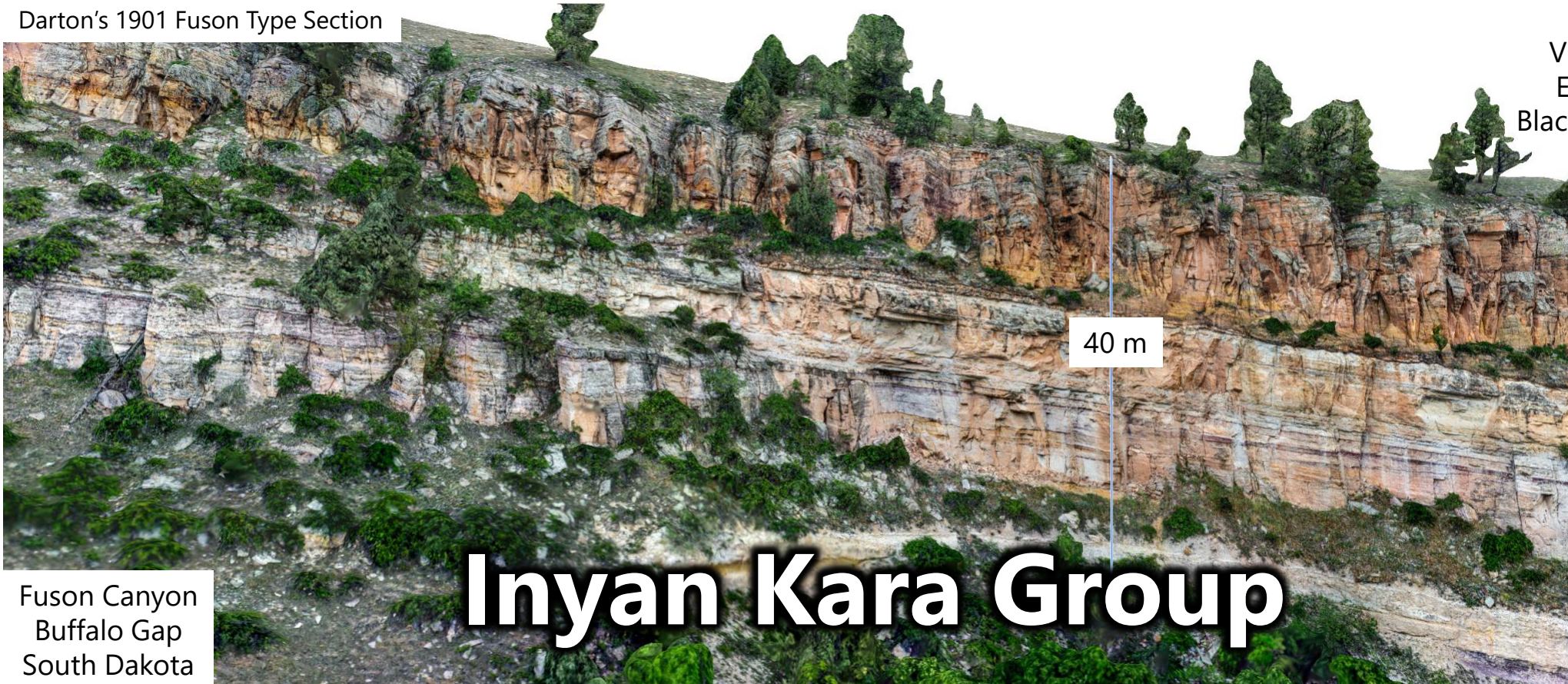


Darton's 1901 Fuson Type Section

View to NE
East Flank
Black Hills Uplift



Fuson Canyon
Buffalo Gap
South Dakota

Inyan Kara Group

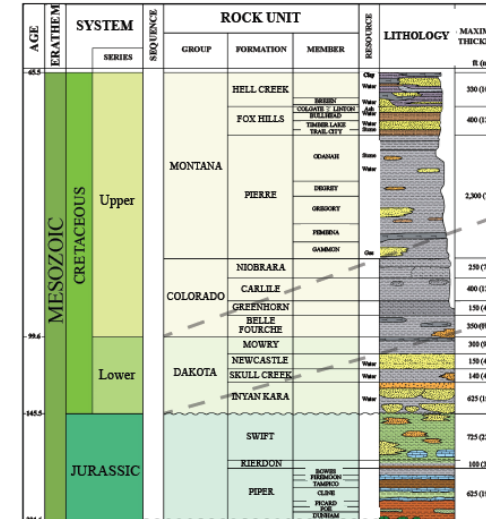
A Black Hills Field Workshop

**Outcrop Studies for Williston Basin Resource Management
and Reservoir Analogs**

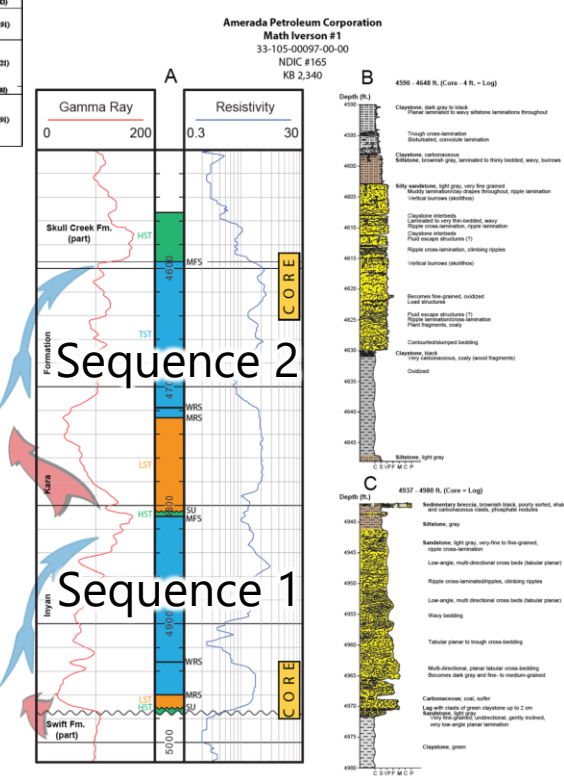
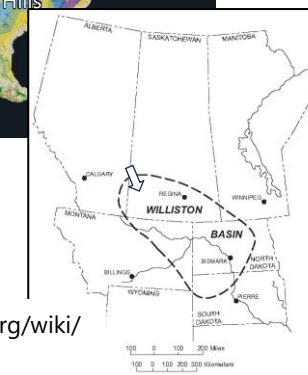
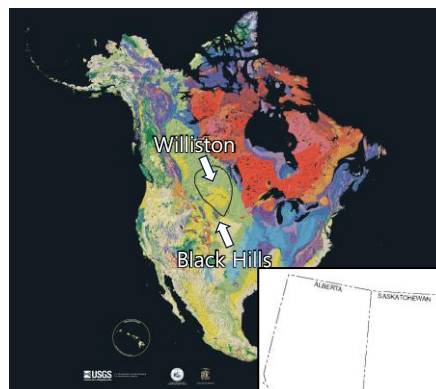
1. The Inyan Kara Formation in the Williston Basin is the lower part of the widespread Dakota Group, a sedimentary geologic unit in Midwestern North America, composed of sandstones and shales deposited in the early to mid-Cretaceous Western Interior Seaway
2. It is equivalent to the Lakota and Fall River formations (Inyan Kara Group) that outcrop in the Black Hills of South Dakota and Wyoming
3. The strata are predominantly non-marine to estuarine, and contain incised valley-fills (IVFs) within multiple sequences reflecting regressive to transgressive depositional cycles within an overall (longer-term) transgressive stacking pattern
4. In North Dakota, the Inyan Kara Formation is the primary subsurface injection zone for produced water, comprised of extensive aquifers overlain by widespread shales of the Skull Creek Fm resulting in large potential for produced water disposal (SWD). It is also considered a geologic sequestration unit (GSU) for carbon capture and storage (CCS)
7. The key uncertainty impacting disposal-related overpressure trends, or CO₂ storage and migration, are the stratigraphic and sedimentologic characteristic of the Inyan Kara aquifer; specifically, the distribution of incised valley fills (IVFs) and their lithofacies
8. The outcrops provide an important analog for the types of stratigraphic and sedimentologic relationships to be expected within the Inyan Kara sequences in the subsurface of the Williston Basin

Inyan Kara Formation, Williston Basin

- Is the lowermost unit of the Lower Cretaceous Dakota Group and consists of sandstone, siltstone, shale, and coal
- Records the regression and transgression of the Early Cretaceous seaway
- Can be subdivided based on well log-patterns and sedimentary structures in core
- Contains incised-valley-fill sandstone bodies, comprising extensive aquifers overlain by widespread shales of the Skull Creek Formation resulting in large potential for produced water disposal
- Is the primary subsurface injection zone for produced water (SWD) and a geologic sequestration unit (CCS)
- Is equivalent to the Lakota and Fall River formations in the Black Hills of South Dakota and Wyoming



From Bader (2019)



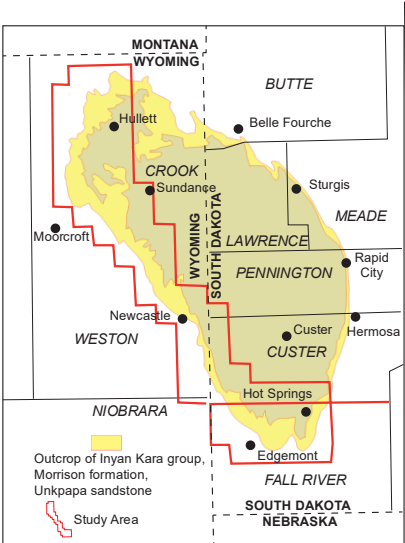
https://en.wikipedia.org/wiki/Williston_Basin

Outcrop Equivalents; Black Hills, South Dakota and Wyoming

The outcrops provide an important analog for the Inyan Kara sequences in the subsurface of the Williston Basin



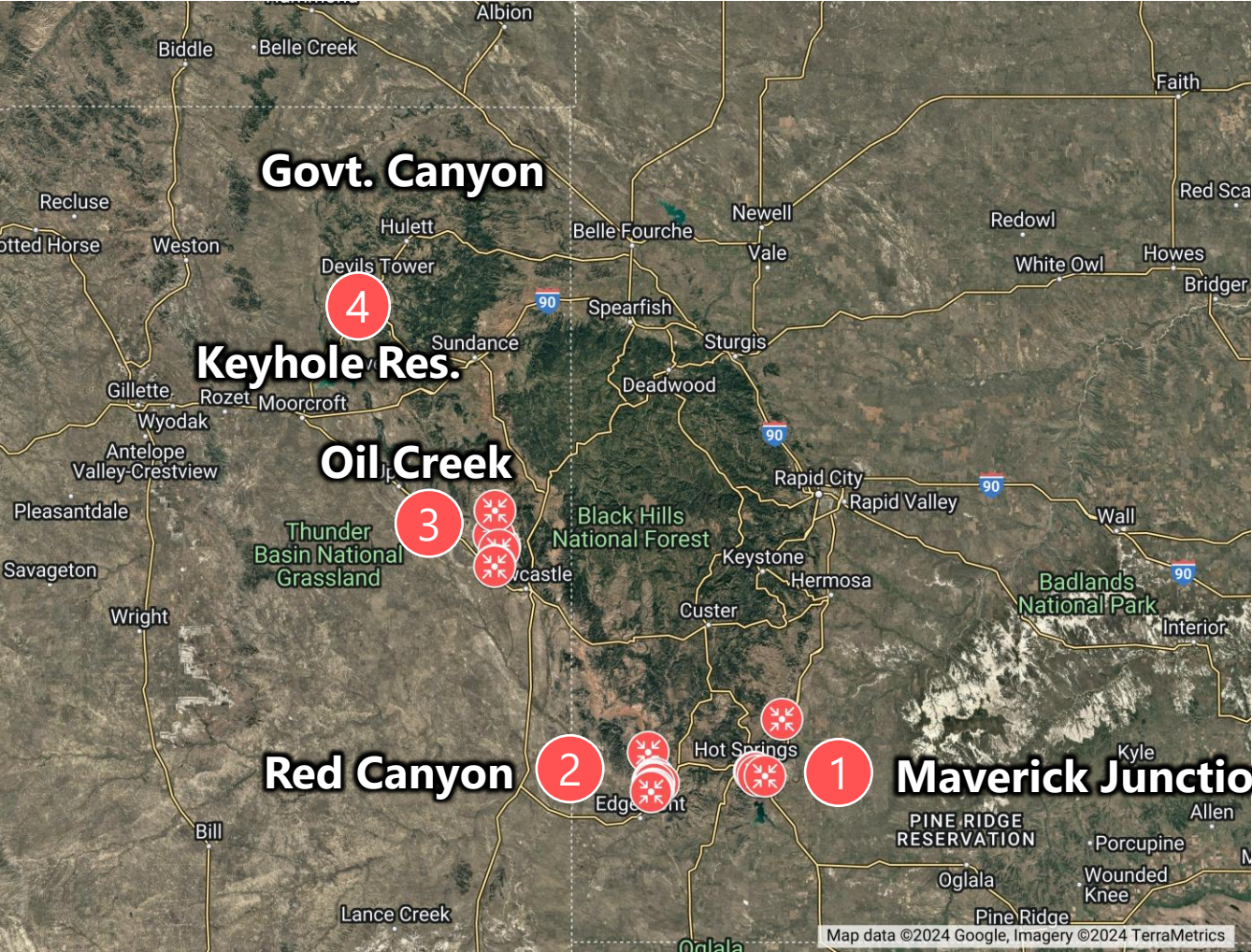
Source: wikipedia.org/wiki/Williston_Basin



Source: USGS

Outcrop Localities

 Drone-based earth models

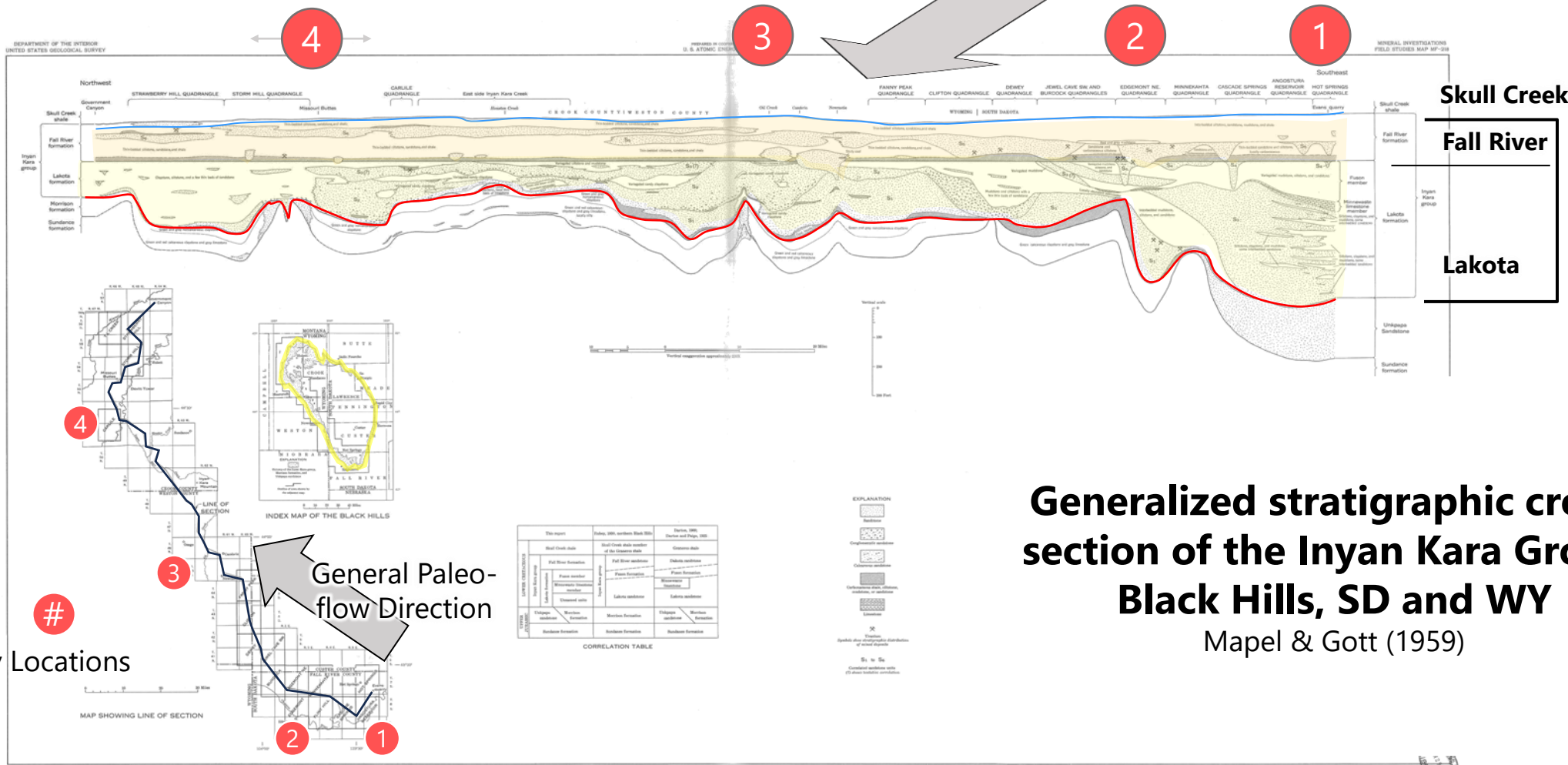


Source: Google Earth, Landsat Image, Copernicus

Outcrop Locations

Outcrop provides oblique cross-sectional view

General Paleo-flow Direction



Skull Creek
Fall River
Inyan Kara group
Lakota

Inyan Kara "Group"
Following Rubey (1930)

Generalized stratigraphic cross-section of the Inyan Kara Group, Black Hills, SD and WY
Mapel & Gott (1959)

Key Locations

Formations	Index, 1906, western Black Hills	Index, 1906, eastern Black Hills
Skull Creek shale	Skull Creek shale	Skull Creek shale
Fall River formation	Fall River formation	Fall River formation
Inyan Kara group	Inyan Kara group	Inyan Kara group
Morrison formation	Morrison formation	Morrison formation
Lakota	Lakota	Lakota
Unkpapa Sandstone	Unkpapa Sandstone	Unkpapa Sandstone
Sundance formation	Sundance formation	Sundance formation

Outcrop Examples – 3D Photogrammetry



Fluvial Lateral Accretion Packages – Lakota Fm

This Study

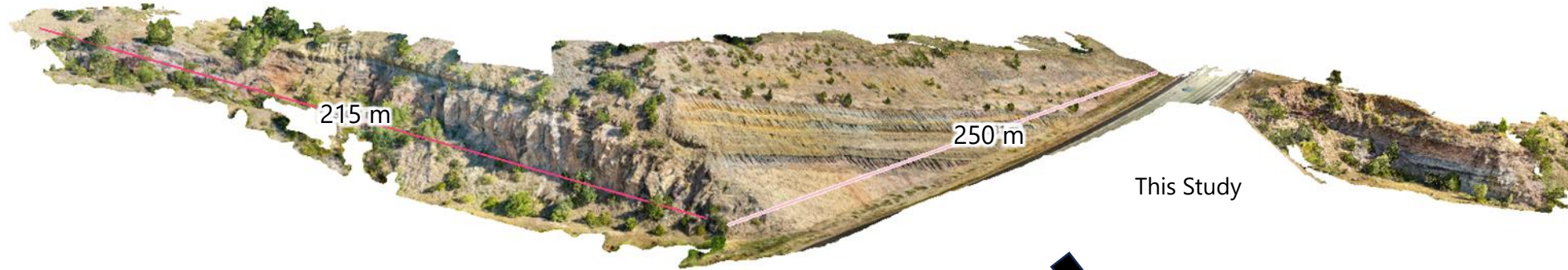


Outcrop Examples – 3D Photogrammetry

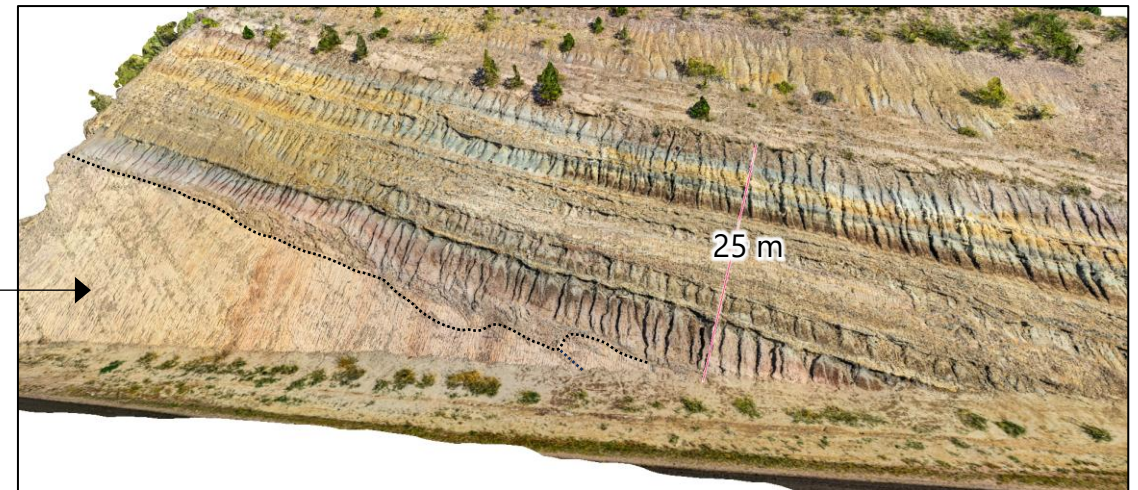
– Inter-Channel —|— Margin —|— Channel Complex —|—



Outcrop Examples – 3D Photogrammetry

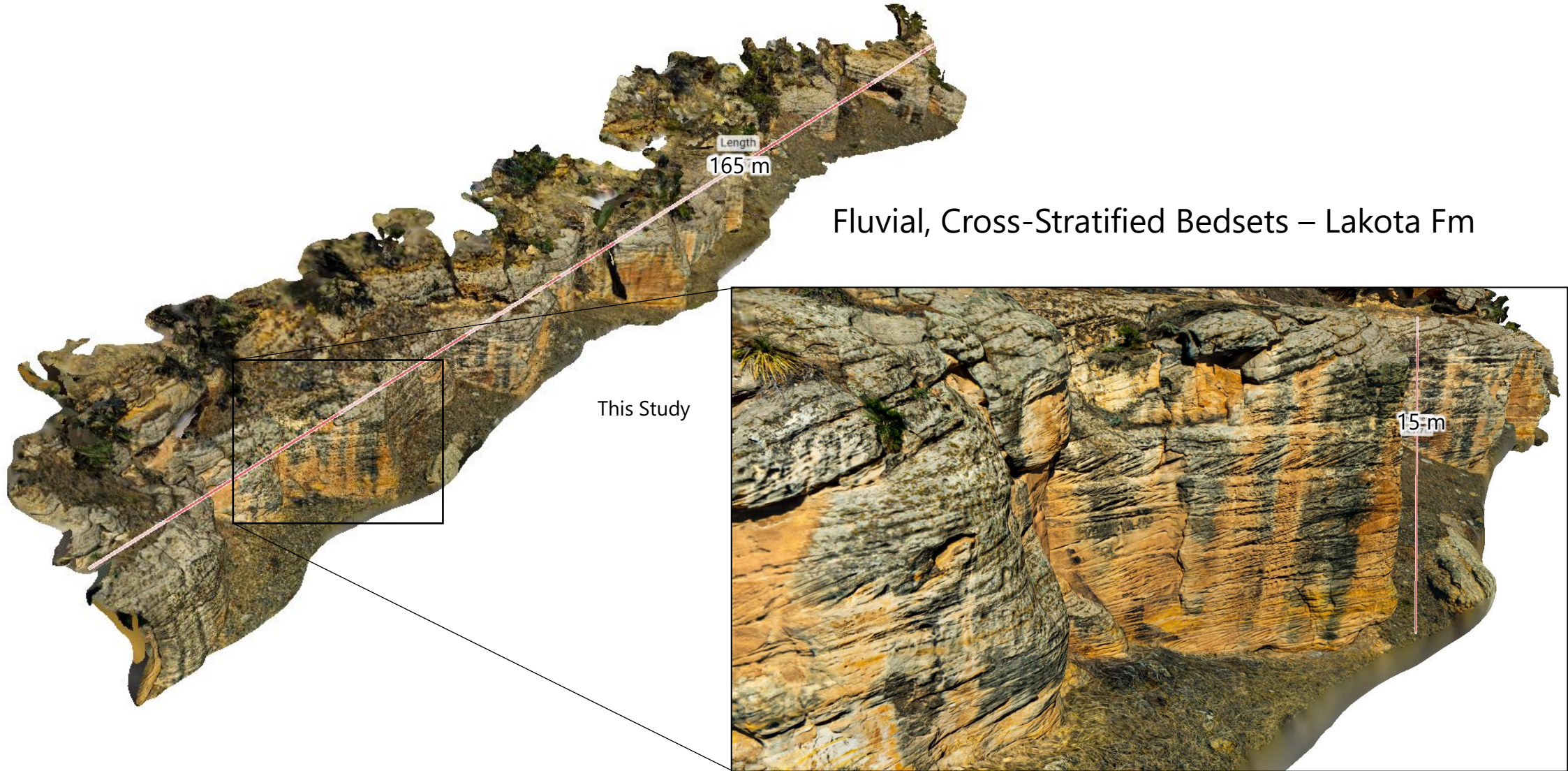


Fluvial Channel-Fill– Fall River Fm



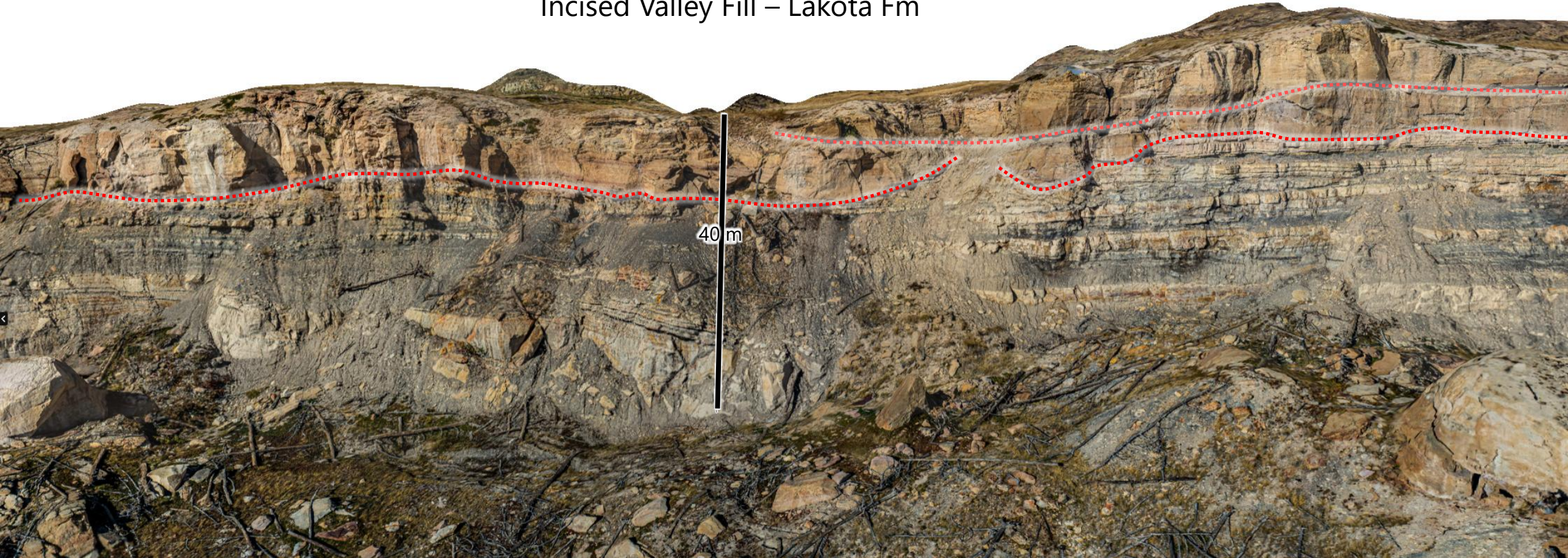
Overlying Tidal-Influenced Coastal Plain

Outcrop Examples – 3D Photogrammetry

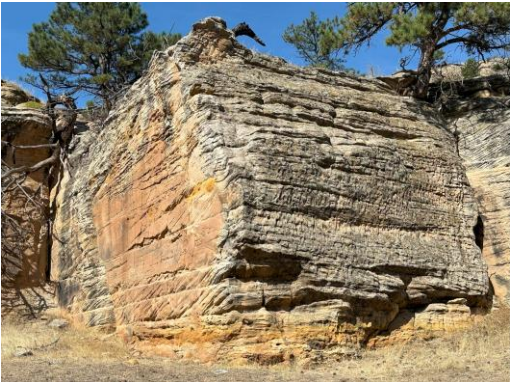
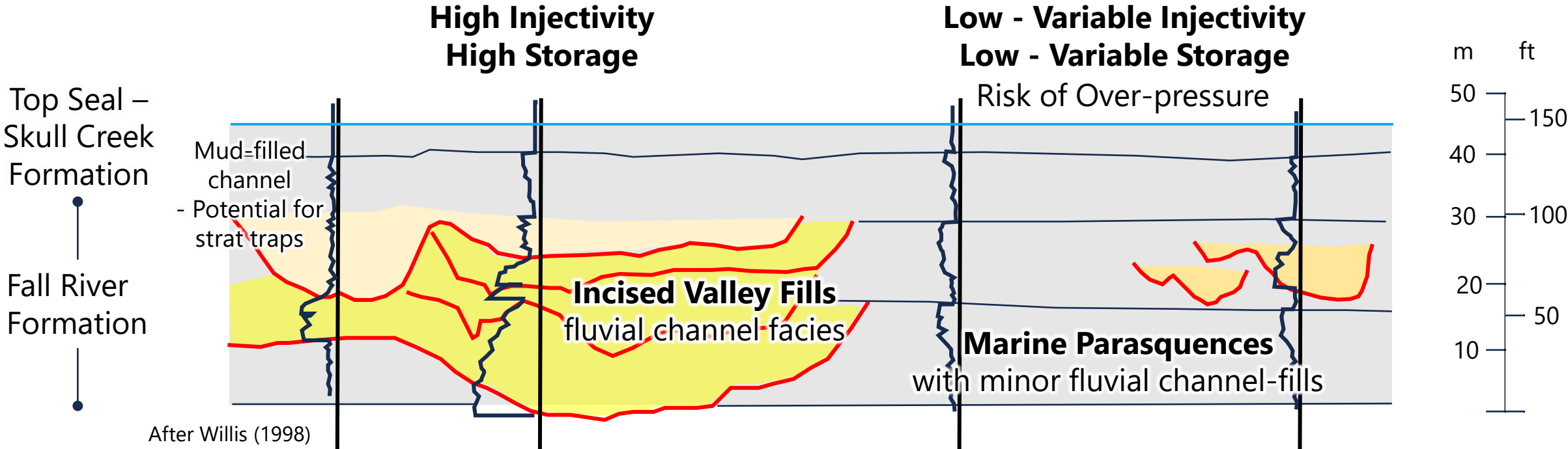


Outcrop Examples – 3D Photogrammetry

Incised Valley Fill – Lakota Fm



SWD Considerations; Upper Inyan Kara Sequence



Field Workshop Objectives

1. To examine the geologic variations of the Inyan Kara Group along an oblique, SSE-NNW transect through the Black Hills of South Dakota and Wyoming
2. Observe and compare the lithofacies and sequence stratigraphic characteristics at different paleo-geographic positions and environments of deposition along this transect
3. Learn how to recognize these different geologic characteristics in well logs and to apply appropriate stratigraphic concepts in subsurface correlation and mapping
4. Apply the outcrop observations to shallow water disposal (SWD) and CO2 sequestration (CCS) application in the Williston Basin
5. Consider the implications of the outcrop lithofacies and geometries to subsurface reservoir modeling

Proposed Agenda

Arrive

Day 1 – Introduction and Hot Springs area outcrops

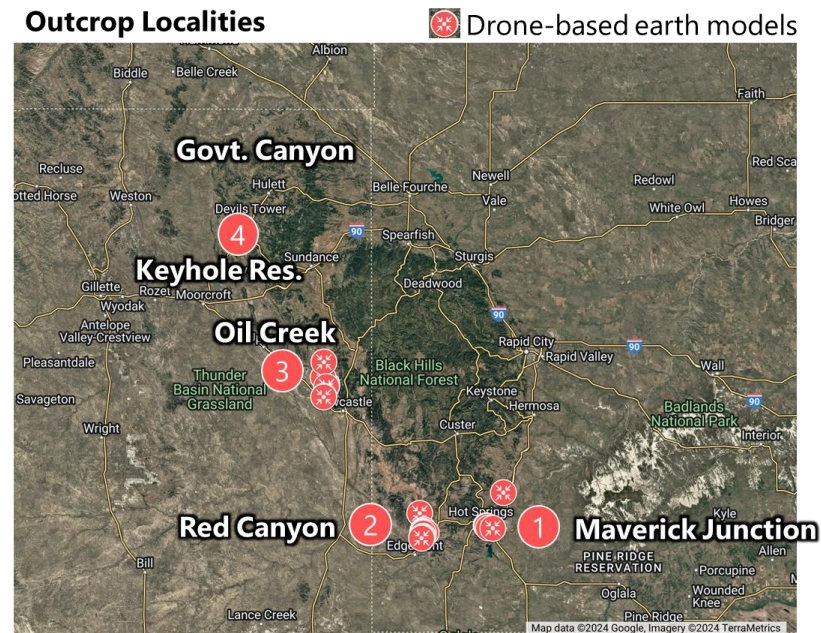
Day 2 – Red Canyon area outcrops

Day 3 – Oil Creek area outcrops

Day 4 – Keystone Reservoir and Government Canyon area outcrops

Day 5 (1/2) – Wrap-up and well log correlation exercise

Depart



Registration, Background and Contact Information

Registration @ [Inyan Kara Field Workshop](#)

RTB GEOSCIENCE LLC

Rick Beaubouef is a geoscientist and subsurface integrator with over 30 years of experience with proven track record in the oil and gas industry. He's held various technical and leadership roles in E-D-P and R&D at ExxonMobil and Hess. Rick has deep expertise in sequence stratigraphy and reservoir description and characterization in a variety of basins and settings. He is focused on integrated approaches where subsurface studies are complimented by outcrop geology, modern depositional systems, and knowledge of geologic processes. He is a teacher, coach, and mentor, but also an avid student of geoscience, and is passionate about his work.

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Geology Field Schools

Chris Oswalt has over two decades of experience in outdoor education and wilderness risk management. For six years, Chris served as the Global Field Safety Director for Nautilus/RPS where he trained field staff, audited courses in the field, and oversaw complex safety protocols and operations for a portfolio of over 100 field courses worldwide. In 2019, he left Nautilus to launch his own company, Geology Field School, dedicating himself to running the highest quality field courses possible. He is a nationally Registered EMT, a member of Texas Search and Rescue (TEXSAR), and a certified FAA Part 107 drone pilot with 11 years of experience.

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