

Recommended Revisions to Mid-Carboniferous Stratigraphy of the Big Snowy Trough, Central Montana, USA*

Richard J. Bottjer¹

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¹Coal Creek Resources, Denver, CO (rjbottjer@coalcreekresources.com)

Abstract

The Heath and Tyler formations of central Montana have been the subject of much study and debate since the Tyler Formation was named in 1922 by Freeman and the Heath was named as the uppermost formation in the Big Snowy Group by Scott in 1935. Numerous workers in the 1950s and 1960s debated whether strata assigned to the Tyler are a mappable unit, the existence of an unconformity between beds assigned to the Tyler and the Heath, and the age of the Tyler. Paleontological studies of the Bear Gulch Limestone began in 1968 and clearly document that it is latest Mississippian in age, and therefore the underlying units, including the Lower Tyler (or Stonehouse Canyon Member of the Tyler), must also be Late Mississippian in age. Studies that have focused on outcrops in the Big Snowy uplift typically regard strata known to most workers as Lower Tyler and Bear Gulch Limestone as the uppermost beds of the Heath Formation. However, regional stratigraphic correlations document a sequence boundary with more than 400 feet of relief between clastic-rich sedimentary strata of the Lower Tyler and marine strata of the Heath. The Lower Tyler is largely confined to incised valleys cut into the underlying Heath, so this erosional relief and much of the Lower Tyler are only locally present.

This study proposes modifications to existing stratigraphic correlation charts for the Carboniferous in central Montana. The base of the Heath Formation/top of the Otter Formation should be re-defined as the top of a laterally persistent oolitic limestone bed that is regionally correlative in the subsurface and is mappable at the surface (Scott, 1935). The current definition of the top of the Otter as the “first green shale” is neither consistent nor mappable. The top of the Heath Formation and the top of the Big Snowy Group should be defined as the sequence boundary above which fine to coarse-grained sandstones are present. The clastic-bearing unit above the Heath, largely present in incised valleys, and the Bear Gulch Limestone are Late Mississippian in age and should be included in the Tyler Formation. Further paleontological studies should be undertaken to better define the ages of strata between the lower Heath and the Bear Gulch Limestone.

The overlying Cameron Creek Member (upper Tyler) is separated from the Bear Gulch by at least one sequence boundary. These strata are Morrowan (Pennsylvanian) in age and are most closely affiliated with the overlying Alaska Bench. Paleontological data from the dark gray shales and sandstones within the Upper Tyler incised valley fills is lacking, and these could be either latest Mississippian or Early Pennsylvanian. If these strata are included in the Tyler Formation, the Mississippian-Pennsylvanian Boundary is within the Tyler. Additional

studies are needed to determine the true stratigraphic affiliations of the “Becket Beds” and the “Surenough Beds”. New core data help subdivide internal strata within the Heath Formation. Past attempts at internal subdivision of the Heath have suffered from poor outcrops and limited core (lithological) control. Core to log calibrations and ensuing regional correlations allow informal definition, in ascending order, of the lower Heath, Van Dusen zone, Cox Ranch Oil Shale Interval (expanded from the original definition), Heath Carbonate unit (which has the Loco Ridge Gypsum bed at the top), a lowstand basin fill shale, carbonate, and gypsum unit, and the upper Heath.

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AAPG Rocky Mountain Section Meeting

Billings, Montana

June 27, 2017

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Coal Creek Resources

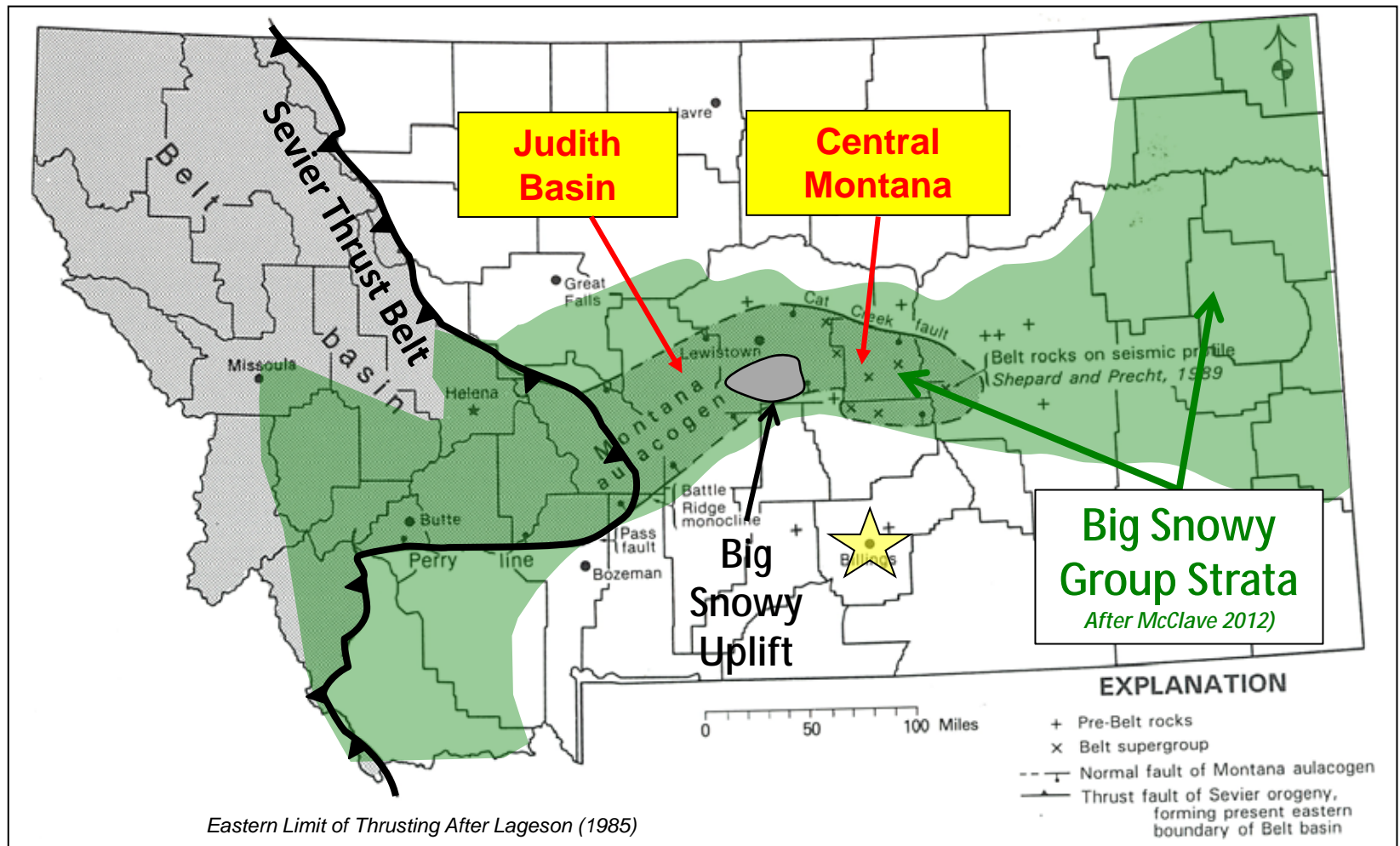
rjbottjer@coalcreekresources.com





STUDY AREA LOCATION

Distribution of Late Precambrian Belt Supergroup Central Montana Aulacogen

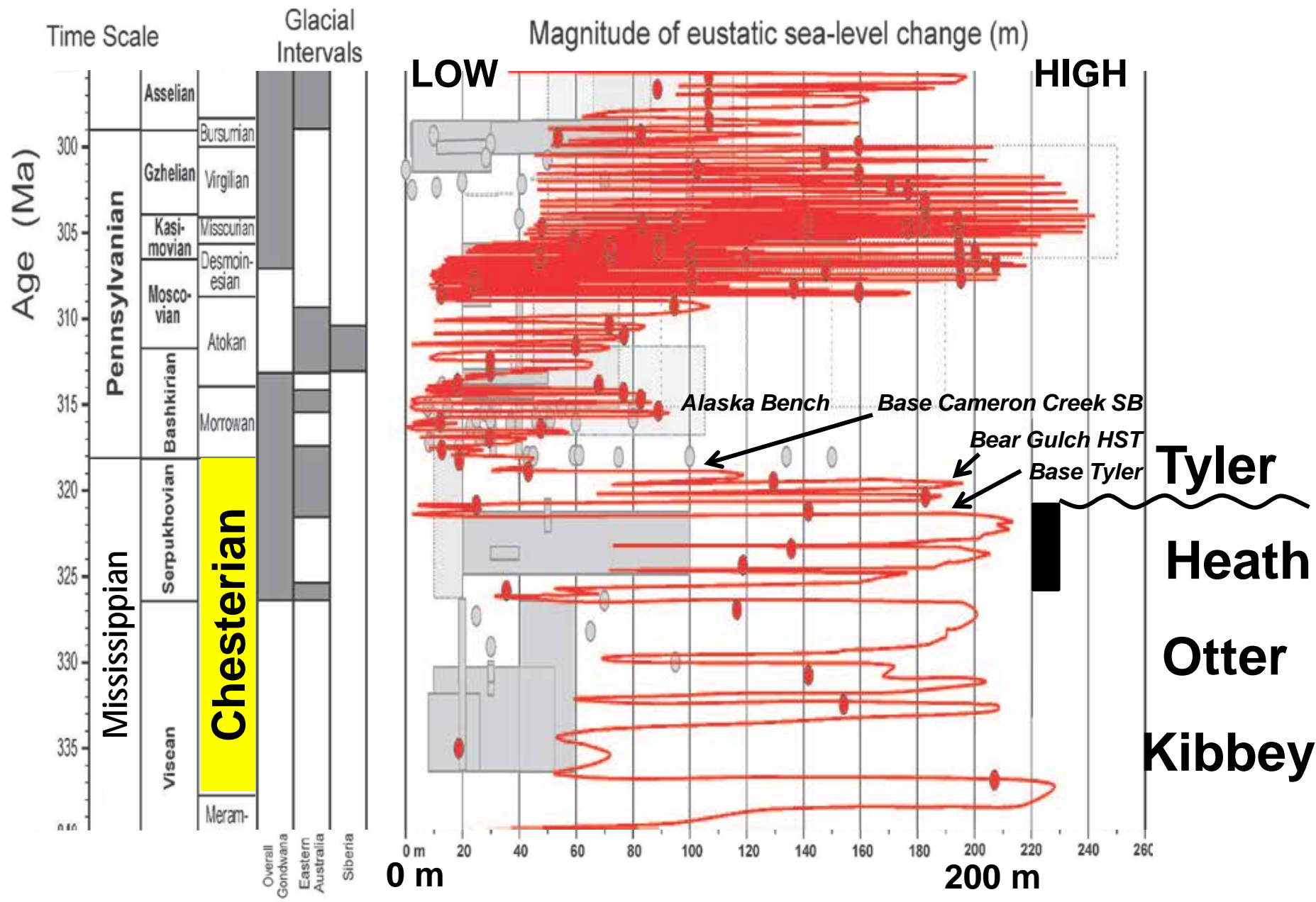


Belt basin and Montana Aulacogen, with surface and sub-surface control points. *After Nelson (1993)*

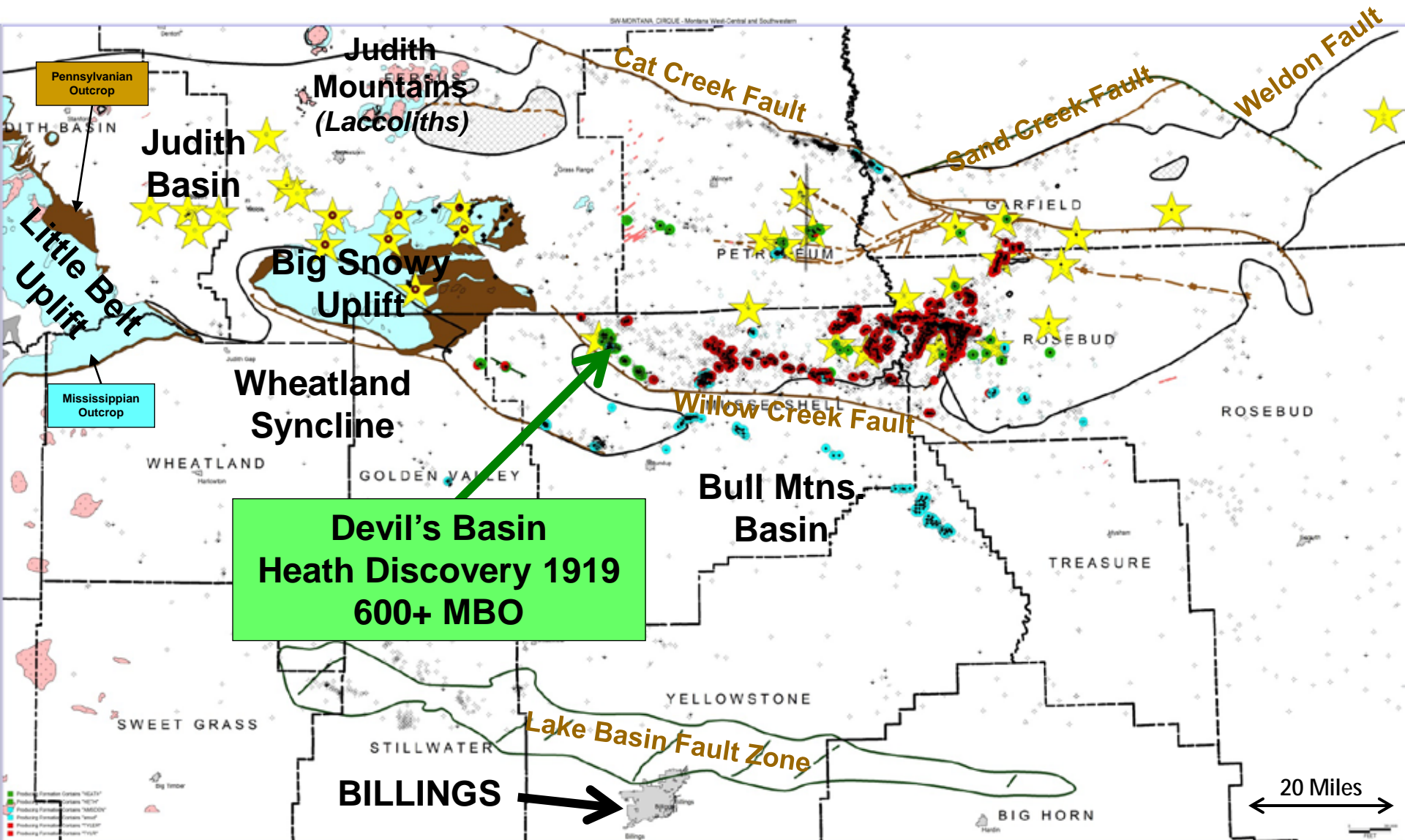


LATE MISSISSIPPIAN – PENNSYLVANIAN SEA LEVEL

After Rygel et al (2008)



Study Location – Central Montana



★ **Heath – Tyler
Core**

● **Amsden LS + Dolomite**

● **Tyler Sandstone**

● **Heath LS + Shale**

Oil Production Zone

Well locations and data from MBMG, I.H.S. Energy & Published Data



KEY PROBLEMS & ISSUES

- **Base of Heath Definition**
 - “First Green Shale” is NOT Consistent Nor is it Mappable
 - Alternative Recommended
- **Top of Heath Definition**
 - Unconformity with Tyler – Regional or Local?
 - Continuous Deposition from Heath up into Bear Gulch?
- **Use of the Term “Tyler”**
 - Bear Gulch & Lower Tyler (Stonehouse Canyon) included in Heath or Separated from Heath by Regional Sequence Boundary
 - Cameron Creek Red & Green Shales – Part of but not equivalent to Upper Tyler
- **Age of Bear Gulch and Lower Tyler (Stonehouse Canyon)**
 - Many Strat Charts Show as Pennsylvanian (Morrowan) = INCORRECT
 - Definitive Mississippian Fossils in Bear Gulch Limestone
 - Miss-Penn Boundary is above Bear Gulch
- **Heath Internal Stratigraphy**



HEATH FORMATION – TYLER CREEK OUTCROP

Heath Originally Defined by Scott 1935

Type Area = “outcrops” at Beacon Hill, southwest end of Alaska Bench, SW ¼, Sec. 36, T13N, R19E

Example Heath Outcrop – Tyler Creek

SE ¼, Sec. 26, T14N, R20E



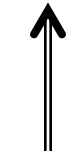
**Heath Defined in 1935 By Scott
as Upper Formation in Big
Snowy Group (group of strata
between Madison and Amsden)**

- **Heath contains Dark Gray to Black Shale, Mudstone, & Limestone**
- **Abundant Vegetation & Cover**
- **Landslides**
- **1935 Heath included strata now included in Tyler Formation by most workers**
- **Heath-Otter Interval 366 feet = 74% Covered at Type Section (based on Maughan & Roberts (1967))**

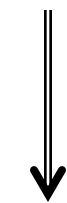


Carboniferous Stratigraphy – More Recent Work

1968

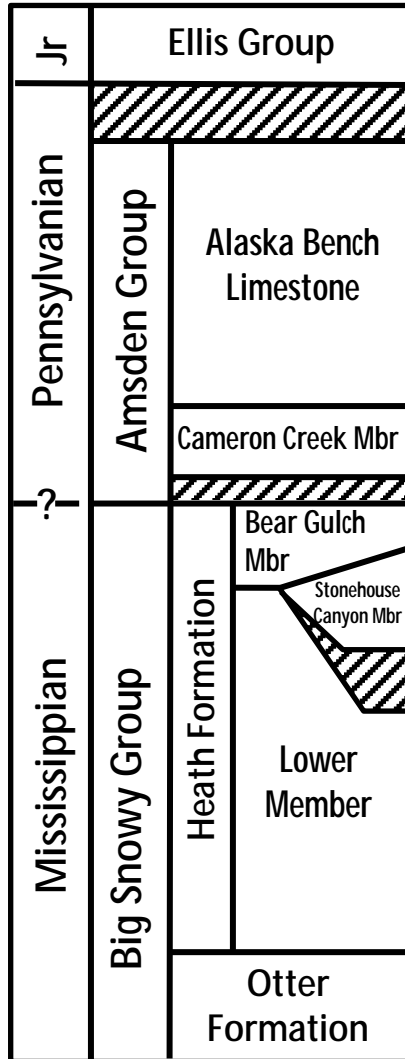


Fish Discovered in Bear Gulch LS



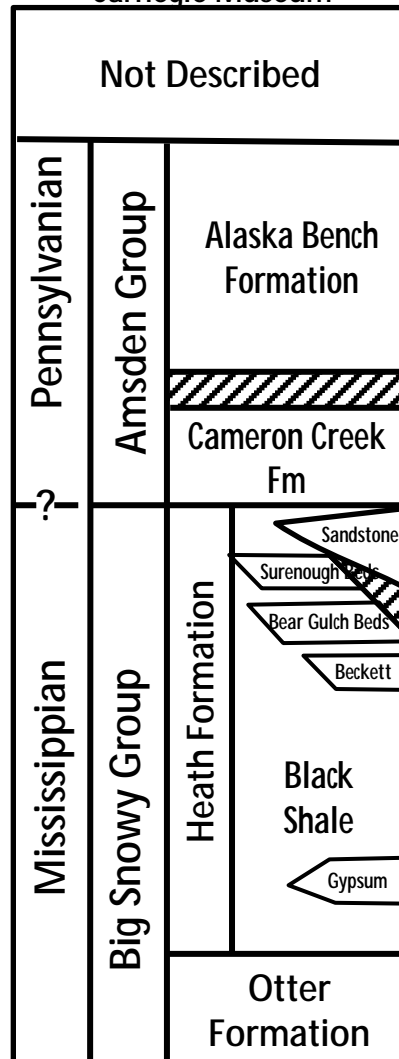
Horner
(1979)

Princeton Univ.



Grogan & Lund
(2002)

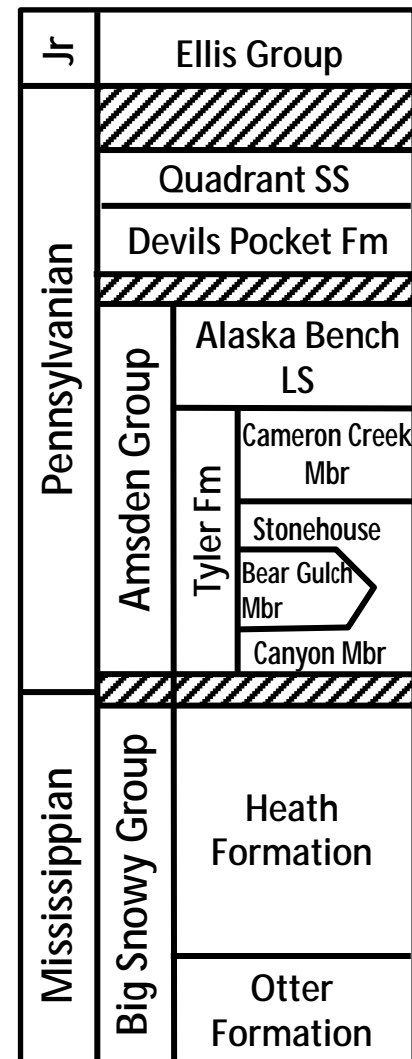
St. Joseph's Univ. &
Carnegie Museum



After Williams (1983)

Maughan
(1984 & 1989)

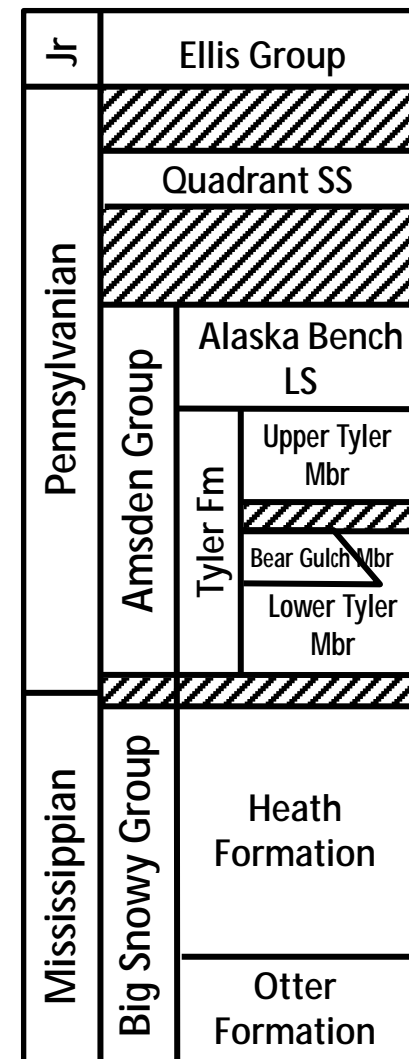
USGS



After Maughan and Roberts (1967)

Stanton & Silverman
(1989)

Consultants/Gustavson Assoc.



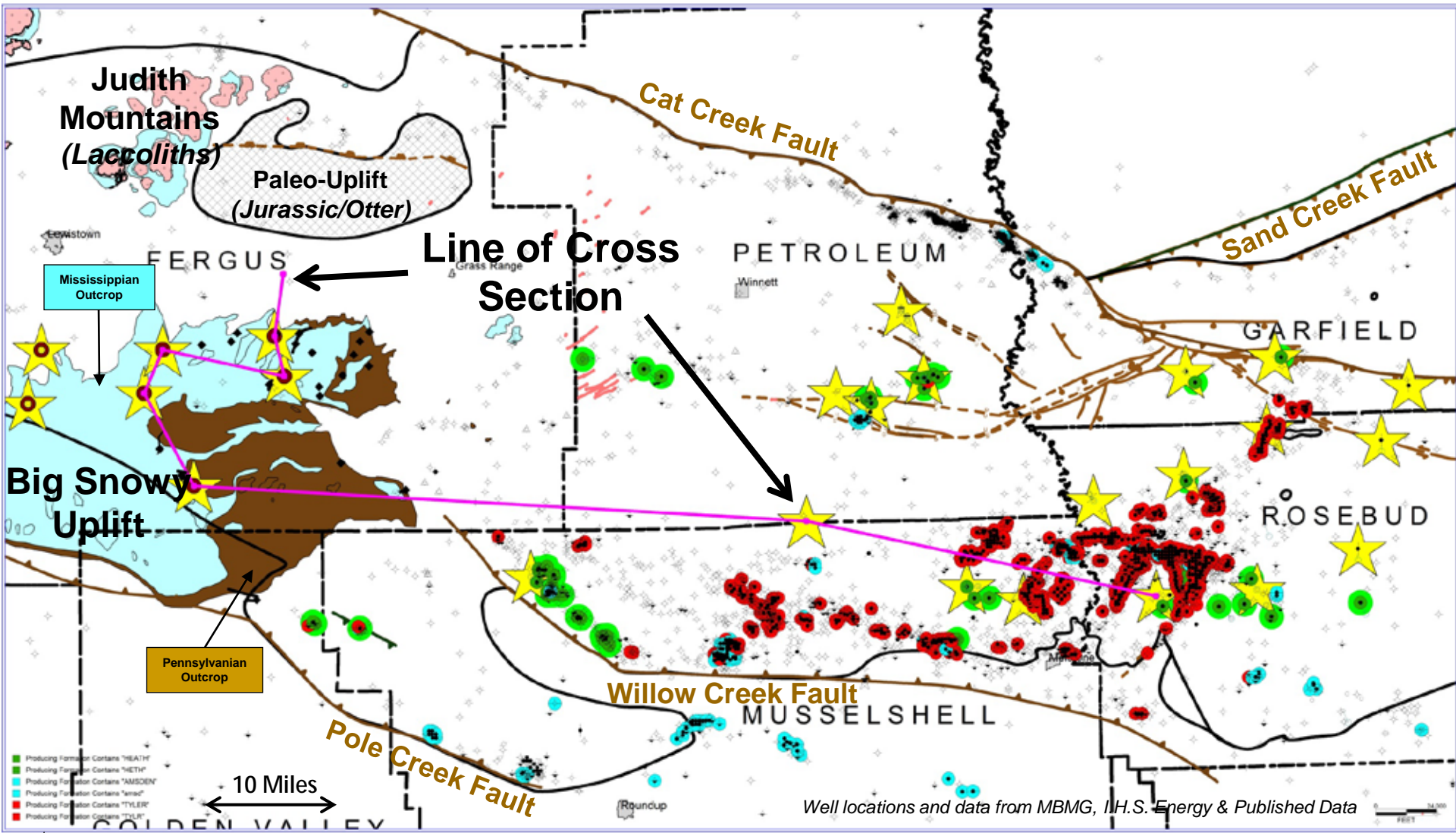


KEY PROBLEMS & ISSUES

- **Base of Heath**
 - **Original Definition in 1935 – Contact Between Green Shales (and soils) Below and Dark Gray to Black Shales (and soils) Above**
 - **Easton (1962) Recommended Moving Heath-Otter Contact Downsection to Stratigraphically Lowest Occurrence of Productid Brachiopods – Open Marine Deposition Belongs in the Heath Formation**
 - **“First Green Shale” is NOT Consistent Nor is it Mappable**
 - **A Mappable Alternative is Recommended**

DEFINITION OF HEATH-OTTER CONTACT

MBMG Coreholes & Regional Correlations



Heath – Tyler
Core

Oil Production Zone



Amsden LS + Dolomite



Tyler Sandstone



Heath LS + Shale

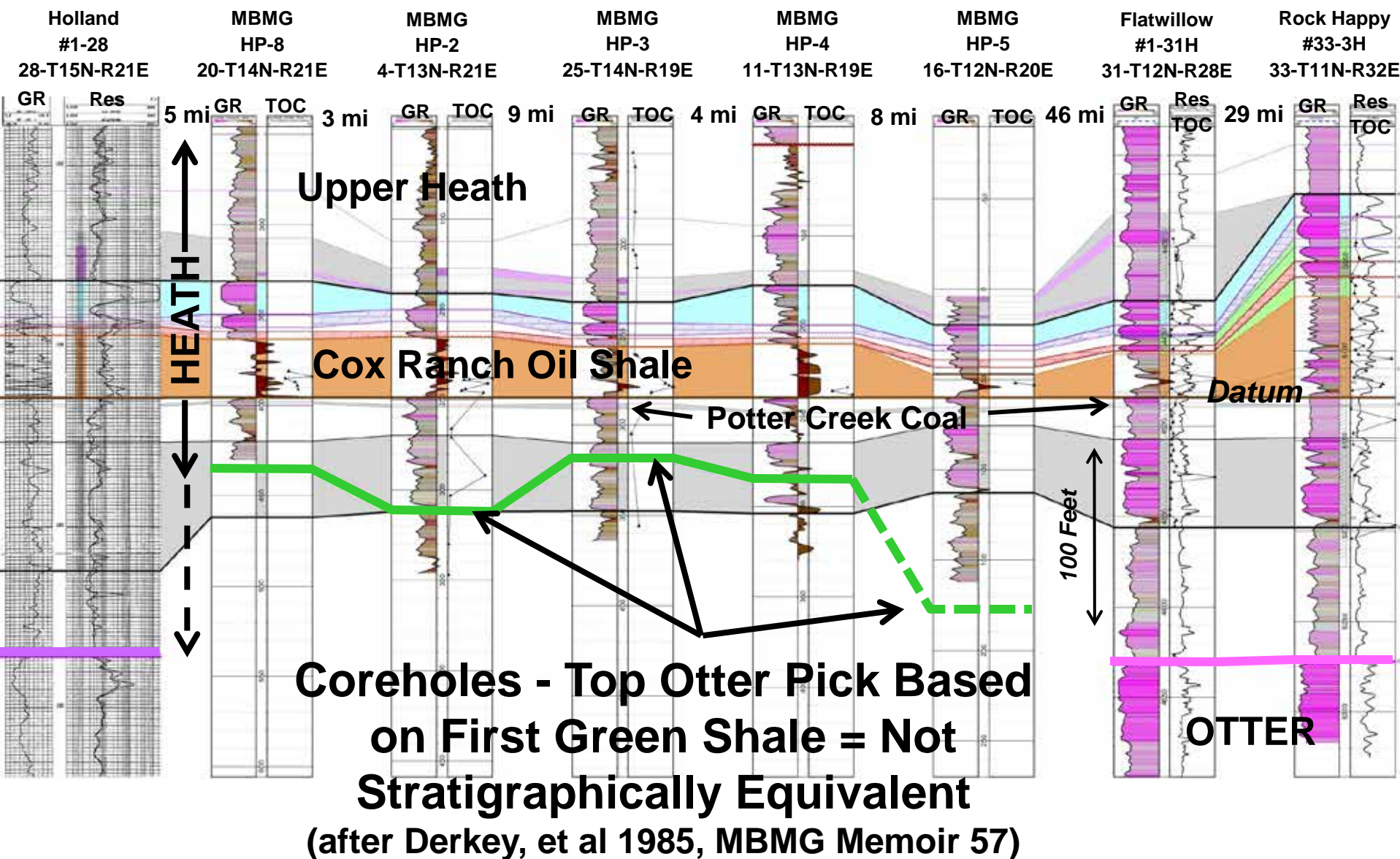


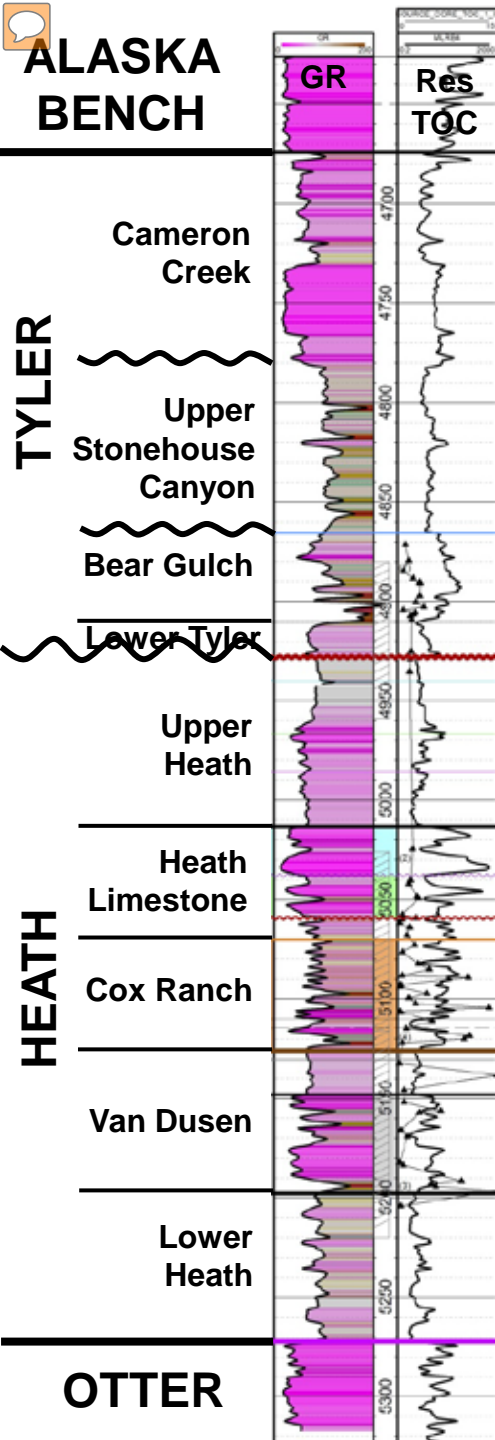
DEFINITION OF HEATH-OTTER CONTACT

MBMG Coreholes & Van Dusen Correlations

Northwest

Southeast





Rock Happy #33-3H
33-T11N-R32E

GREEN SHALES

- Light Greenish-Gray Claystones
- Paleosols
- Cyclic Deposition

Core Interval Shown

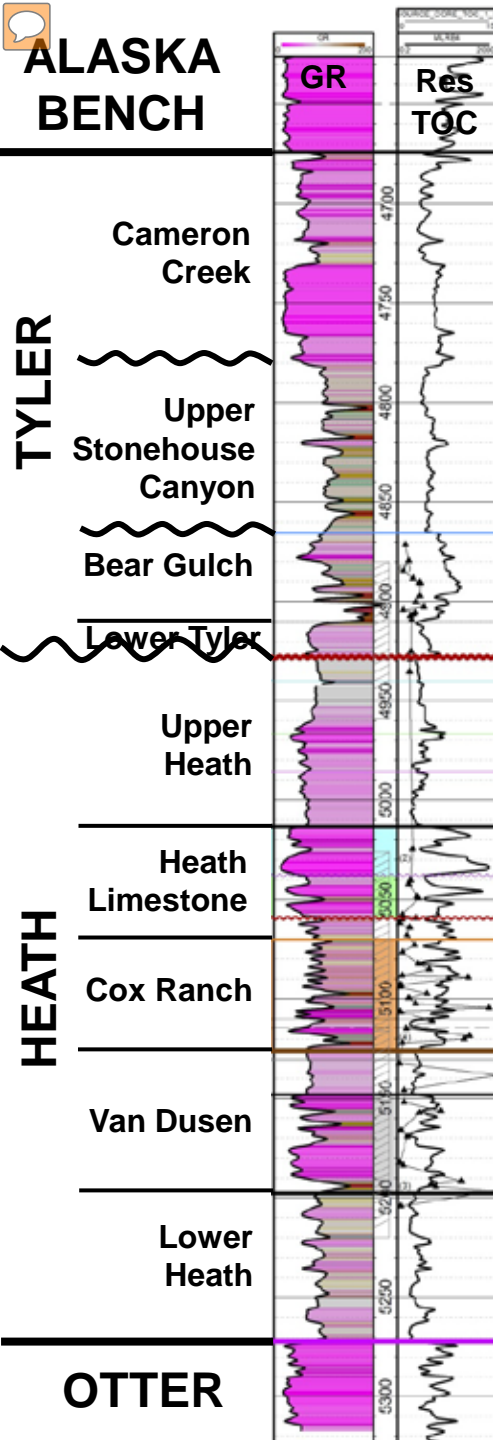
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ALASKA BENCH

Rock Happy
#33-3H
33-T11N-R32E



Todd

#1-32

32-T17N-R14E

GR

Res

Flatwillow

#1-31H

31-T12N-R28E

GR

Res

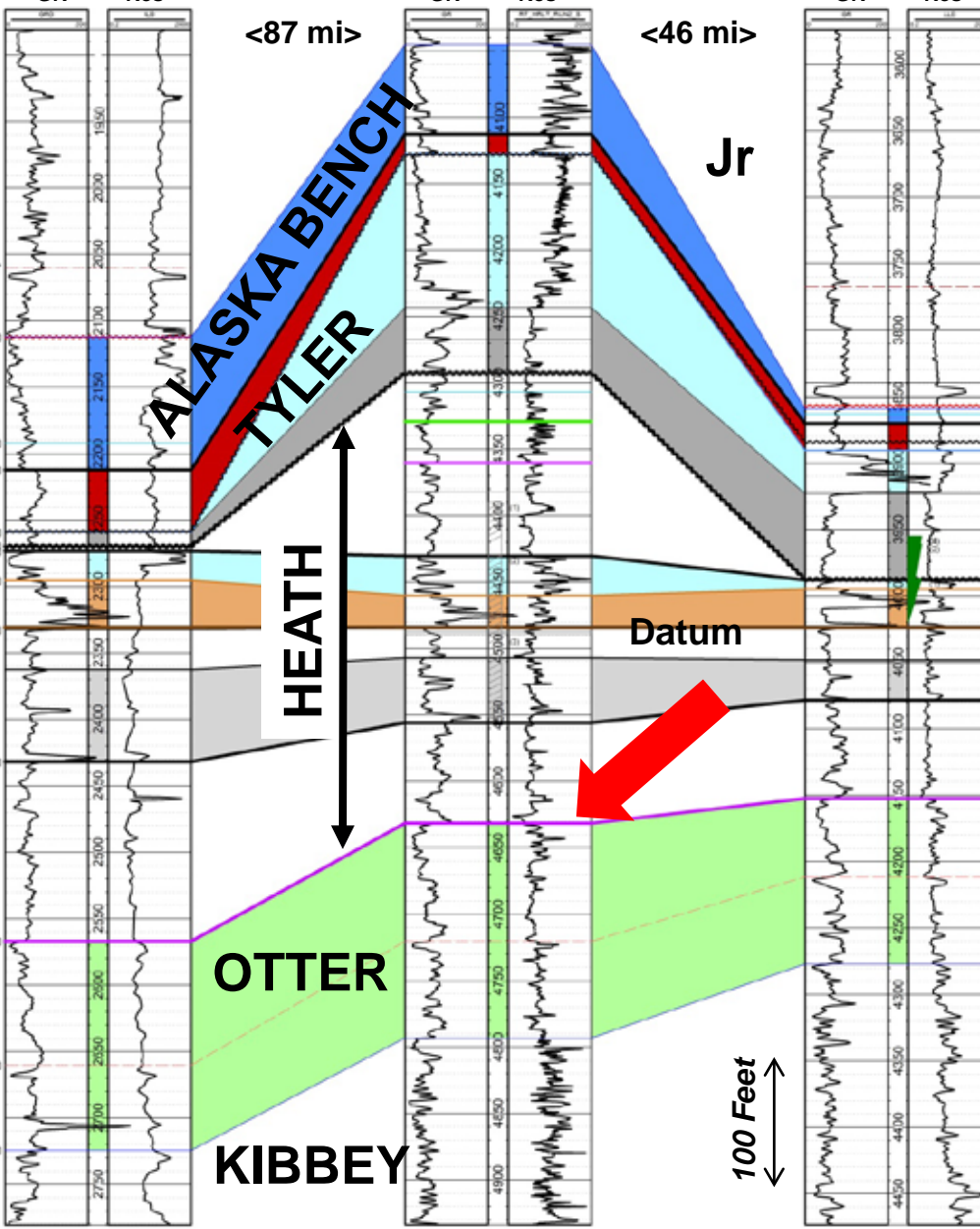
McGinnis

#1-2

2-T12N-R35E

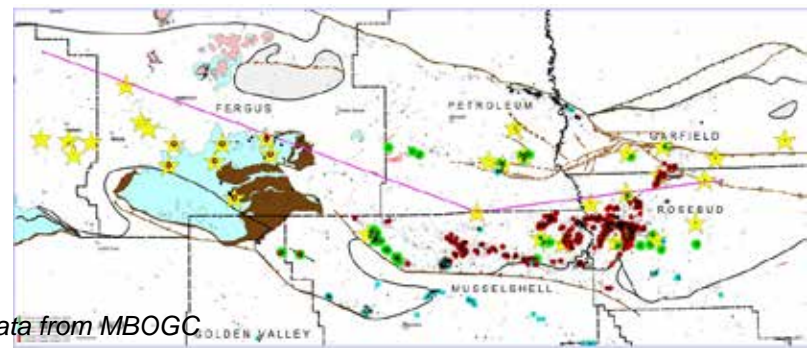
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PROPOSED RE-DEFINITION OF HEATH-OTTER CONTACT

- Base of Heath / Top of Otter Re-Defined as Top of Cream-Tan Limestone at 4632' in EOG Flatwillow #1-31H Pilot Hole
- Regionally Correlative & Mappable Marker





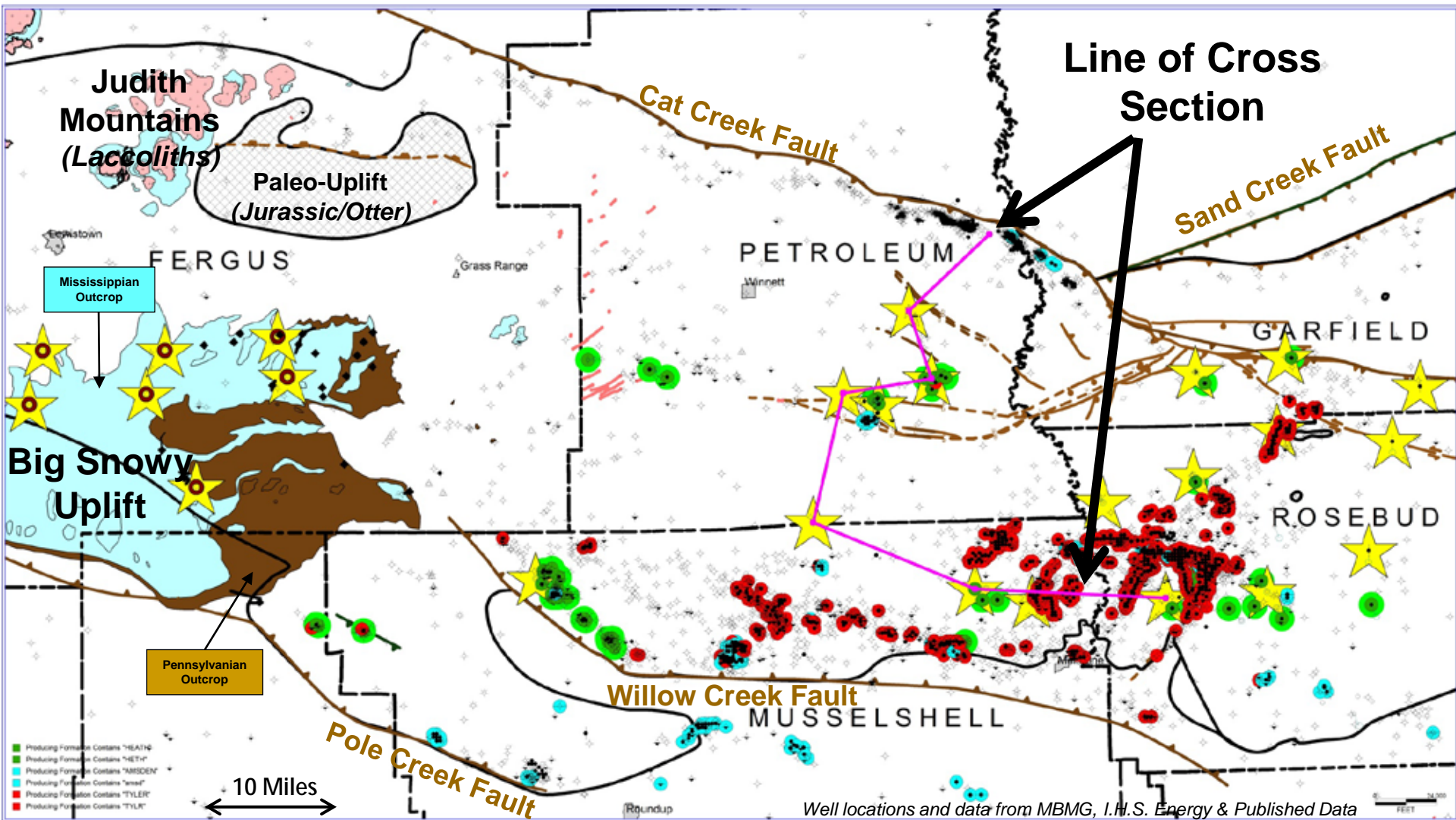
TOP OF HEATH

- **Original Definition - 1935**
 - **Top of Dark Gray to Black Shale – Dominated Unit**
 - **Conformably Overlain by Red & Green Shales of Cameron Creek**
 - **Included Sandstone – Bearing Units Now Commonly Called Tyler**
 - **Poor Outcrops – “Type Section” had > 50% Covered Interval (Otter-Heath)**
 - **Still Followed by Some Field Geologists**
- **Use of the Term “Tyler”**
 - **Bear Gulch & Lower Tyler (Stonehouse Canyon) included in Heath or Separated from Heath by Regional Sequence Boundary?**
 - **Field Geologists in 1930s-1950s Argued That Tyler is not Mappable – See Surface Mapping by Derkey et al (1985) and Porter and others (1990s)**
- **Age of Bear Gulch and Lower Tyler (Stonehouse Canyon)**
 - **Many Strat Charts Show as Pennsylvanian (Morrowan) = INCORRECT**
 - **Definitive Mississippian Fossils**
 - **Miss-Penn Boundary is above Bear Gulch**



TOP OF HEATH FORMATION

Basal Tyler Unconformity vs Contact with Cameron Creek



**Heath – Tyler
Core**

Oil Production Zone



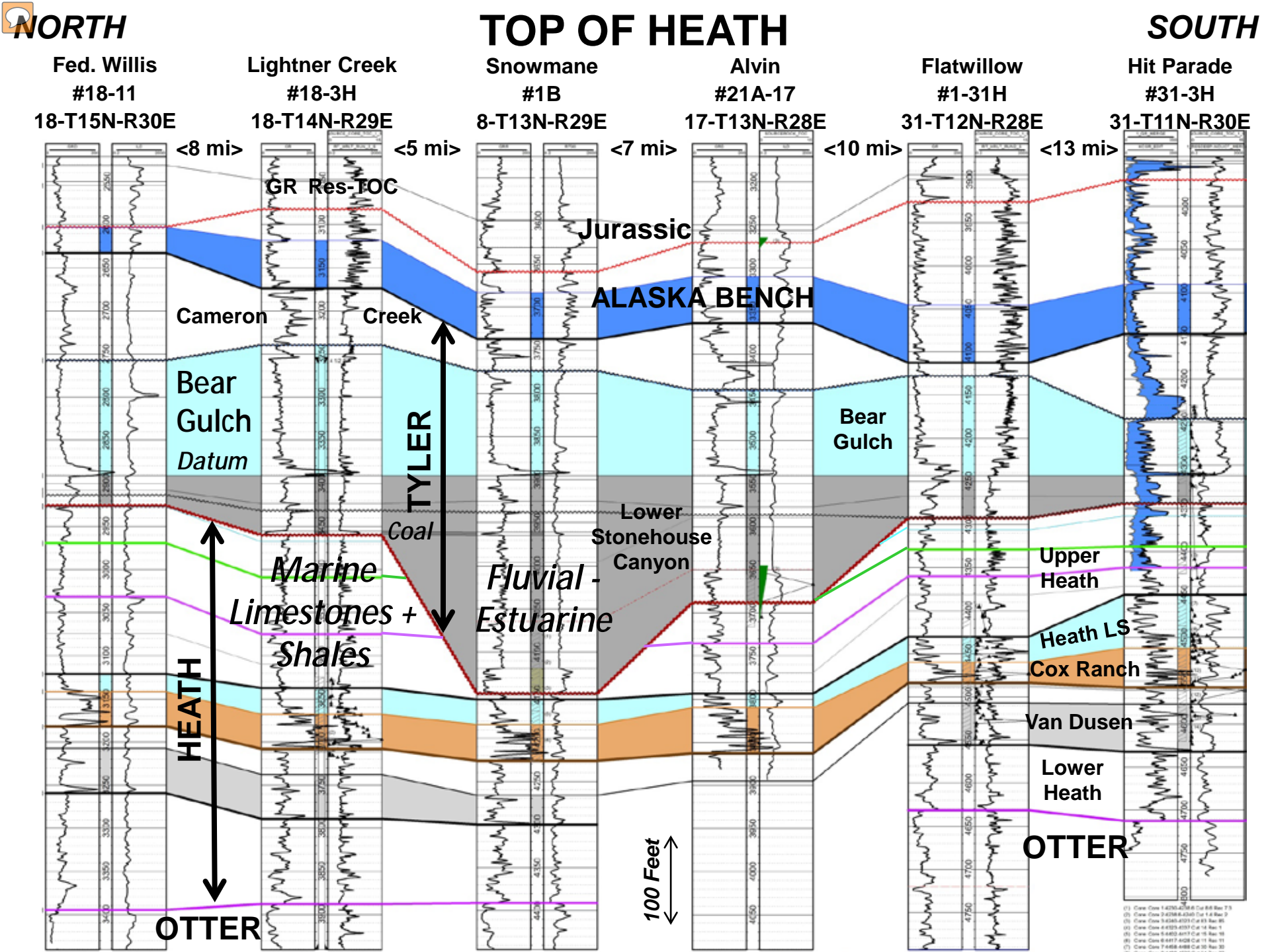
Amsden LS + Dolomite

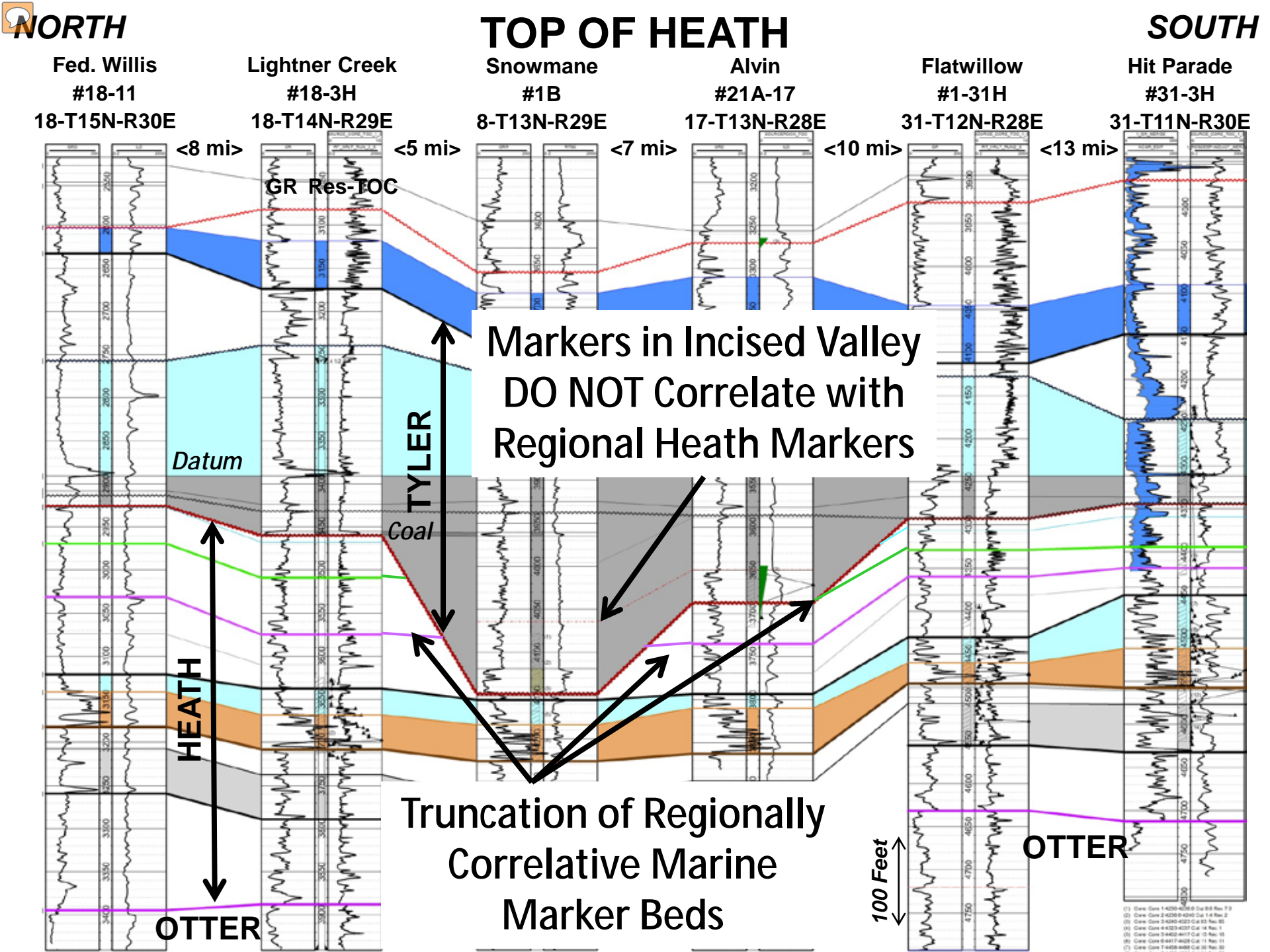


Tyler Sandstone



Heath LS + Shale





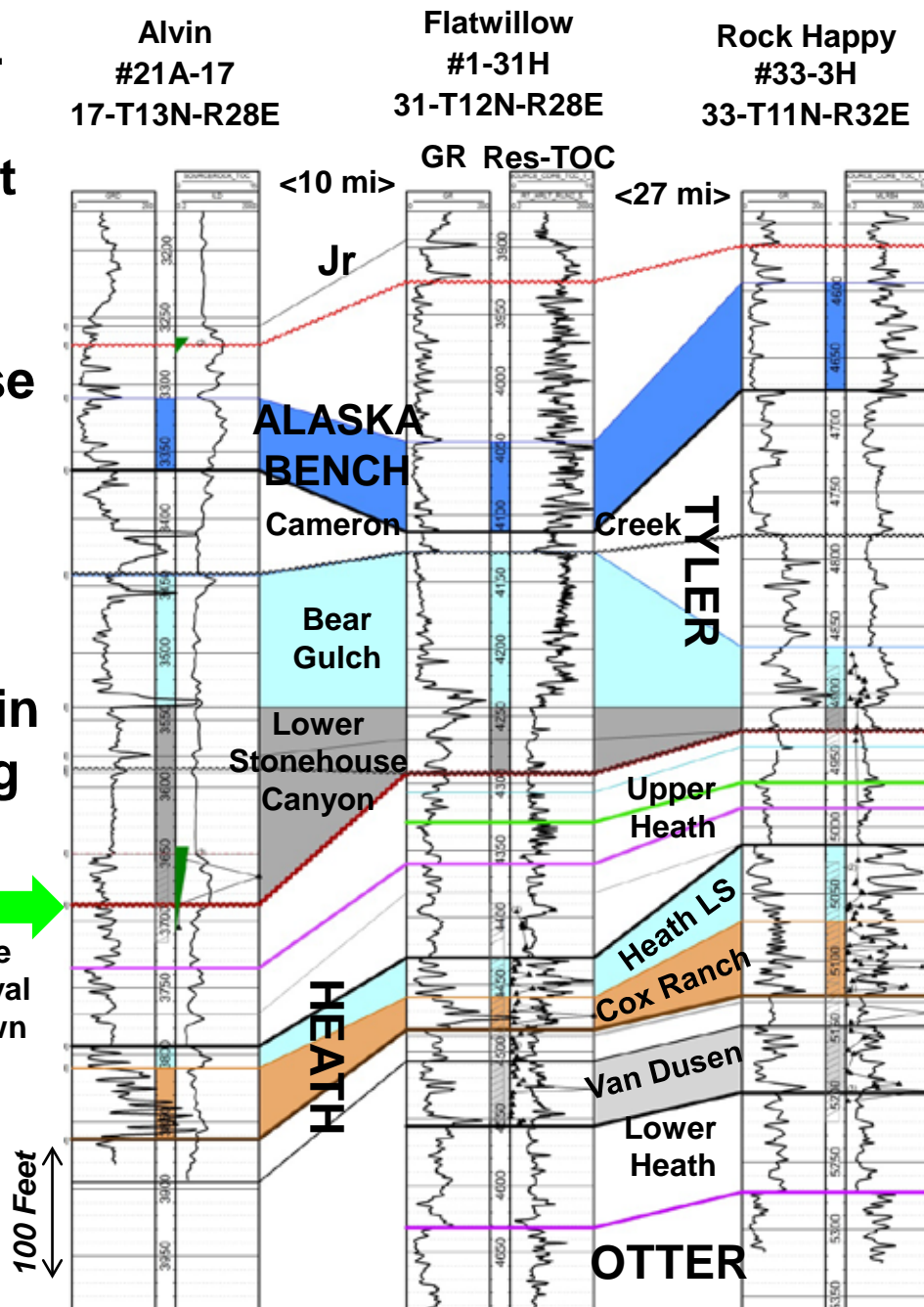


○ TYLER-HEATH

- Core in Lower Part of Incised Valley
- Sharp Base Tyler Erosional Surface
- Evidence for Roots in Underlying Heath

Core Interval Shown

TOP OF HEATH



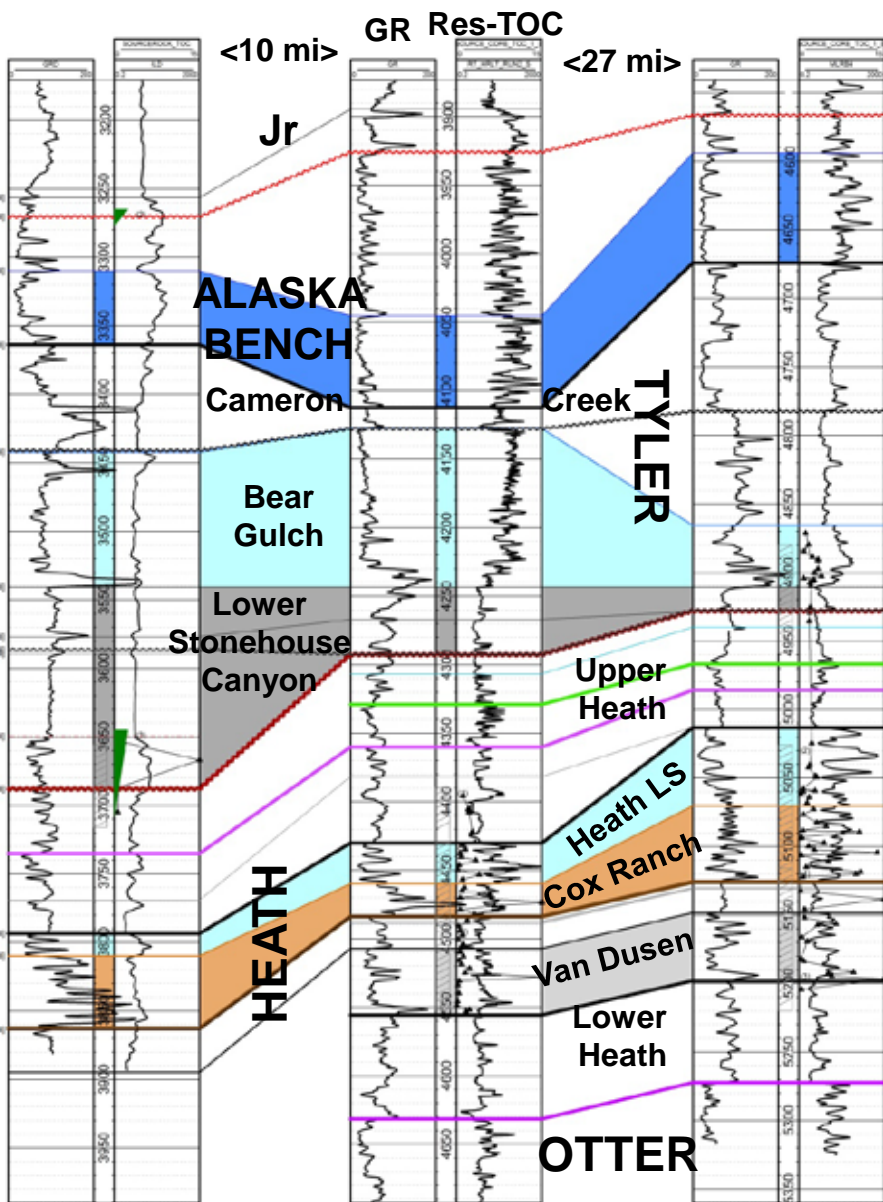


TOP OF HEATH

Alvin
#21A-17
17-T13N-R28E

Flatwillow
#1-31H
31-T12N-R28E

Rock Happy
#33-3H
33-T11N-R32E



○ TYLER-HEATH

- Core from “Interfluve” or Inter-Valley Area
- Sharp Base Tyler Erosional Surface

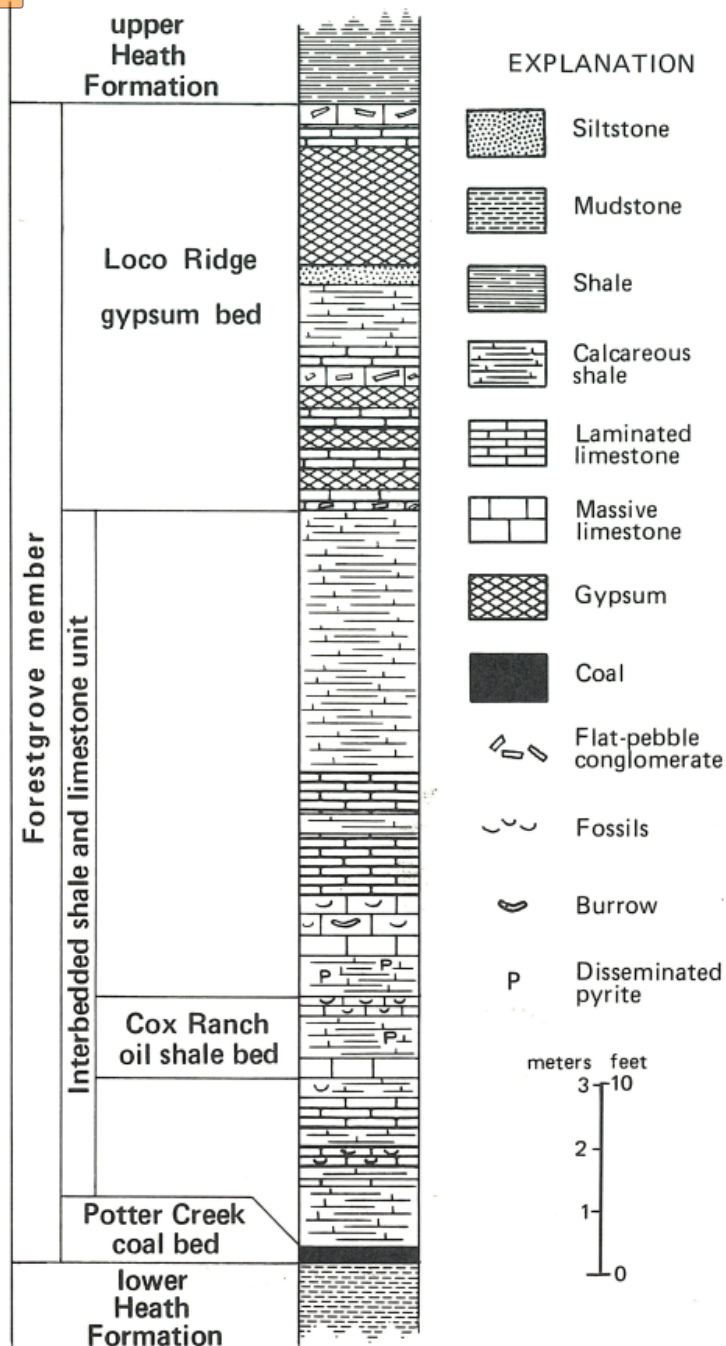
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TOP HEATH / BASE TYLER CONTACT

- **Erosion Surface Is Present Across The Entire Area**
 - **Multiple Incised Valleys**
 - **Truncation of Otherwise Regionally Correlative Marker Beds in Marine Upper Heath**
 - **Sandstones & Conglomerates Occur ABOVE the Sequence Boundary**
 - **Evidence for Erosion Present in Inter-Valley Areas**
- **Tyler & Heath Separated by Major Sequence Boundary**
 - **Best to Map and Correlate as Distinct Formations**
 - **Tyler is Mappable at the Surface & in the Subsurface**



HEATH INTERNAL STRATIGRAPHY

Previous Work

Derkey, et al., 1985

- **Heath Internal Stratigraphy**
 - Van Dusen Zone Defined by Knapp (1956) for Oil-Productive Interval at 1919 Devils Basin Discovery
 - Recommendations by Derkey et al (1985) based on MBMG coreholes
 - New Cores facilitate Internal Correlations & Lithological Calibration of Logs
 - Cores have better coverage than outcrop sections (high % covered intervals)



HEATH SUBSURFACE STRATIGRAPHY

VAN DUSEN TYPE WELL TO CIRQUE ROCK HAPPY #33-3H

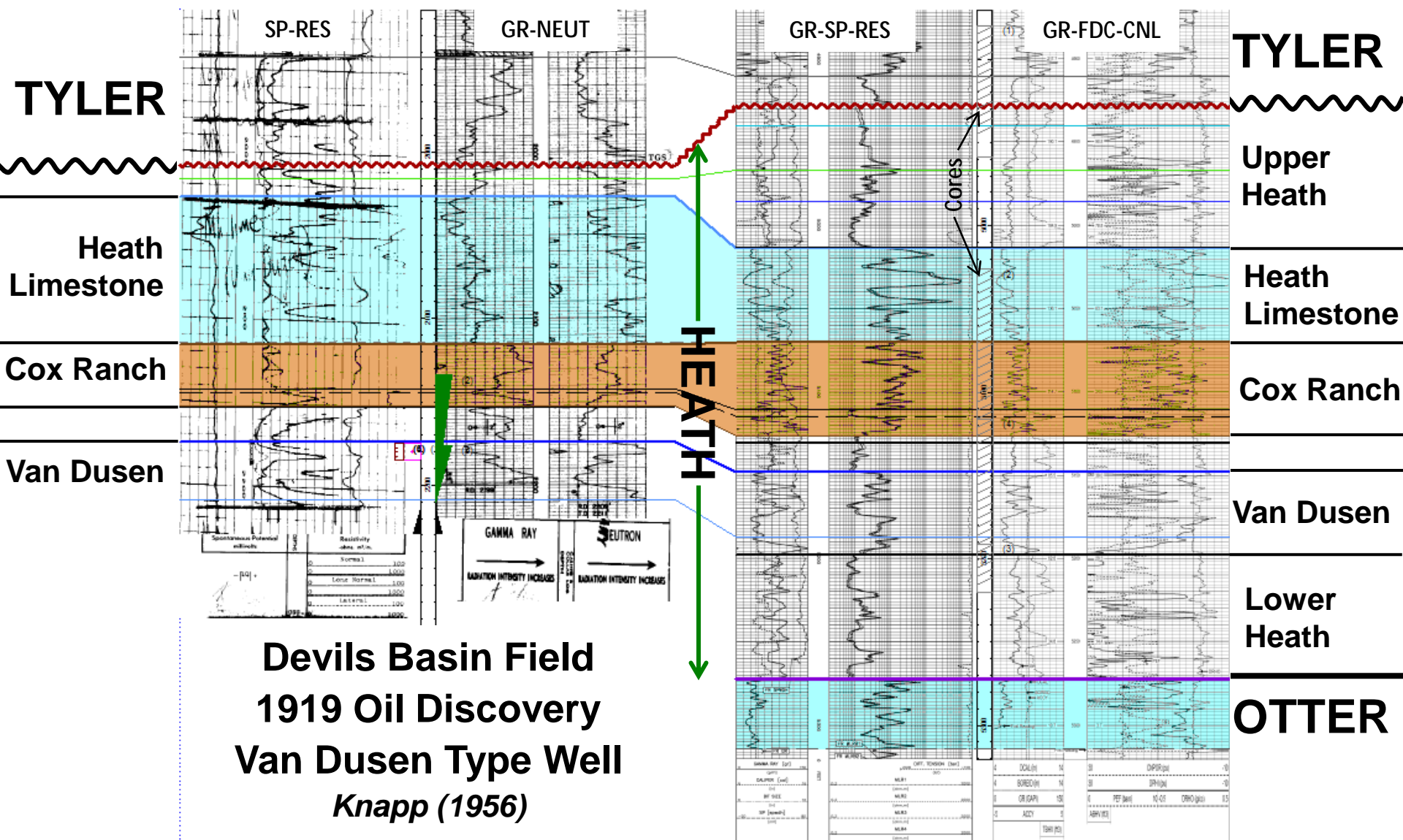
N. P. #2

Rock Happy #33-3H

5-T10N-R25E

42.8 mi.

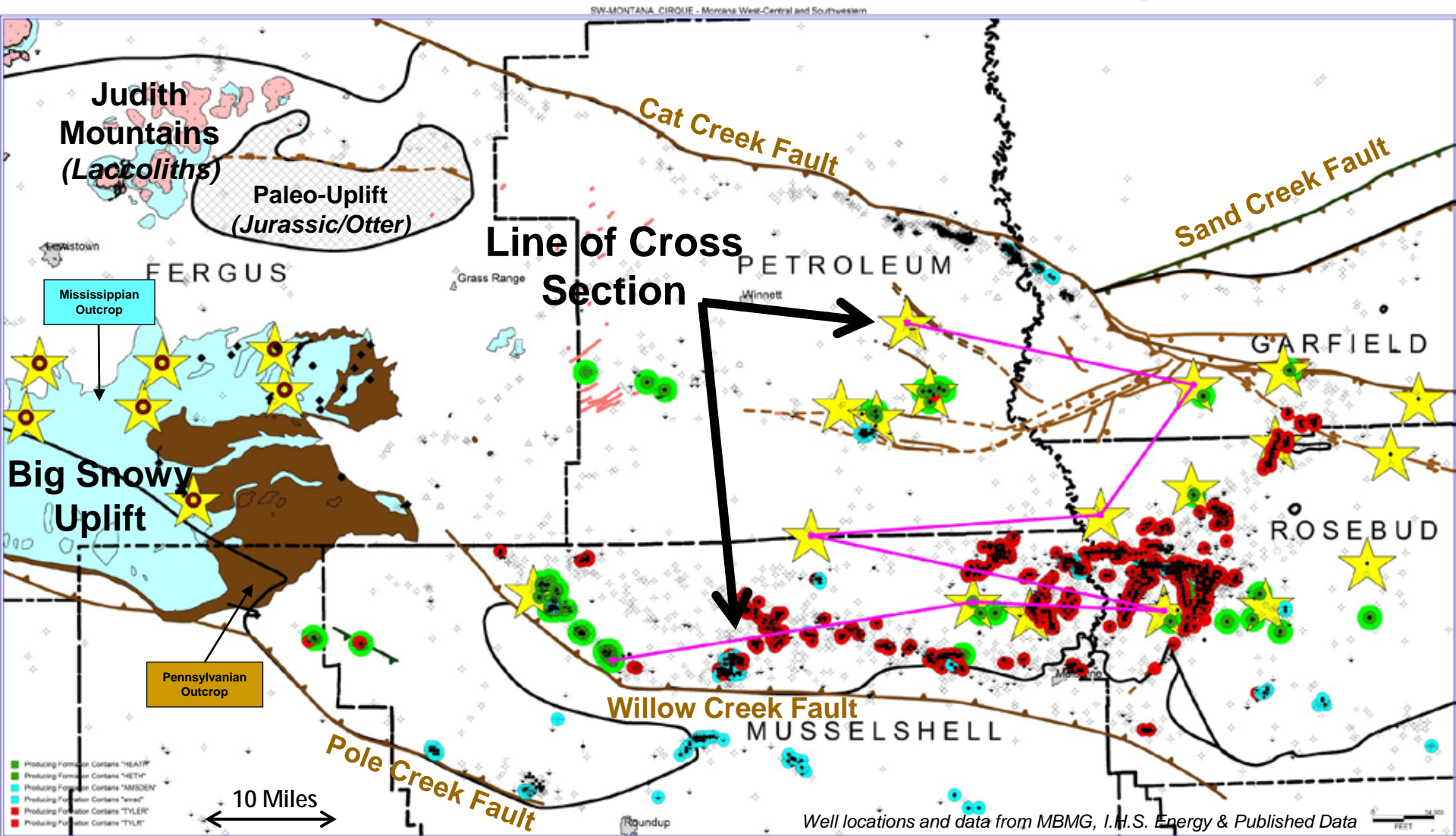
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HEATH FORMATION INTERNAL STRATIGRAPHY

New Cores Facilitate New Correlations & Interpretations



Heath – Tyler
Core

Oil Production Zone



Amsden LS + Dolomite



Tyler Sandstone



Heath LS + Shale

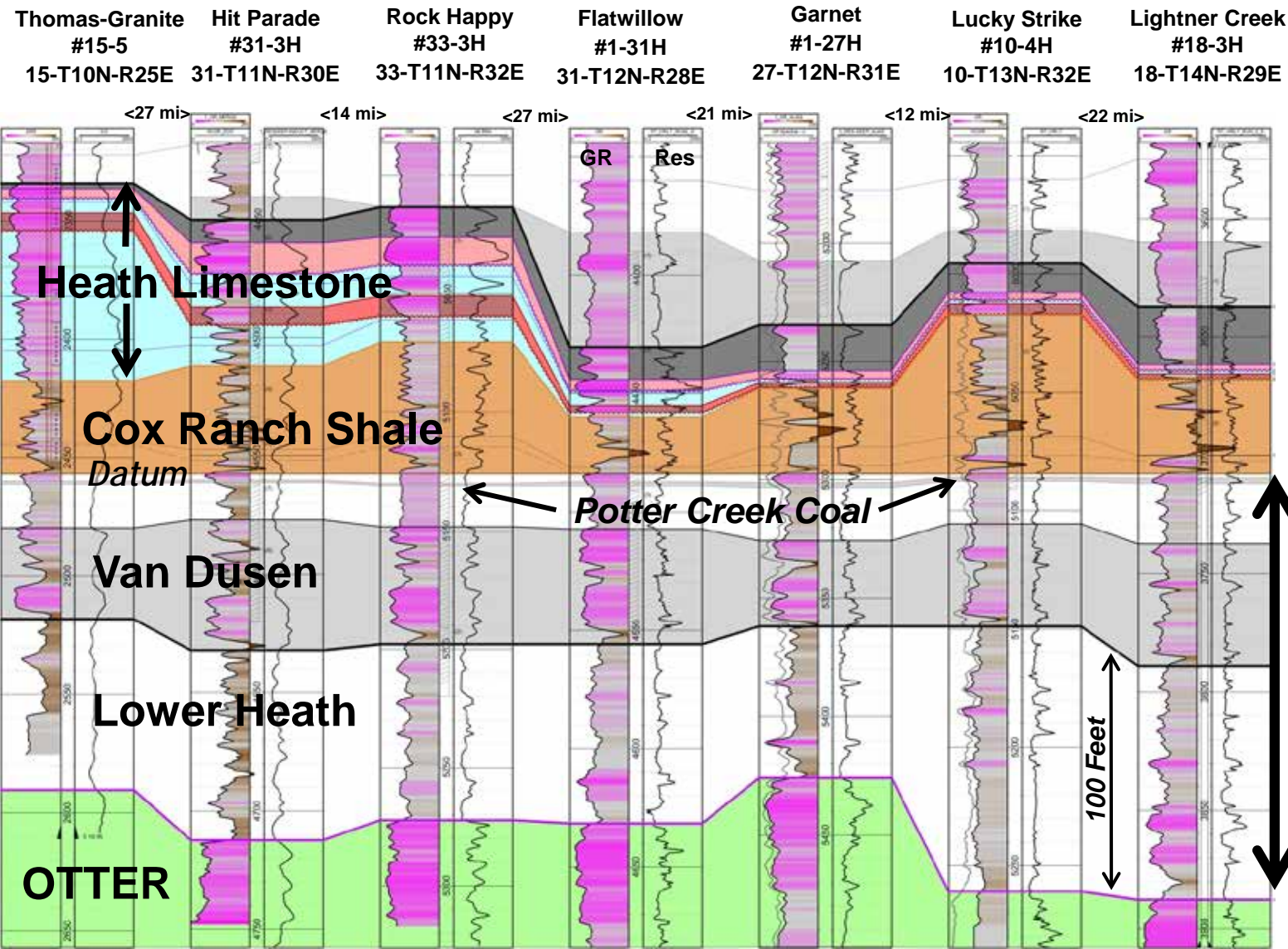


LOWER HEATH INTERNAL STRATIGRAPHY

Datum Base of Cox Ranch

SOUTH

NORTH



- Ø Laterally Correlative Over Large Area
- Ø Cyclic Deposition
- Ø Coals – Marine Shales – Limestones – Paleosols
- Ø Karsted Limestones
- Ø Cox Ranch = Excellent Regional Marker w/ Thickness Variability

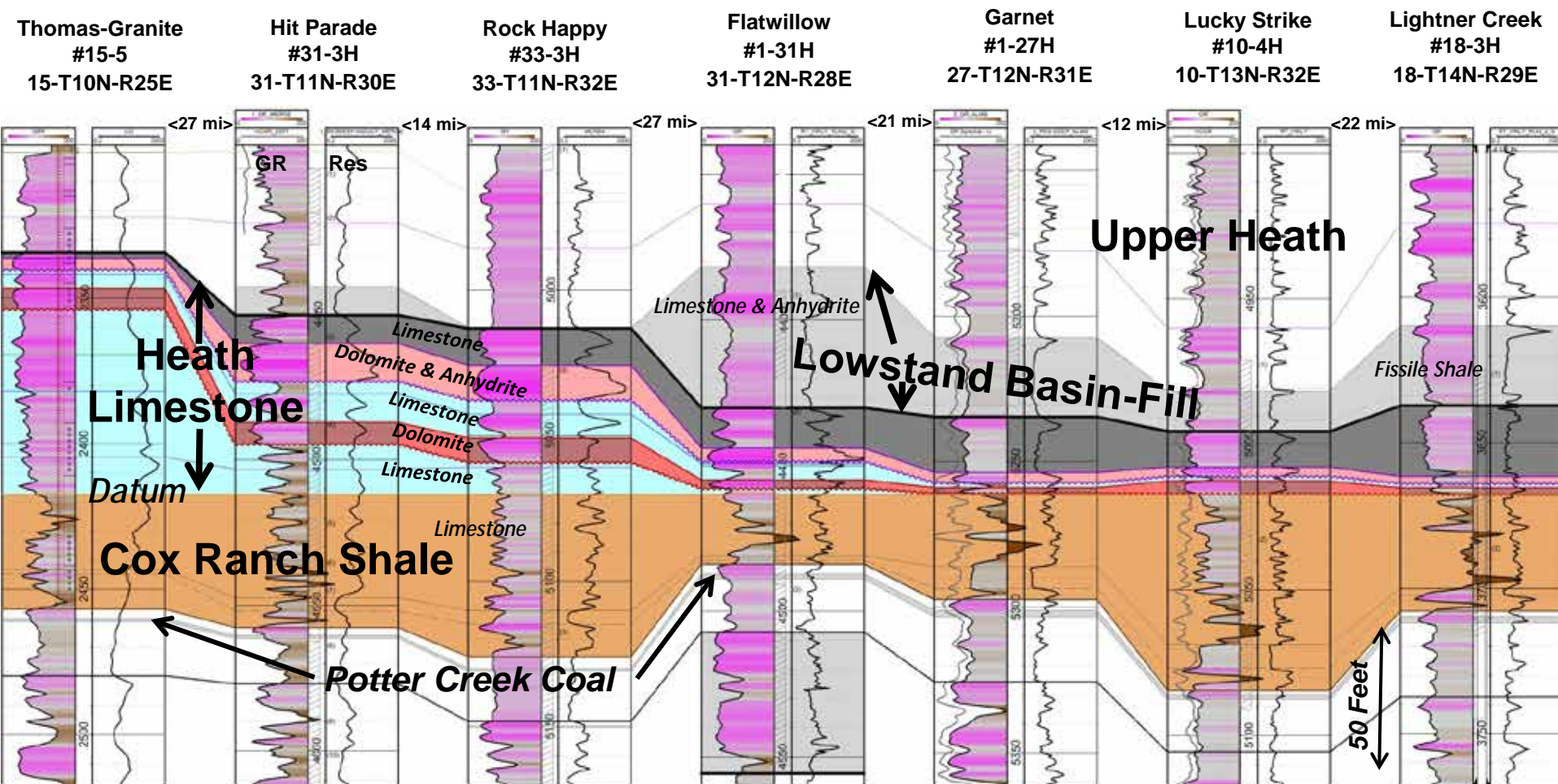


MIDDLE HEATH INTERNAL STRATIGRAPHY

Datum Base of “Heath Limestone”

SOUTH

NORTH



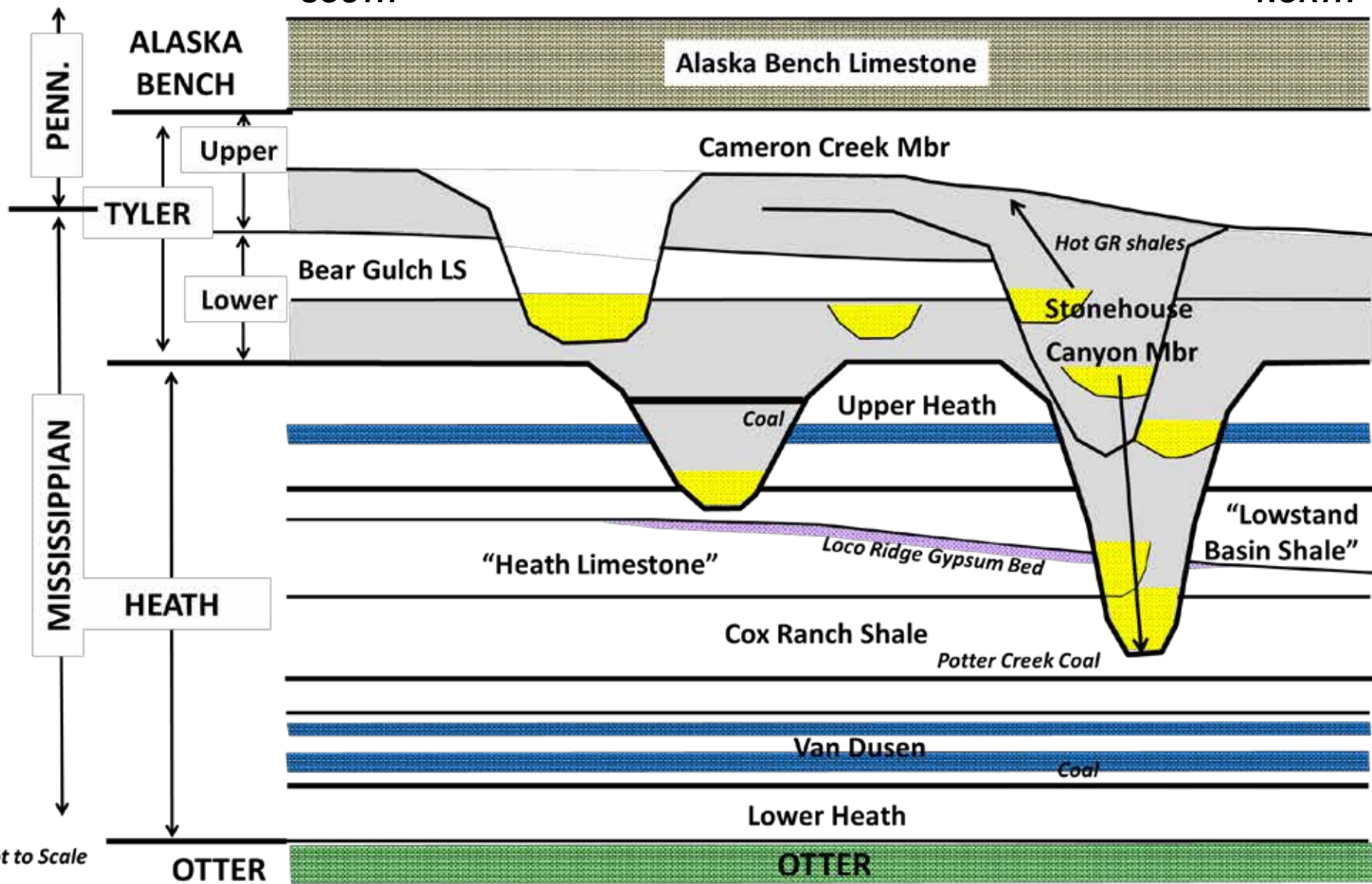
- Ø Overlying Upper Heath & Underlying Cox Ranch Correlative Over Large Area
- Ø “Heath Limestone” – 2 Forced Regressions w/ Shoreline Dolomites & Anhydrites (Loco Ridge Gypsum Bed of Derkey, et al (1985))
- Ø Lowstand Basin–Filling Shale in North



Schematic Lithostratigraphic Correlation Chart Carboniferous, Central Montana

SOUTH

NORTH





ACKNOWLEDGEMENTS

CIRQUE RESOURCES

Peter Purrazzella

Iain Scotchman

Martin Cohen

Taylor Gray

Dave Hindman

Lynn Peyton

John Rhoades, Jeannine

Honey, Staff at USGS CRC

Justin Ahern

John Curtis

Barron Gimza

Mike Dumestre

Steve Lipari

Chip Oakes

Graham McClave

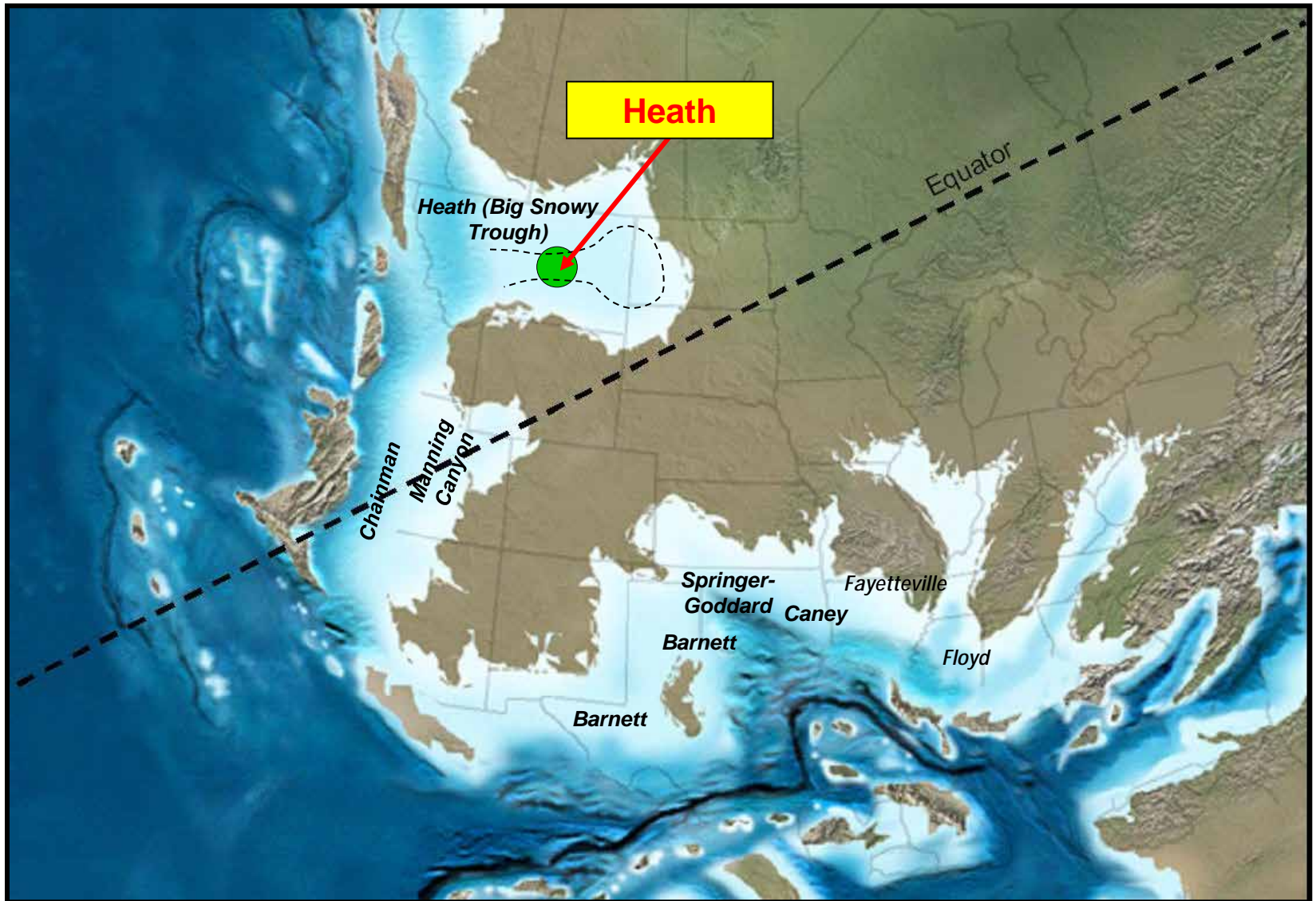


Cirque Resources Rock Happy #33-3H-2 Heath horizontal on production

Extra Slides

Late Mississippian Paleogeography

North America ~ 325 MYA

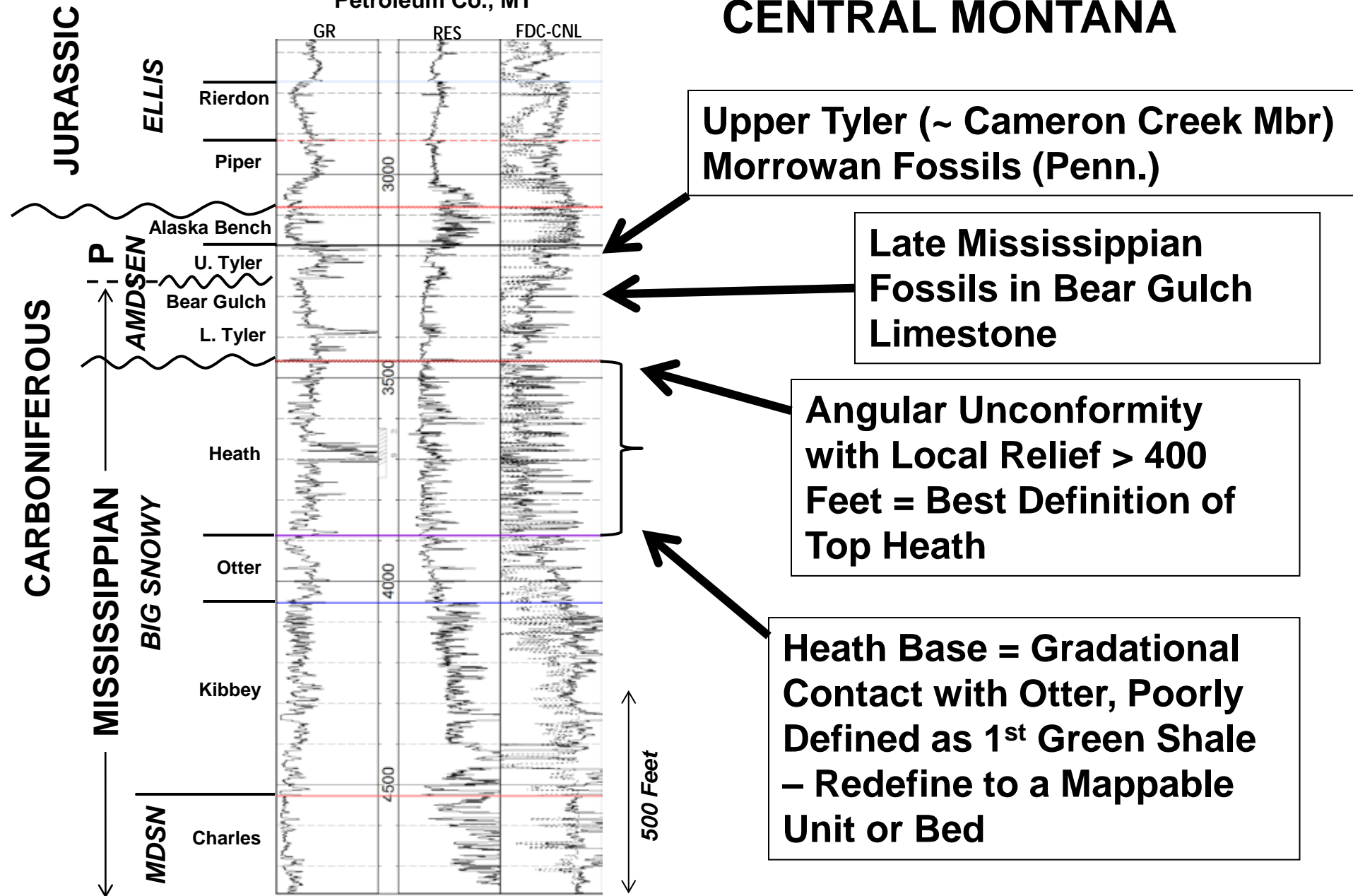


Mississippian	Miss or Penn?	Penn	Jr	Ellis Group
			P-P-Tr	
				Undifferentiated
				Devils Pocket Fm
				Alaska Bench Fm
Big Snowy Group			Cameron Creek Fm	
			Heath Formation	
			Otter Formation	



Cirque Resources
Lightner Creek #18-3H
Sec. 18-T14N-R29E
Petroleum Co., MT

CARBONIFEROUS STRATIGRAPHY CENTRAL MONTANA





○ TYLER-HEATH

Core in Lower Part of Incised Valley

Sharp Base Tyler Erosional Surface

Evidence for Roots in Underlying Heath

Core Interval Shown

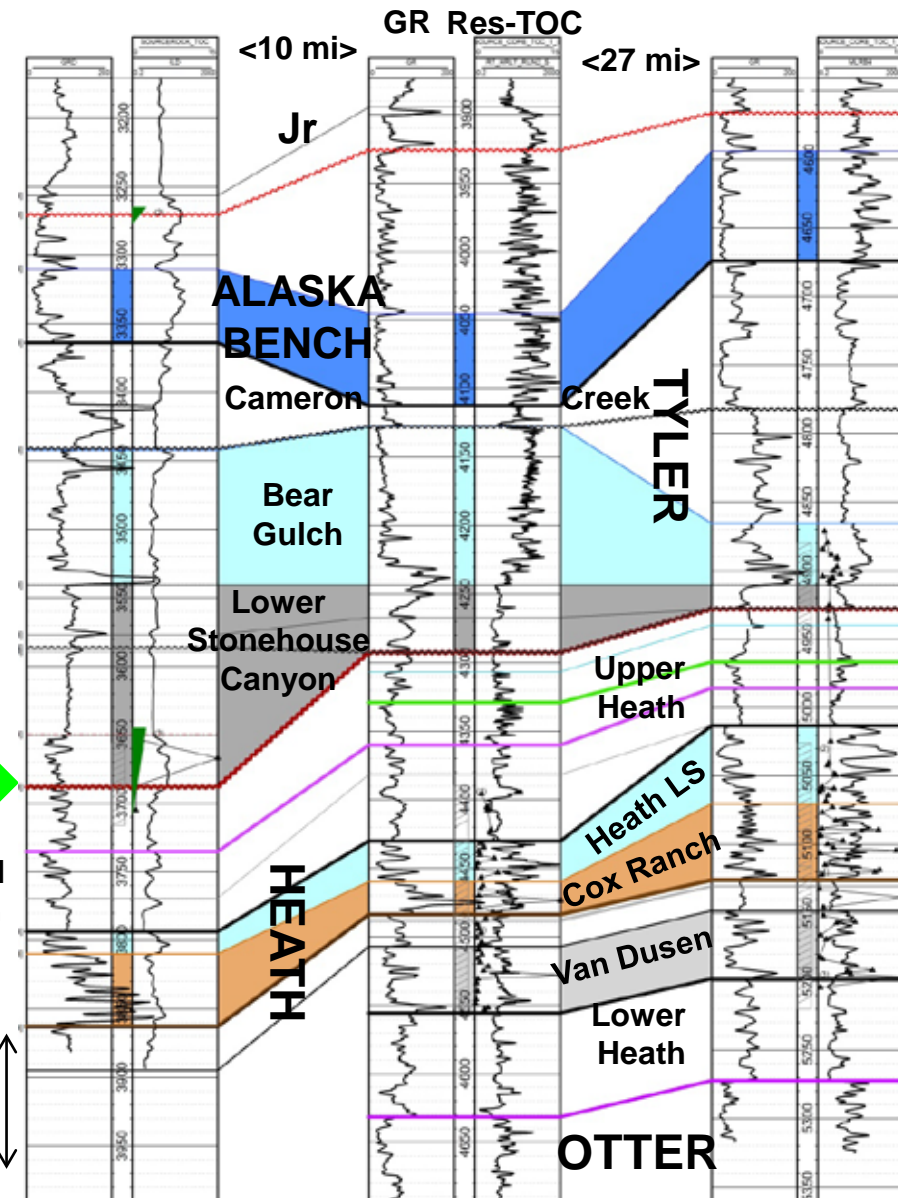
100 Feet

TOP OF HEATH

Alvin
#21A-17
17-T13N-R28E

Flatwillow
#1-31H
31-T12N-R28E

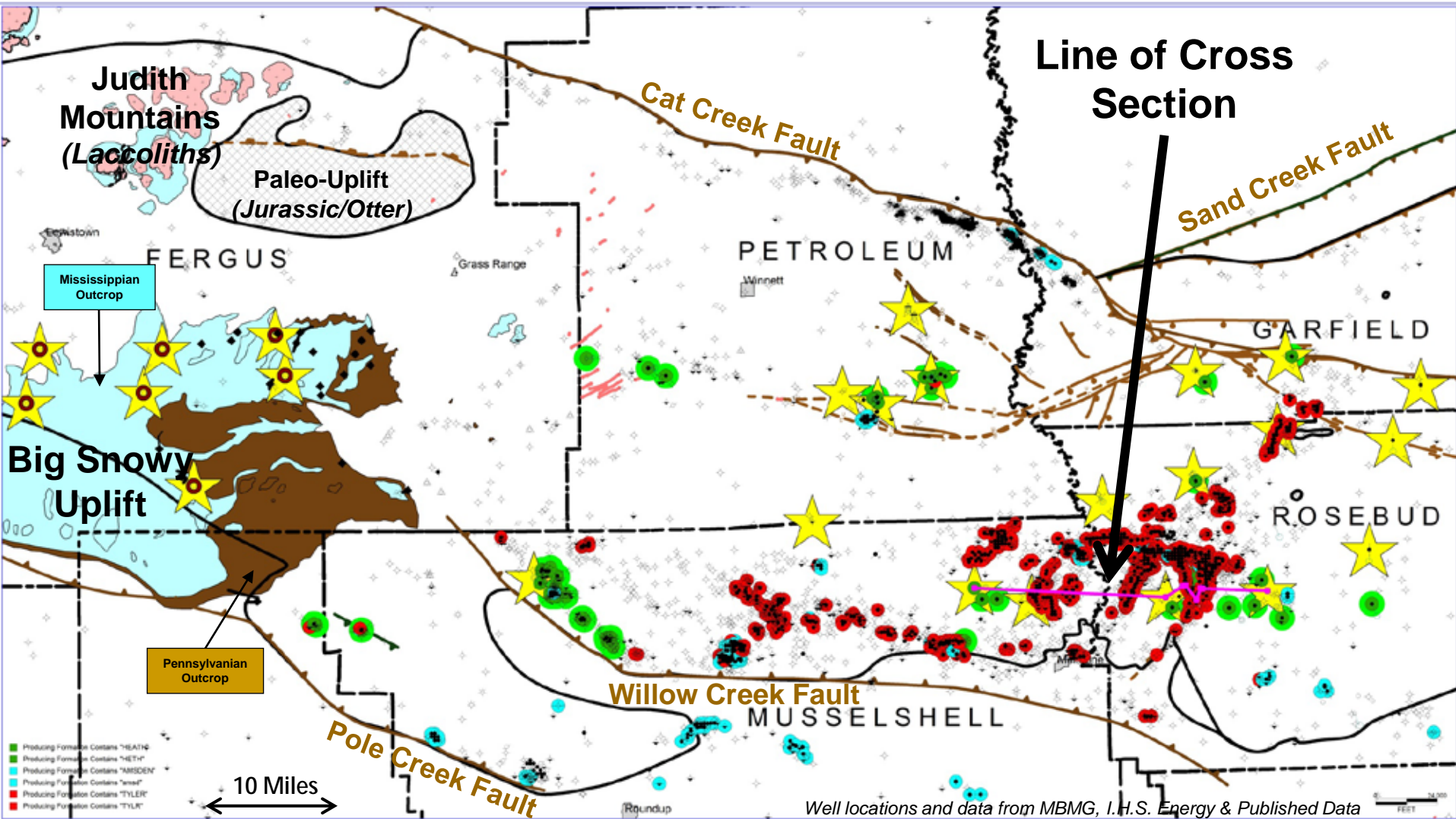
Rock Happy
#33-3H
33-T11N-R32E





TOP OF HEATH FORMATION

Basal Tyler Unconformity vs Contact with Cameron Creek



**Heath – Tyler
Core**

Oil Production Zone



Amsden LS + Dolomite



Tyler Sandstone



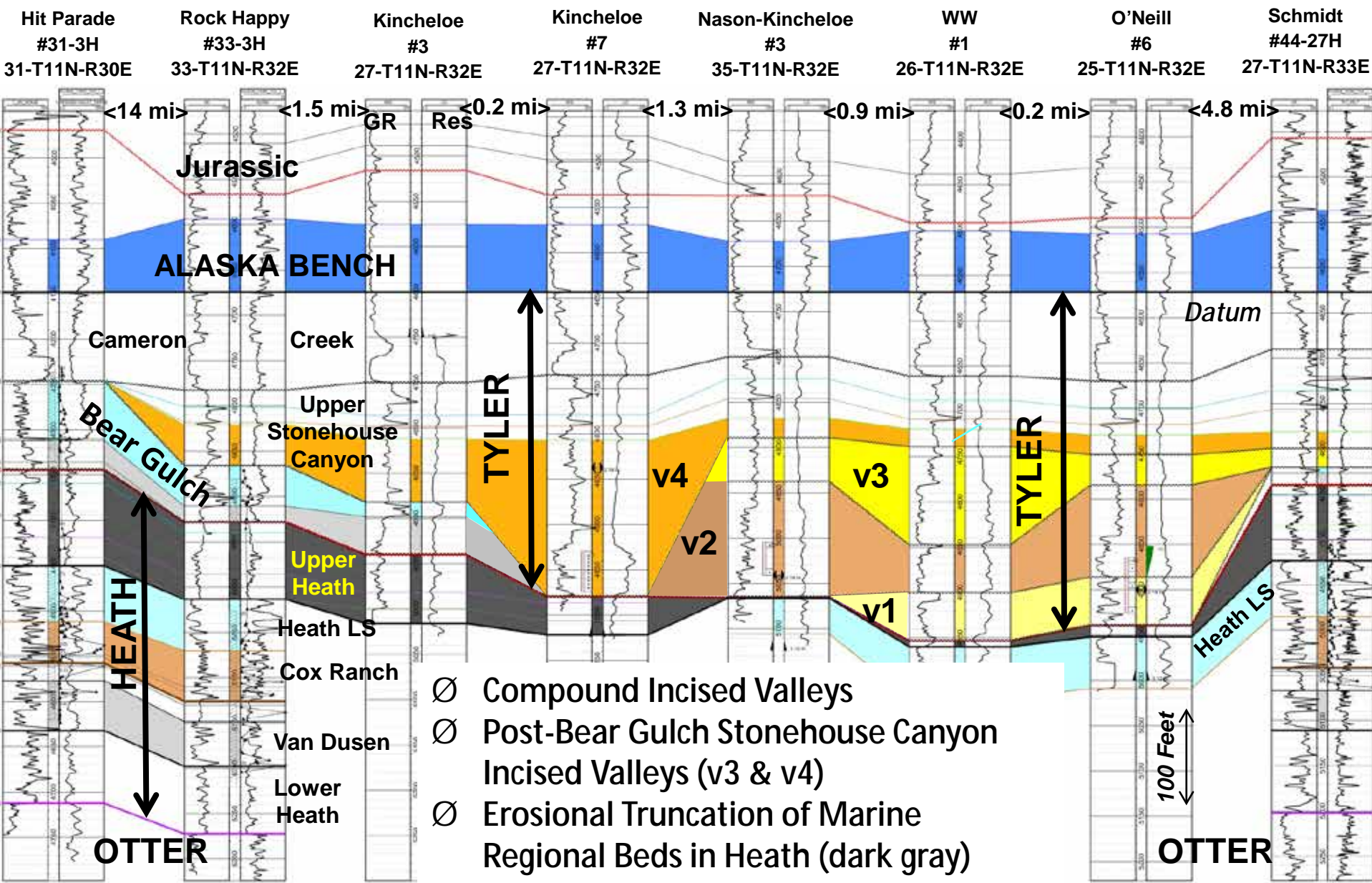
Heath LS + Shale

WEST

TOP OF HEATH

EAST

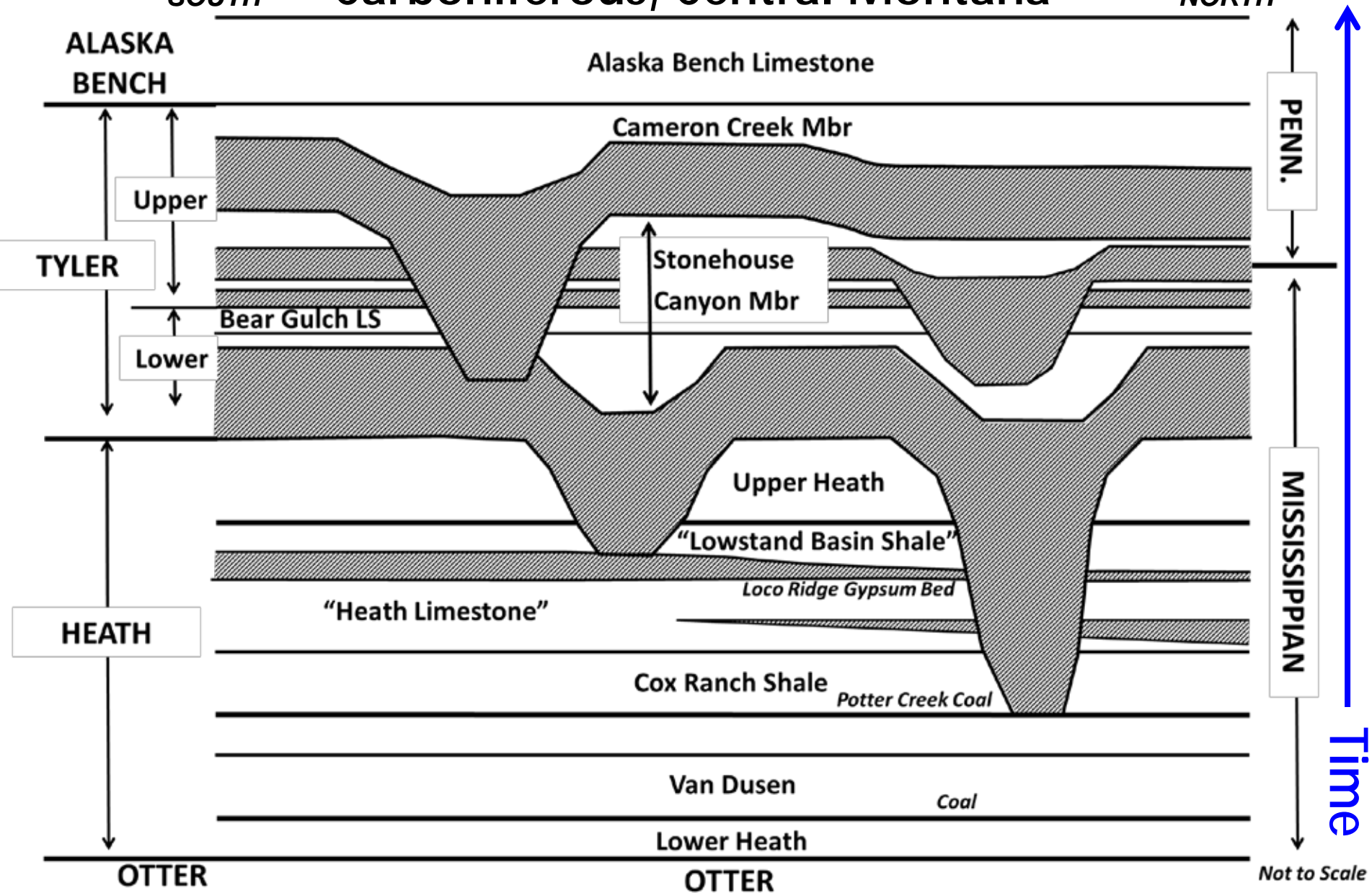
Compound Tyler Incised Valleys



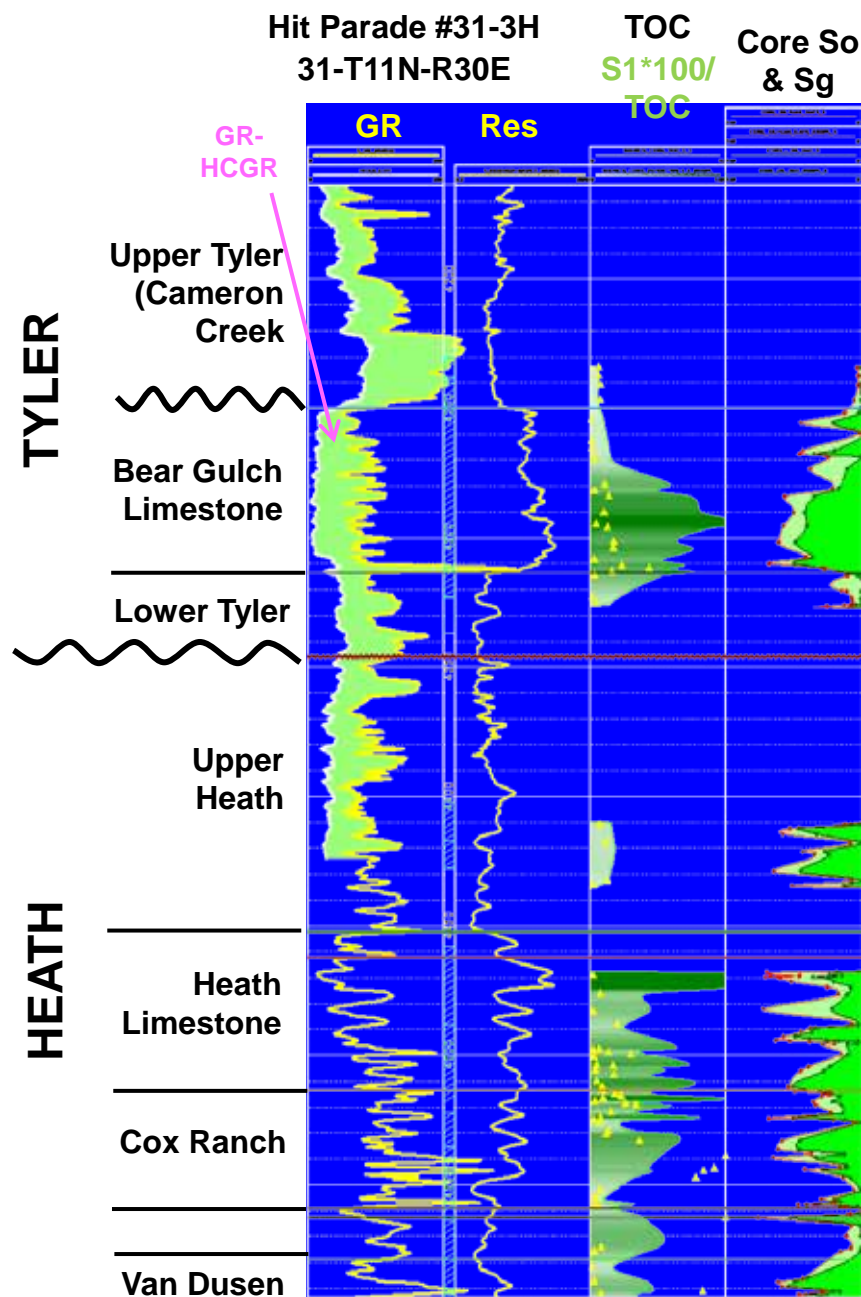


Schematic Chronostratigraphic Correlation Chart

Carboniferous, Central Montana



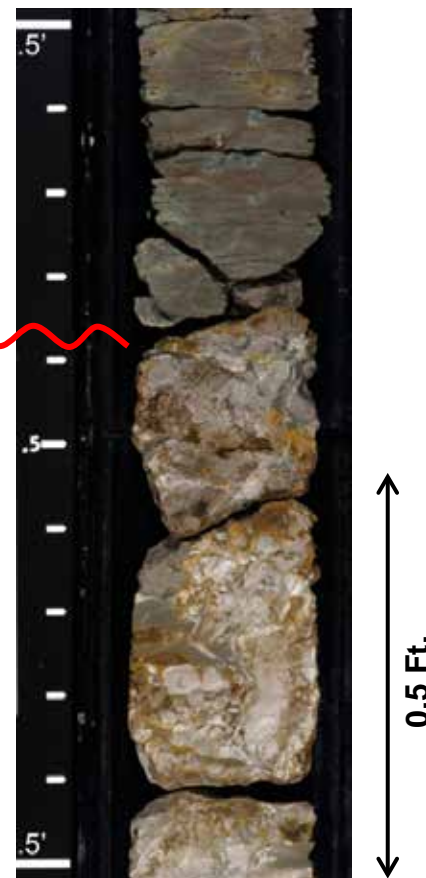
Upper Tyler - Bear Gulch Member Tyler Contact



Green to Red
Hematitic
Shale

PENN.
LSE
MISS.

Karsted
Limestone,
Brecciated in
upper 20 Feet



Depth Shift Log = Core + 6.0'