

The Relative Roles of Channel Types and Facies for Reservoir Characterization in Fluvial Tight-Gas Sands, Upper Williams Fork Formation, Piceance Basin, Colorado*

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Abstract

Fluvial sandstones in the Upper Williams Fork Fm show a variety of geometries, sedimentary facies, and amalgamation styles important for hydrocarbon production in the Piceance Basin. This study is based on measuring stratigraphic sections, acquiring outcrop gamma ray curves, and measuring lateral extent using GPS data in Rifle Gap and Coal Gulch, CO. Outcrop gamma ray logs are used for comparison with subsurface logs. Paleoflow data help correct for apparent vs. true channel width, and determine local drainage patterns. This high-resolution dataset will be integrated with a regional sequence stratigraphic and fracture dataset for a comprehensive understanding of the Upper Williams Fork Formation and the eastern Piceance Basin. Four sandbody types have been recognized: (1) single-story isolated channels, (2) laterally amalgamating channels, (3) multi-story channels, and (4) small single-story channels/crevasse splays. Sandbody types 1-3 are potential reservoirs, whereas type 4 is evaluated to be too small for economic production. Type 1 sandbodies (60% of sandbodies) are medium- to very fine-grained, structureless to cross-stratified sandstones with little-to-no muds. Type 2 (10%) consists of similar sandstones, but 0.5-1.5-m mud layers dissect the sand-rich intervals. Type 3 (20%) facies are similar to type 2. Type 4 (10%) is fine- to very fine-grained, structureless to cross-stratified and thinly laminated sandstone, with little-to-no muds. Sandstone facies variability is relatively low within the identified sandbody types, and thus less significant, compared to the channel dimensions and amalgamation style. In contrast, differences in mud distribution and architecture play a substantial role in pressure communication between sand-rich intervals within individual wellbores and adjacent wells. Stratigraphically, type 3 sandbodies are volumetrically more significant in the lower part of the section. Type 1 occurs throughout the section, but most commonly in the Middle and Upper Williams Fork. Types 2 and 4 do not have a clear relationship to stratigraphic position at the studied localities. Geographically, type 3 is more common in western part of the basin, whereas type 1 in the Rifle Gap area. This new understanding of geometry, architecture, and occurrence of sandbody types aims to help guide future drilling within Piceance fields, as well as similar fluvial, tight-gas sand plays.

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THE RELATIVE ROLES OF CHANNEL TYPES AND FACIES FOR RESERVOIR CHARACTERIZATION IN FLUVIAL TIGHT-GAS SANDS, UPPER WILLIAMS FORK FORMATION, PICEANCE BASIN, COLORADO

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21 May 2013



Geologic Setting

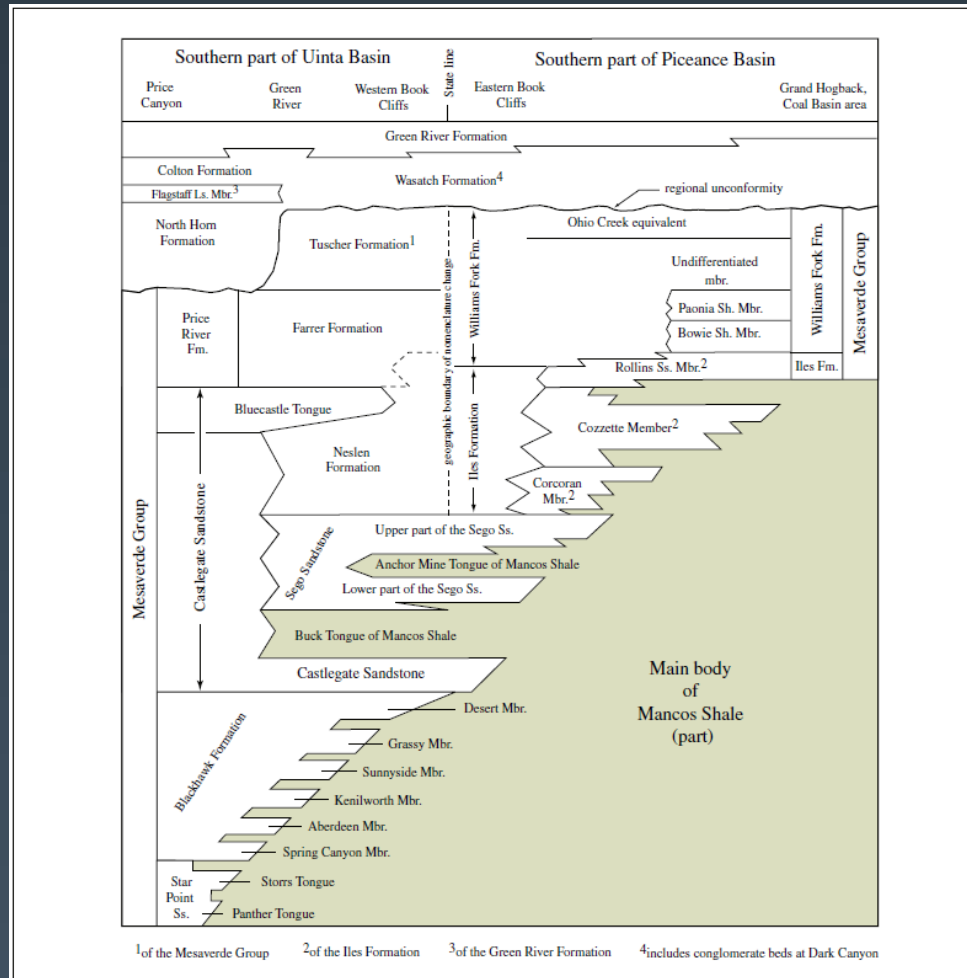
- ▶ The Williams Fork Formation (WFF) is a Late Cretaceous–age sedimentary unit consisting of:
 - Discontinuous, fluvial sandstones
 - Mudstones
 - Coals
- ▶ Depositional environment interpreted to be alluvial plain, lower coastal plain, and marginal marine



Image from Blakey (2011)

Cole and Cumella (2003); Pranter et al. (2008)

Stratigraphy



From Hettinger and Kirschbaum (2003)



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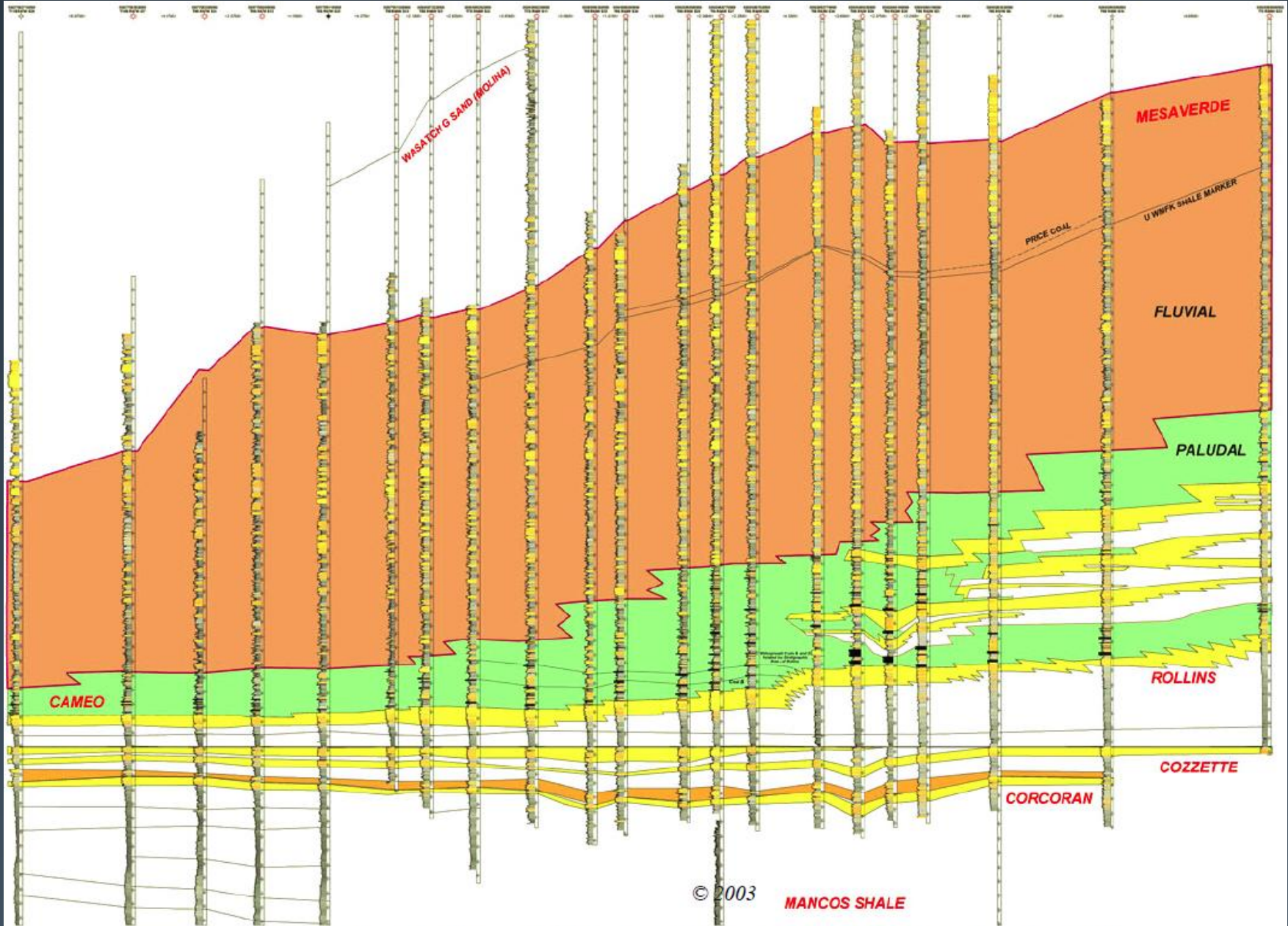
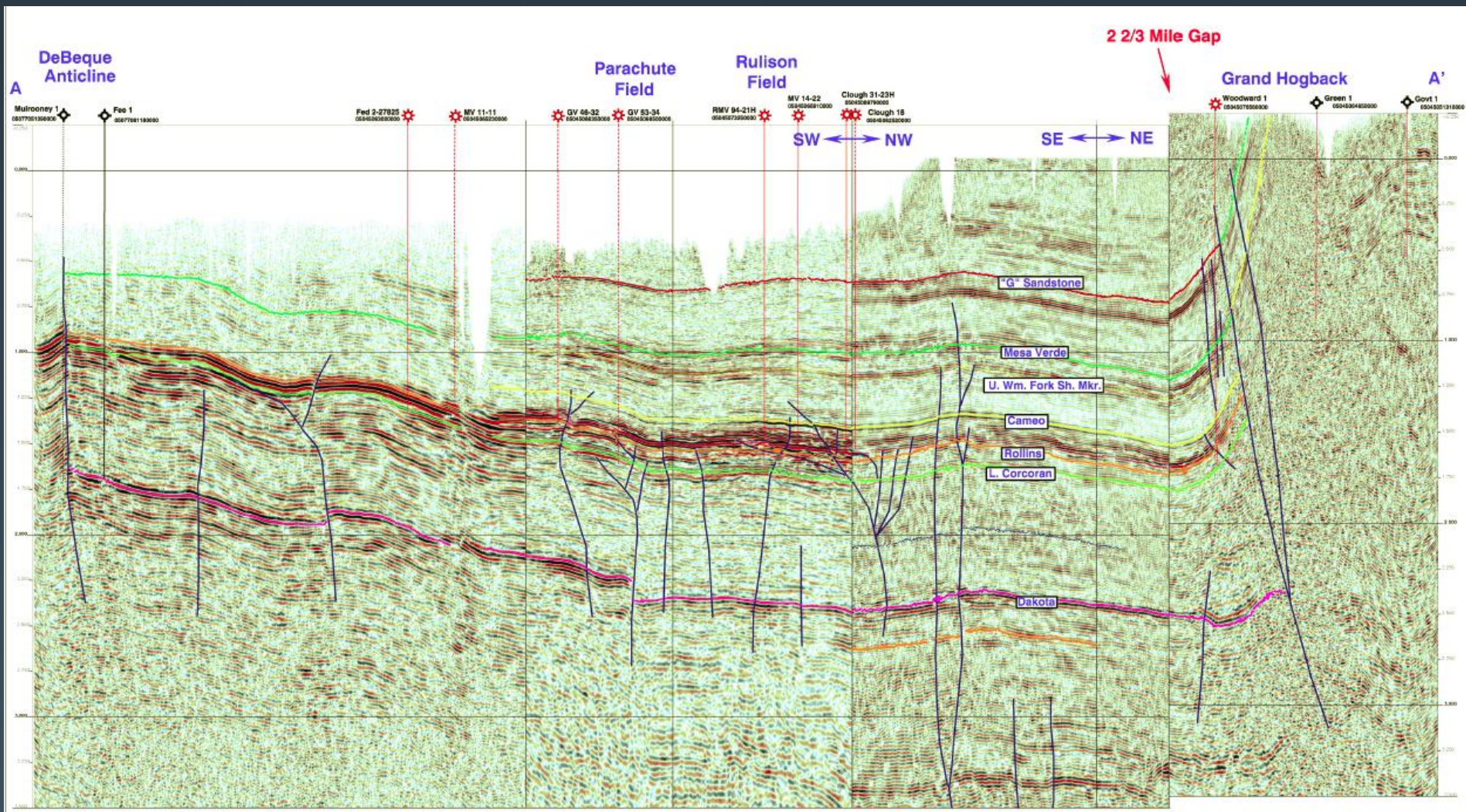


Figure 6. Regional cross section of the Mesaverde Group from Grand Mesa to the Grand Hogback. Line of Section shown on Figure 8.

From Cumella and Ostby (2003)



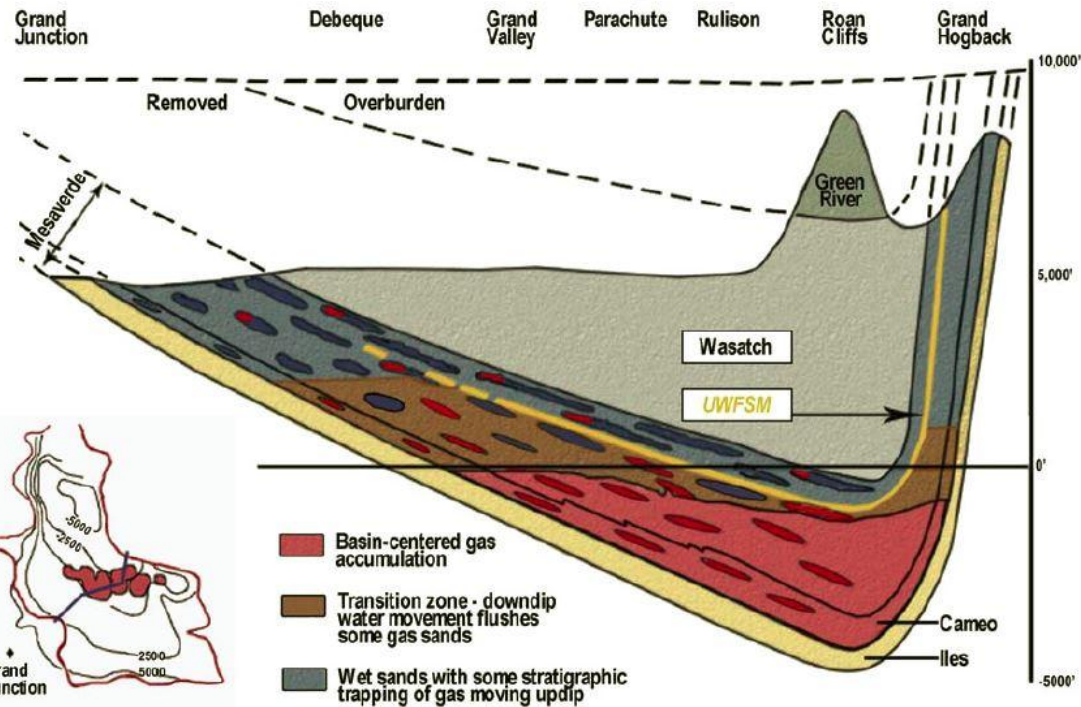
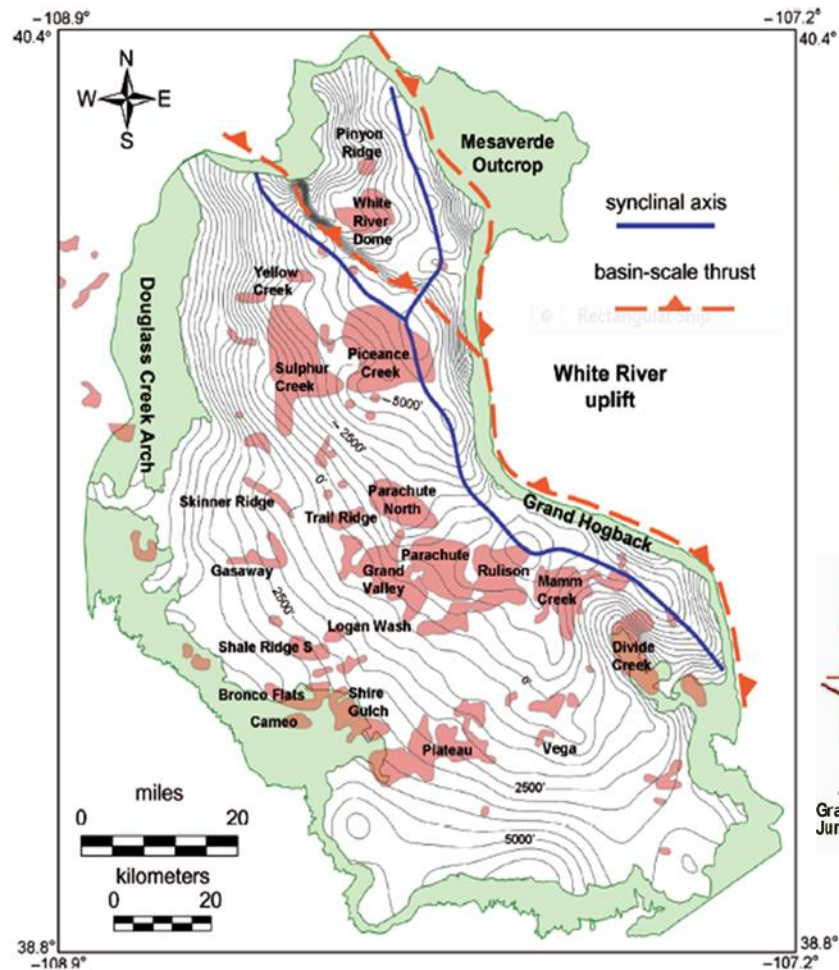
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From Cumella and Ostby (2003)



Petroleum System



From Cumella and Ostby (2003)

From Hood and Yurewicz (2008)

Previous Work

- ▶ Lorenz (1982)
- ▶ Lorenz et al. (1985)
- ▶ Hodges et al. (1981)
- ▶ Patterson et al. (2003)
- ▶ Pranter et al. (2009)

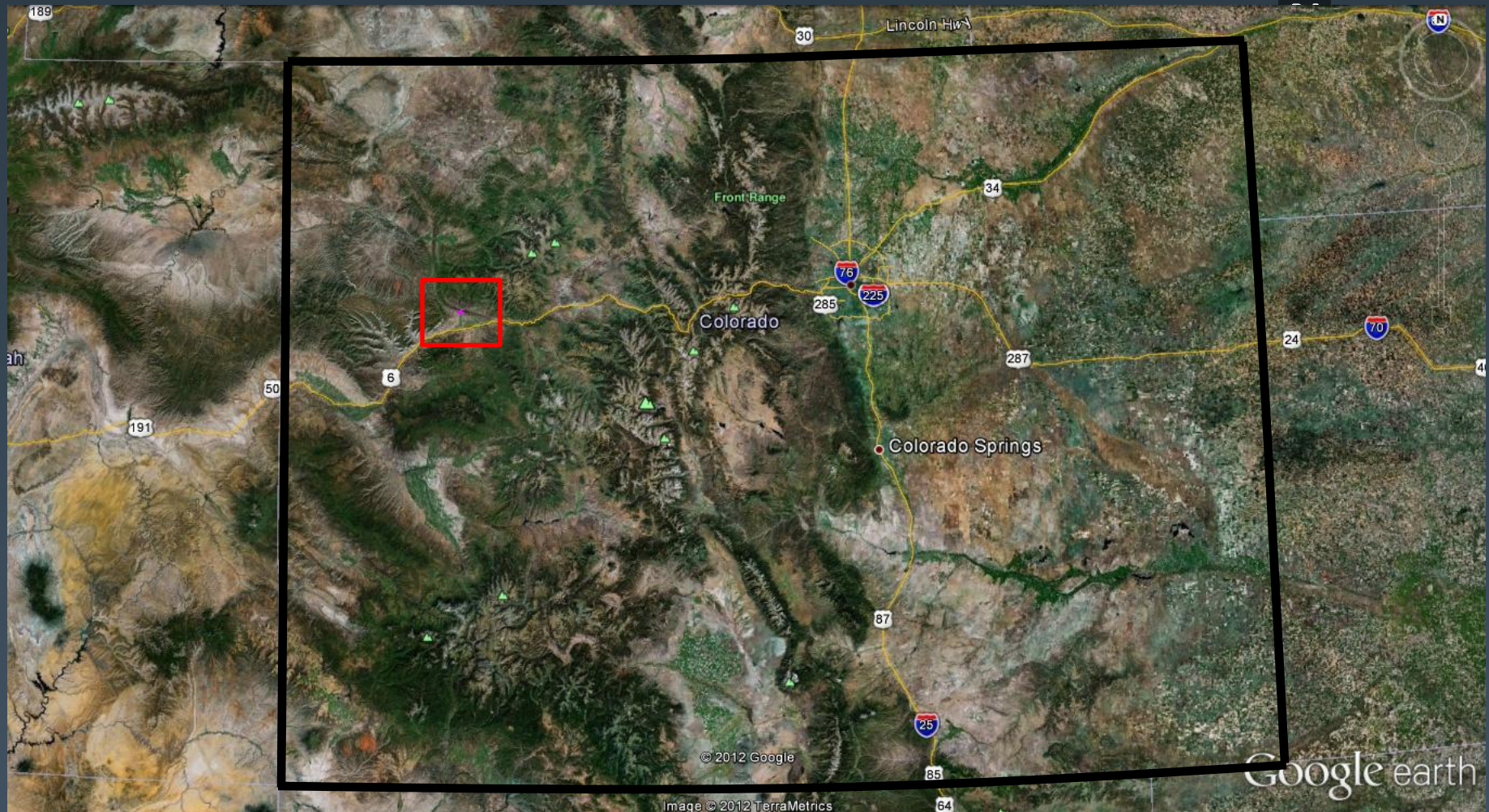


Research Focus

1. Define different types of sandbodies found along the Grand Hogback
2. Measure the geometries of these potential reservoirs
3. Determine facies types and abundance within respective sandbody types
4. Find potential barriers to reservoir production



Study Area



* Image from Google Earth



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* Image from Google Earth



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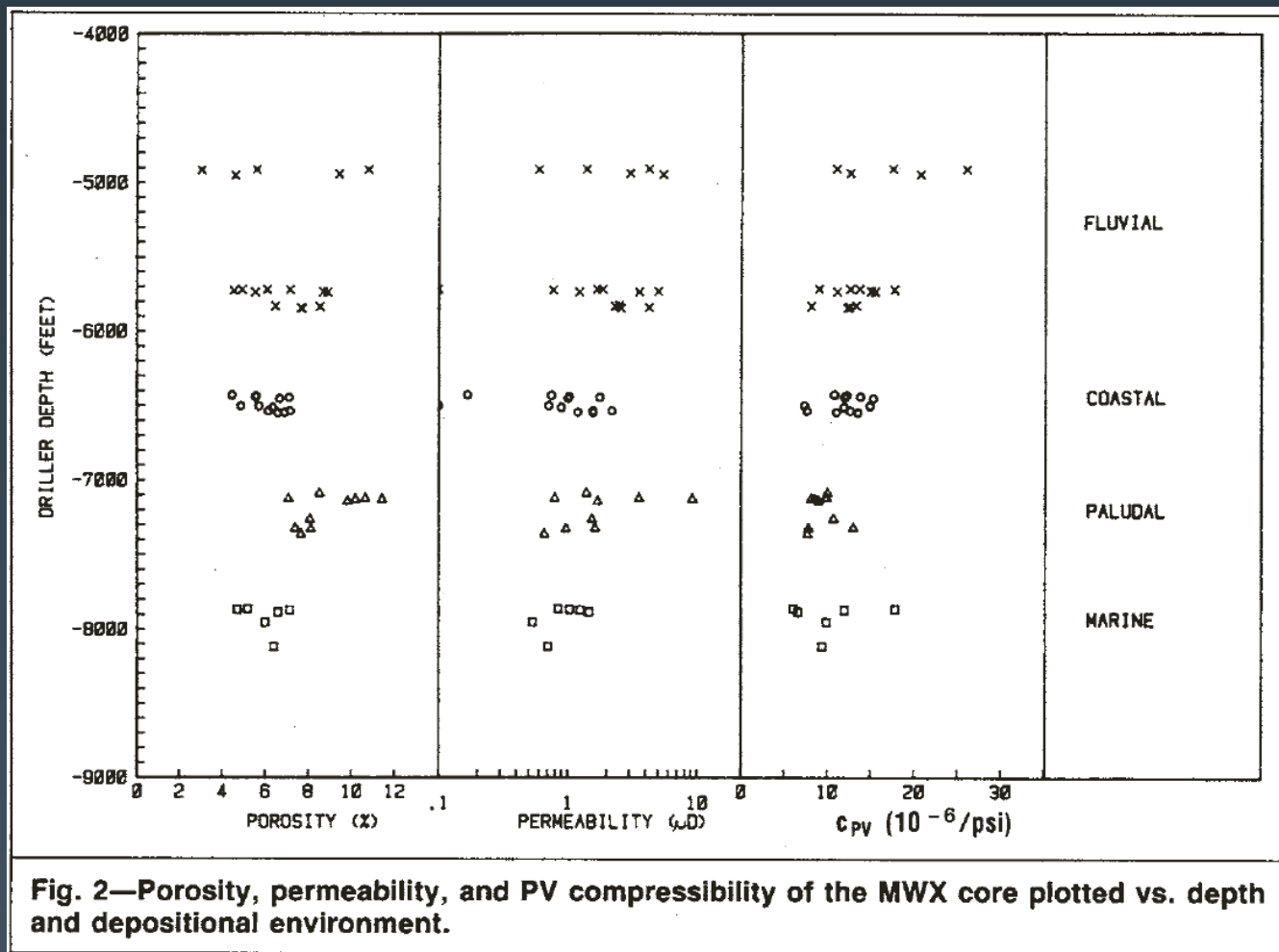
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Lithofacies

LITHOFACIES	LITHOFACIES TYPE	GRAIN SIZE	SORTING	ROUNDNESS
1	Planar-Laminated Sandstone	Upper-Fine to Lower-Medium	Moderate to Well	Sub-angular to Sub-rounded
2	Trough Cross-Laminated Sandstone	Upper-Fine to Lower-Medium	Moderate	Sub-rounded
3	Planar Cross-Laminated Sandstone	Upper-Fine to Lower-Medium	Well	Sub-rounded
4	Massive Sandstone	Upper-Fine to Lower-Medium	Well	Sub-rounded
5	Rippled Sandstone	Silt to Lower-Fine	Well to Very-Well	Rounded (?)
6	Channel-Fill Mudstone	Silt	-	-
7	Floodplain Mudstone	Silt	-	-
8	Thinly-Laminated Sandstone	Silt to Lower-Fine	Well to Very-Well	Rounded (?)

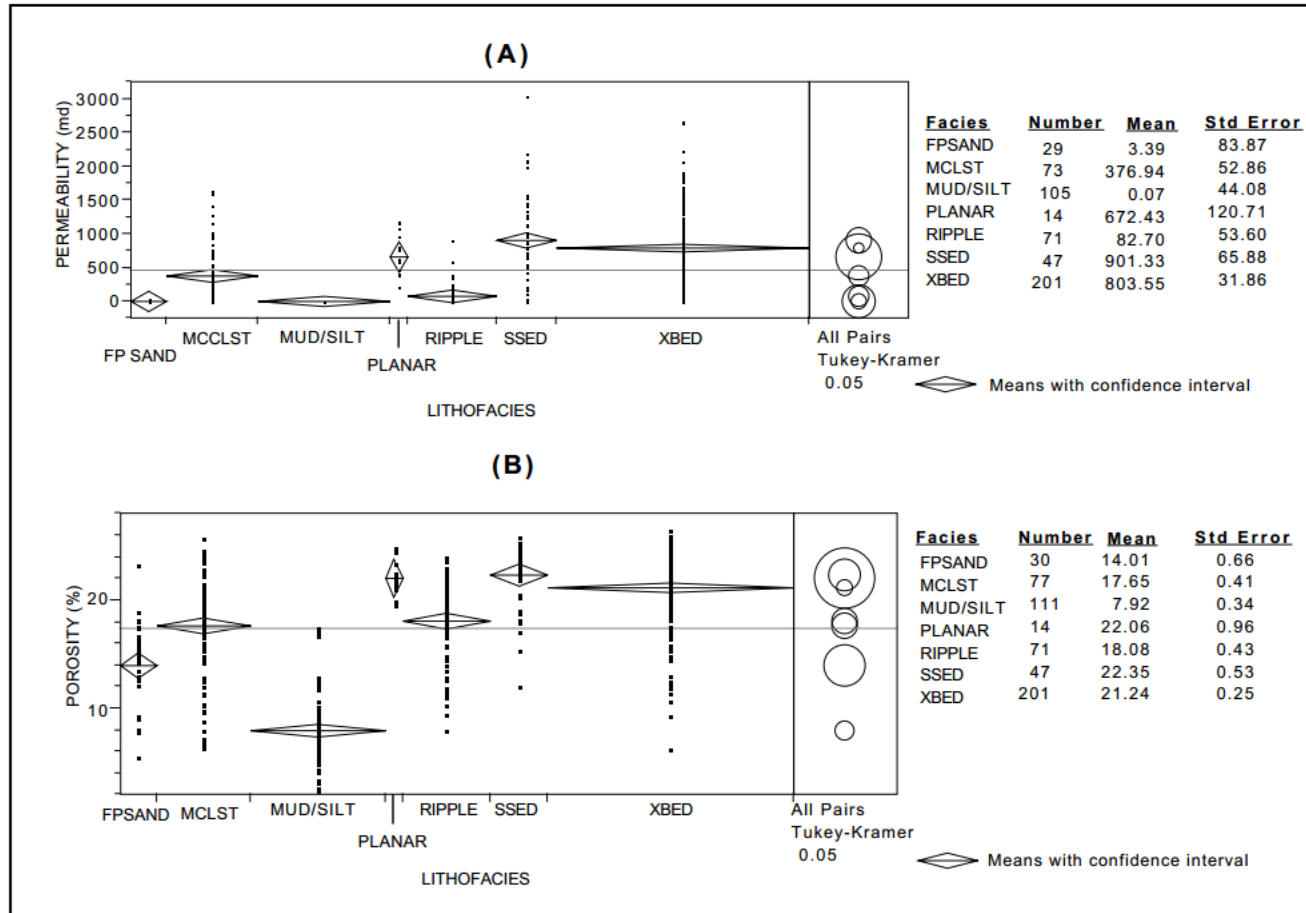


Environment & Porosity/Permeability



From Soeder and Randolph (1987)

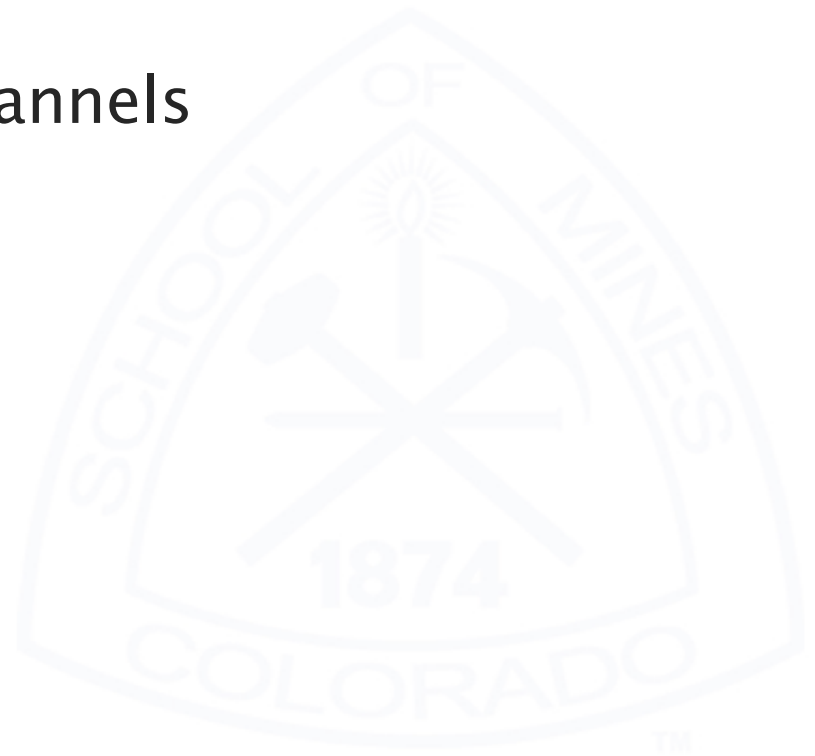
Sedimentary Structure P&P



From Doyle and Sweet (1995)

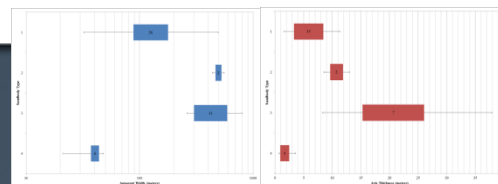
Sandbody Types

1. Single-Story, Isolated Channels
2. Laterally-Amalgamating Channels
3. Multi-Story Channels
 - i. Highest reservoir potential
4. Crevasse Channels & Splays
 - i. Lowest reservoir potential



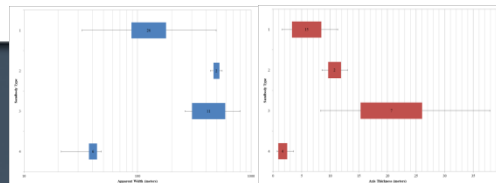
Type 1 (Single-Story, Isolated Channels)

- ▶ Occurrence = 58%
- ▶ Mean Apparent Width = 157 m
 - Range = 33 to 494 m
- ▶ Mean Axis Thickness = 6.0 m
 - Range = 1.6 to 8.5 m
- ▶ Most Abundant Facies:
 - Planar-laminated sandstone = 60%
 - Planar cross-laminated sandstone = 20%
 - Rippled sandstone = 15%
 - Little-to-no mudstones



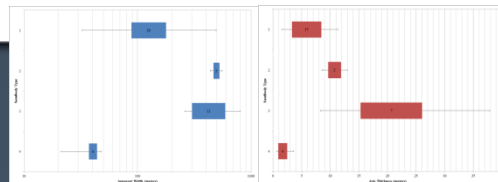
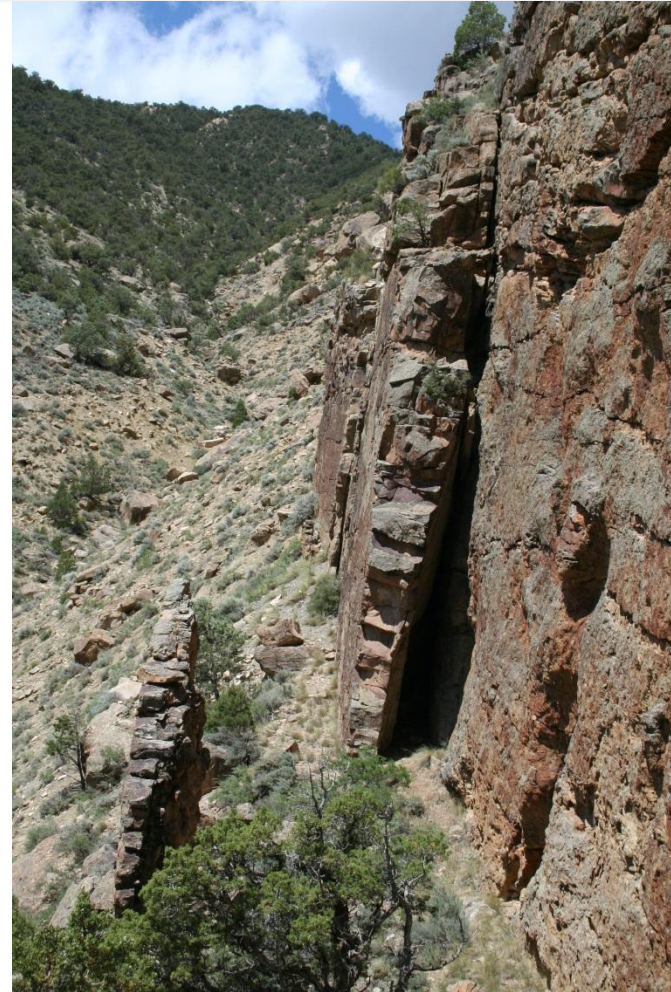
Type 2 (Laterally-Amalgamating Channels)

- ▶ Occurrence = 4 %
- ▶ Mean Apparent Width = 496 m
 - Range = 436 to 556 m
- ▶ Mean Axis Thickness = 10.8 m
 - Range = 8.5 to 13.0 m
- ▶ Most Abundant Facies:
 - Massive sandstone = 50%
 - Rippled sandstone = 35%
 - Planar-laminated sandstone = 5%
 - Mudstone/highly rippled sandstone between channels



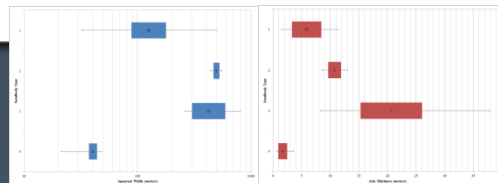
Type 3 (Multi-Story Channels)

- ▶ Occurrence = 25%
- ▶ Mean Apparent Width = 463 m
 - Range = 262 to 797 m
- ▶ Mean Axis Thickness = 21.3 m
 - Range = 8.3 to 37.9 m
- ▶ Most Abundant Facies:
 - Planar-laminated sandstone = 40%
 - Planar cross-laminated sandstone = 20%
 - Rippled sandstone = 20%
 - Mudstone/highly rippled sandstone between respective channels

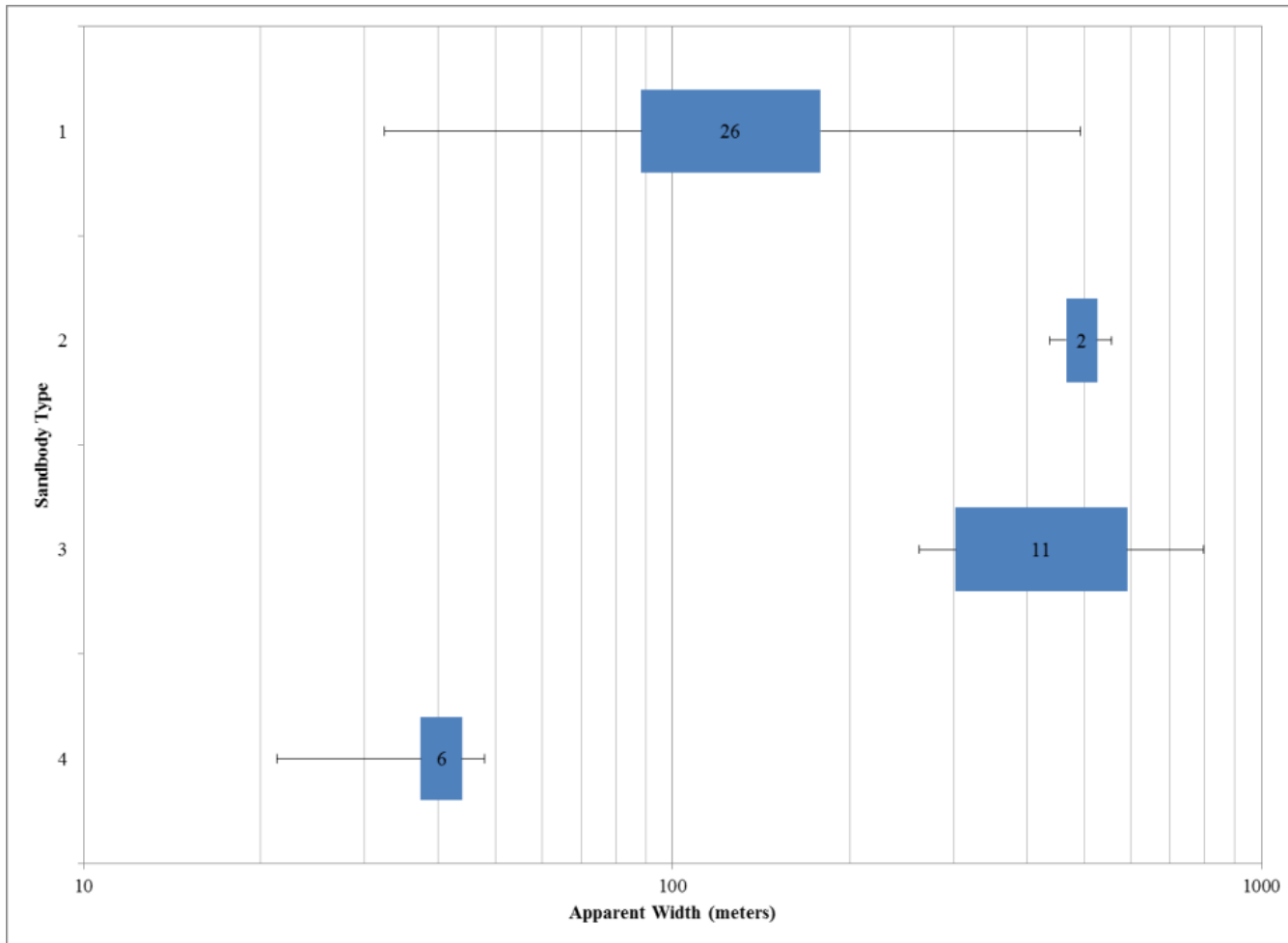


Type 4 (Crevasse Channels & Splays)

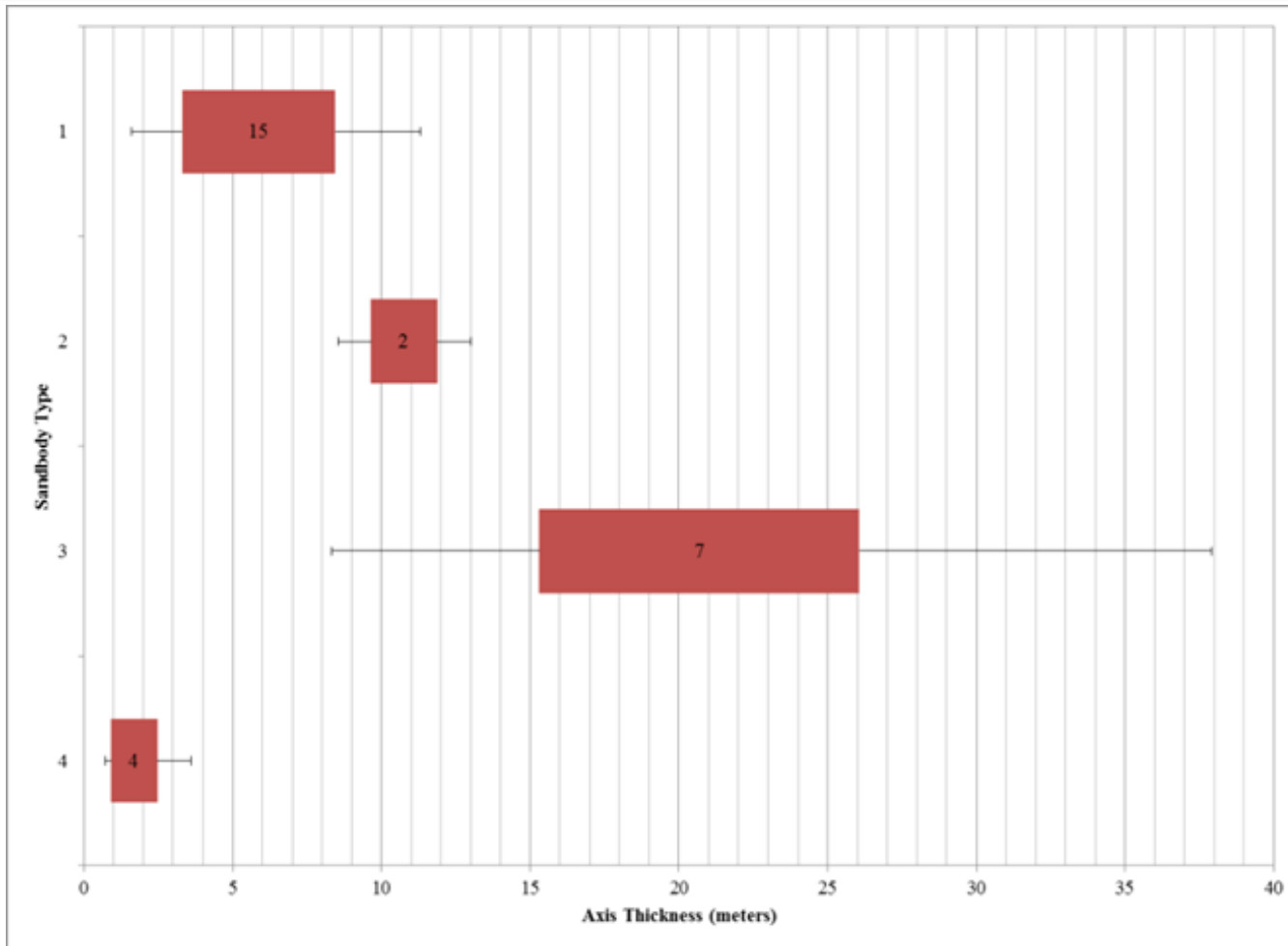
- ▶ Occurrence = 13%
- ▶ Mean Apparent Width = 38 m
 - Range = 21.3 to 48.0 m
- ▶ Mean Axis Thickness = 1.9 m
 - Range = 0.7 to 3.6 m
- ▶ Typically composed of thinly laminated or massive sandstones
 - Little-to-no mudstones

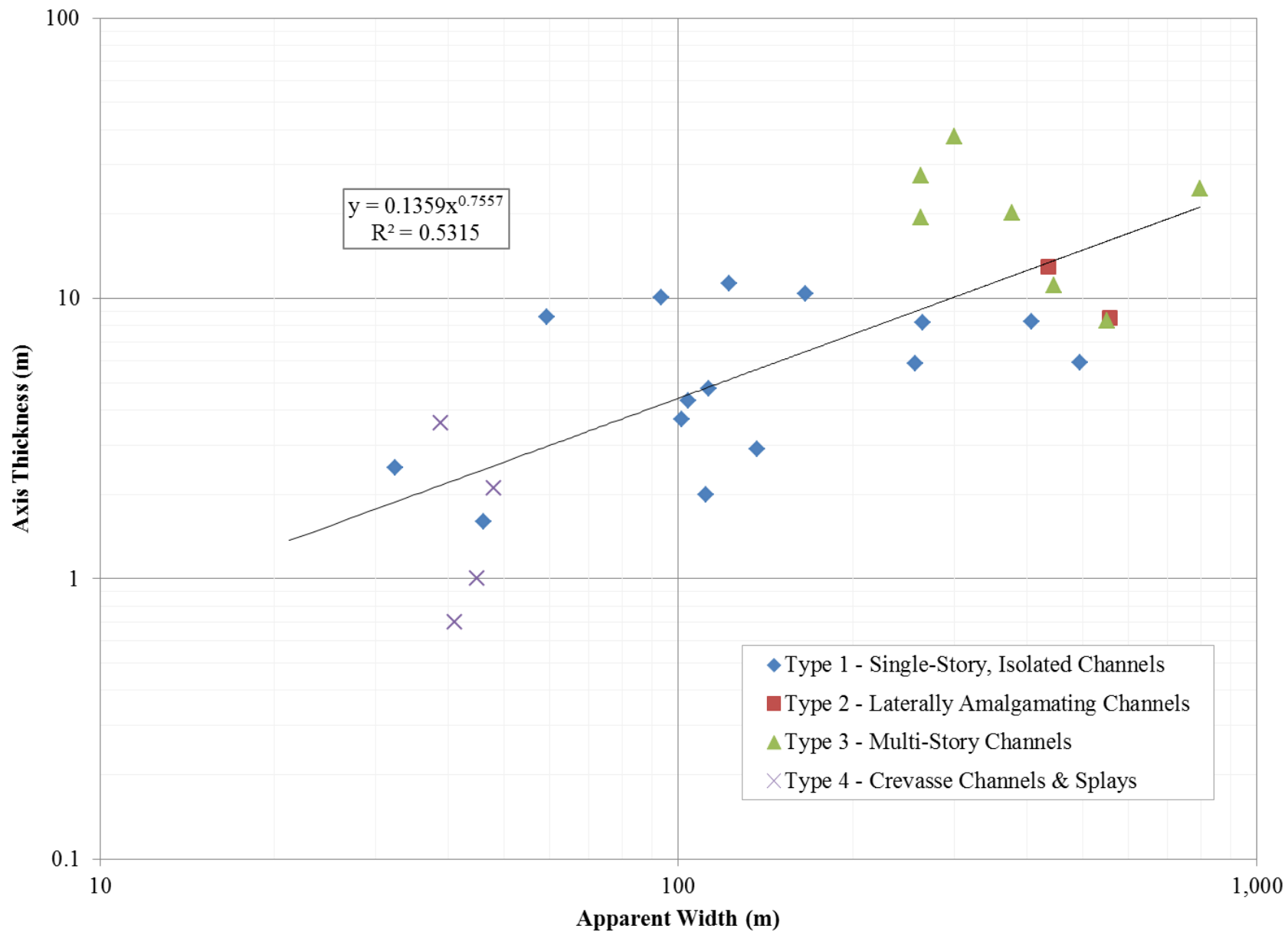


Apparent Width



Axis Thickness





Future Work

- ▶ Continue measurements in Rifle Gap
 - Stratigraphic sections
 - Outcrop Gamma Ray
- ▶ Expand field area to Meeker and New Castle



Conclusions

- ▶ Eight lithofacies used to define stratigraphic architecture
 - Based on sedimentary structures in effort to better characterize permeability within respective sandbody types
- ▶ Four sandbody types recognized in Rifle Gap based on channel architecture and geometry
 - Type 1 = Single-Story, Isolated Channels
 - Type 2 = Laterally Amalgamating Channels
 - Type 3 = Multi-Story Channels
 - Type 4 = Crevasse Channels & Splays
- Apparent relationship between geometry/lithofacies content and sandbody type



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Questions?

