

Regional Correlation of Carboniferous Heath and Tyler Strata from Central Montana to the Williston Basin, North Dakota, USA *

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Abstract

Correlation of the mid-Carboniferous Heath and Tyler formations from the type area in central Montana east to the Williston Basin in North Dakota and Montana has been historically challenging. New cores and well penetrations along with detailed analyses of new and existing cores facilitate a more robust regional evaluation of this interval. A newly completed 671 BOPD Heath horizontal well in central Montana and several oil-saturated Tyler sandstones identified in vertical sections of deeper horizontal wells in North Dakota are reviving interest in these source-rock rich intervals. The Heath-Tyler interval thins from greater than 700 feet thick in central Montana to 200 feet thick in North Dakota. The Mississippian-Pennsylvanian boundary is probably in the upper part of the Stonehouse Canyon, above the top of the Bear Gulch, or at the base of the Cameron Creek, in central Montana and near the contact between the lower and upper Tyler in southwestern North Dakota.

Recent analyses lead to the following conclusions: a) the HGR shales in the Central Basin area of North Dakota correlate to high-gamma ray shales in the lower and middle part of the Heath in central Montana, specifically HGR shale A correlates with the lowest units in the Van Dusen zone, HGR shale B correlates with the lower Cox Ranch shale, and HGR bed C correlates with the upper Cox Ranch shale; b) the abundance of wood and plant debris, lateral discontinuity of markers due to numerous erosion surfaces (incised valleys), and late Mississippian spores and conodonts found in the lower Tyler in the southwestern North Dakota area indicate that it is generally correlative with the lower part of the Stonehouse Canyon of central Montana, c) the presence of dark gray to black shales and marine limestones, and Pennsylvanian fossils and spores found in the upper Tyler

in the southwestern North Dakota area suggests that it is correlative to the uppermost part of the Stonehouse Canyon of central Montana (above the Bear Gulch Limestone), and d) the lithological similarity of the uppermost upper Tyler in North Dakota, dominated by red shales, sandstones, and breccias, to the Cameron Creek of central Montana suggests that these units are correlative.

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Cheyenne, Wyoming
September 16, 2019

Regional Correlation of Carboniferous Heath and Tyler Strata from Central Montana to the Williston Basin, North Dakota, USA

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Bev Rice

Mercedes di Pasquo

**Gus Gustason & Bob
Larsen (Enerplus)**

Orion Skinner (Whiting)

Mitch Meyer (Three Forks)

Justin Ahern

Chris Fielding

Dave Eby

**Jim Suydham (Sunburst
Consulting)**

MBMG Staff – cuttings

Jim Halvorsen

John Curtis

Graham McClave

Dave Bowen

Devon Orme

**Multiple Landowners that
allowed access to
private lands**

September 15th, 2019

OUTLINE

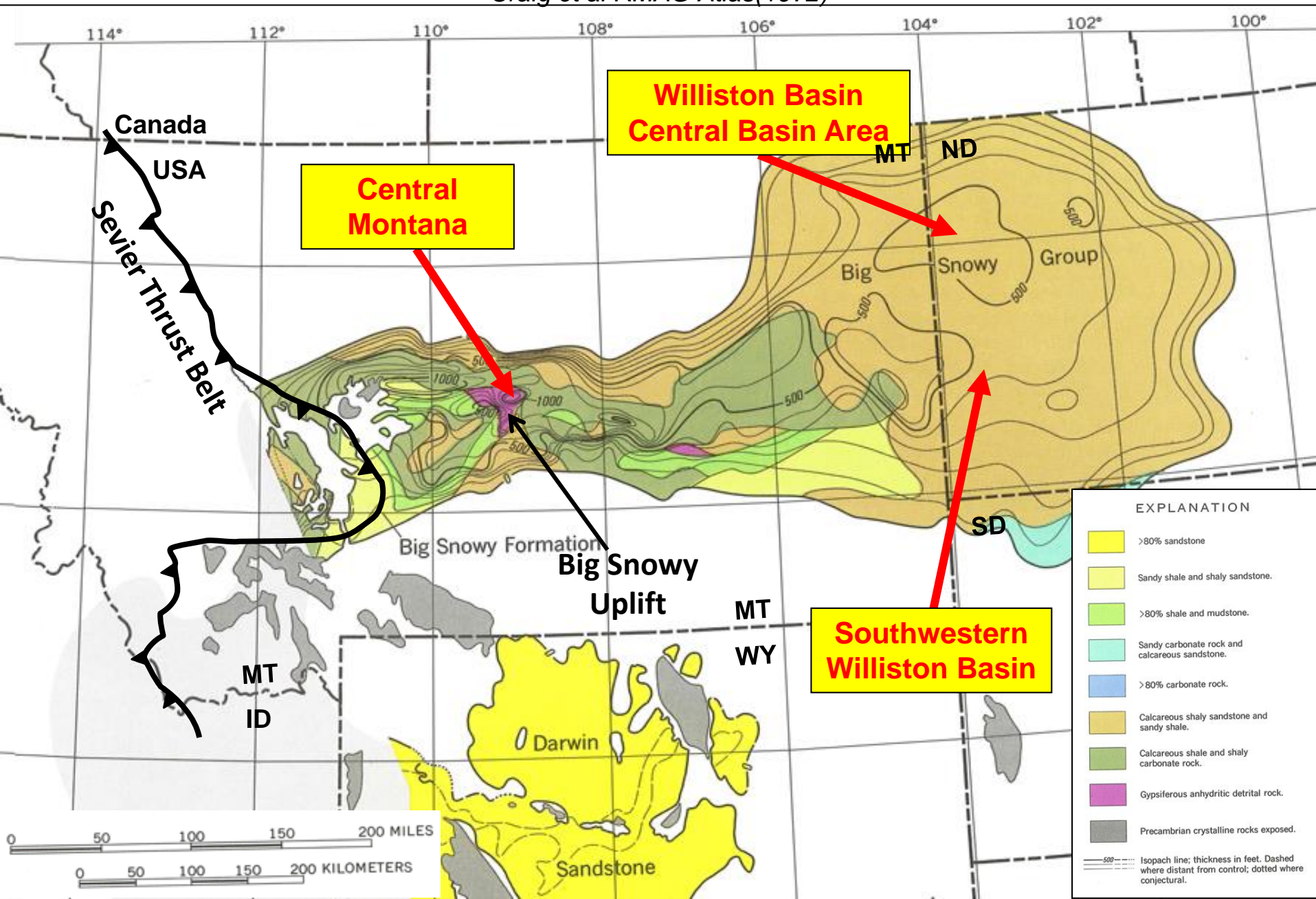
- **Heath & Tyler at the “Type Section”**
- **Montana Lithofacies**
- **North Dakota Lithofacies**
- **ND-MT Comparison**

Questions:

- **What are the differences between the Heath and Tyler near the type section in Montana?**
- **Can Montana descriptions be used to help interpret North Dakota stratigraphy?**
- **Is there any Heath in North Dakota?**
- **How does the North Dakota Central Basin area relate to the North Dakota southwestern Williston Basin area?**

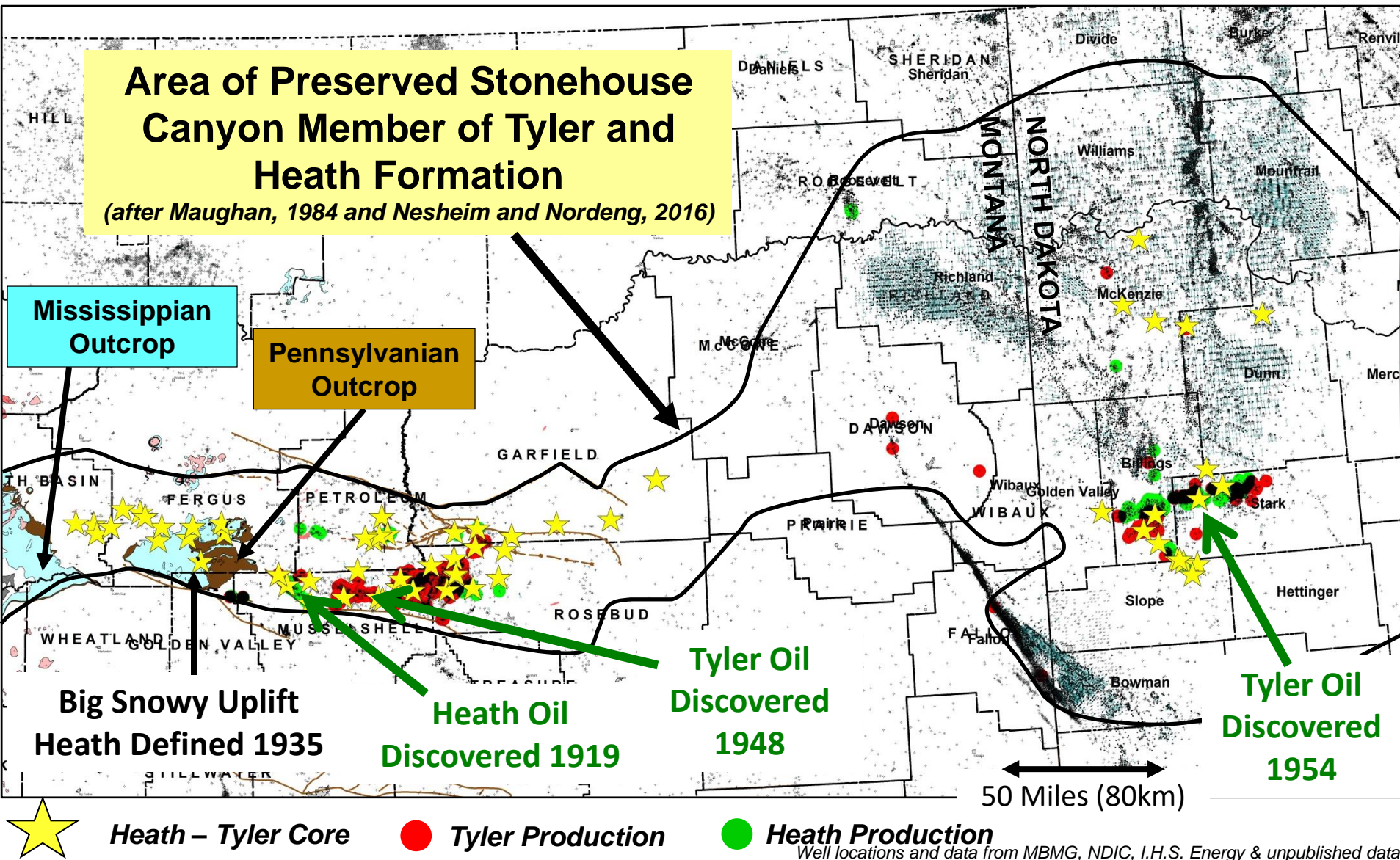
LATE MISSISSIPPIAN ISOPACH

Craig et al RMAG Atlas(1972)



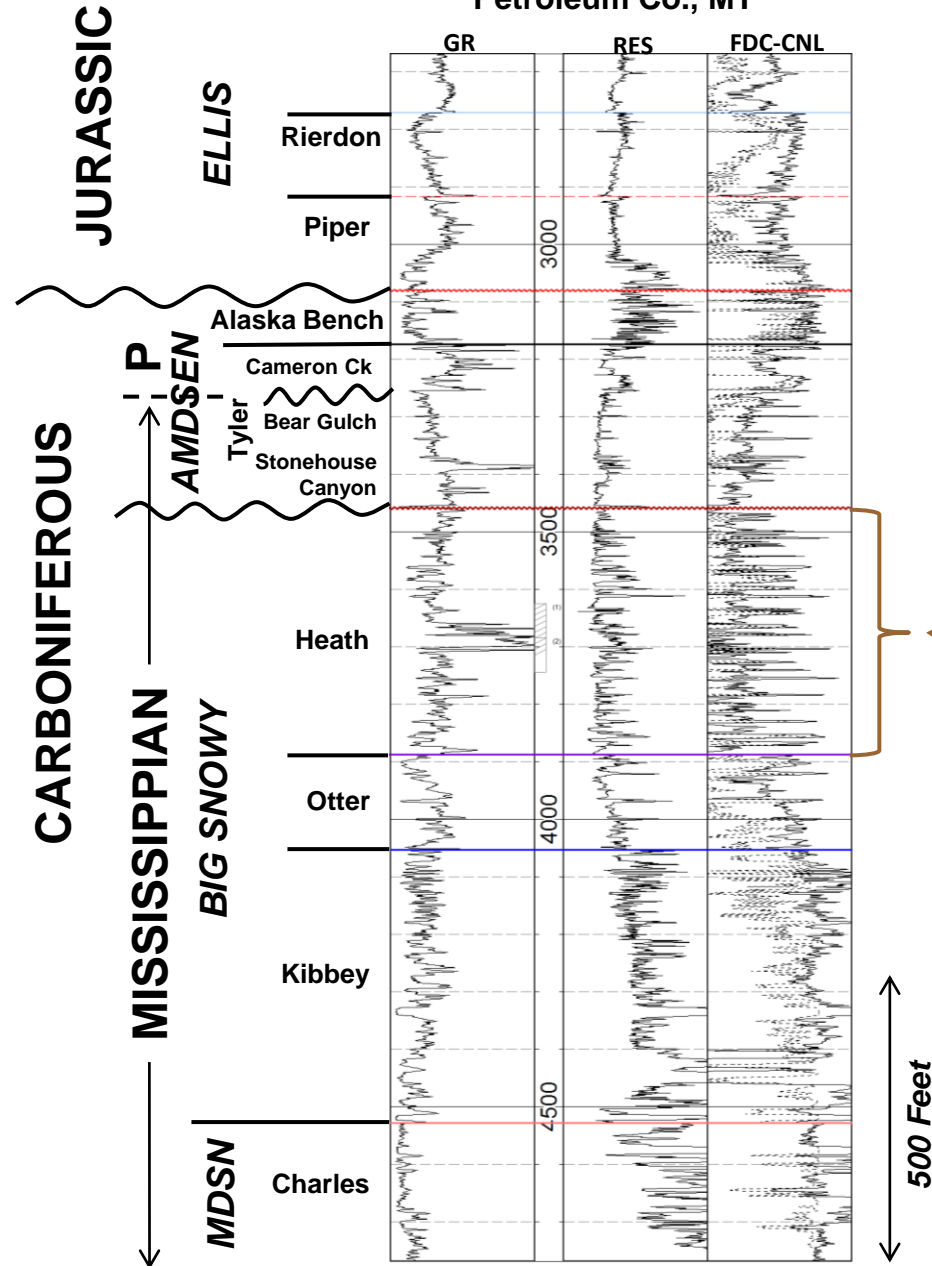
Central Montana to Williston Basin, North Dakota

Heath-Tyler Production & Cores



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

CARBONIFEROUS STRATIGRAPHY CENTRAL MONTANA



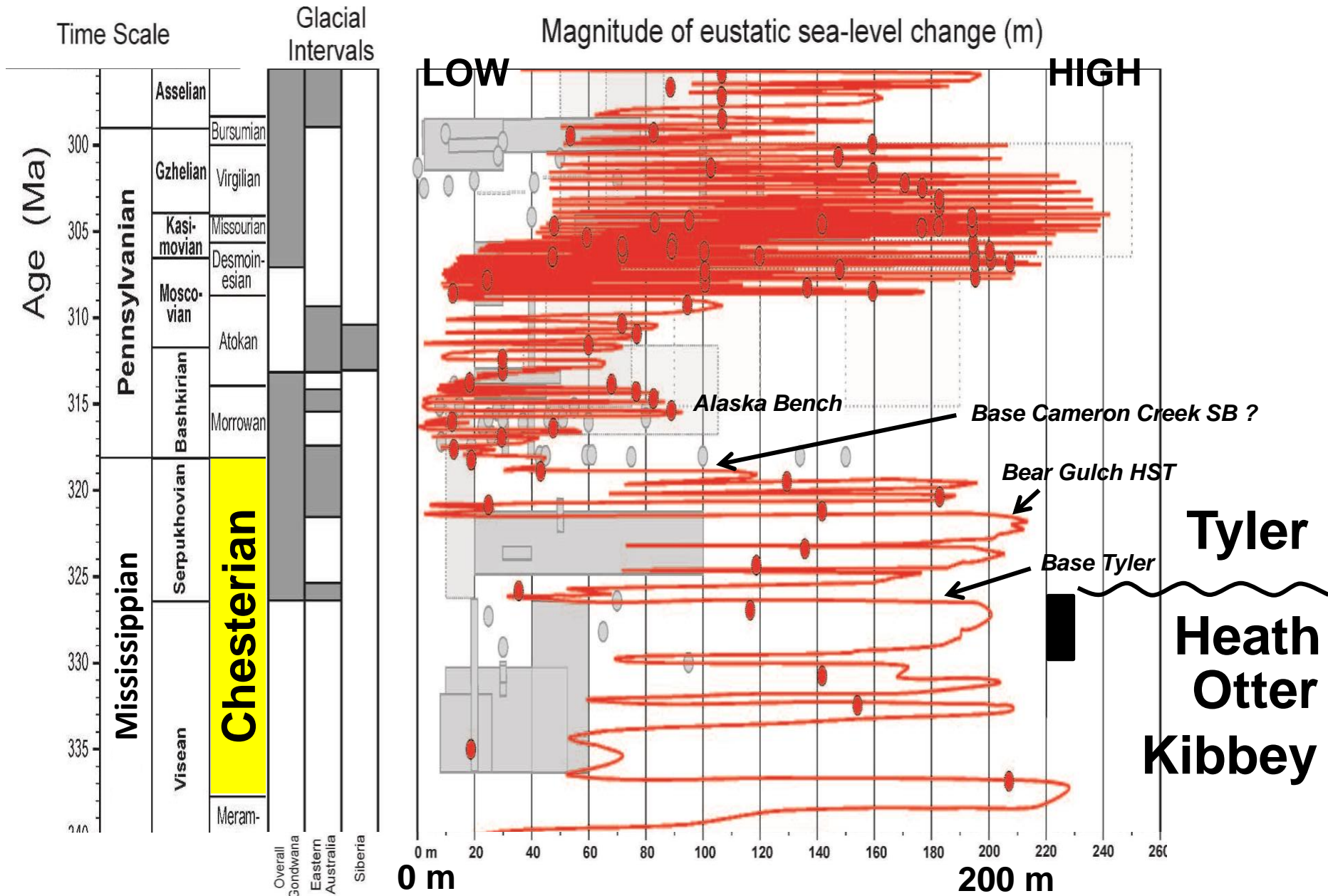
Tyler + Heath thickness up to 825 ft (251m) in central Montana

Heath thickness up to 475 ft (145m) in central Montana

Total Heath + Tyler thins to 150-200 ft. (46-61m) in North Dakota

LATE MISSISSIPPIAN – PENNSYLVANIAN SEA LEVEL

After Rygel et al (2008)



Central Montana Mid-Carboniferous Stratigraphy Definitions

**Alaska Bench “Beacon Hill” sec 36-T13N-R19E, Fergus Co., MT
Type Section of Big Snowy Group and Heath Formation (Scott, 1935)
Re-measured by Easton (1962) and Maughan & Roberts (1967)**

Tyler - Cameron Creek: Red mudstones and limestones. (originally included in Amsden by Scott 1935)

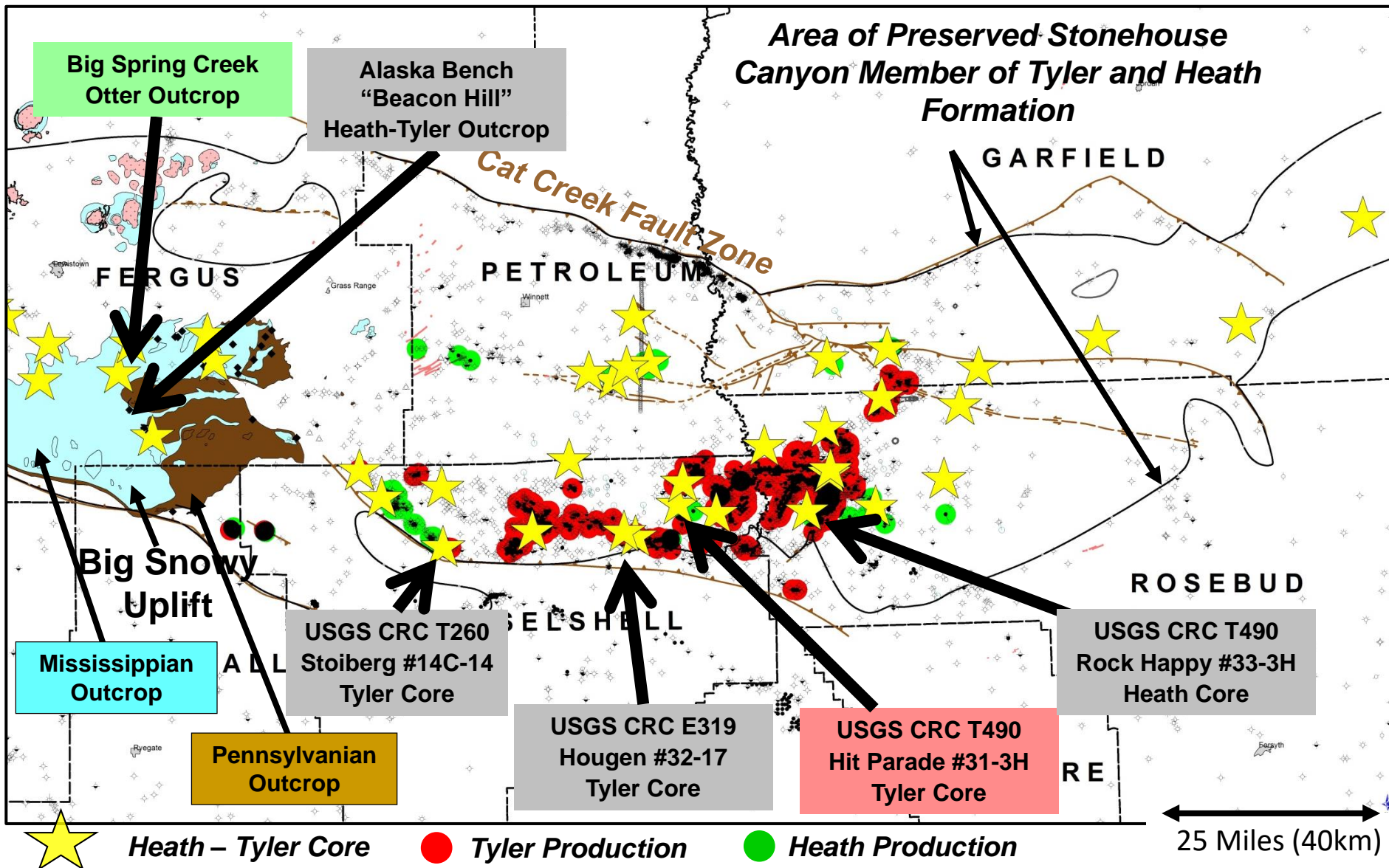
Tyler - Stonehouse Canyon: Interbedded lenticular sandstones and black shale. (Named by Freeman 1922, later included in Heath by Scott 1935). Boundary with overlying Cameron Creek is a color change upsection from black to red.

Heath: Marine, dark to light gray to black petroliferous shales and limestones, locally silty, commonly calcareous & fossiliferous, locally present gypsum and coal.

Otter: Gray to green shales intercalated with oolitic and fossiliferous limestone. “Otter shales are predominantly green in color...” “...upper part of the formation commonly consists of a vivid green shale...” (Scott, 1935)

Central Montana Index Map

Heath-Tyler Outcrops, Cores, & Production



Carboniferous Stratigraphy – Definitions: OTTER

Brei Ranch, Big Spring Creek, sec 35-T14N-R19E, Fergus Co., MT



Limestone intraformational ripup clast conglomerate

Bright green mudstone to clayshale



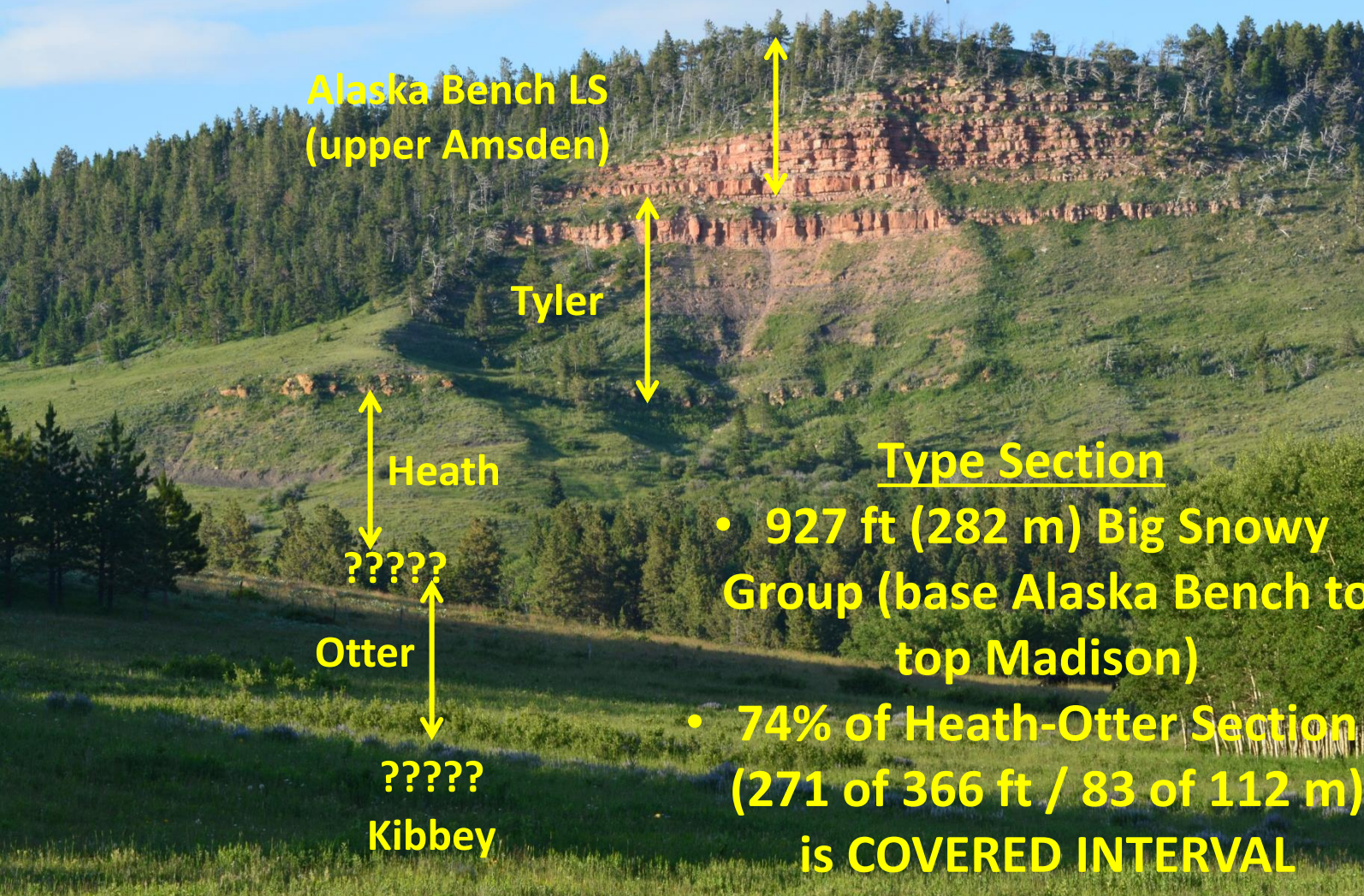
Laminated limestone grainstone with claystone ripup clasts



Carboniferous Stratigraphy – Definitions

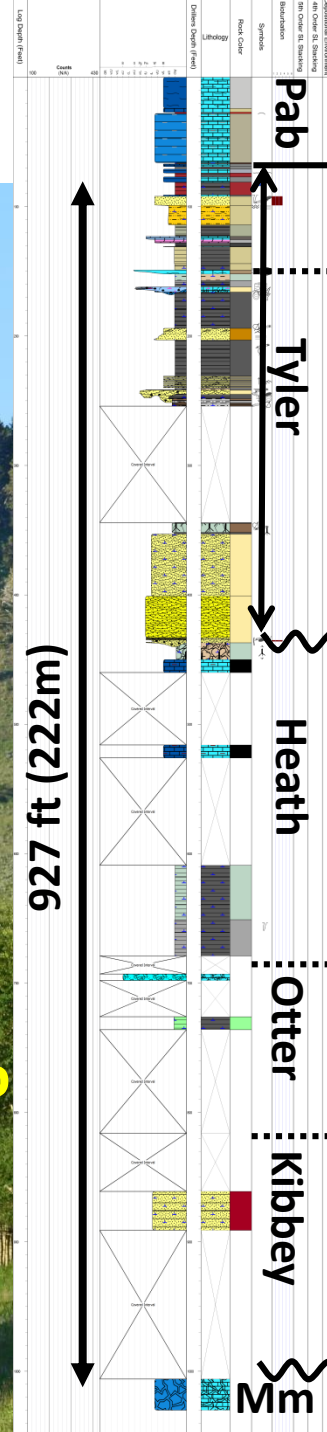
HEATH-TYLER

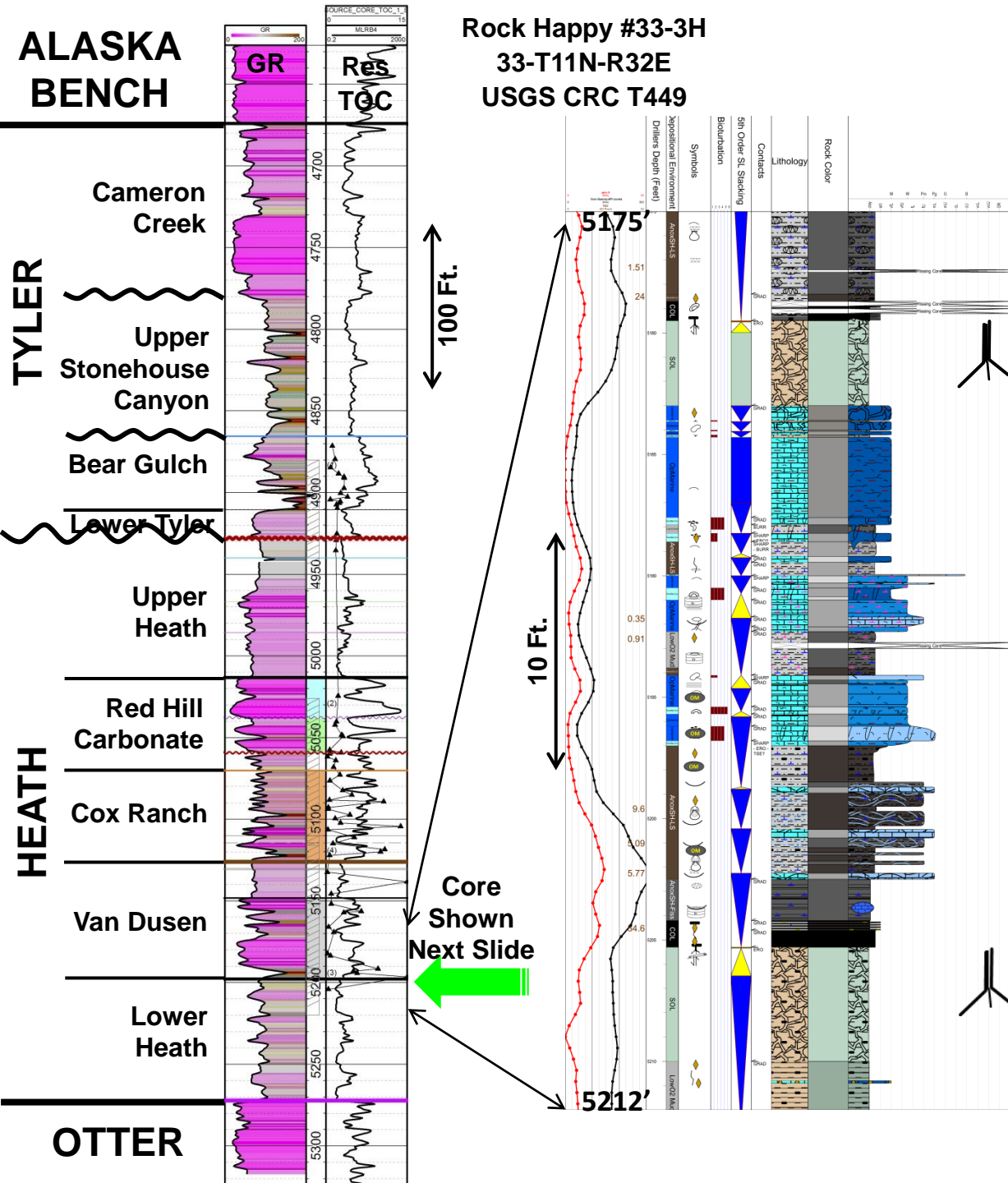
Alaska Bench “Beacon Hill” sec 36-T13N-R19E, Fergus Co., MT
 Measured sections by Easton (1962) and Maughan & Roberts (1967)
 Type Section of Big Snowy Group and Heath Formation (Scott, 1935)



Type Section

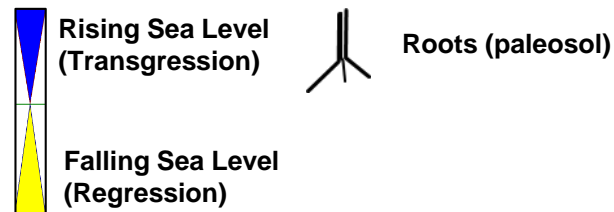
- 927 ft (282 m) Big Snowy Group (base Alaska Bench to top Madison)
- 74% of Heath-Otter Section (271 of 366 ft / 83 of 112 m) is COVERED INTERVAL



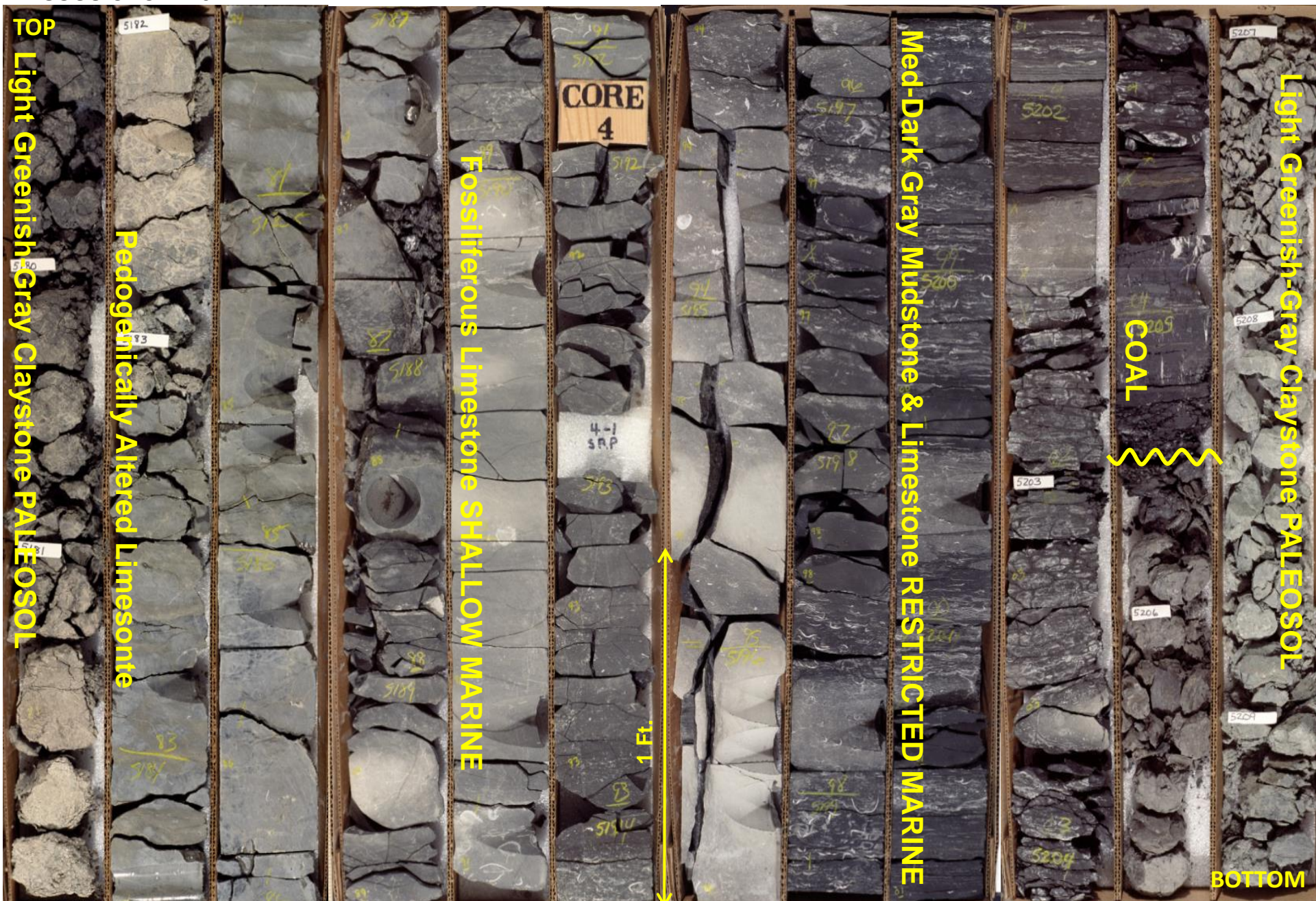


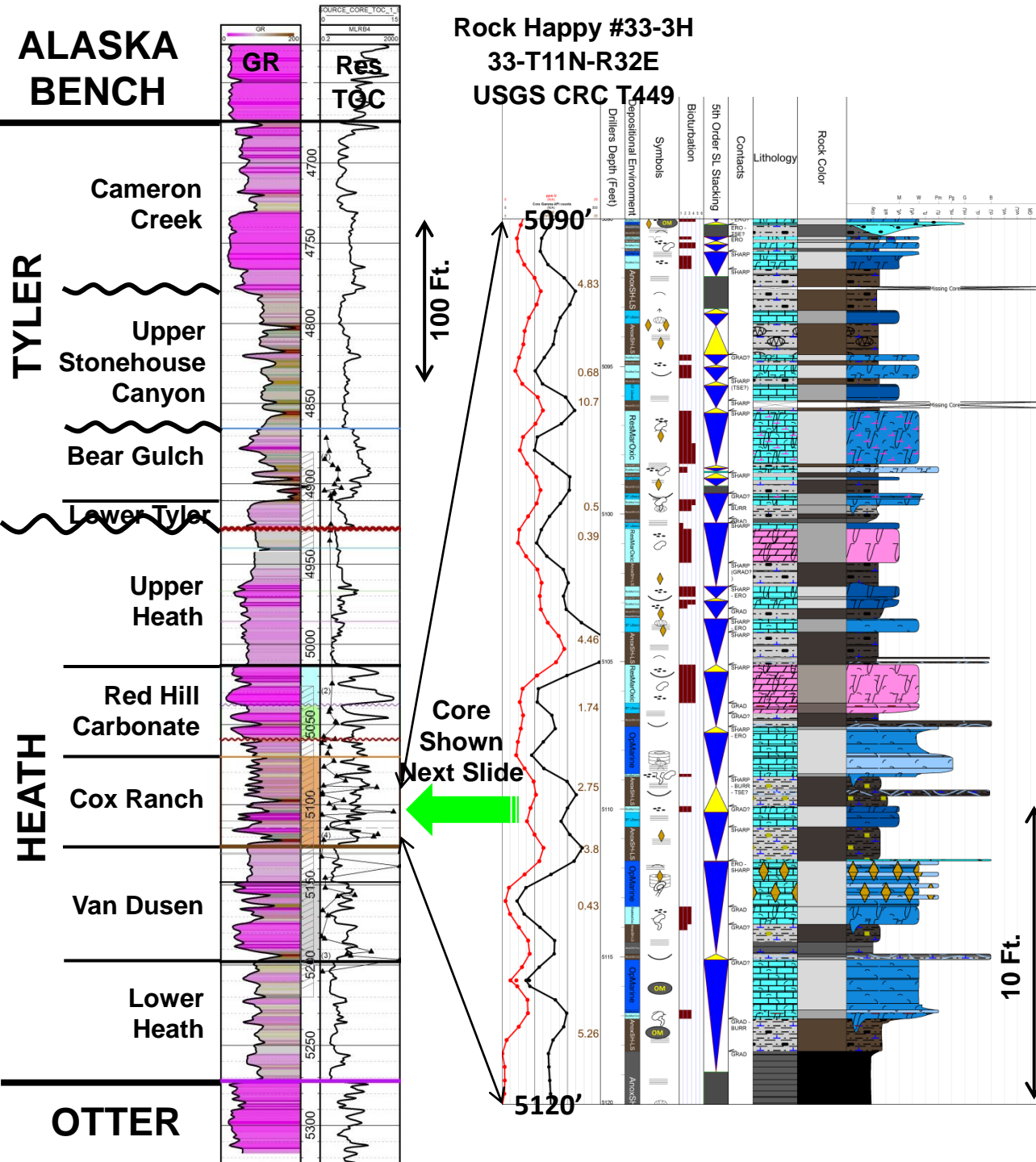
Heath - VAN DUSEN ZONE

- Light Greenish-Gray Claystones (Paleosols)
- Open Marine Limestones
- Restricted Marine Shales/ Mudstones
- Coal
- Subaerial exposure at cycle base
- Good correlations for long distances



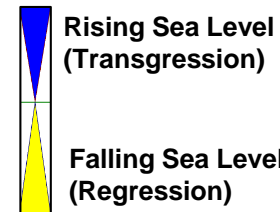
Heath - VAN DUSEN ZONE ZONE





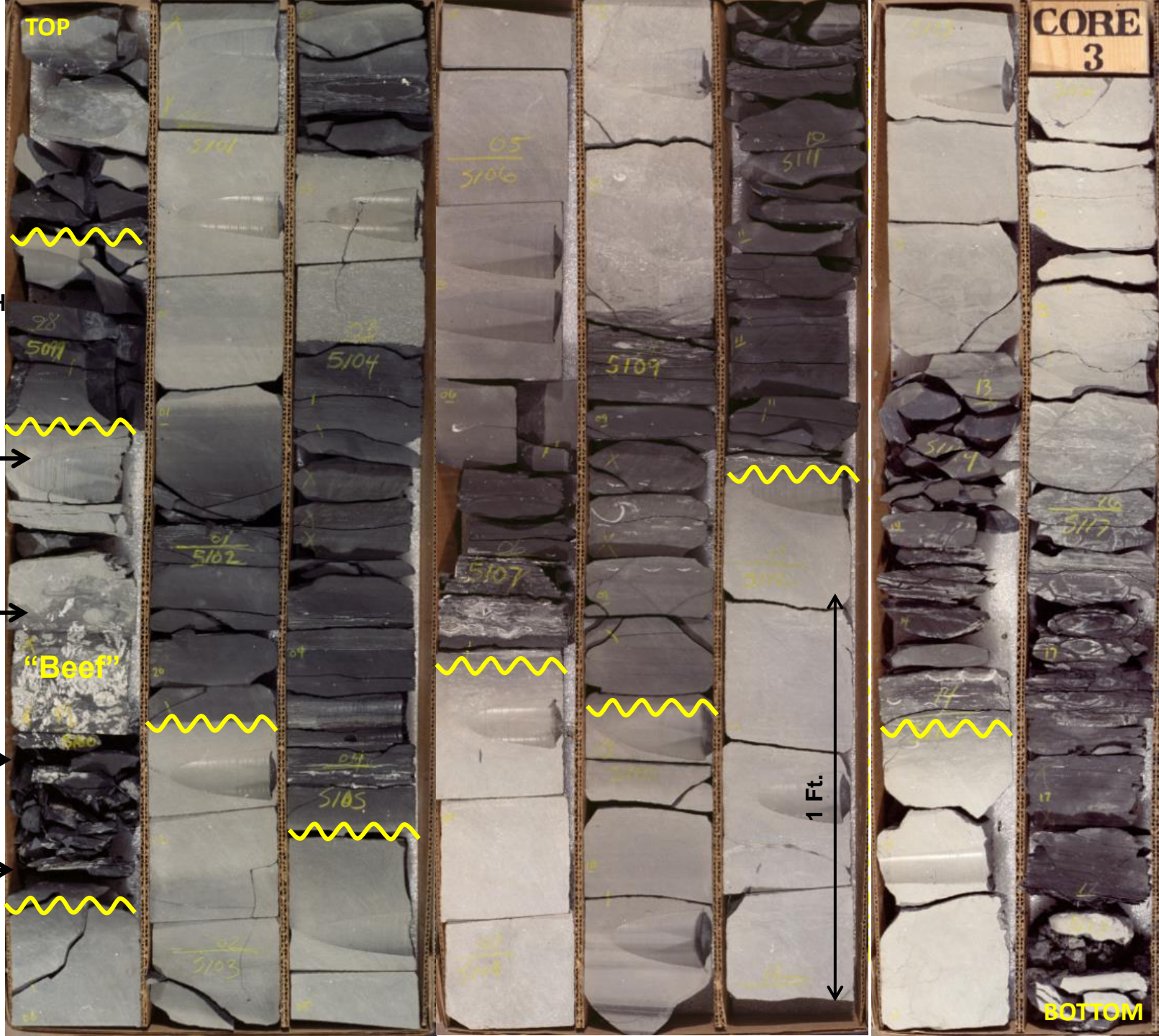
Heath - COX RANCH SHALE

- Fossiliferous marine limestone
- Burrowed limestone
- Calcareous dark brownish-gray to black mudstones
- Fissile black clayshale
- Common erosion at cycle base
- Good correlations for long distances



Heath - COX RANCH SHALE

Rock Happy #33-3H
33-T11N-R32E
USGS CRC T449



TOP

CORE
3

Wackestone →

Burrowed
Limestone or
Dolostone →

"Beef"

Calcareous
Mudstone →

Fissile
Clayshale →

1 Ft.

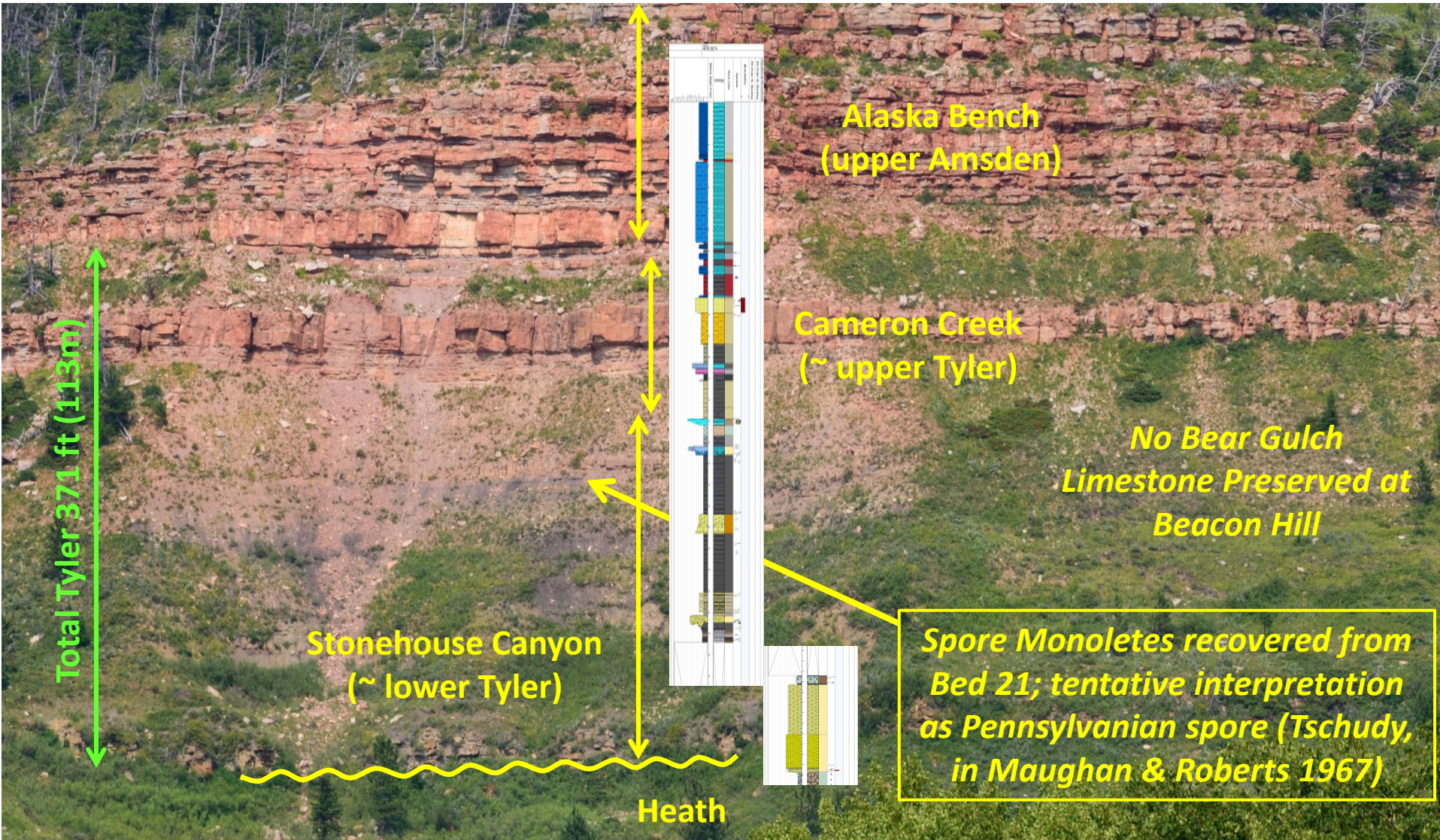
BOTTOM

Definition & Age of the Tyler

Alaska Bench "Beacon Hill" sec 36-T13N-R19E

Prior Measured sections in area by Easton (1962) and Maughan & Roberts (1967)

Type Section of Big Snowy Group and Heath Formation (Scott, 1935)



Definition & Age of the Tyler

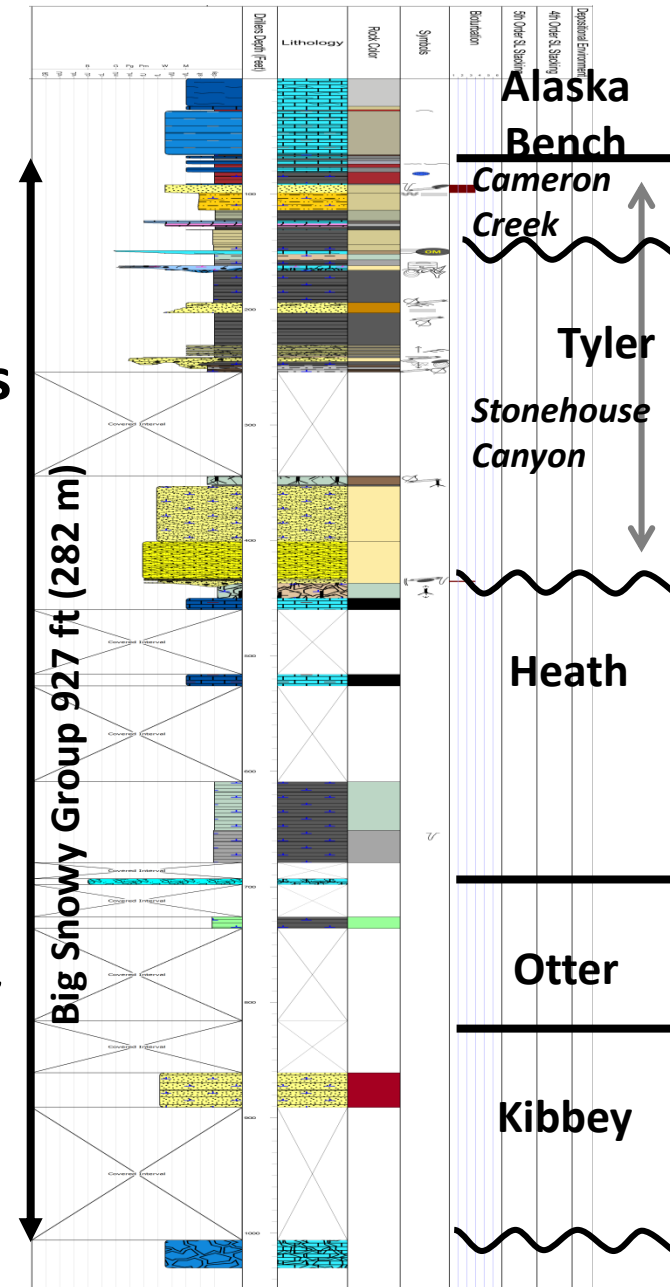
Alaska Bench “Beacon Hill”

sec 36-T13N-R19E, Fergus Co., MT

Section modified after Maughan & Roberts (1967)

Tyler Definitions

- Cameron Creek = Red, green, and lt. gray shales, with fossiliferous sandy limestones & red-tan sandstones
- Stonehouse Canyon = Dk. gray to black shales with tan, lenticular sandstones & abundant wood fragments
- 1967 *Monoletes* sample from upper Stonehouse Canyon – 271 ft. (83m) above base of Stonehouse Canyon
- *Monoletes* today is known as *Schopfipollenites* & has range from Late Visean – Serpukhovian - Penn. **NOT DIAGNOSTIC OF PENN** (di Pasquo, pers comm, 2019)
- Bear Gulch Limestone – dated as Miss./Chesterian in 1968 – Not preserved at Beacon Hill



USGS CRC E319

Quinoco Hougen #32-17

T10N-R29E-17

4293'-4313'

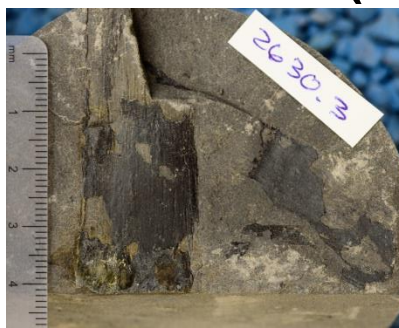
Stonehouse Canyon Sandstone



TYLER - STONEHOUSE CANYON

LITHOFACIES

- Dark gray to black mudrocks, fissile clayshale, calcareous mudstone
- Sandstones, fine- to coarse-grained, local pebble conglomerate, light gray to tan
- High energy cross-bedded facies and soft-sediment deformed inclined heterolithic strata
- Abundant wood fragments and leaf impressions
- Thin limestones and dolostones, ranging from mudstone to fossiliferous grainstone (not including Bear Gulch)
- Correlations for short distances only – highly channelized (multiple incised valleys)



USGS CRC T260
Champlin Stoiberg
#14C-14
T10N-R25E-14
Wood fragments &
leaf impressions,
silty claystone



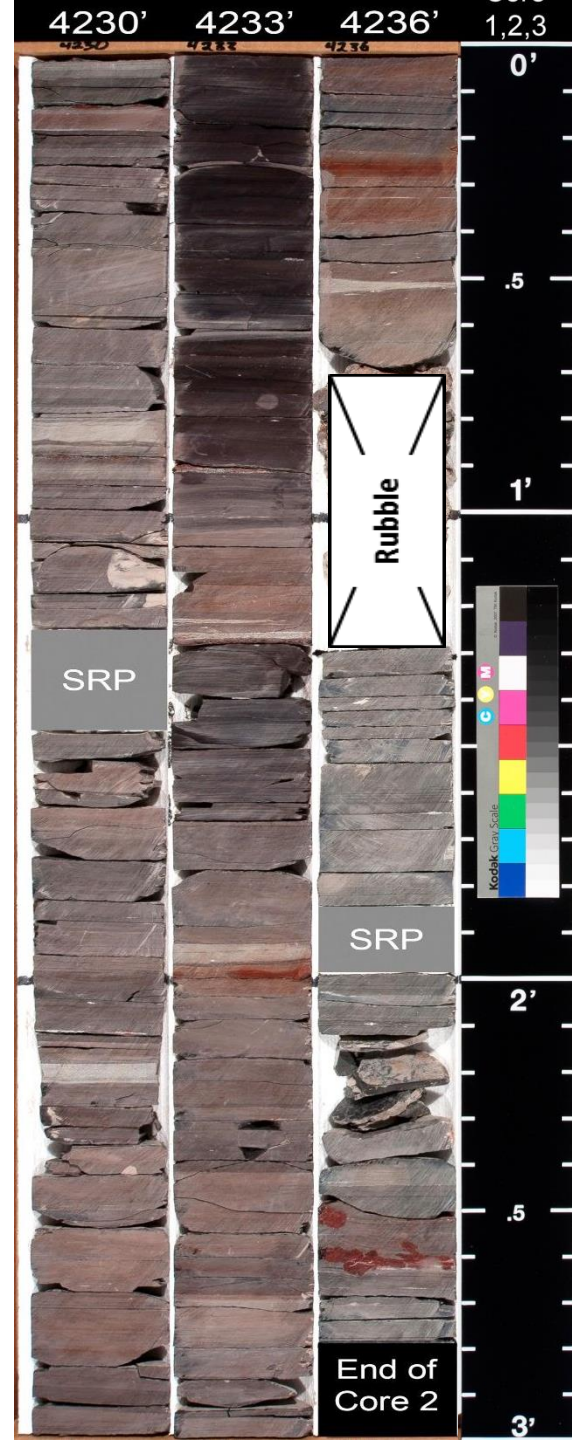
TYLER - CAMERON CREEK

LITHOFACIES

- Maroon to brick red, light gray, grayish-green mudrocks
- Sandstones, fine- to coarse-grained, local pebble conglomerate, red to light gray to tan, abundant limestone clasts
- High energy cross-bedded sandstone and ripple cross-laminated lower energy sandstone, commonly fossiliferous
- Abundant oxidized wood fragments
- Thin limestones and dolostones, ranging from mudstone to fossiliferous grainstone, commonly sandy
- Rarely cored in Montana

USGS CRC T490
Cirque Hit Parade #31-3H
T11N-R30E-31
4230-4239

Fissile clayshale to silty mudstone, medium reddish gray to maroon red, hematitic, occ. red hematite beds, diagenetic calcite "beef" beds up to 4mm thick

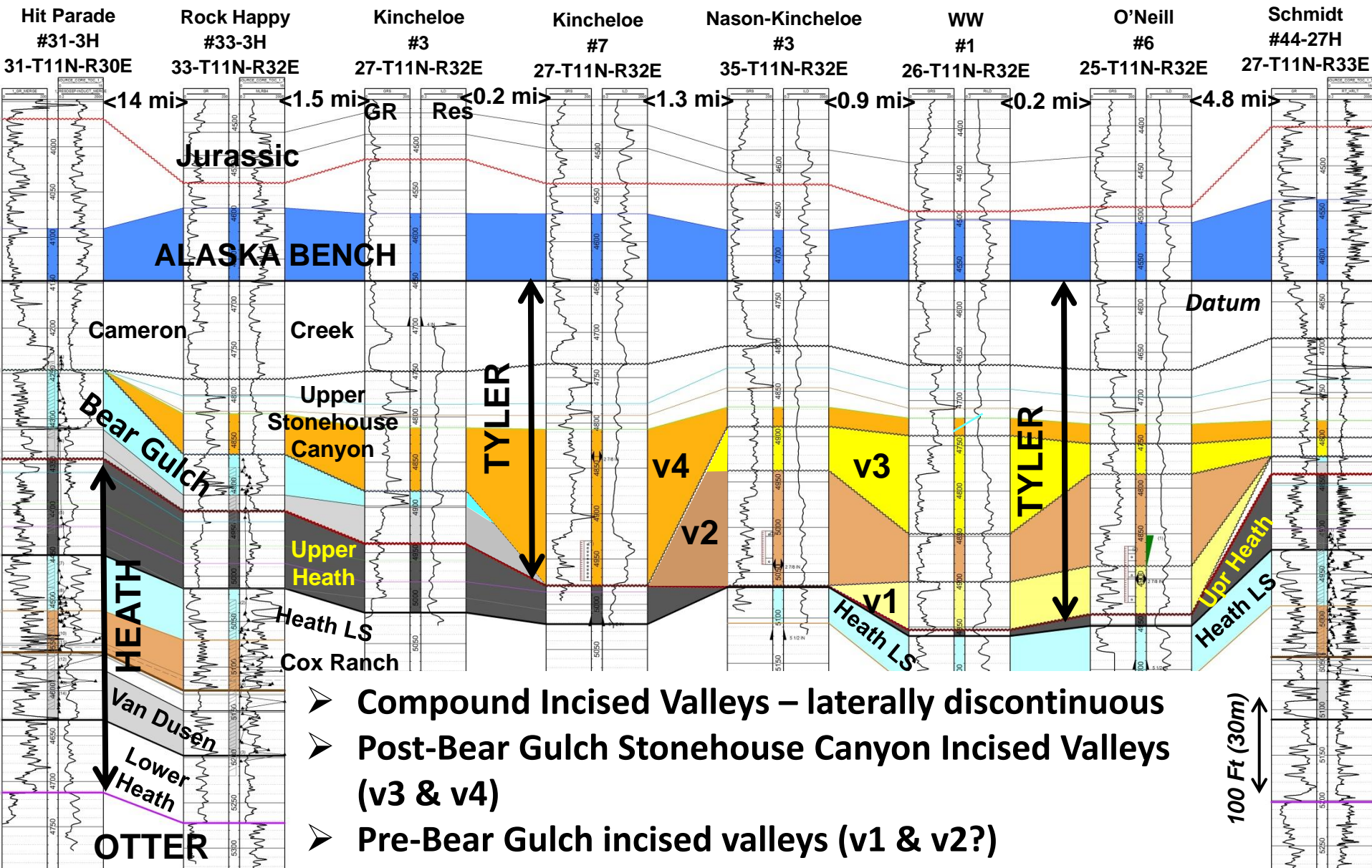


WEST

STONEHOUSE CANYON MBR OF TYLER

EAST

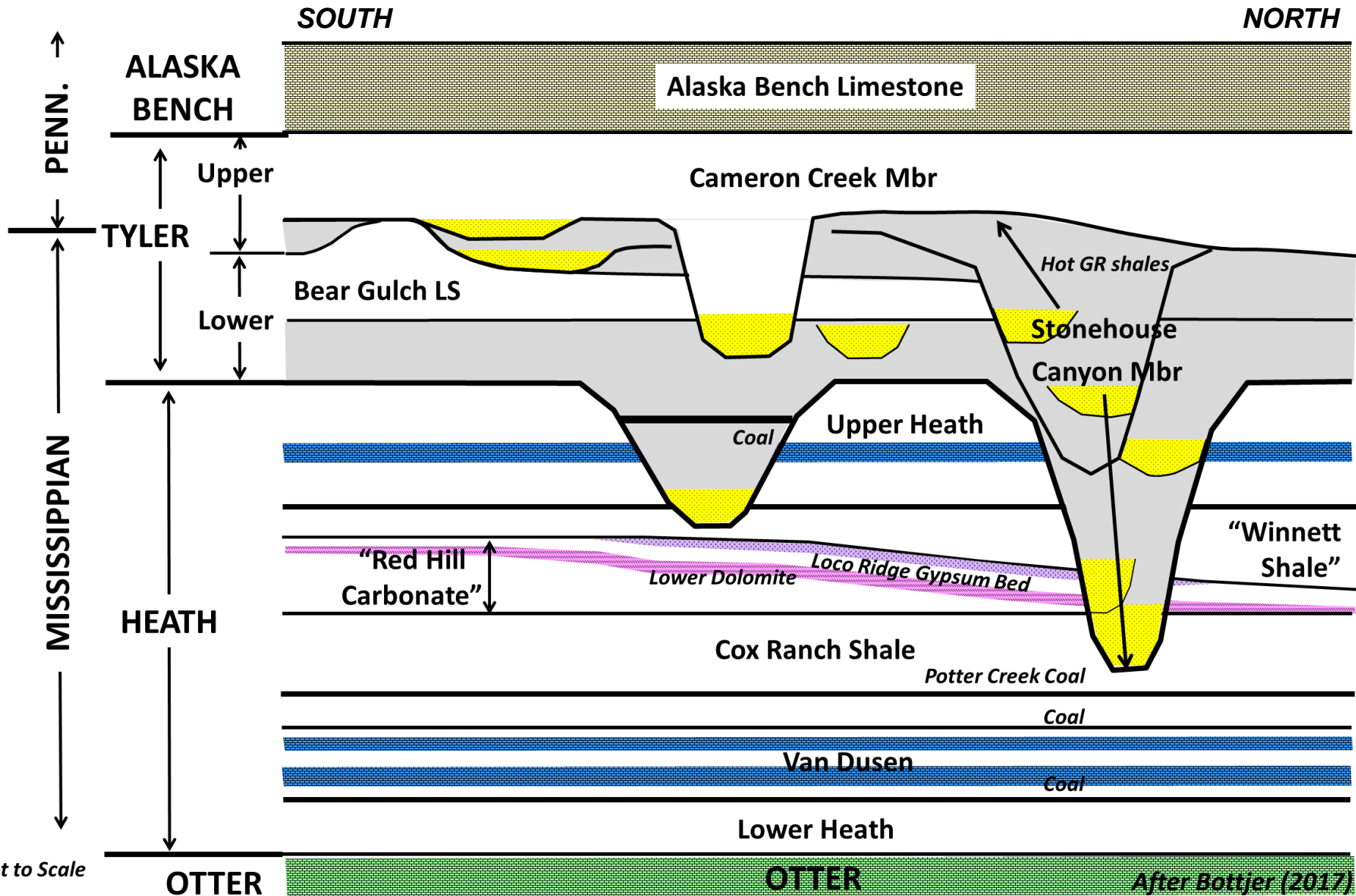
Compound Tyler Incised Valleys



- Compound Incised Valleys – laterally discontinuous
- Post-Bear Gulch Stonehouse Canyon Incised Valleys (v3 & v4)
- Pre-Bear Gulch incised valleys (v1 & v2?)
- Heath markers laterally continuous for long distances

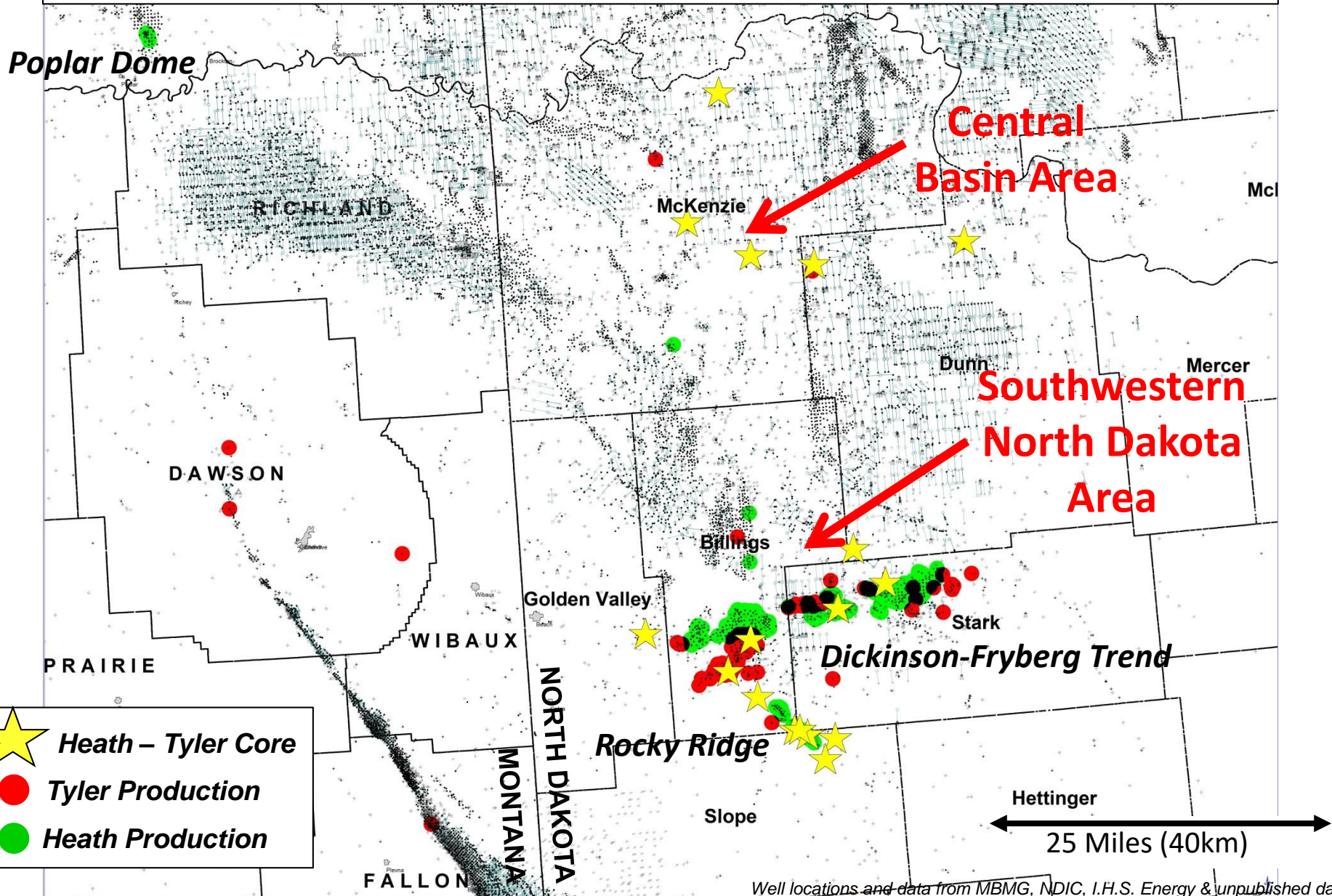
Schematic Lithostratigraphic Correlation Chart

Mid-Carboniferous, Central Montana



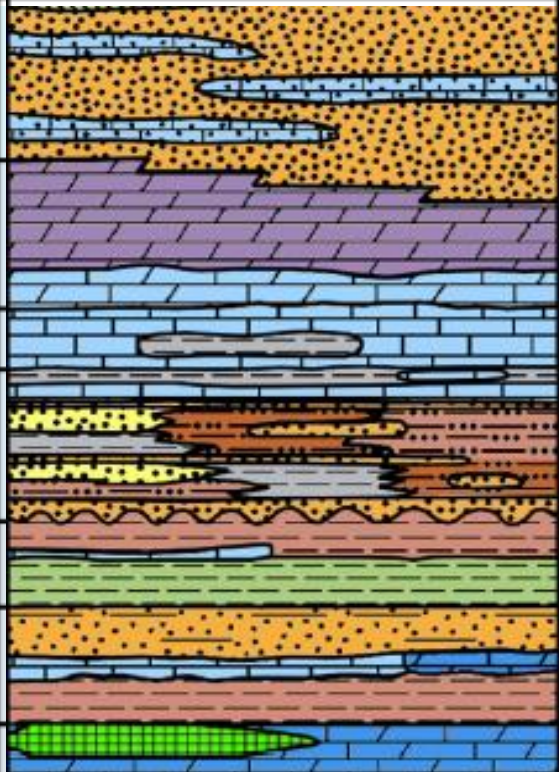

Williston Basin, North Dakota & Montana

Heath-Tyler Production & Cores



Williston Basin, North Dakota

Mid-Carboniferous Stratigraphy 2009 to Present

GROUP	FORMATION	EXPOSED UNITS SHOWN WITH IRREGULAR, ERODED RIGHT-HAND MARGIN
MINNELUSA	BROOM CREEK	
	AMSDEN	
	TYLER	
BIG SNOWY	OTTER	
	KIBBEY	

The name Heath was removed from North Dakota correlation charts in the early 1960s after recommendations by Foster (1961) & Ziebarth (1964)

Tyler Oil Discovered 1954

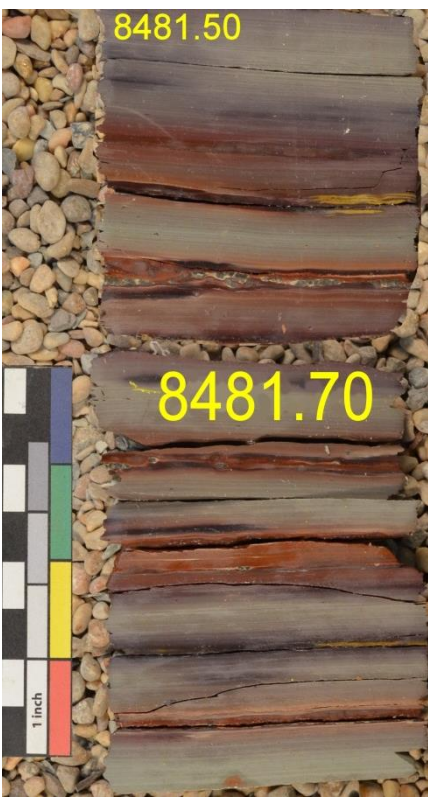
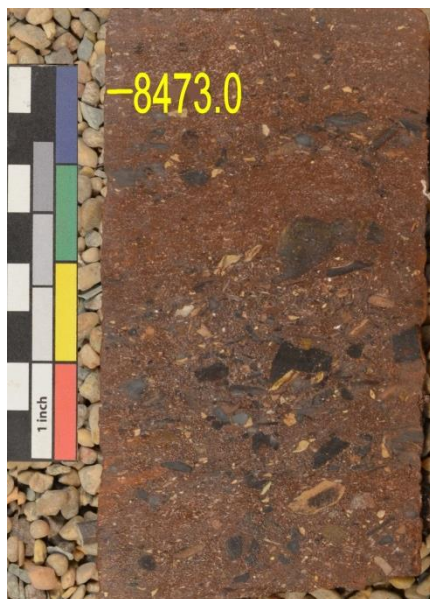
After Murphy et al (2009) NDGS MS-91

Upper Tyler in North Dakota – Cameron Creek equivalent

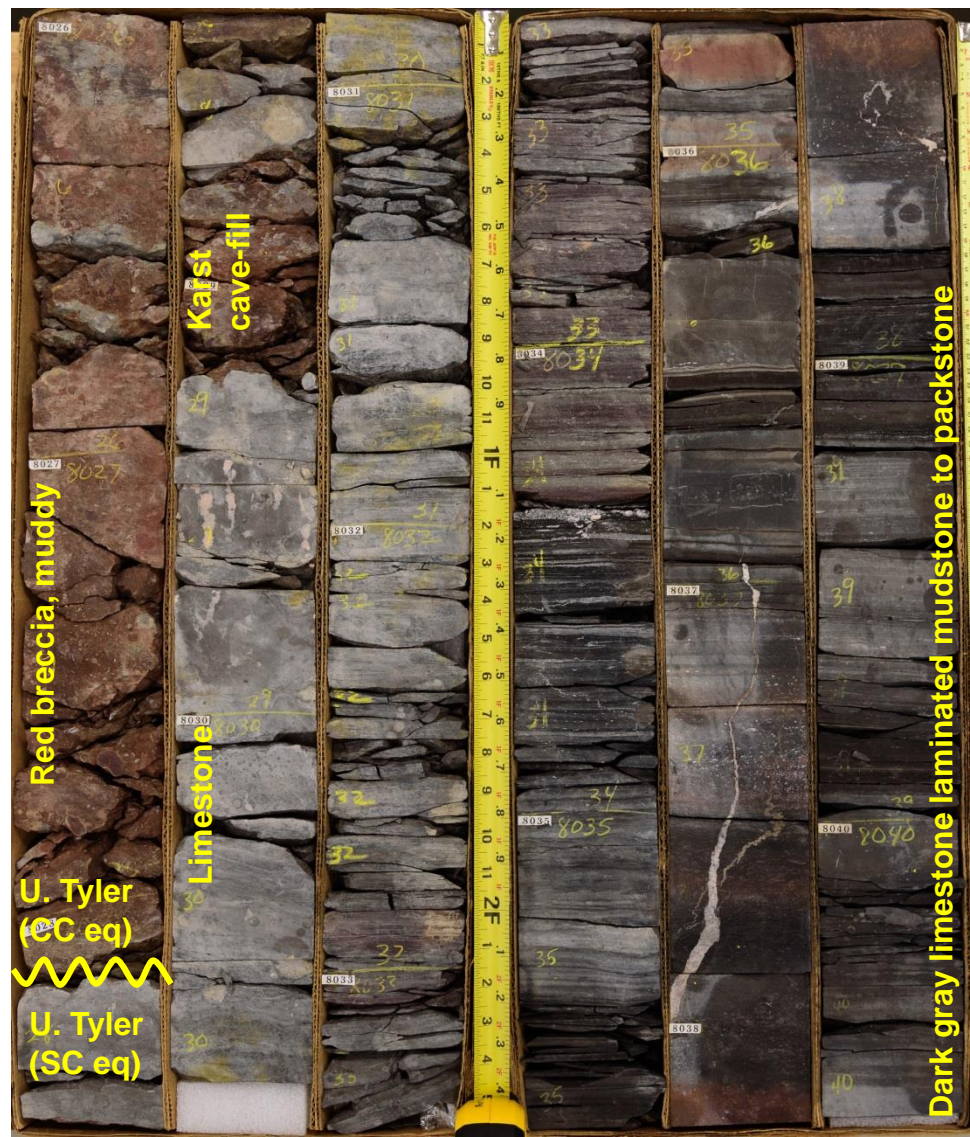
Continental Morison #1-14H
T148N-R99W-14, McKenzie Co.
NDIC #22104

Duncan Jiggs #32-16
T138N-R101W-16, Billings Co.
CRC T129, NDIC #13396
Boxes 1-2, 8026-8040 ft.

Conglomerate to breccia, mixed clast lithology, red sandy matrix



Clayshale to silty mudstone, medium reddish gray to maroon red interlaminated with grayish-green, hematitic, red hematite beds



Red breccia, muddy

Kaist cave-fill

Limestone

U. Tyler (CC eq)

U. Tyler (SC eq)

Dark gray limestone laminated mudstone to packstone

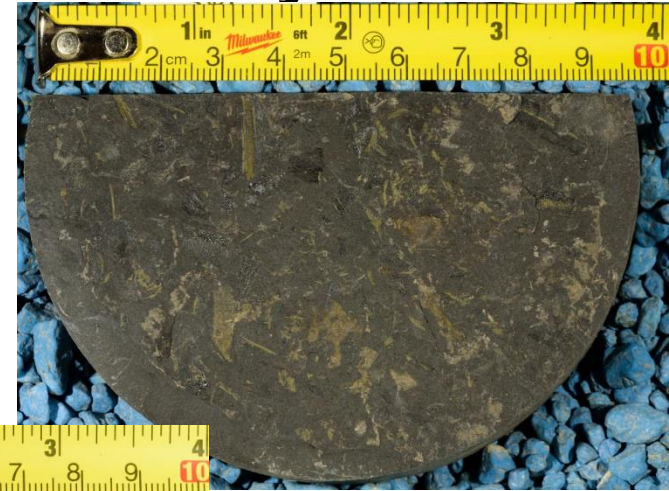
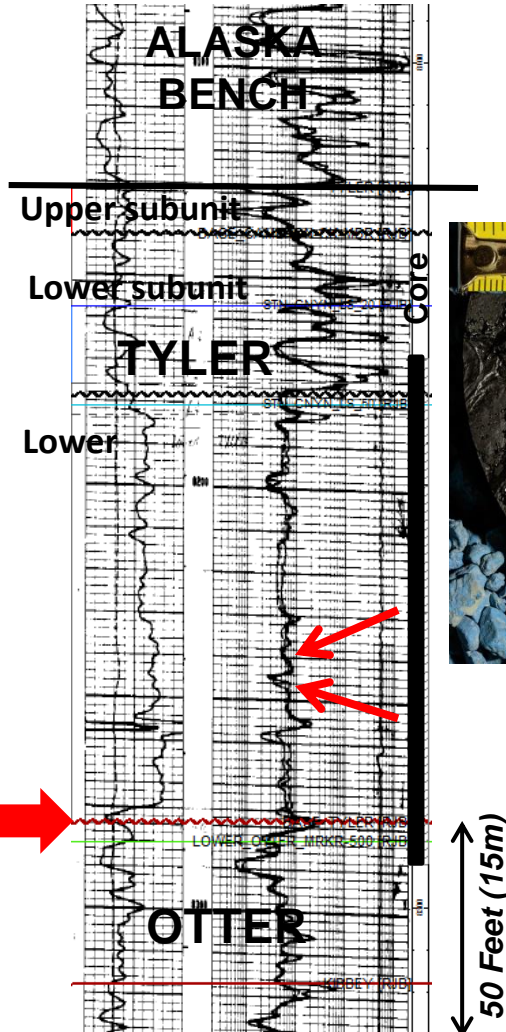
Lower Tyler, Southwestern North Dakota – Stonehouse Canyon equivalent erosionally on Otter



Lower Tyler, Southwestern North Dakota – Stonehouse Canyon equivalent erosionally on Otter



S615
Union Texas Smith #6-1
T137N-R100W-6



Wood & Plant Fragments @
8231.5' (8239.5' log)



Lepidodendron @
8235' (8243' log)

Leaf Impressions &
Wood Fragments @
8235' (8243' log)

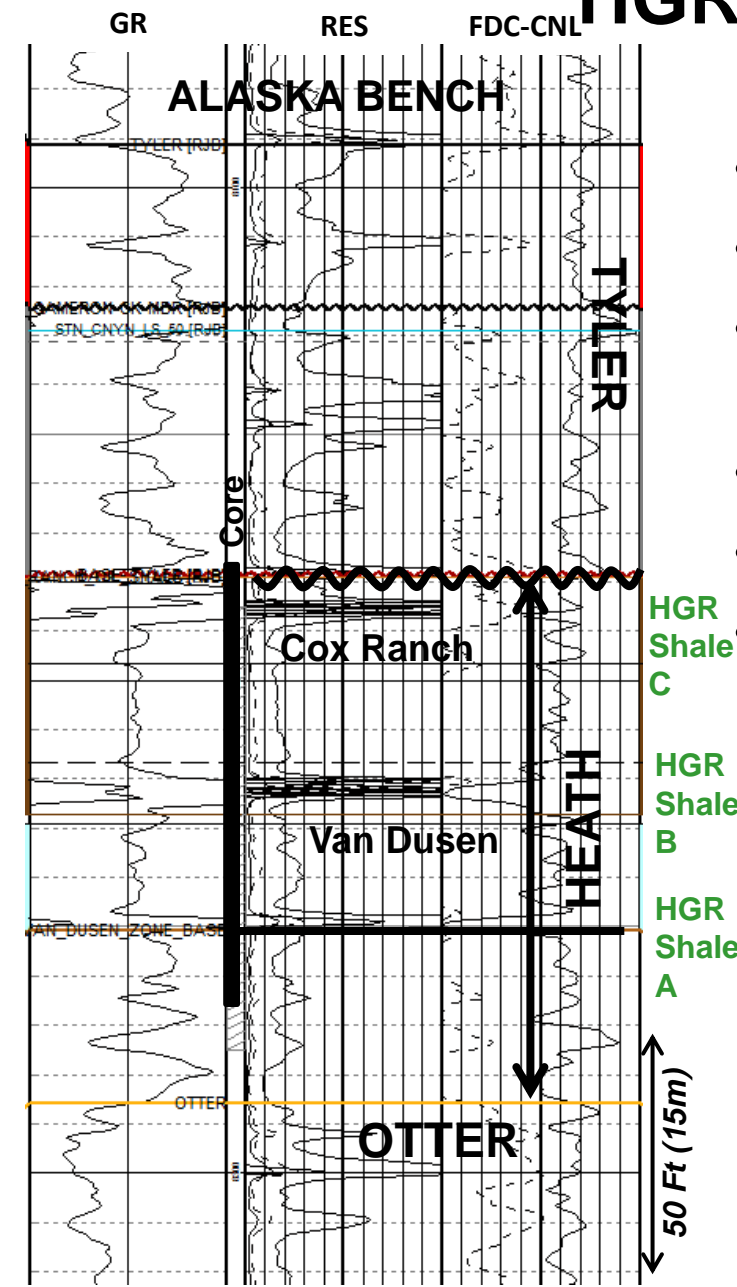


Tyler / Otter
contact @ 8269.9'
(8280.9' log)

Lower Tyler, Central Basin Area

HGR Shales = Heath equivalent

COX RANCH CYCLES



- Fossiliferous Marine Limestone
- Burrowed Limestone
- Calcareous Dark Brownish-Gray to Black Mudstones w/brachiopods
- High-gamma w/ high resistivity (HGR B&C)
- Fissile Black Clayshale
- Correlate for long distances

VAN DUSEN CYCLES

- Open Marine Limestones
- Calcareous Dark Brownish-Gray to Black Mudstones w/brachiopods
- High-gamma w/ high resistivity (HGR A)
- Coal
- Light Greenish-Gray Claystones (Paleosols)

Lower Tyler, Central Basin Area –HGR Shales = Heath equivalent

Whiting Curl #23-14

T149N-R100W-14

8264-8285

NDIC # 16581



Williston Basin Tyler Regional Comparison & Interpretation

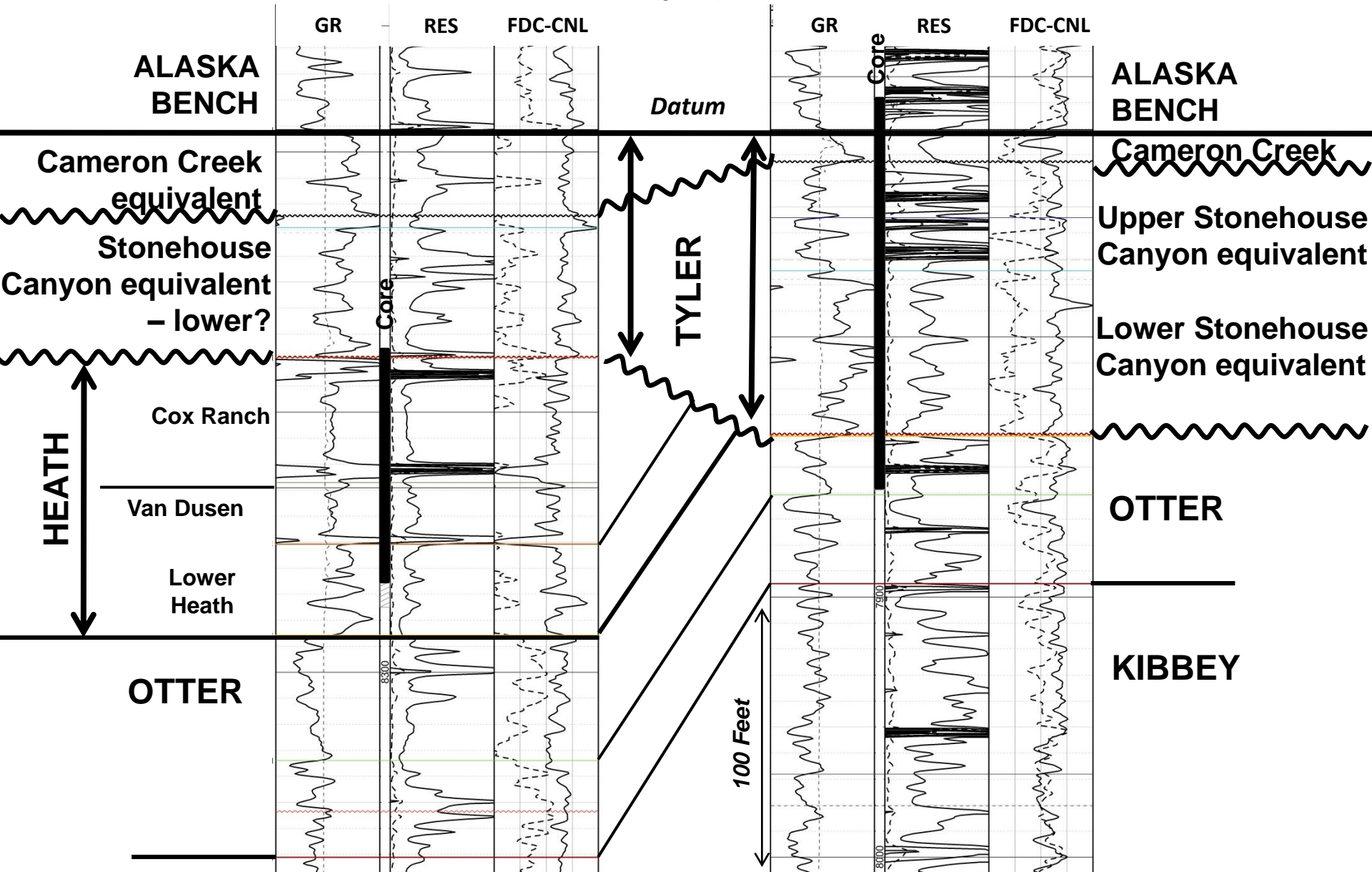
NORTH

Whiting Curl #23-14
T149N-R100W-14, McKenzie Co.
NDIC #16581

<81 mi>

Marathon Rundle Trust #11-29TH
T136N-R99W-29, Slope Co.
NDIC #26223

SOUTH



Central Montana to North Dakota – Central Basin Area

West

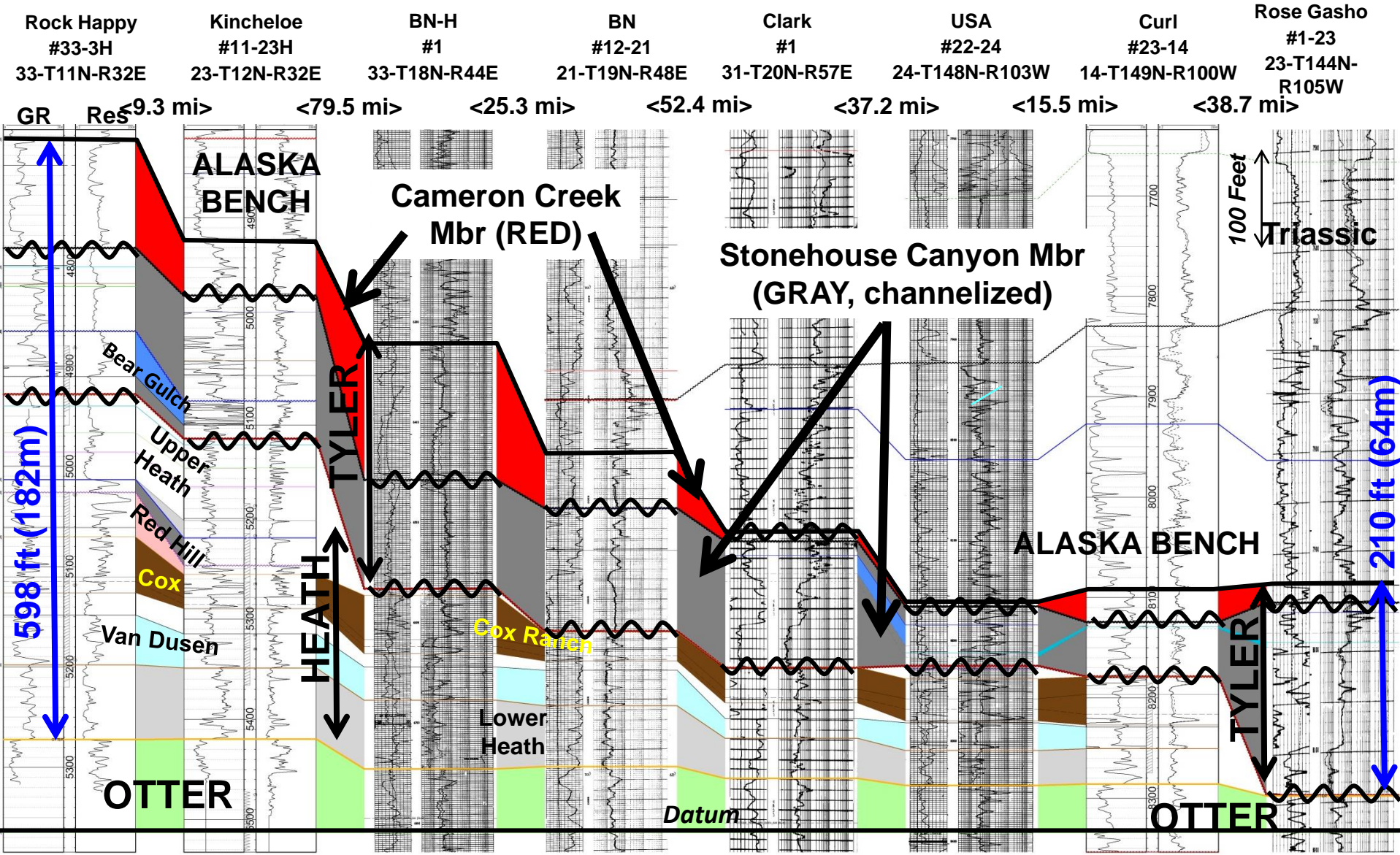
Datum Mid-Otter Marker

East

Central Montana

Eastern Montana

North Dakota



CONCLUSIONS

- **The Heath & Tyler are distinct units separated by a sequence boundary in central Montana. Subdivision of the Tyler based on mudrock color changes is useful for genetic stratigraphic correlations.**
- **The Heath-Tyler interval thins from >800 feet in central Montana to ~200 feet in North Dakota.**
- **Heath Cox Ranch and Van Dusen markers can be correlated with confidence into McKenzie Co., North Dakota. THERE IS HEATH IN NORTH DAKOTA!**
- **Strata in North Dakota equivalent to the Stonehouse Canyon Member of the Tyler in central Montana are gray to black shale-dominated units with abundant wood fragments and lenticular sandstones.**
- **Strata in the upper parts of the Tyler in North Dakota containing red mudstones, breccias, and sandstones, are stratigraphically related to the Cameron Creek Member of the Tyler in central Montana.**

Thank You!



View to North from Sacajawea Peak in the Bridger Range, southwestern Montana