Fluvial Architecture and Sequence Stratigraphy of the Burro Canyon Formation Using UAV-Based Outcrop Models, Southwestern Piceance Basin, Colorado*

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Search and Discovery Article #51640 (2020)**
Posted February 3, 2020

*Adapted from oral presentation given at 2019 AAPG Rocky Mountain Section Meeting, Cheyenne, Wyoming, September 15-18, 2019. Please see closely related article based on poster presentation, "UAV-Based Photogrammetry for Facies Architecture and Fluvial Sequence Stratigraphic Definition of the Burro Canyon Formation, Piceance Basin, Colorado", Search and Discovery article #51615.
 DOI:10.1306/51640Tellez2020

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Abstract

Well-exposed outcrops of the Lower Cretaceous Burro Canyon Formation in the southwestern Piceance Basin, Colorado, are evaluated along a 48-mile (77 km) transect for identification of depositional environments, fluvial architectures, and sequence stratigraphy. The Burro Canyon Formation in the area represents a sequence deposited unconformably over the Jurassic Morrison Formation and truncated by a regional unconformity that defines the base of the Dakota Formation. The architecture of these fluvial deposits is described using seven composed measured sections combined with eight UAV-based outcrop models, core, and well-log data. Analysis of facies, architectural elements and bounding surfaces allows for determination and mapping of the resulting depositional environments that are placed in a sequence-stratigraphic context.

The Burro Canyon Formation in the area represents local incised-valley fills comprised of sandstone-rich amalgamated channel complexes overlain by non-amalgamated channel complexes. Deposits within the amalgamated channel complex interval include multiple upward-fining, conglomerate-to-sandstone deposits recognized as unit bars and bar sets. These deposits are interpreted to result from lateral and down-stream accretion, which is characteristic of low-sinuosity braided-fluvial environments. Channel-fill architectural elements exhibit cross-bedding and numerous truncated contacts and are interpreted to have formed during periods when the geomorphic base level was relatively low (lower to moderate accommodation). Vertically and laterally stacked channel-fill elements (N= 131) exhibit an apparent-width range of 137-1300 feet (40-420 m) and a thickness range of 5-60 feet (1.5-18 m). The sequence transitions upward into non-amalgamated channel-complex deposits that contain inclined-heterolithic strata interbedded with mudstone-drape successions deposited by low net-to-gross, high-sinuosity braided- to meandering-fluvial environments. Mudstone-prone intervals of the nonamalgamated channel complex contain isolated channel-fill elements interbedded with floodplain mudstones and represent a period of relatively high base level. Associated channel-fill elements range in apparent width from 200-1000 feet (60-300 m) and thickness from 20-30 feet (6-9 m). These fluvial deposits serve as outcrop analogs for subsurface interpretations and development of hydrocarbons in similar reservoirs.

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Cheyenne WY, September 2019

Reservoir Characterization and Modeling Laboratory

RCML

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SCHOOL OF GEOSCIENCES
The UNIVERSITY of OKLAHOMA

Outline

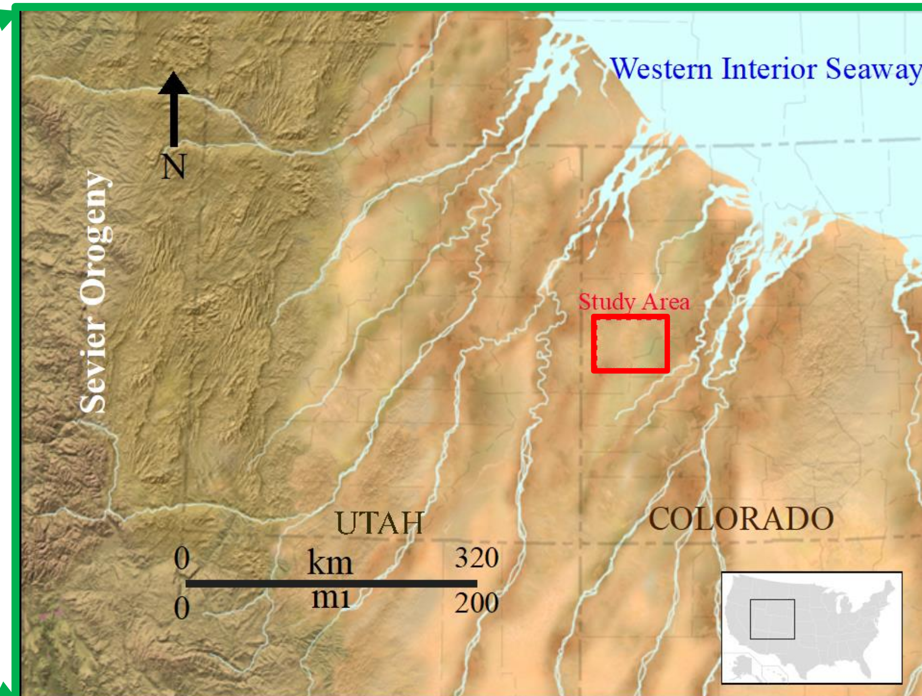
- **Introduction**
  - Geological setting
  - Data set and location
- **Methods**
  - Measured Sections
  - UAV-models (Unmanned Aerial Vehicle)
- **Fluvial Architecture and Depositional Environment**
  - Lithofacies
  - Facies associations
  - Architectural Elements
- **Sequence stratigraphic framework**
  - Hierarchical elements

Geological setting - Paleogeography

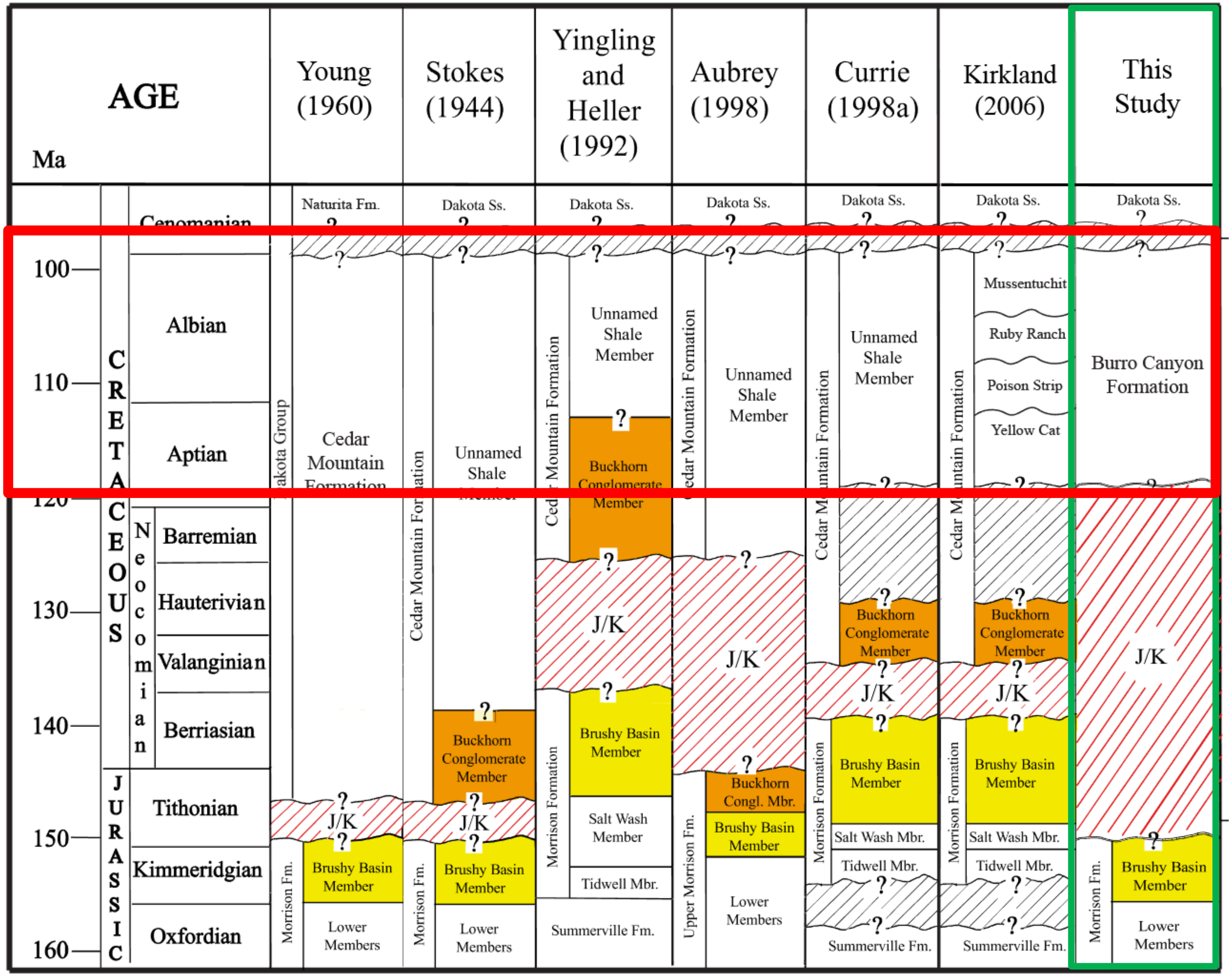
Burro Canyon Formation Kbc

(Cedar Mountain Formation equivalent)

- ✓ Aptian/Albian ~ 100 Ma
- ✓ Foreland basin setting
- ✓ Alluvial plain environment

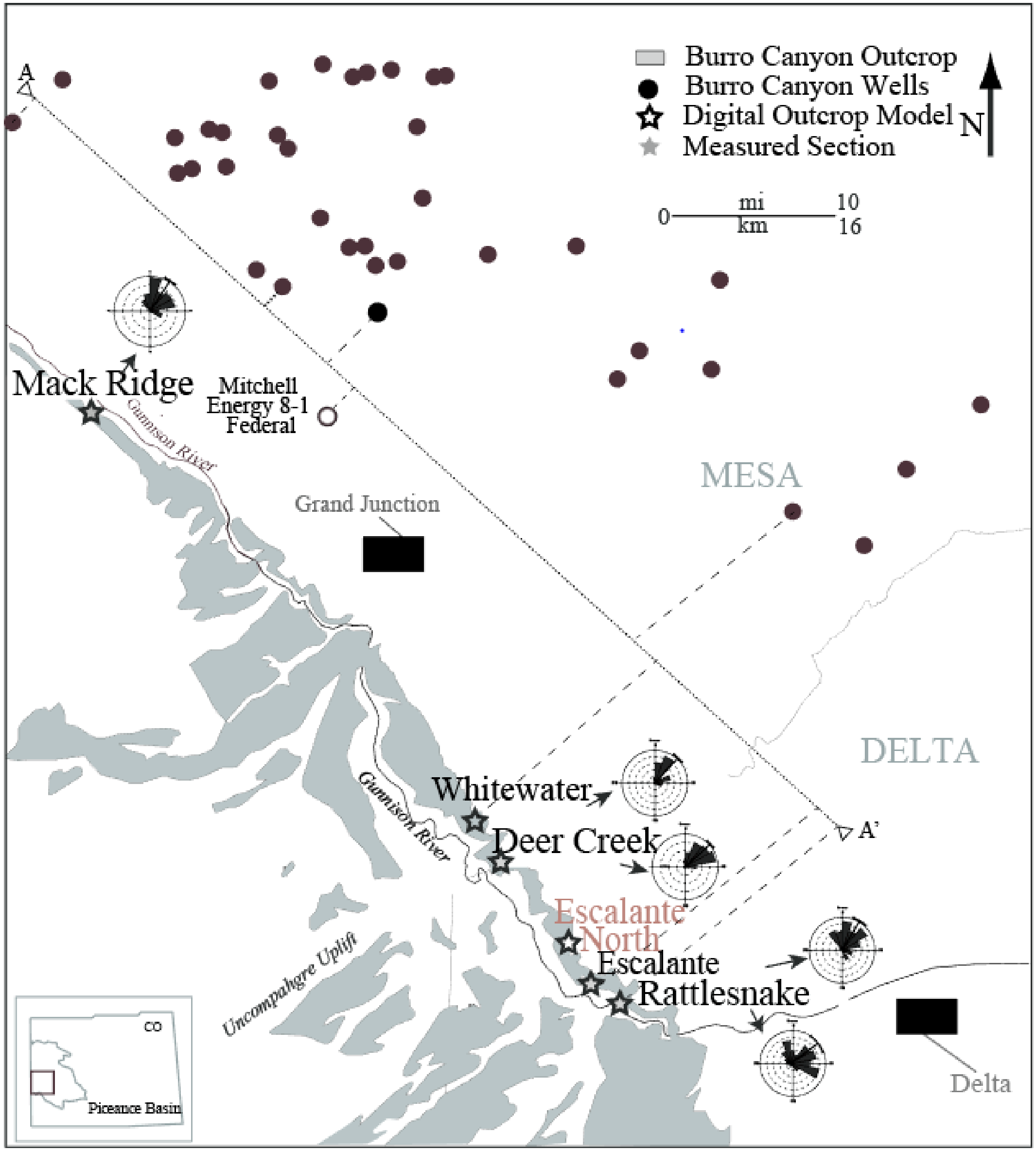


Geological setting- Strat Column



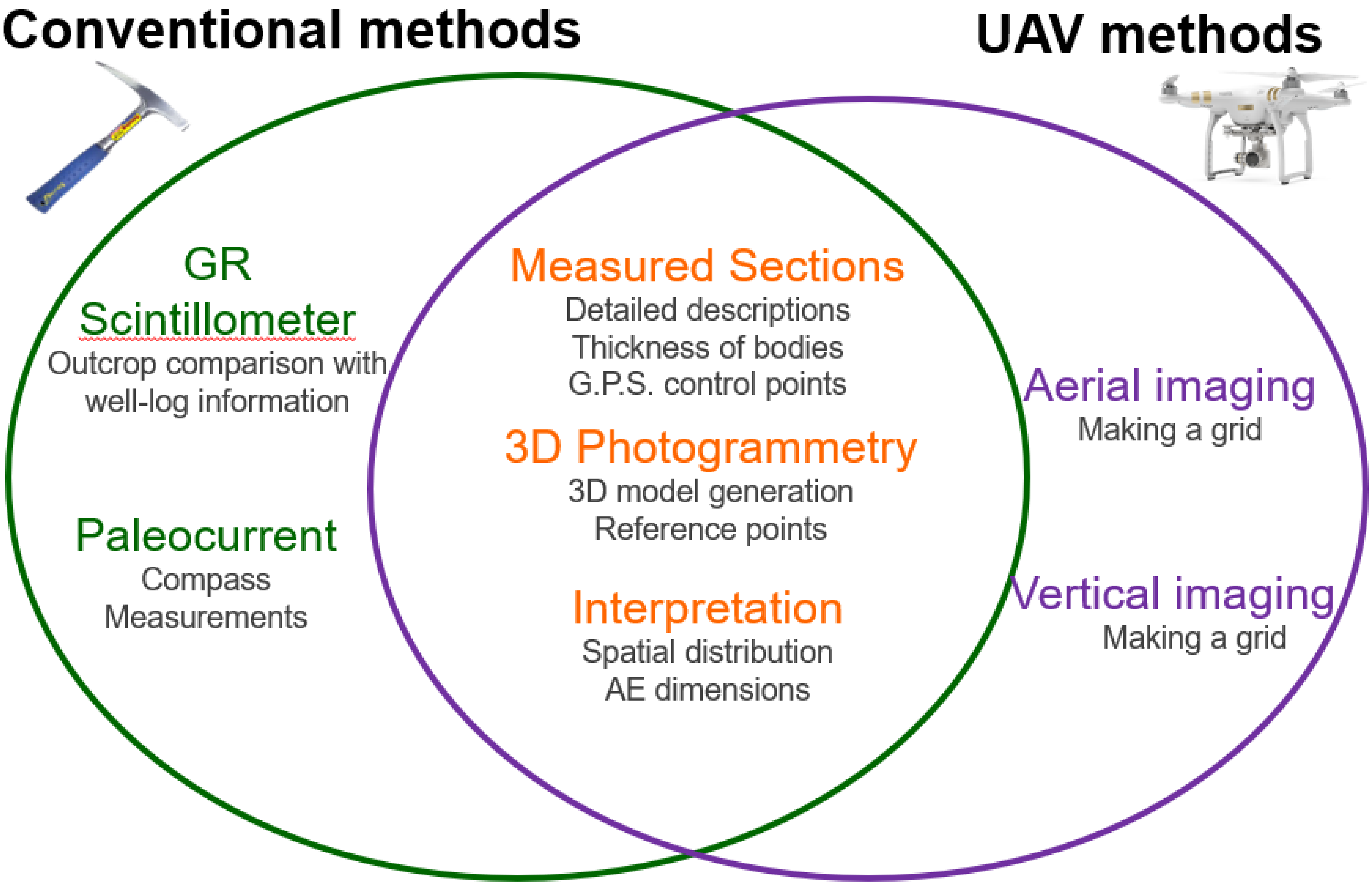
Modified from Roca and Nadon (2007)

Data set



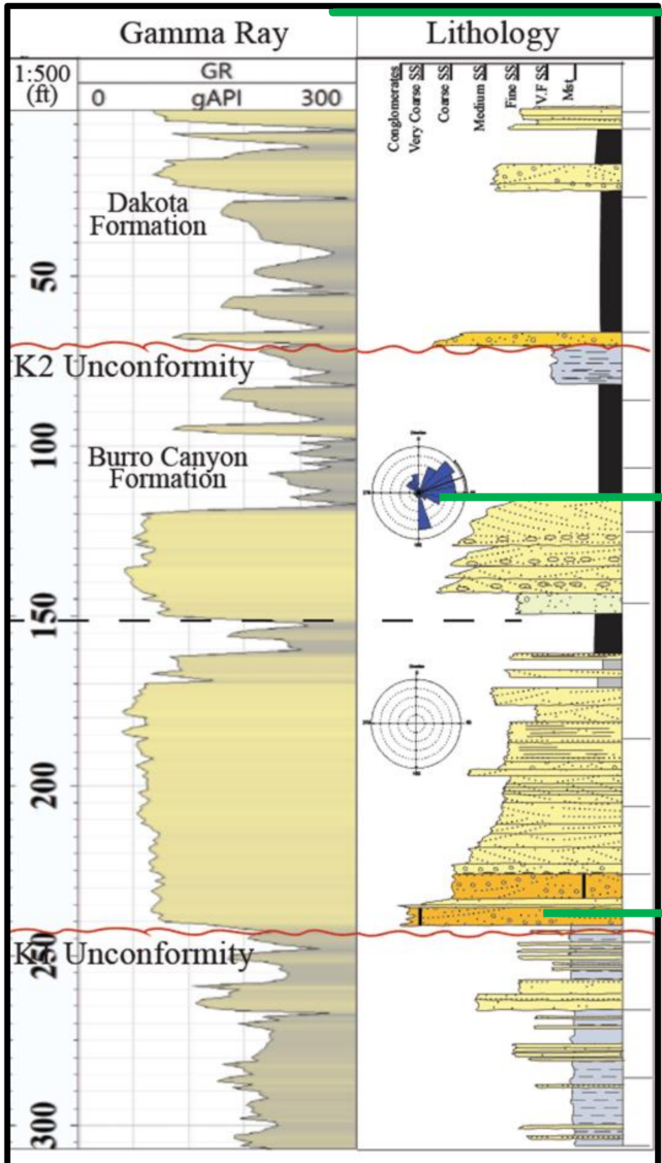
- ✓ Mesa and Delta counties
- ✓ Six outcrop locations
- ✓ ~1500 ft of measured section from five locations
- ✓ 551 Paleocurrent measurements
- ✓ 48 wells with log data
- ✓ Six 3-D outcrop reconstructions

Methods

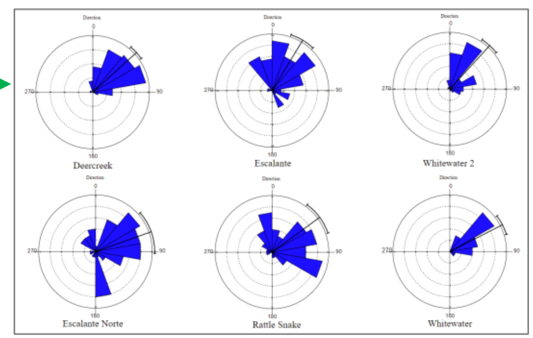

Conventional methods
UAV methods
GR
Scintillometer
Outcrop comparison with
well-log information
Paleocurrent
Compass
Measurements
Measured Sections
Detailed descriptions
Thickness of bodies
G.P.S. control points
3D Photogrammetry
3D model generation
Reference points
Interpretation
Spatial distribution
AE dimensions
Aerial imaging
Making a grid
Vertical imaging
Making a grid

Methods – Measured sections

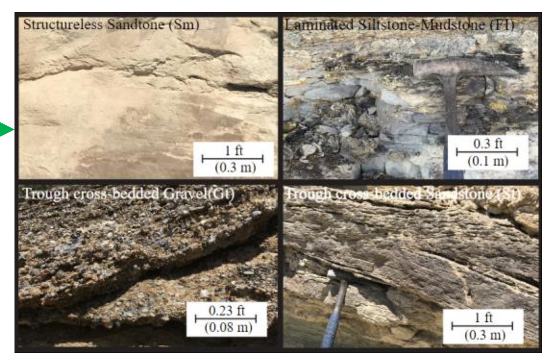
Composited Escalante Canyon Measured Section



- ✓ Gamma Ray scintillometer



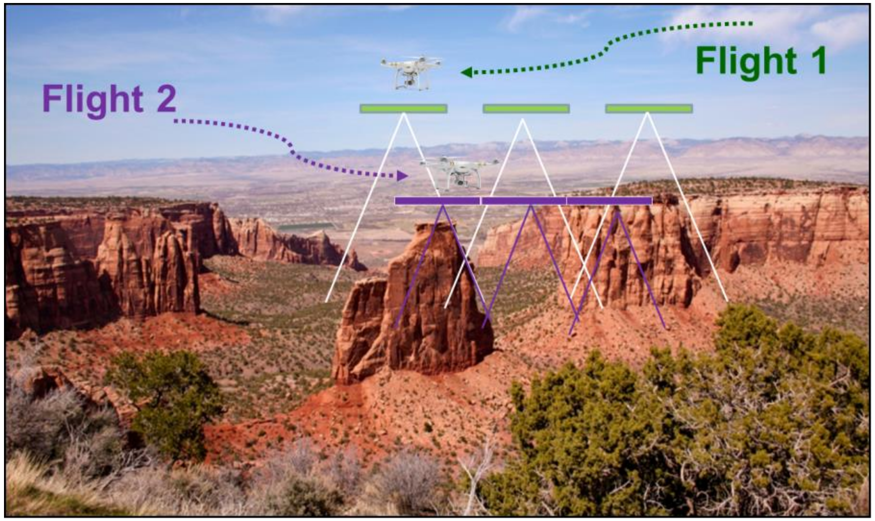
- ✓ Paleocurrent measurements



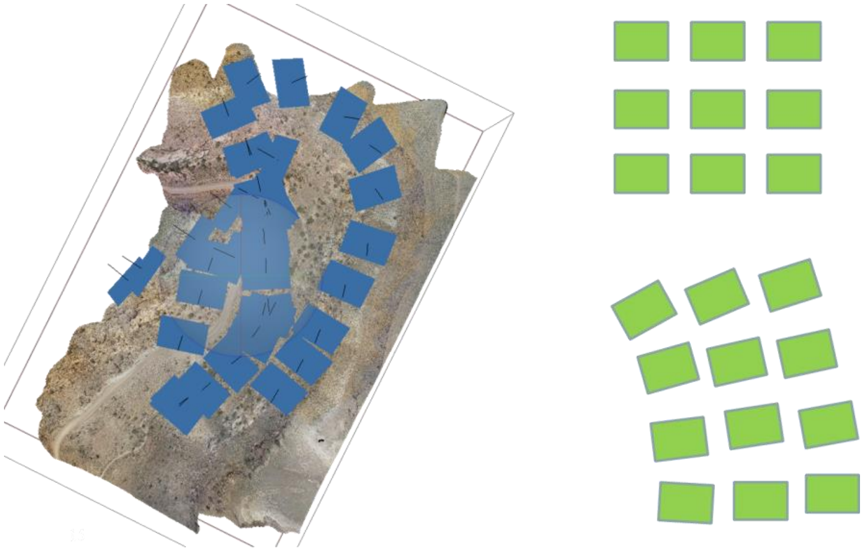
- ✓ Lithological and sedimentological description

Methods - UAV

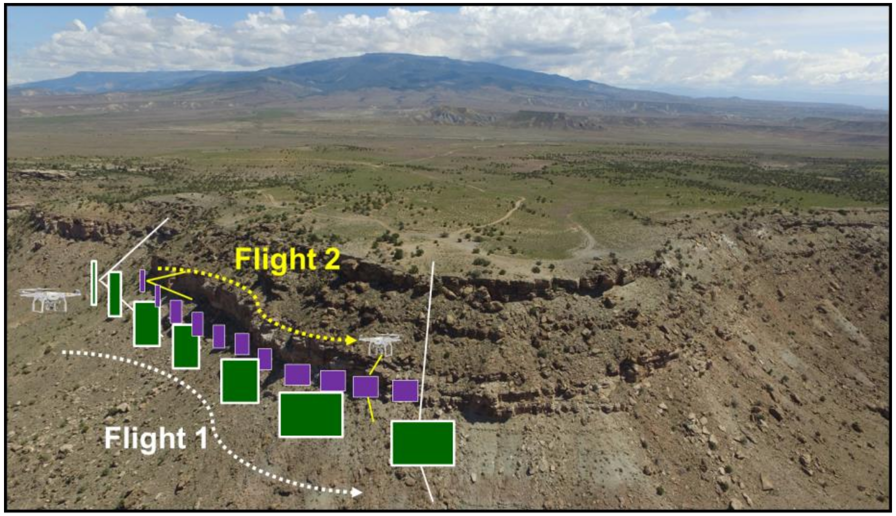
Aerial imaging



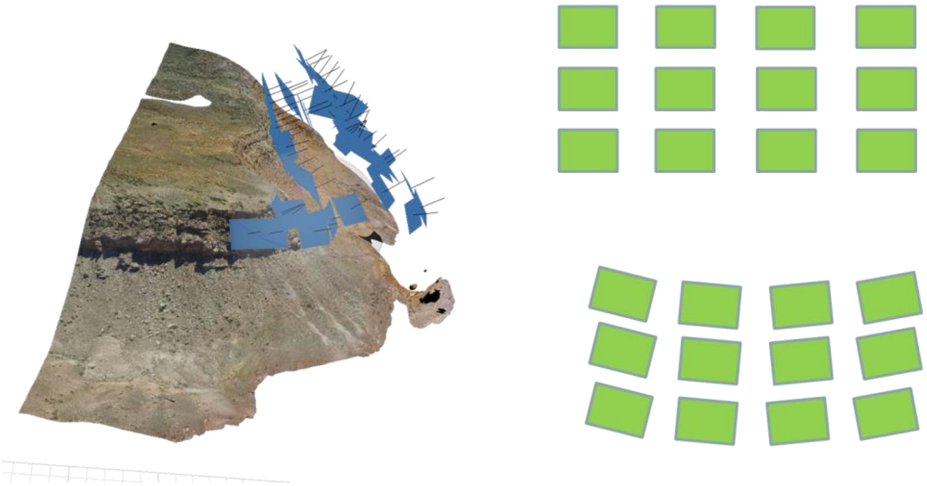
Not to scale



Oblique imaging

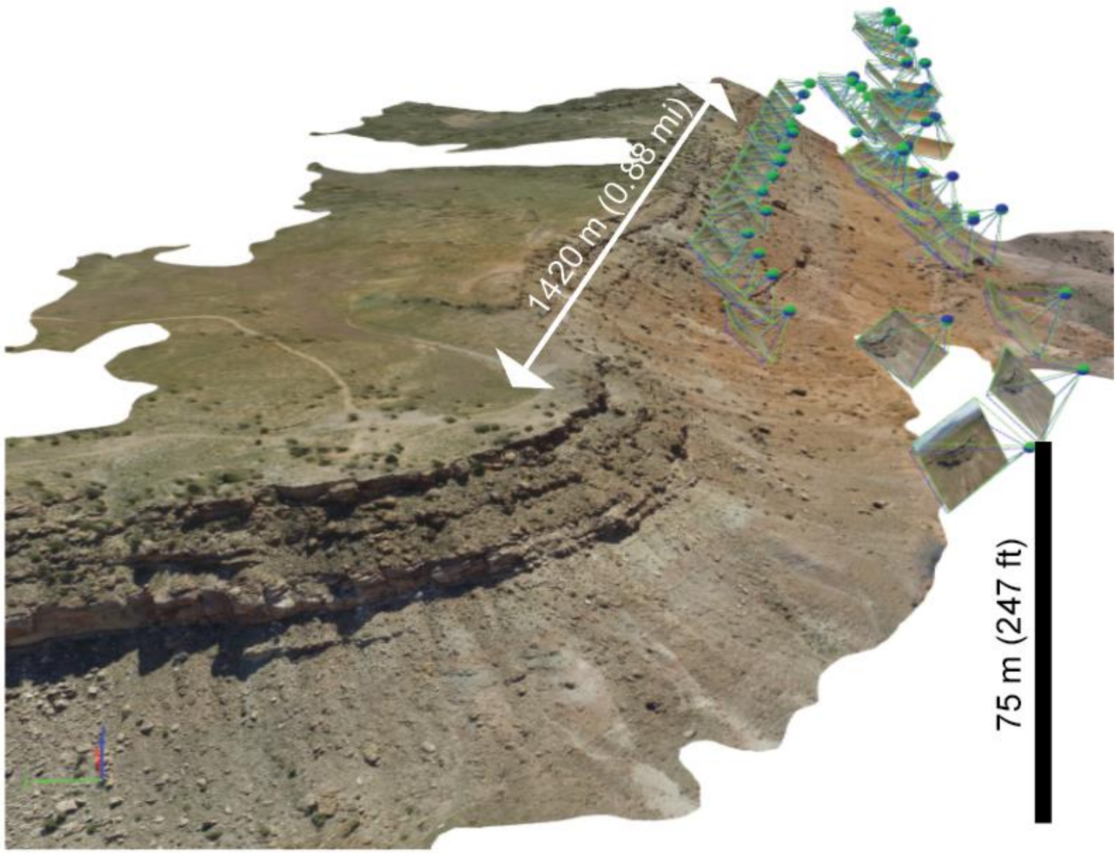


Not to scale



Methods - UAV

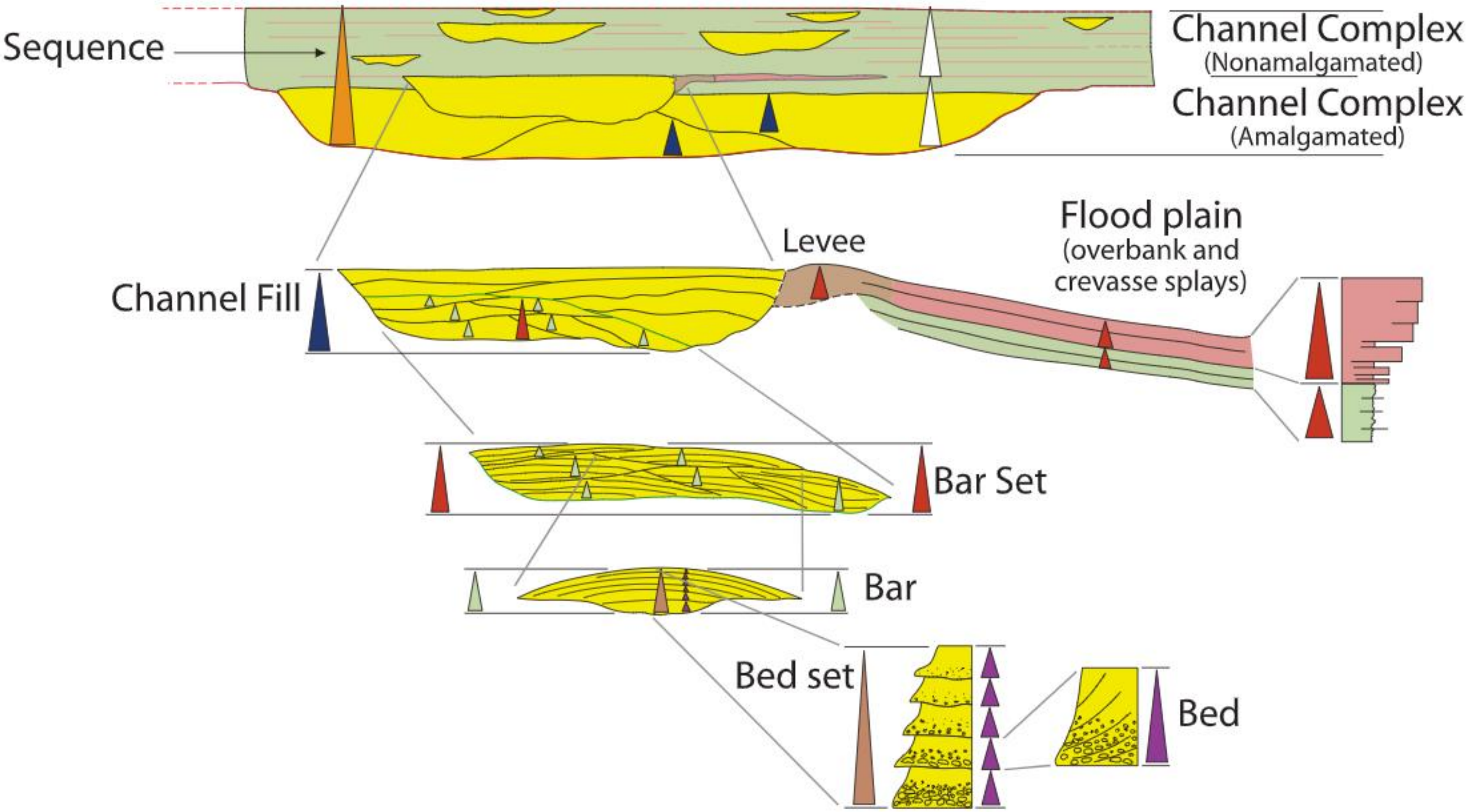
North side Escalante Canyon
3D photogrammetry reconstruction



- ✓ Aerial and oblique grids of photographs
- ✓ Photo editing before reconstruction
- ✓ >70% overlap between photos
- ✓ Ground control points in each outcrop

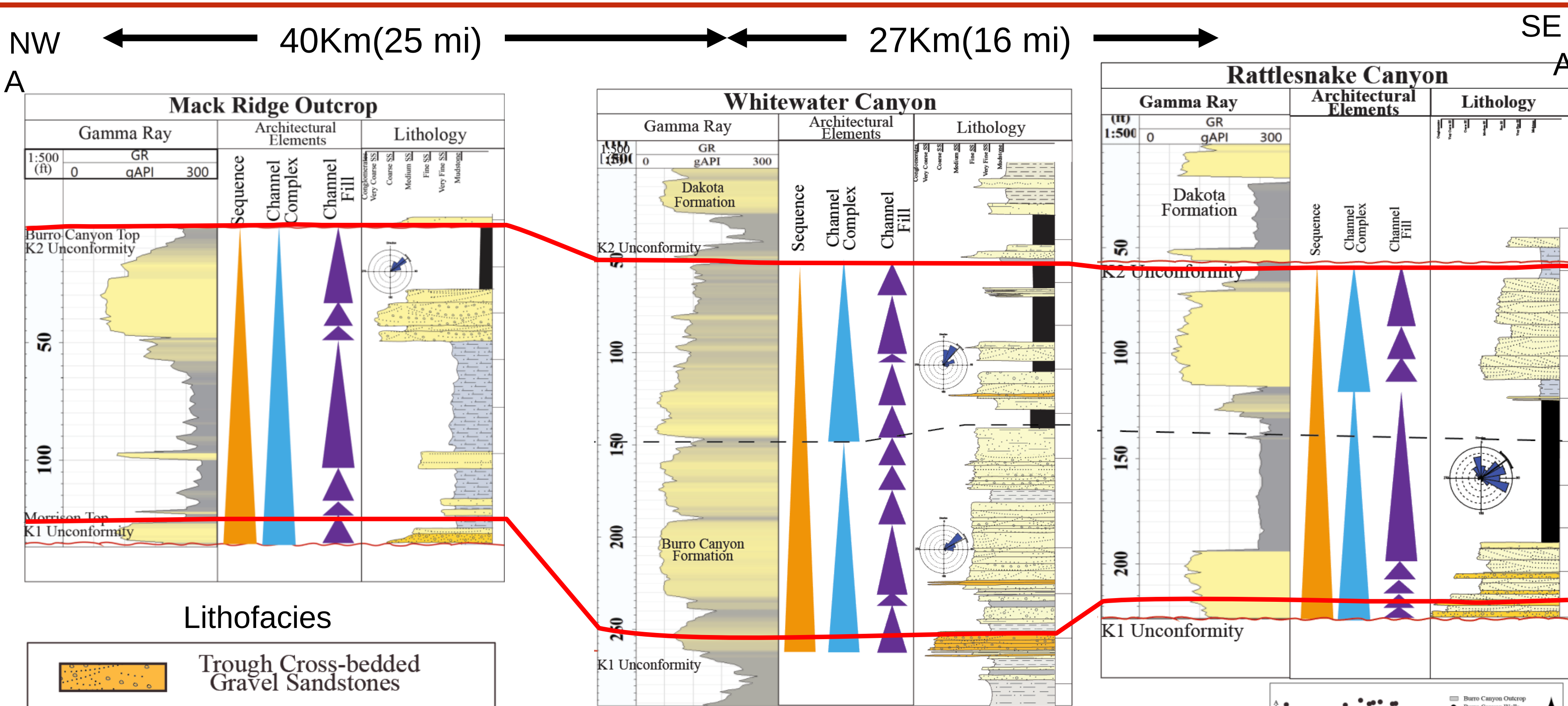
Fluvial Architecture

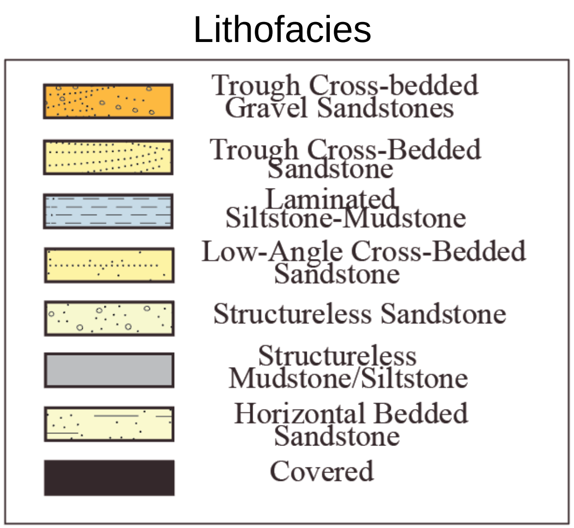
Hierarchy of Alluvial Strata



(Patterson et.al, 2002)

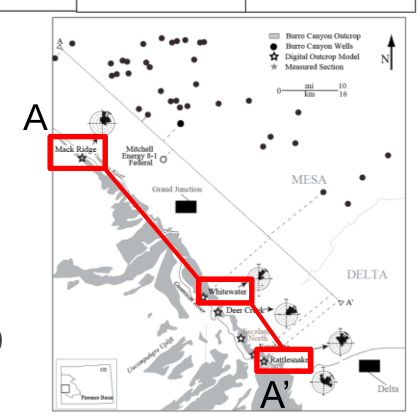
Stratigraphic measured sections - Fluvial Architecture





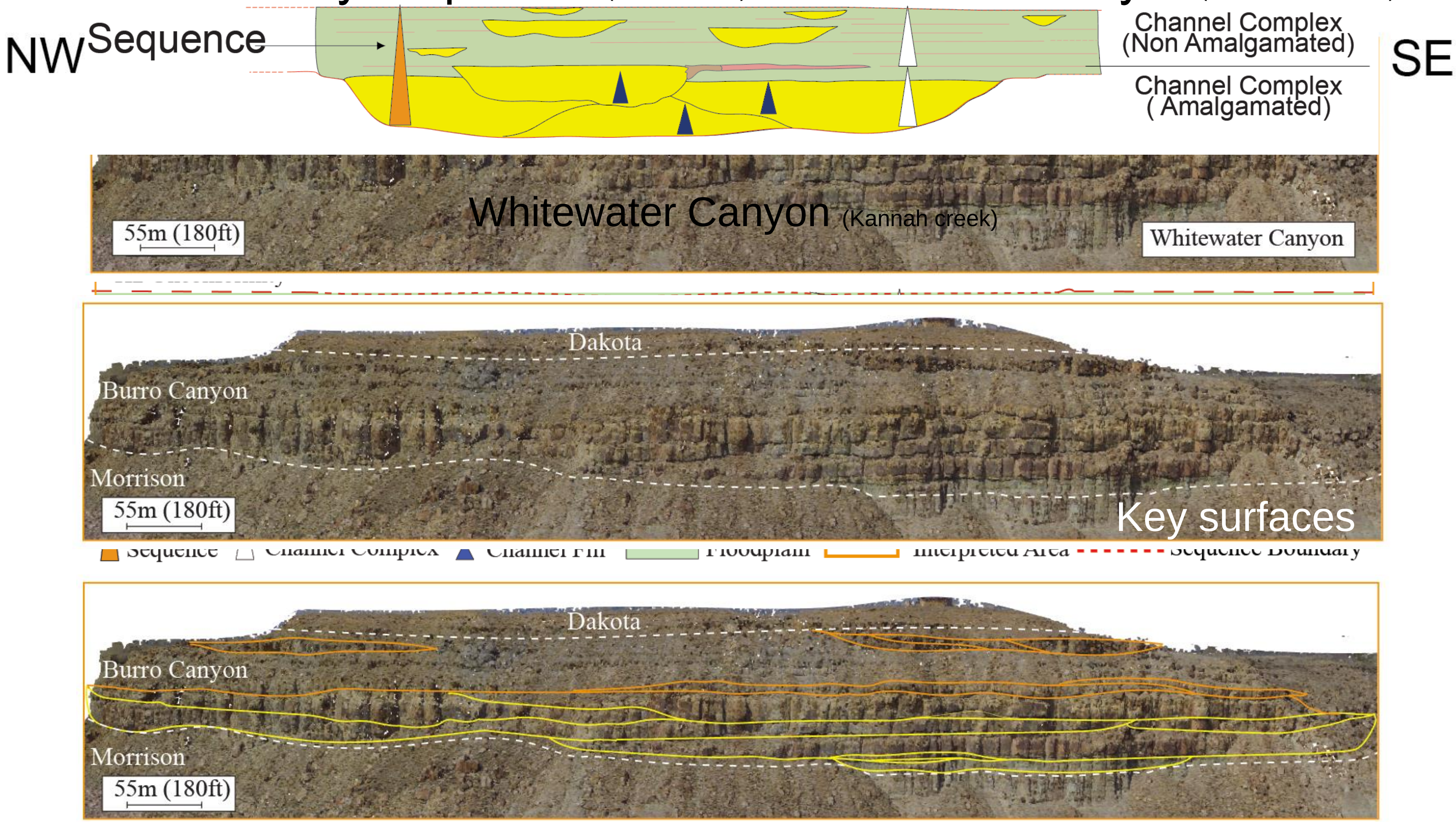
Facies associations: 1.Coarse sandy-bar
2.Sandy-bar
3.Floodplain

Paleoflow direction ~ 52° azimuth (Vector Mean)

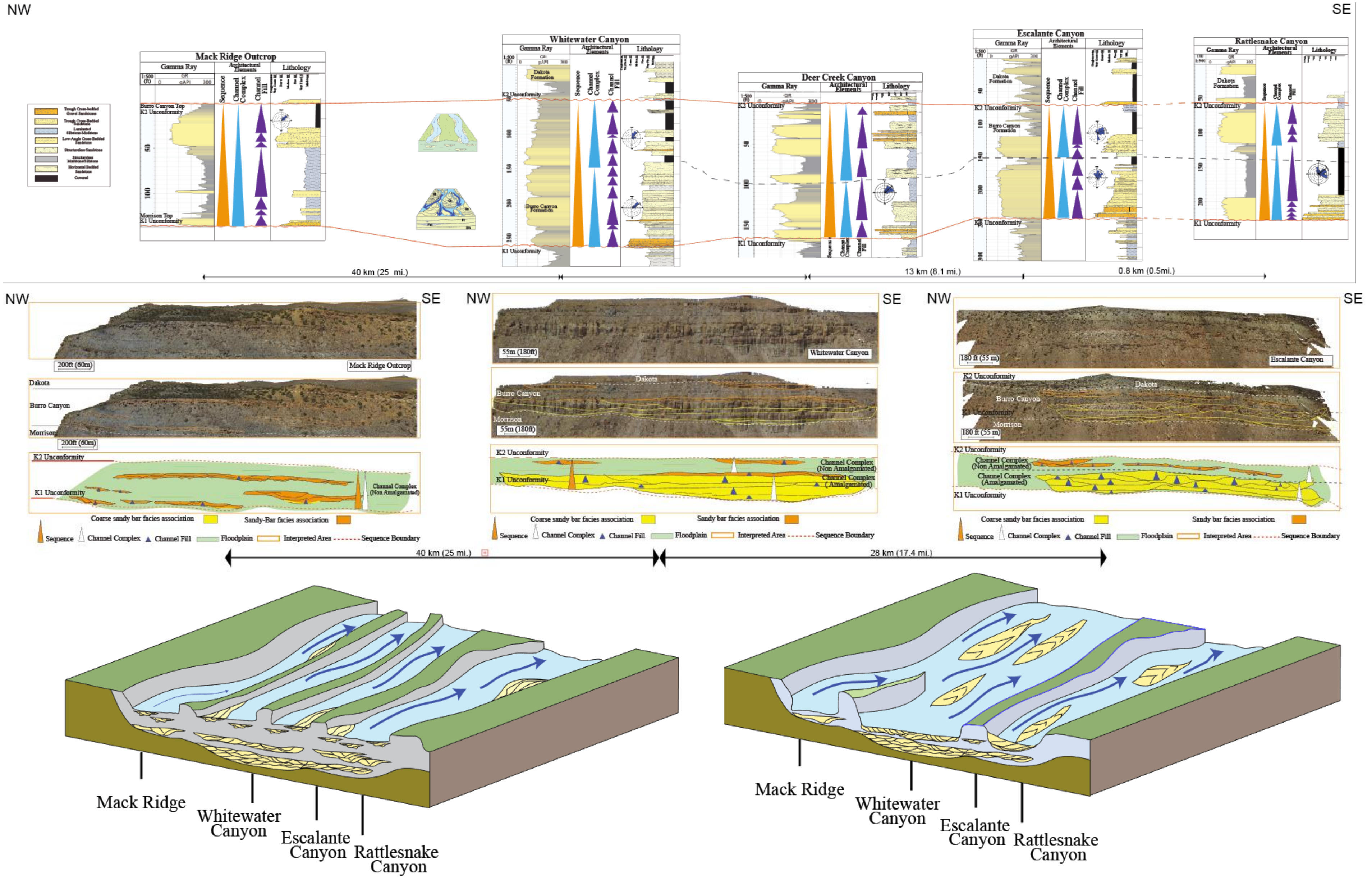


Fluvial Architecture - UAV-models

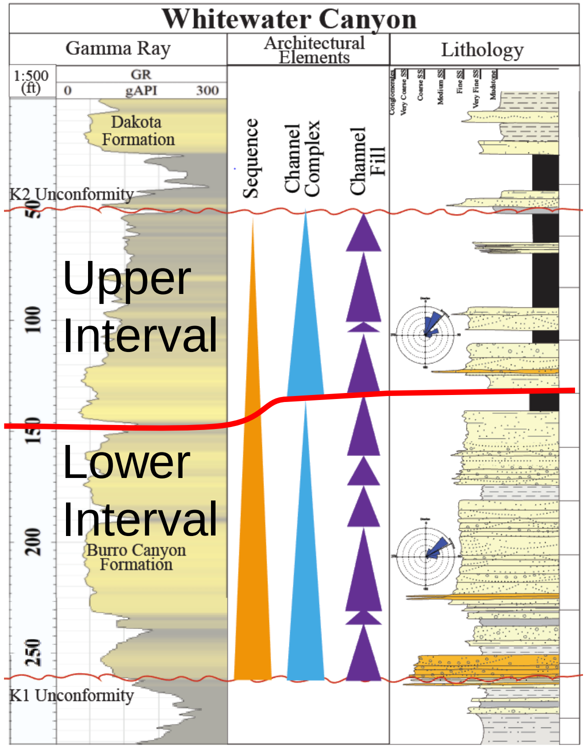
Fluvial hierarchy sequence (Patterson) Whitewater Canyon(Kannah creek)



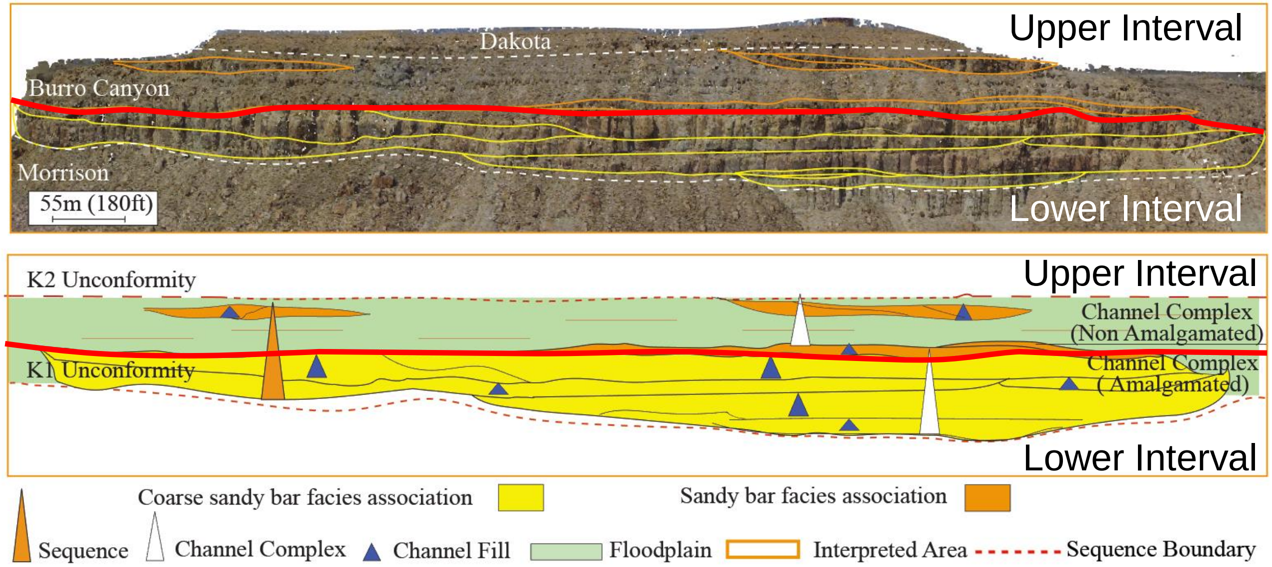
Fluvial Architecture - EOD



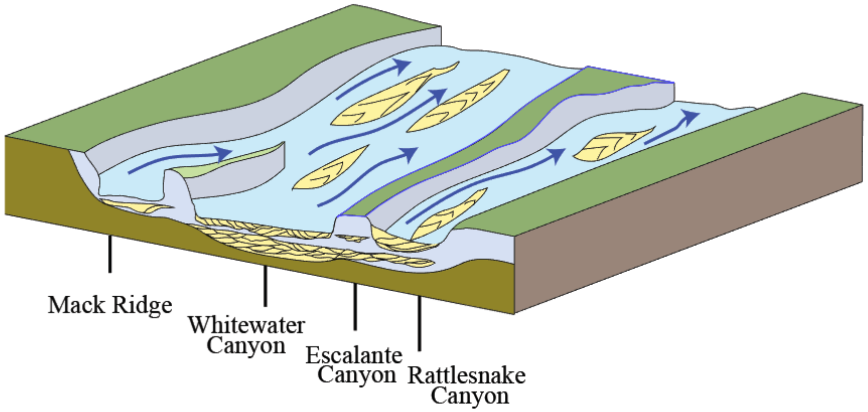
Fluvial Architecture – EOD Lower interval



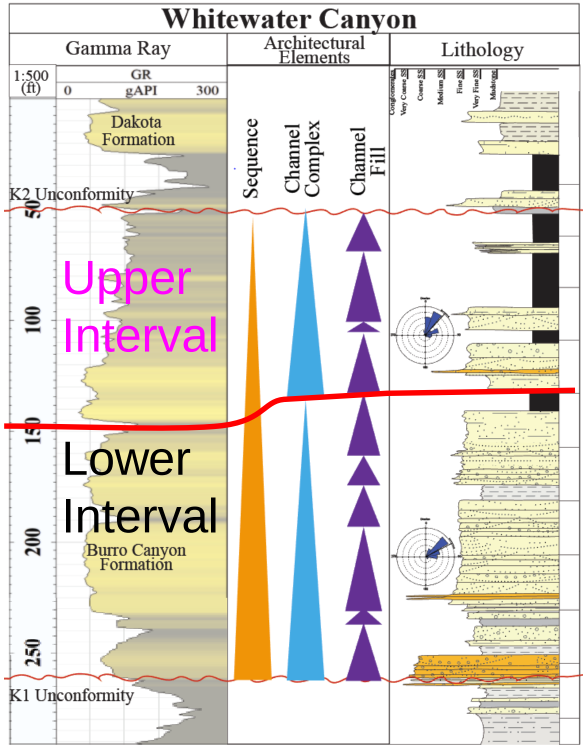
Whitewater Canyon

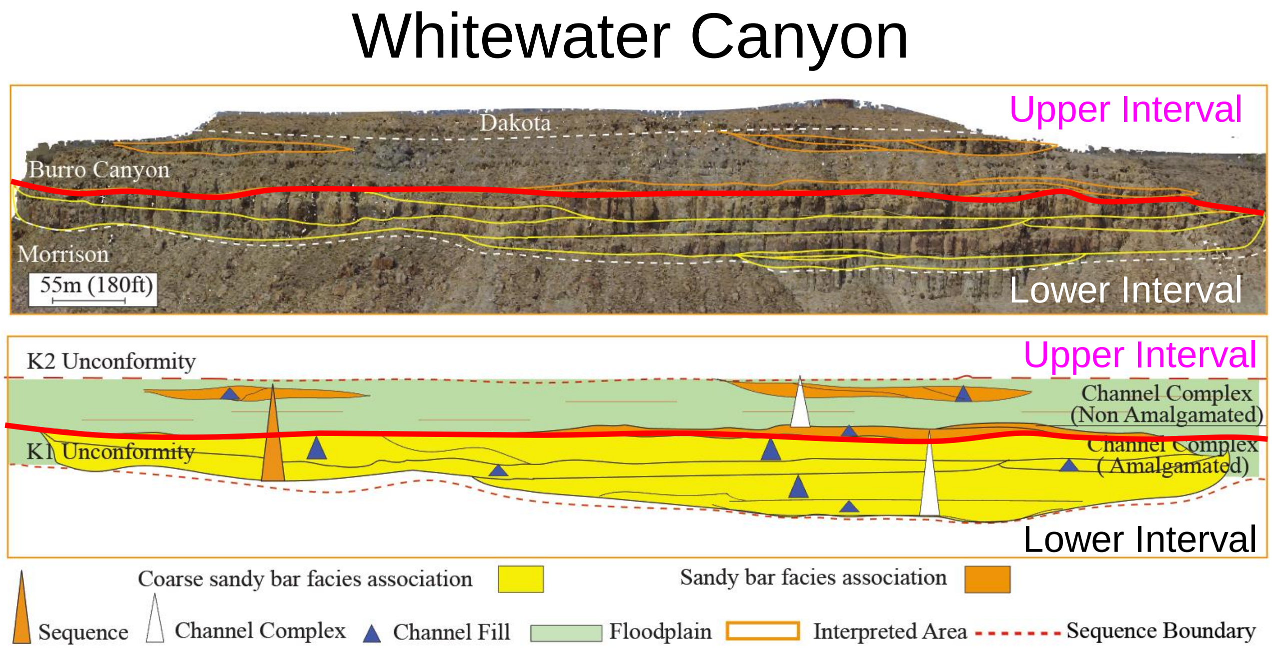


- ✓ Longitudinal - downstream accreted bars
- ✓ Conglomeratic and coarse sandy bar facies
- ✓ Amalgamated channel complex elements

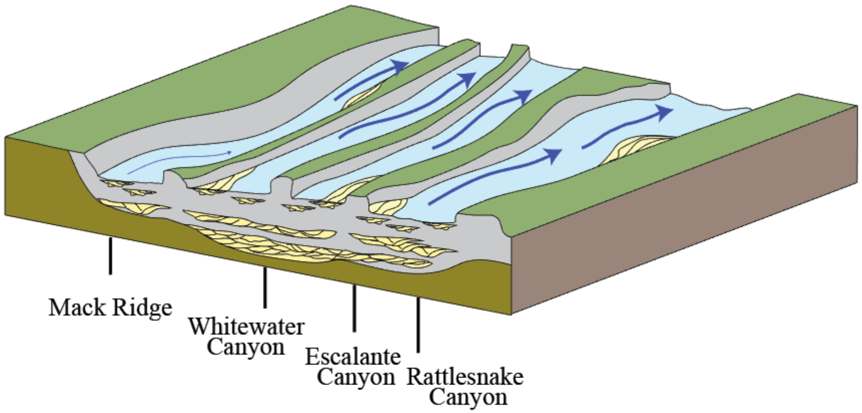


Fluvial Architecture – EOD Upper interval





- ✓ Laterally accreted bars
- ✓ Floodplain deposits
- ✓ Coarse to medium sandy bar facies
- ✓ Non-Amalgamated channel complex and isolated channel elements

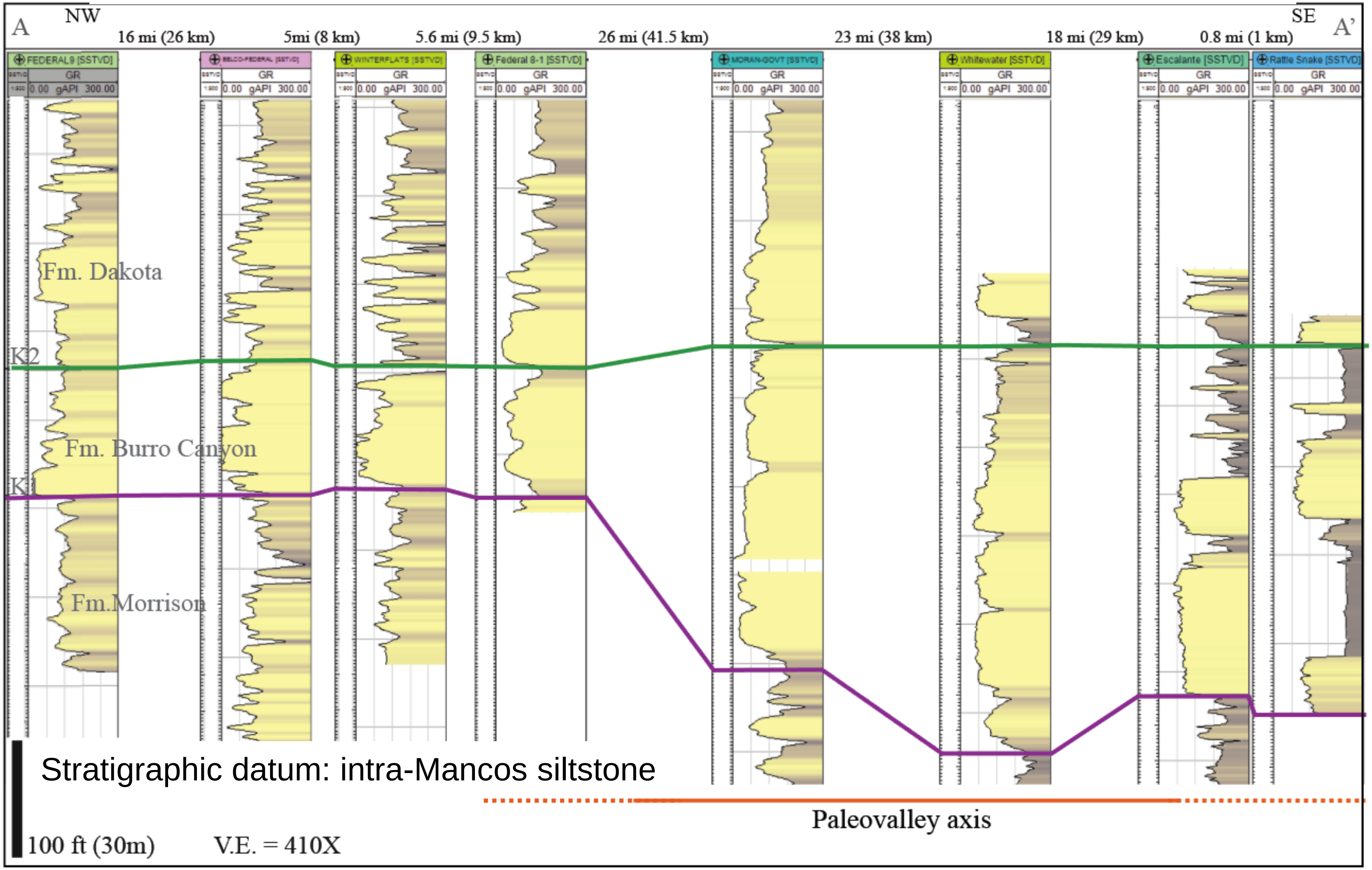


EOD well-log correlations and regional thickness map

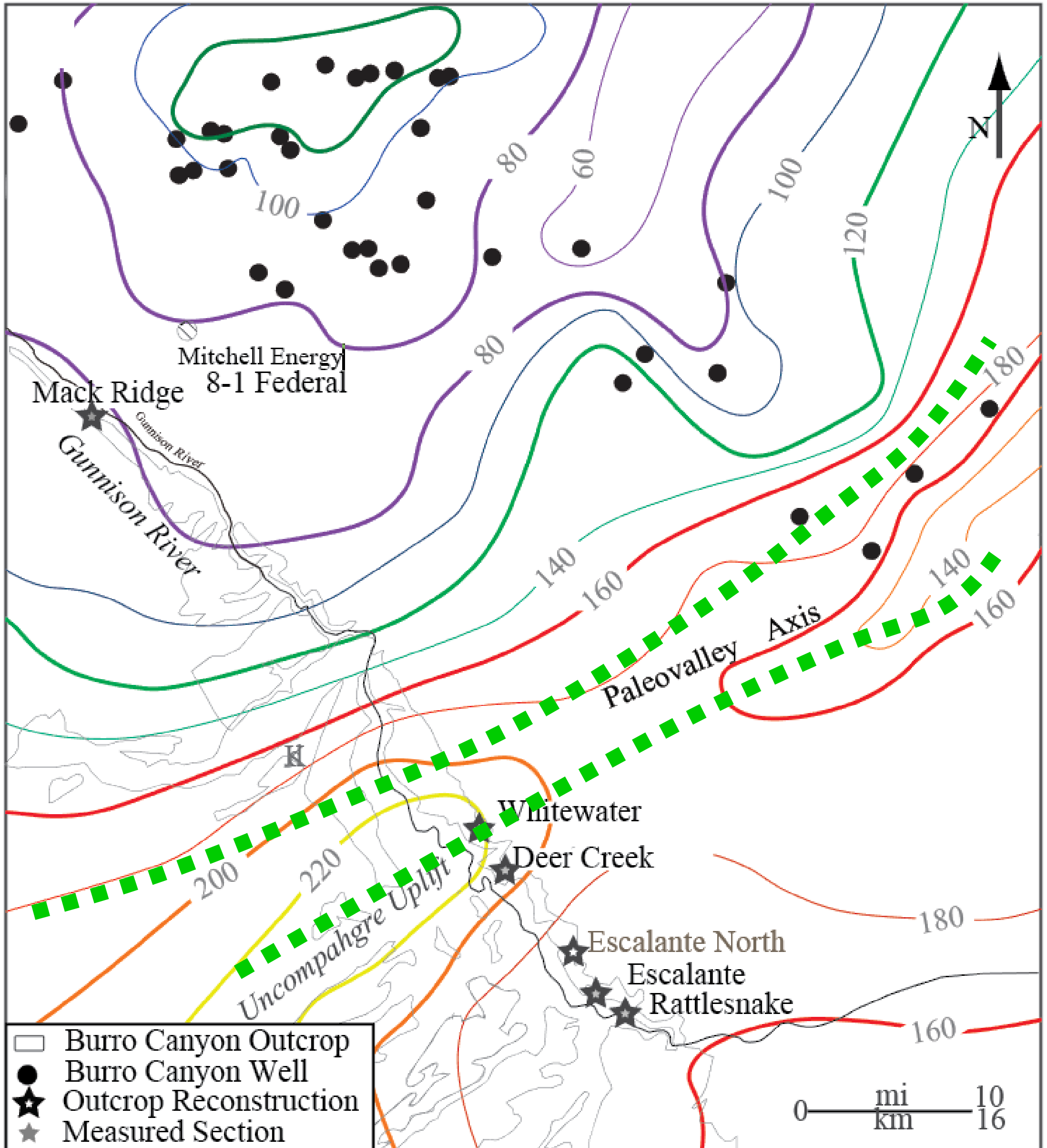
Stratigraphic cross-section

NW

SE



EOD Regional thickness map



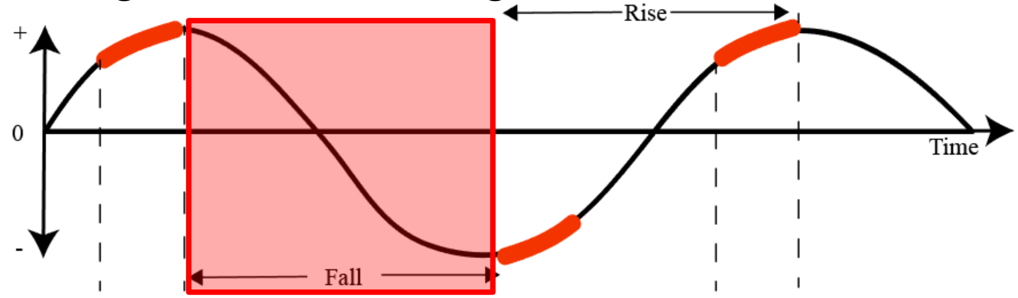
Regional isopach map for the Burro Canyon Formation

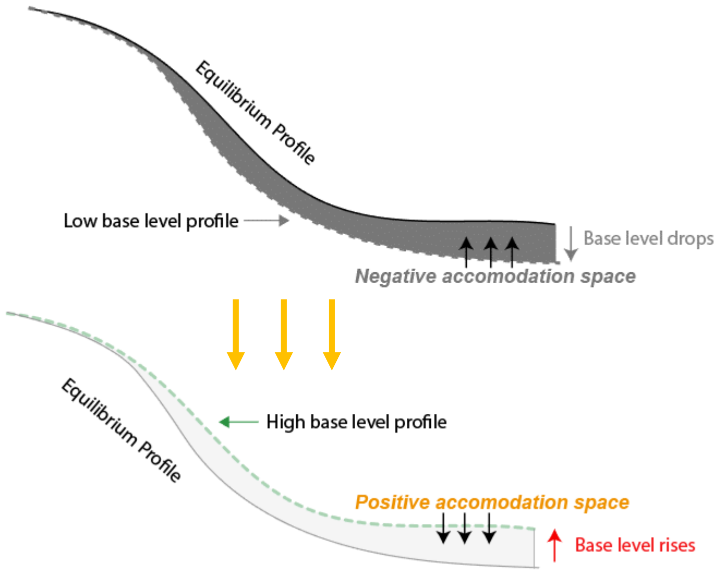
Green lines indicate the axis of an interpreted paleovalley

Fluvial sequence stratigraphy

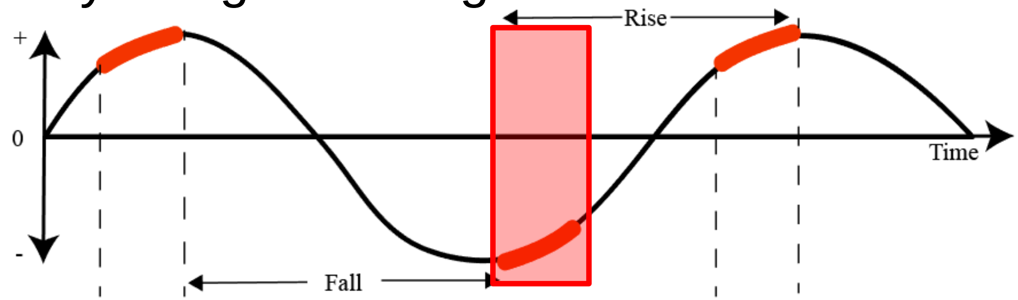
Falling base level stage

Modified from (Catuneanu, 2006)

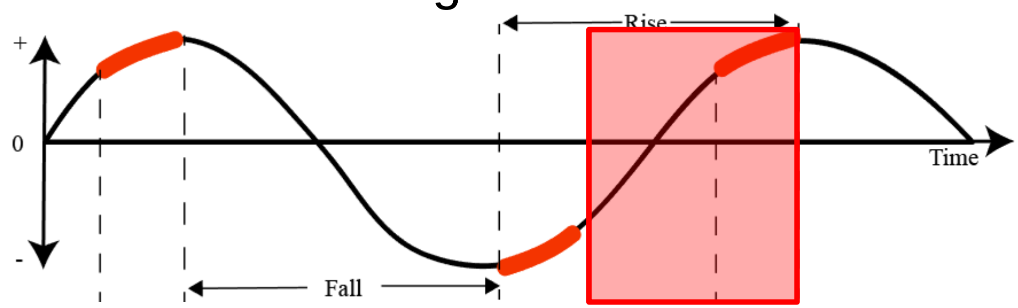




Early rising level stage



Rise base level stage

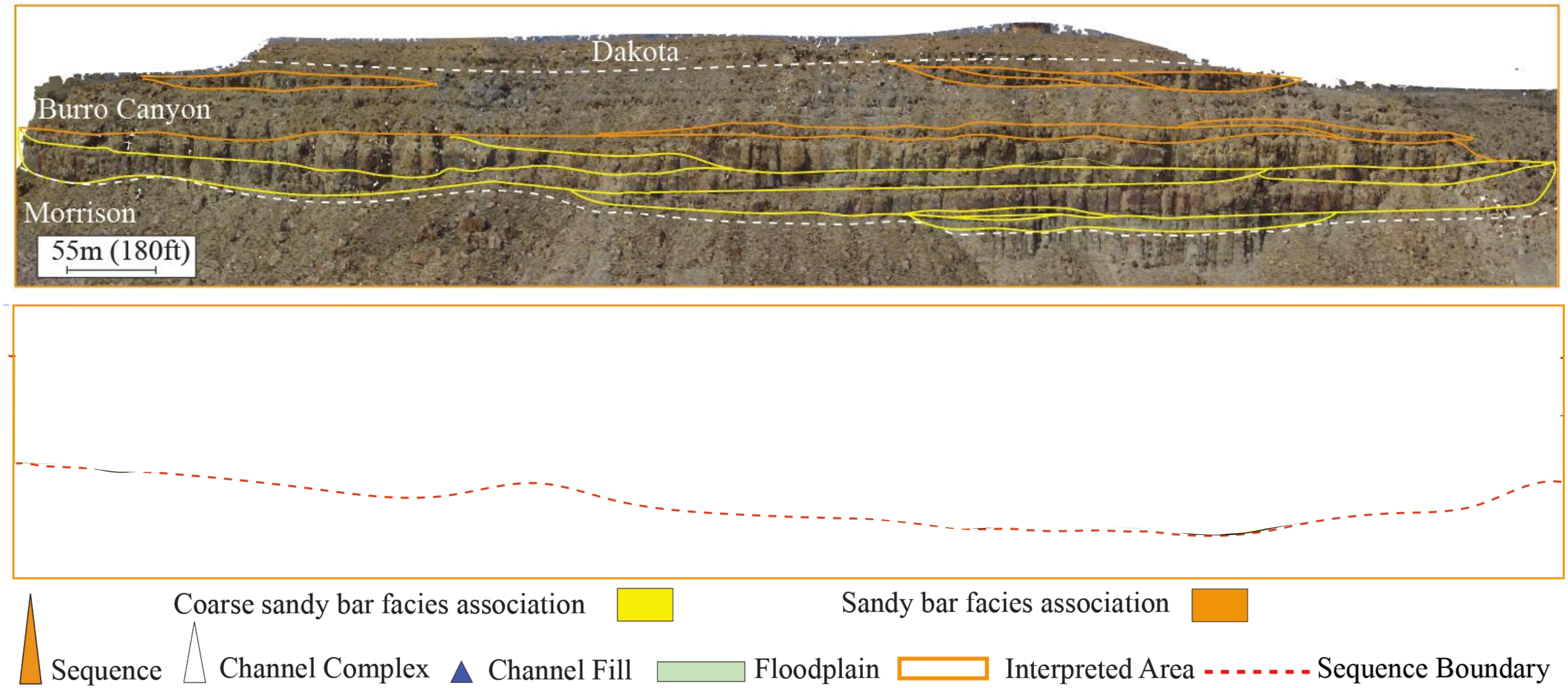


1. Erosion and incision

2. Amalgamated conglomeratic to coarse grain sandstone bodies deposition

3. Non amalgamated to isolated coarse to medium grain sandstone bodies deposition

Fluvial sequence stratigraphy



1. Erosion and incision

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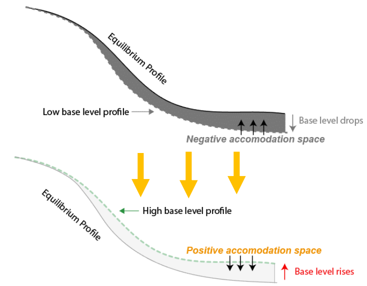
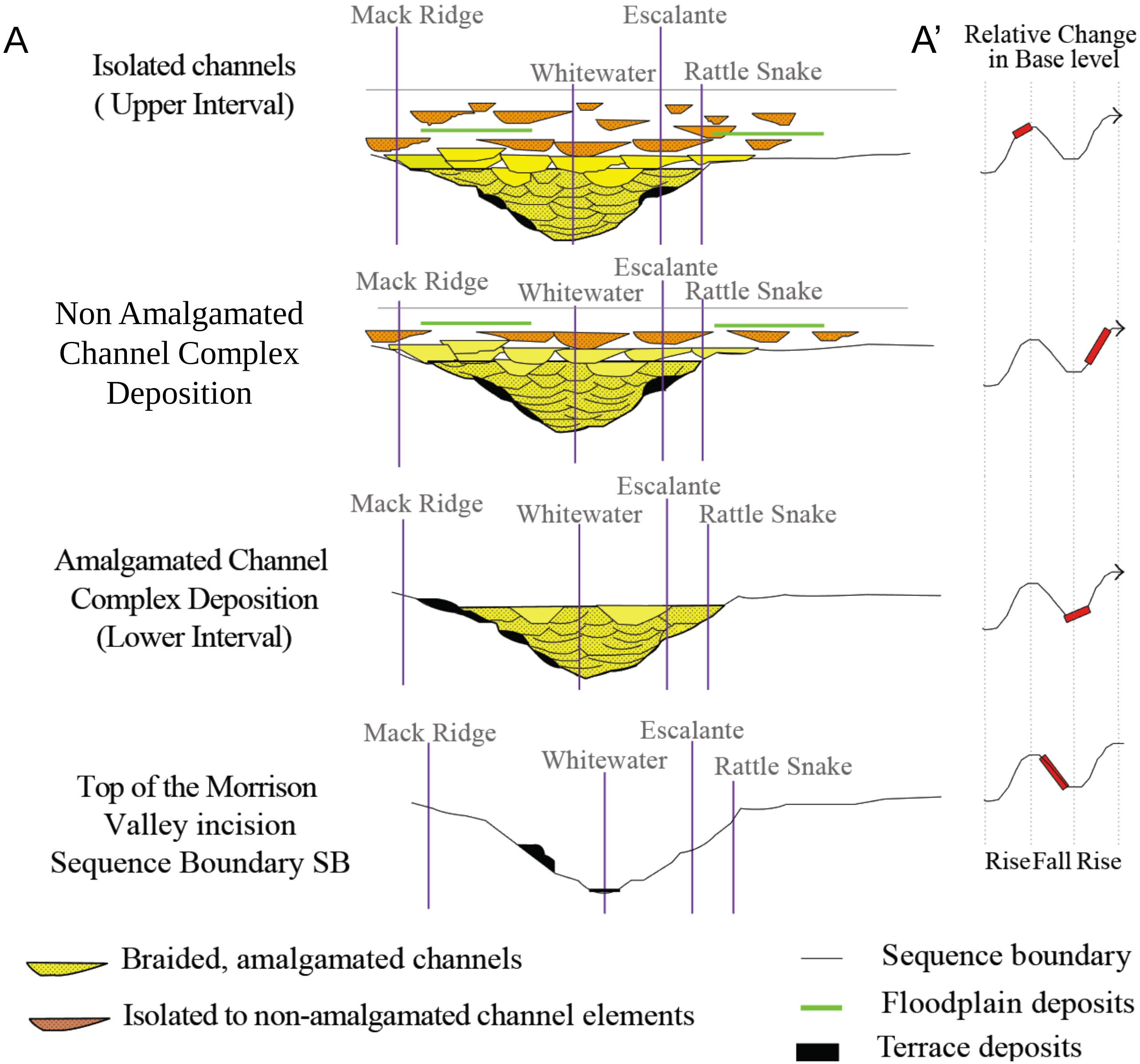
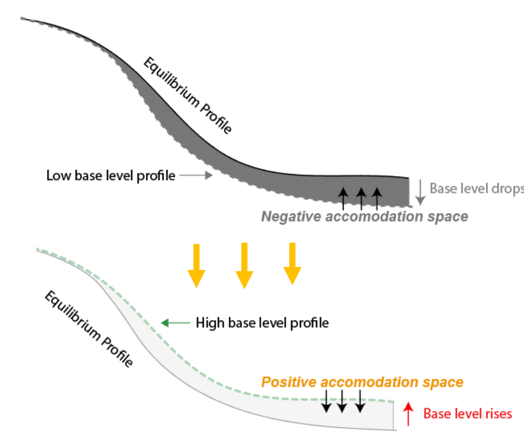
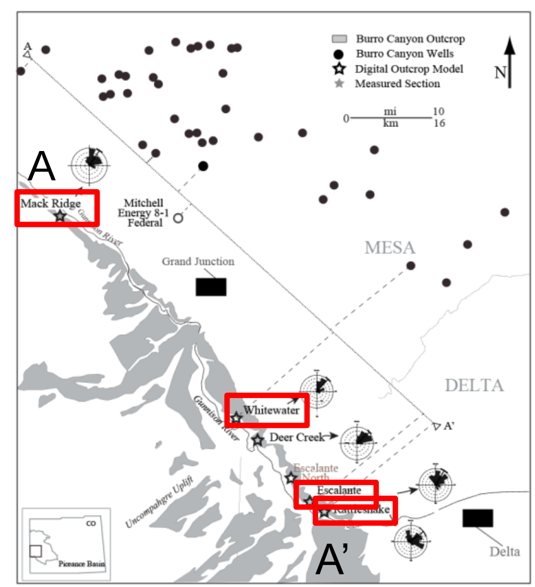


Fluvial sequence stratigraphy



(Modified from Shanley et.al, 1994)





Conclusions

- Kbc corresponds to one depositional sequence subdivided into an upper interval (aggradational) and a lower interval (transitional)

- Two intermediate-scale architectural elements were defined, channel fill and floodplain that compose larger-scale architectural

- The lower interval is characterized by conglomeratic and coarse sandstone deposits, laterally extensive and deposited by braided channels within an incised valley

- The upper interval is characterized by non-amalgamated channel complex elements deposited by low sinuosity to anastomosing channels within an alluvial plain

Aknowledgements

- Funding provided by the University of Oklahoma
- AAPG Foundation Grants-in-Aid “Jon R. Withrow grant”
- Schlumberger software
- Pix4D Mapper pro software
- Sarah Clark, Kelsey Lewis and Layne Hardisty for help in field work

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Questions