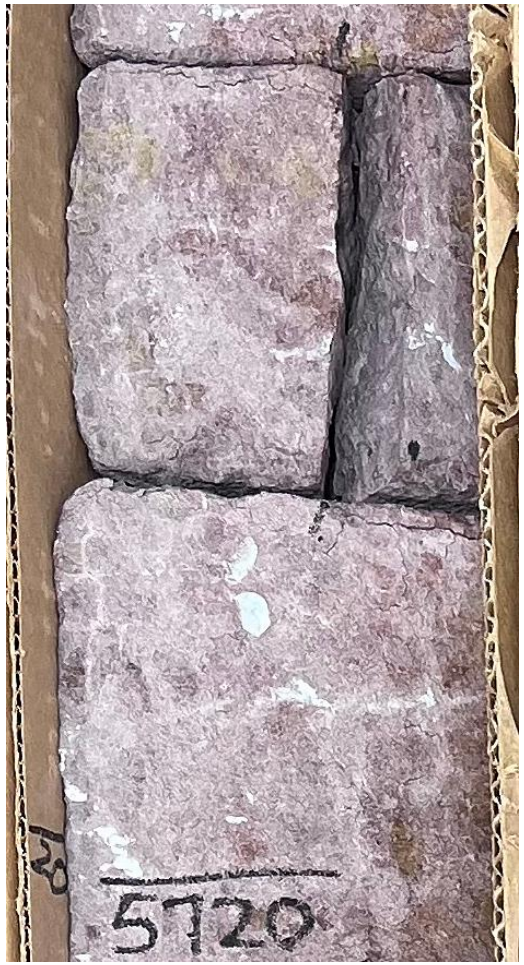
From Plink-Bjorklund 2010



Northern Basin Margin

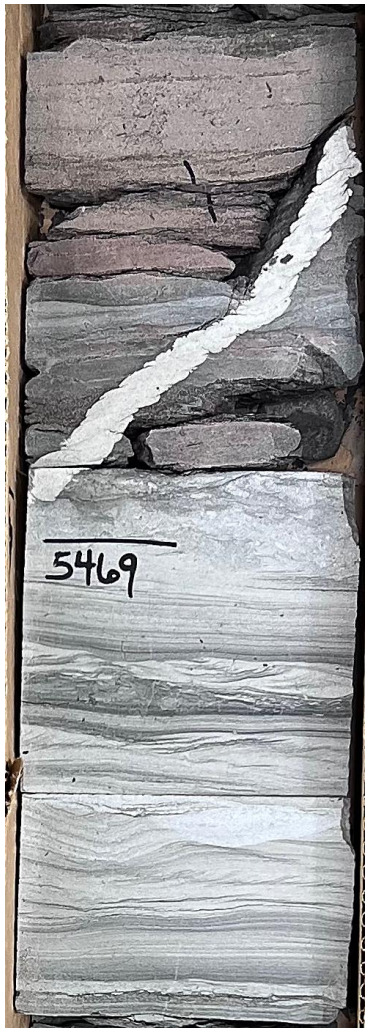
Facies Examples in Core

Subaerial and Shallow Water



Red beds
Red Wash 24-27B
5720’

Medium to coarse-grained sandstone
Chevron Walker #1
11908’



Rippled sands overlain by burrowed ostracod grainstone
Red Wash 42-23B
5469’

Ostracod grainstone
Red Wash 42-23B
5657’

Additional Facies References
Birgenheier et al 2019
Gall et al 2022
Gearon et al 2022
Pommer et al 2023
Tanavsuu-Milkeviciene et al 2017

Facies Examples in Core

Moderate to Deep Water

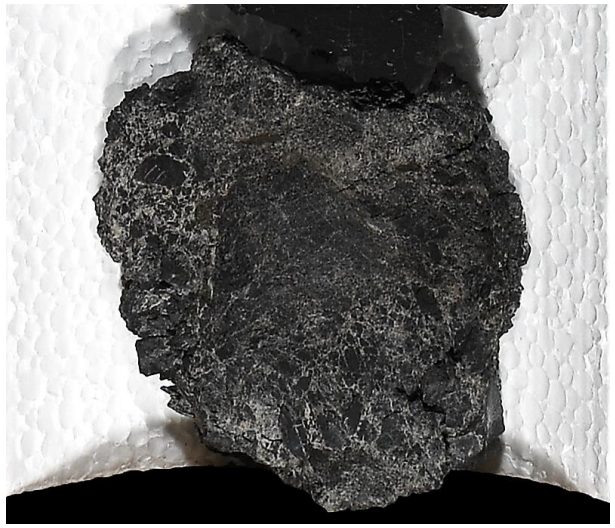
Massive medium-grained salt & pepper sandstone
XCL Pilot Hole
10085’

Bioturbated fine-grained sandstone
BTR 5-23-36
9016.5’

Bioturbated dark grey calcareous mudstone
XCL Pilot Hole
10085’

Black shale with slickensides
Lamicq-Urruty 3-17A2
13666’

Fossiliferous packstone
Lamicq-Urruty 3-17A2
13649’

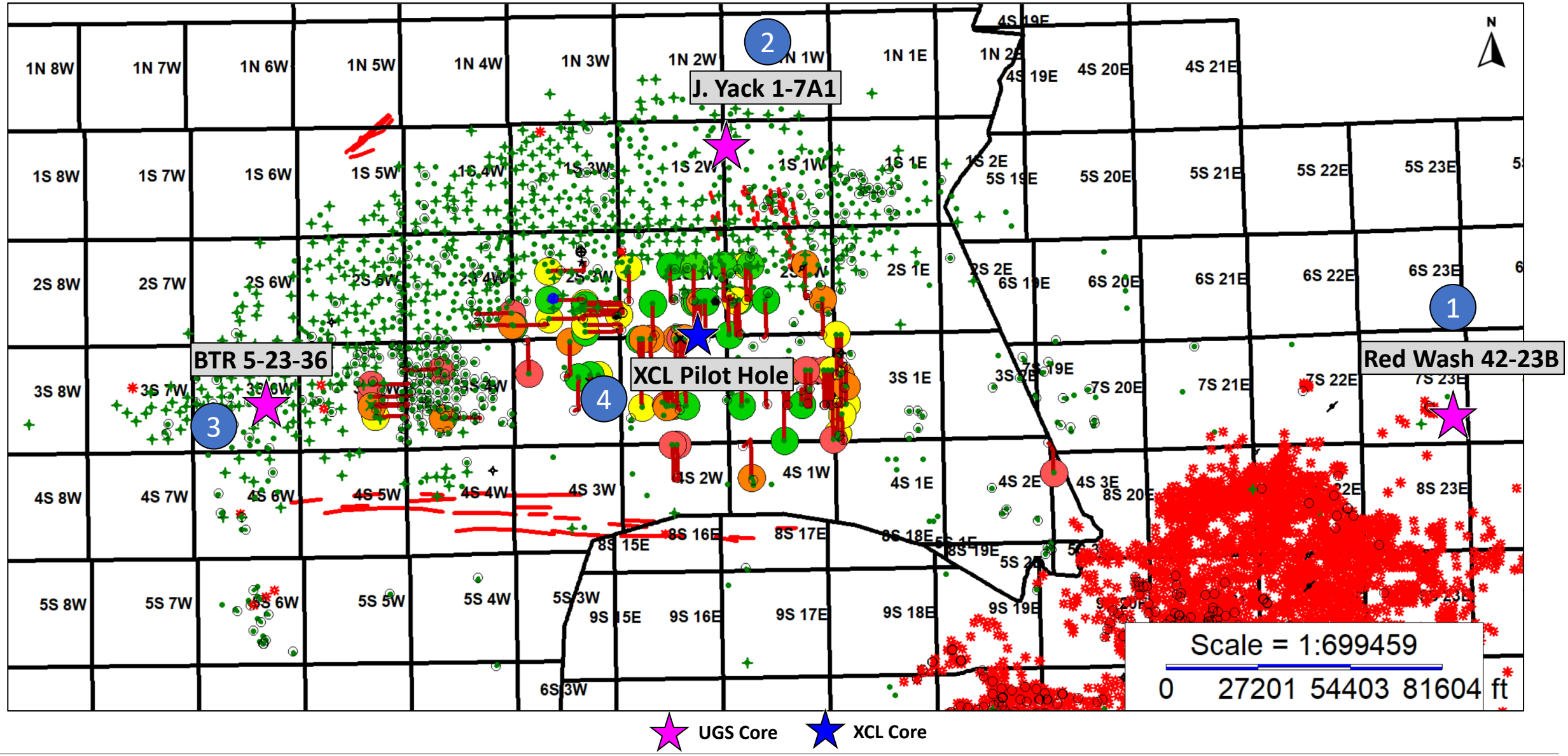


Brecciated calcareous mudstone conglomerate
XCL Pilot Hole
10095.8’

Proposed Analog & Origin

Slab of paraconglomerate with lime mudstone clasts in shaly lime mud matrix interpreted to be caused by storm reworking (Markello & Read, 1981, see also Wang et al 2019))

Detailed Core Study Locator Map



Shallow Lake Stacking Pattern

Red Wash 42-23B

- Red Wash 43-23B records a transgressive depositional package over 14’ of core
- Coarse breccia lag deposit→ fine bioturbated sand → medium-grained sand with inclined foresets and soft-sediment deformation → coarse oil-stained sand → brecciated lag deposit
- **Interpretation:**
  - Brecciated intervals at base and top of sequence represent depositional hiatuses and subsequent scours from water influx
  - Overall coarsening-upward package of sand indicates progradation of fluvial-deltaics into a shallow lake
  - Abundant sedimentary structures and rapid loading features indicate rapid deposition into a proximal environment

Interpreted top of sequence

Lowstand lag/hiatus

Marginal Lake Stacking Pattern

J. Yack 1-7A1

- J. Yack 1-7A1 in northern Bluebell/Altamont records a transgressive depositional package over 14’ of core
- Brecciated calcareous fine-grained sand → med- to coarse-grained sand → fine-grained greenish sand → brecciated interval
- **Interpretation:**
  - Brecciated intervals at base and top of sequence represent depositional hiatuses
  - Coarser white and cream-colored sands represent progradation of sands into lake
  - Fine-grained green sands represent well-drained floodplain deposits in back delta area

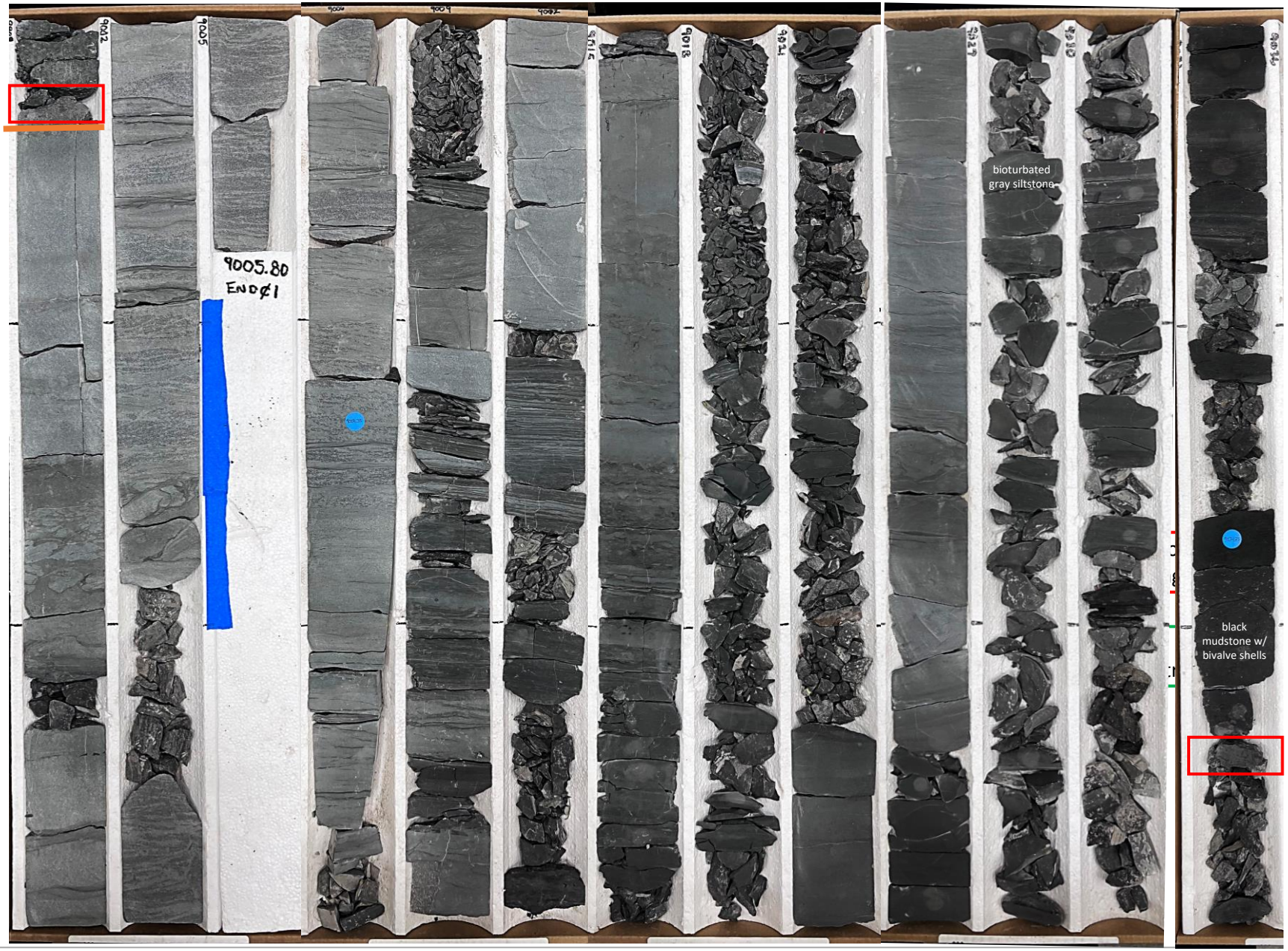
Interpreted top of sequence

Lowstand lag/hiatus

Moderately Deep Lake Stacking Pattern

BTR 5-23-36 Core

- BTR 5-23-36 in southwestern Altamont records a transgressive depositional package over 24’ of core
- Brecciated black calcareous mudstone→ black fossiliferous calcareous mudstone → gray bioturbated siltstone → very fine-grained rippled sand → fine to medium-grained sand
- **Interpretation:**
  - Brecciated interval at base records a depositional hiatus
  - Black fossiliferous mudstone represents initial flooding event, lake depth shallow enough for macro-organisms to live
  - Siltstone records introduction of more clastics into lake with plenty of biologic activity to bioturbated sediments
  - Fine-grained rippled sands and fine- to medium-grained sands indicate progradation of delta front to this area
- Additional brecciated hiatal events may be present in rubbleized sections of core



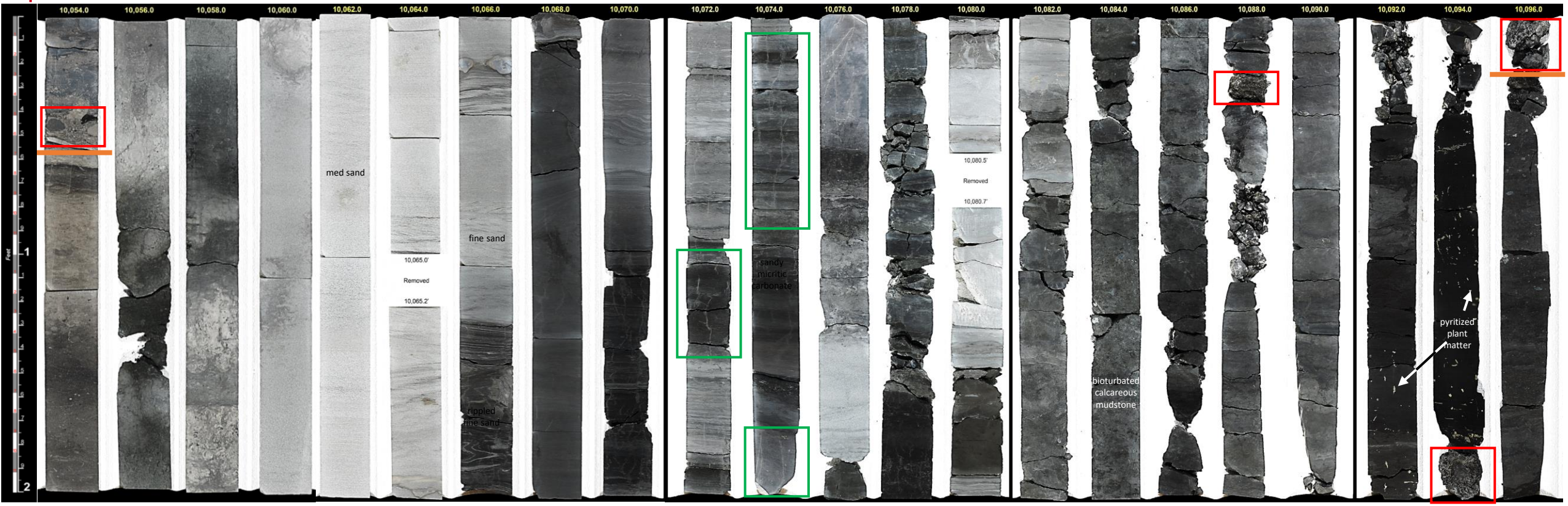
Interpreted top of sequence

Lowstand lag/hiatus

Deep Lake Stacking Pattern

XCL Pilot Hole Core

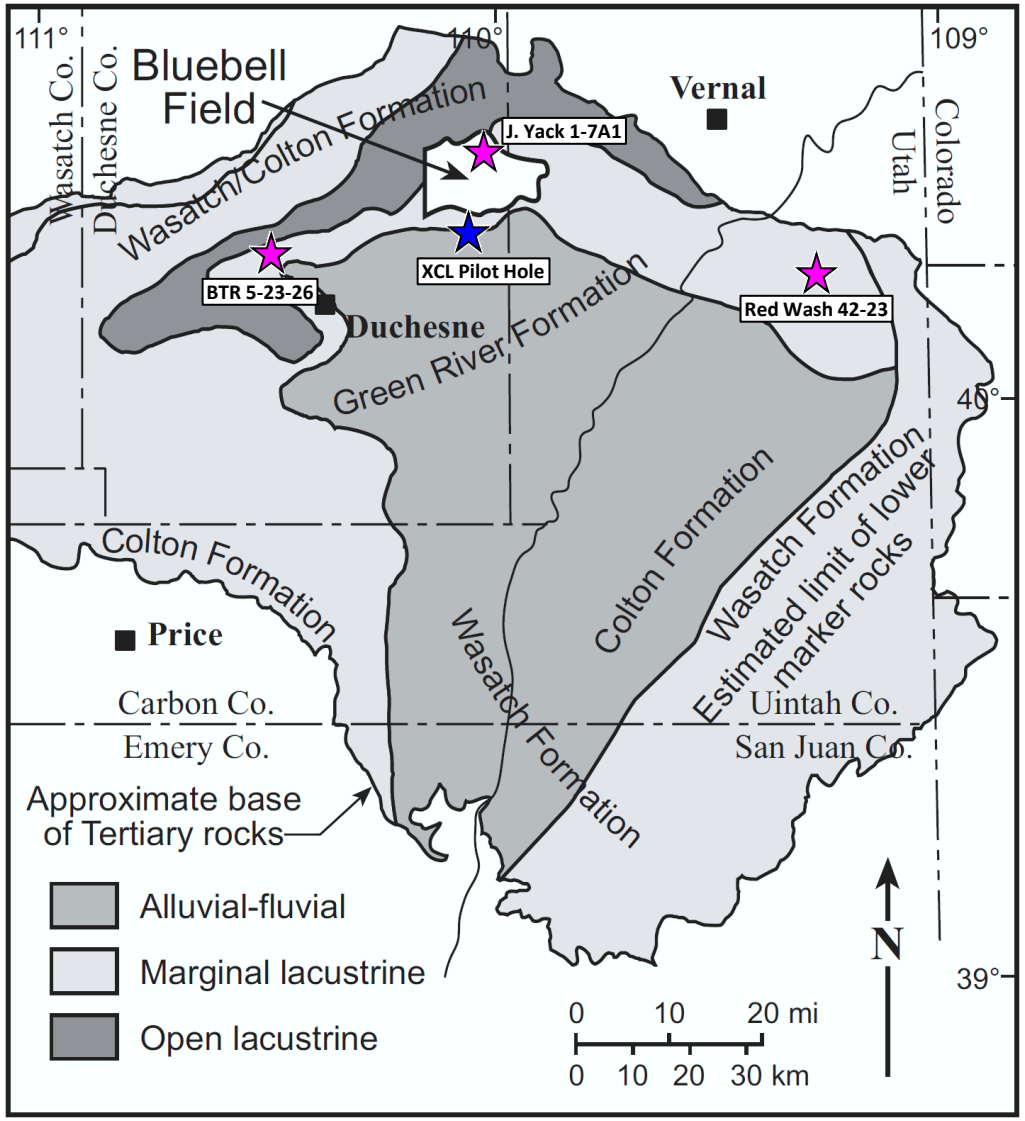
Lowstand lag/hiatus | Root structures | Interpreted top of sequence



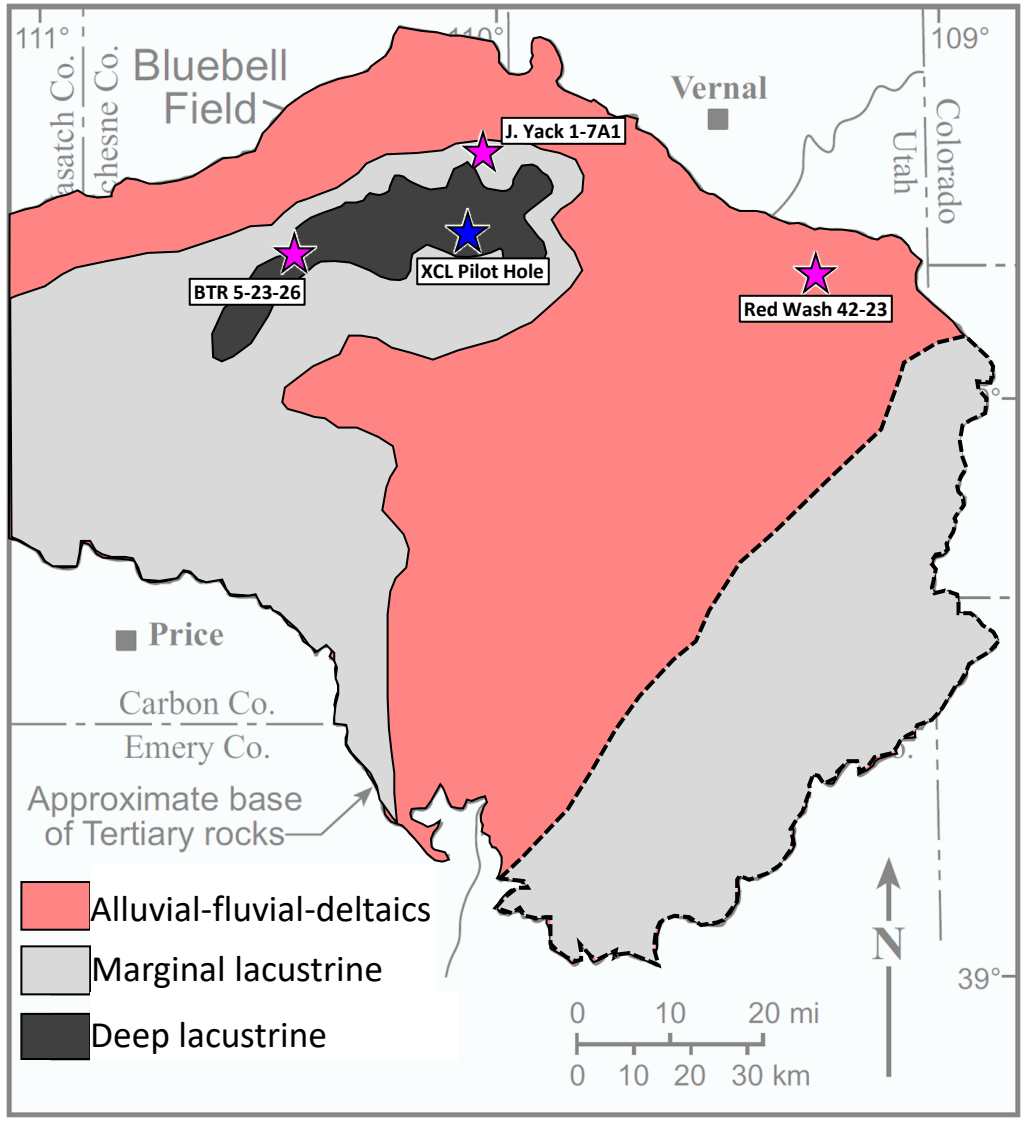
- XCL's pilot hole core records a transgressive progradational package over 42'
  - Brecciated calcareous mudstone → black shale → bioturbated calcareous mudstone → thin fine-grained rippled sands → massive med-grained sand → bioturbated calcareous mudstone
  - **Interpretation:** Depositional hiatus followed by flooding event and deposition of black mudstone with terrestrial organic matter swept in from shoreline; slight shallowing into photic zone which allowed bioturbation of calcareous mudstone; fine sands start to be deposited as delta progrades; massive medium sands record max progradation; bioturbated calcareous mudstone deposited in deep lake as water and sediment supply wanes

Persistent Wasatch Lake and Deep Lake

Morgan (2003) Original Map



Revised Interpretation



Conclusions

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- The Wasatch is more than just red beds and contains a wide range of facies depending on location and depositional water depth
- The best horizontal production results are concentrated in areas of deep lake deposition, similar to the Uteland Butte
- Supply-generated sequence stratigraphic concepts are helpful in the interpretation of stacking patterns in various water depths

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