

Re-Visiting the Ordovician Bighorn Dolomite and Devonian Darby Subcrop Geometry across SW Wyoming: New Light from an Old Well*

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Abstract

The eastward pinchout of the Upper Ordovician Bighorn Dolomite and Upper Devonian Darby Formation is well known from outcrops in mountain ranges surrounding the Greater Green River Basin (GGRB). Less studied, especially in the last 40 years, is the subsurface distribution of these two units. In addition, published isopach maps of the two formations mostly rely on pre-1972 data when well control was much less than today. A new interpretation of the subsurface pinchout geometry of the Bighorn Dolomite and overlying Darby Formation comes from a well drilled on the crest of the Rock Springs Uplift in 1962. The Mountain Fuel Supply UPRR-11-19-104-4 well is one of only four wells that penetrate all or part of the Devonian-Ordovician succession in the subsurface of the GGRB between the Moxa Arch and the Rawlins Uplift. It was also almost completely cored from above the Mississippian Madison Limestone to Precambrian basement, and the core is archived at the USGS CRC in Lakewood, CO. From a reinterpretation of the stratigraphy in the core, 25 feet of Bighorn Dolomite is recognized based on the characteristic *Thalassinoides*-bioturbation fabric in crinoidal-peloidal dolo-wackestone typical of Late Ordovician subtidal carbonate facies ranging from Nevada to Greenland. The Bighorn-like lithology is in complete contrast to the alternating dolomitic flat-pebble conglomerate and mudstone of the underlying Cambrian Gallatin Limestone and the brecciated anhydritic, sandy dolo-mudstone to coated-grain grainstone and quartz sandstone of the overlying Darby Fm. This re-interpretation affects the isopach maps of the two units across the southwestern GGRB. The Darby Fm. isopach and pinchout geometry is slightly modified from past interpretations. The Bighorn Dolomite extent is substantially modified. It is more widespread than previously thought, and the eastward pinchout geometry is more consistent with that exposed in outcrop along the southeastern flank of the Wind River Range.

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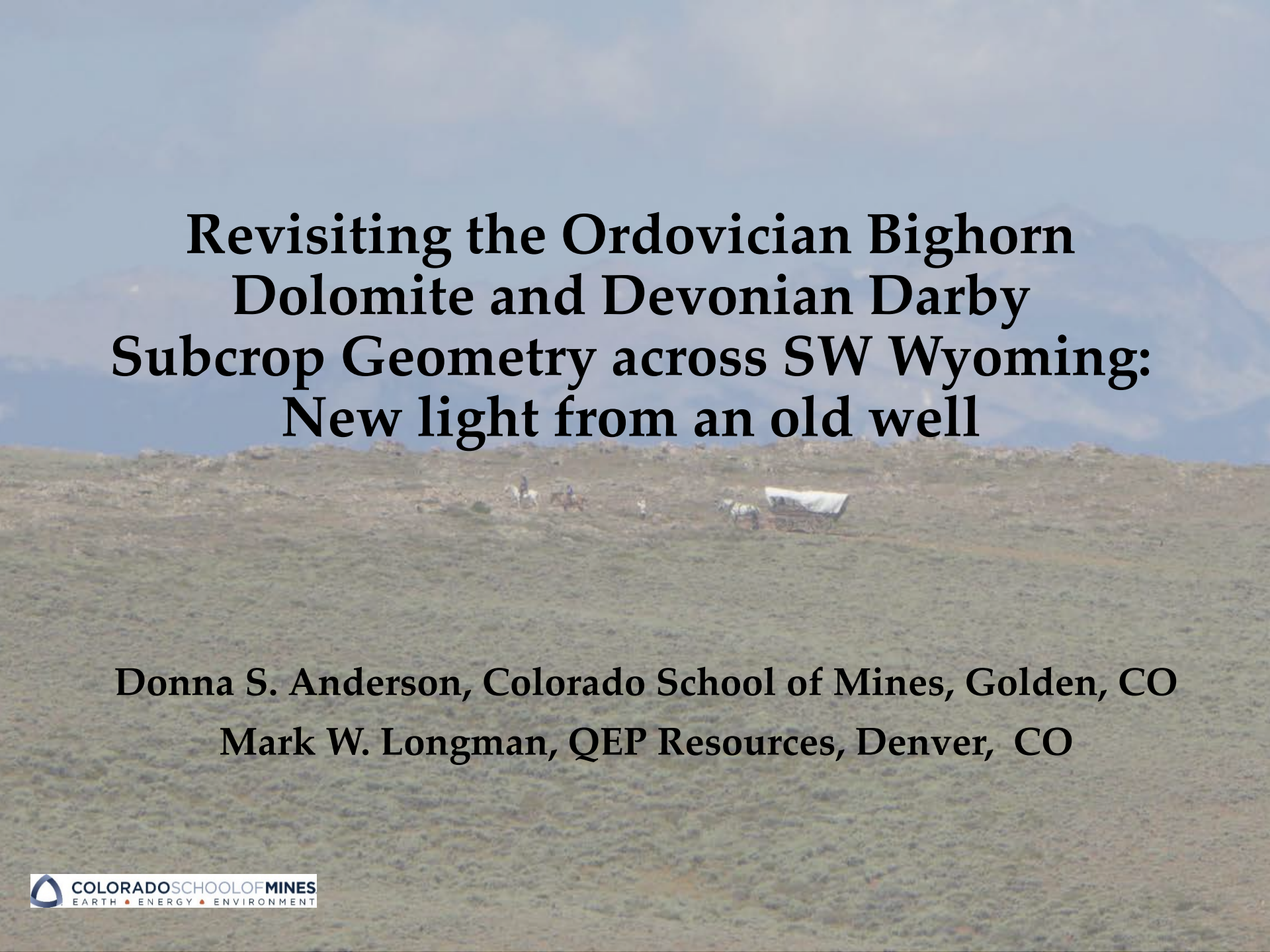
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Revisiting the Ordovician Bighorn Dolomite and Devonian Darby Subcrop Geometry across SW Wyoming: New light from an old well

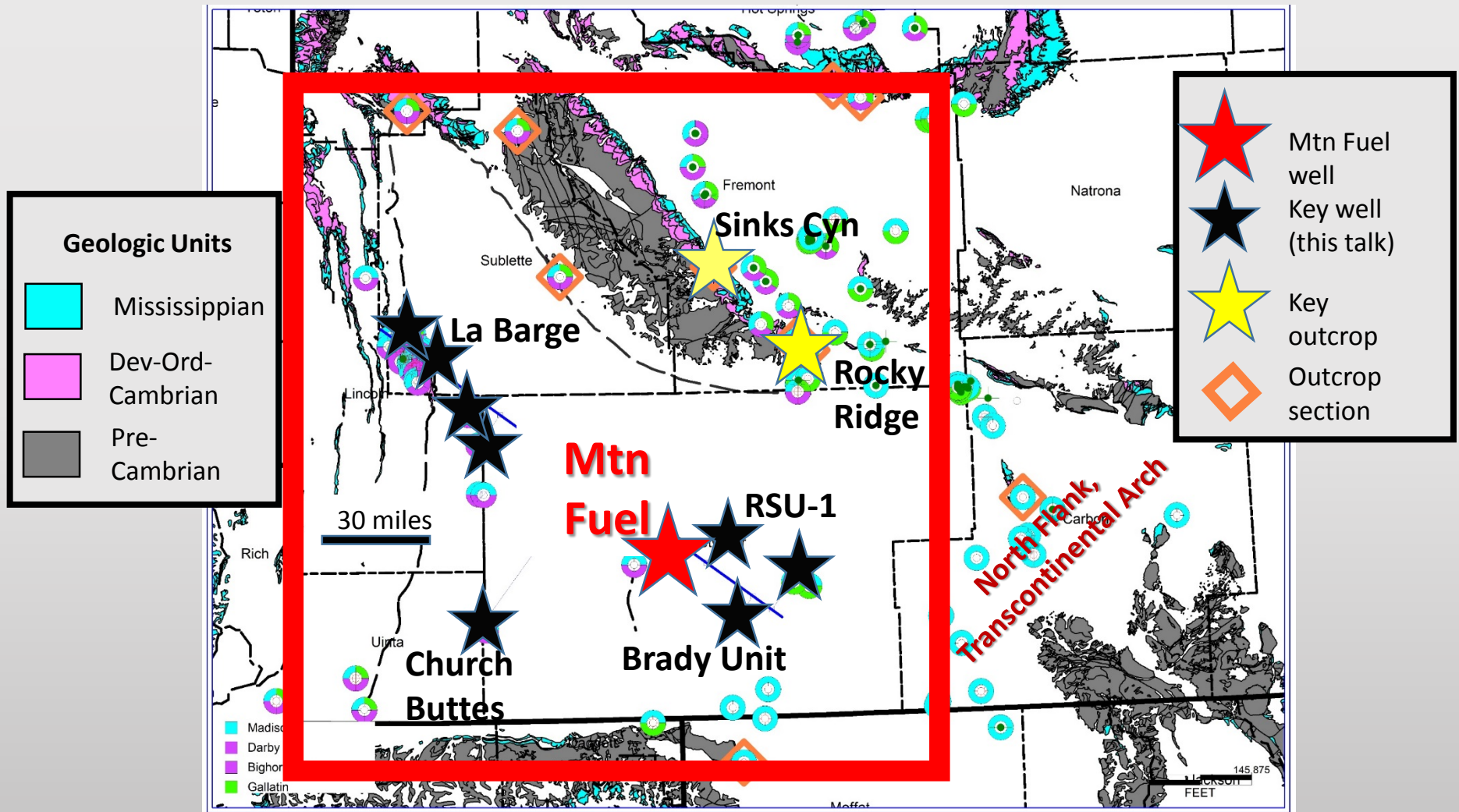
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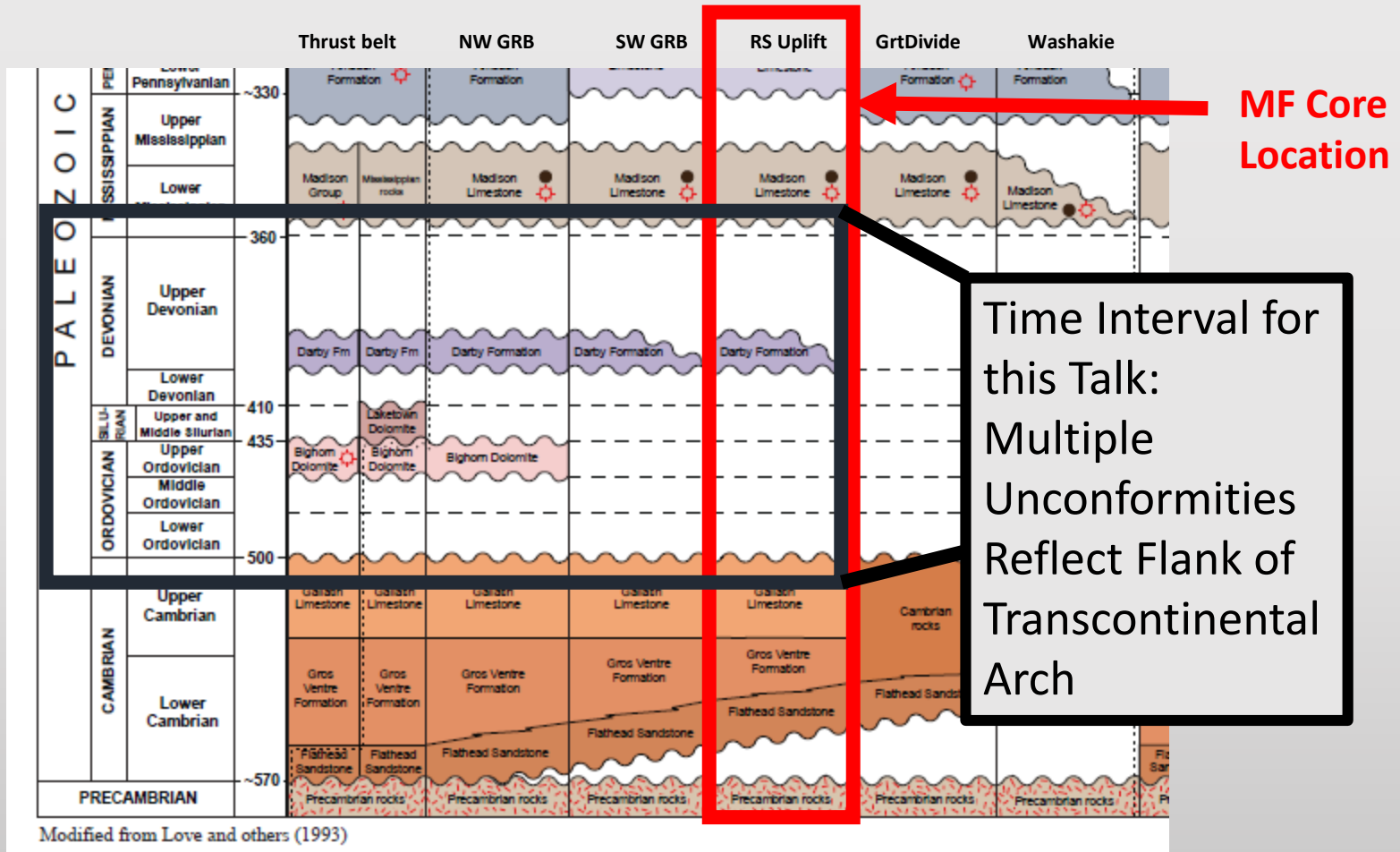
Plan of Attack

- Study area & General Stratigraphy
- Mountain Fuel (MF) Core:
 - History
 - “Mystery” Interval, likely the Bighorn Dolomite (BHD)
 - Facies in Mountain Fuel core
 - Comparison to regional/global Late Ordovician Facies
 - Comparison to Younger/Older Dolostone Facies in the MF Core
- Implications:
 - Isopach Maps
 - Unconformity Relationships
 - Onlap vs Top Truncation

Study Area



Stratigraphic Column

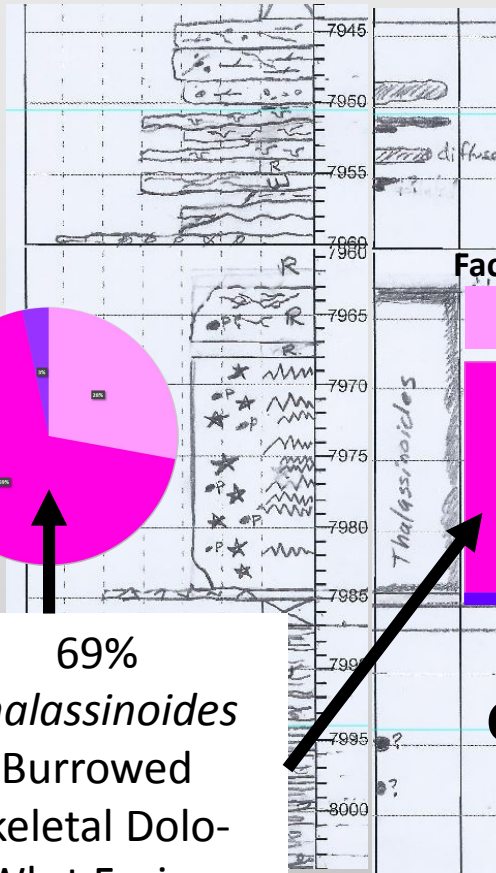


Wyoming State Geological Survey: Stratigraphic Chart of Laramide Basins (after Love, 1993)

The Mountain Fuel Well & Core

- Well drilled and cored in December 1961 through April 1962 by Mountain Fuel Supply Co.
 - UPRR 11-19-104 No. 4, North Baxter Basin gas field, TD 9153 in “Granite Wash”
 - Logged with GR, Neutron, Sonic and Resistivity
- Cored nearly continuously from 6404 ft (Weber) to 9153 ft MD (basal Flathead+): about 2749 ft
- Cores archived at USGS Core Research Center since mid-late 1970s
- Core slabbed in early 1980s
- Published Description History
 - 1962-1964 Described from Core Chips for Amstrat
 - 2010 Lynds et al. as part of Carbon Sequestration project on Rock Springs Uplift

Core-Log Across Darby-Gallatin Interval



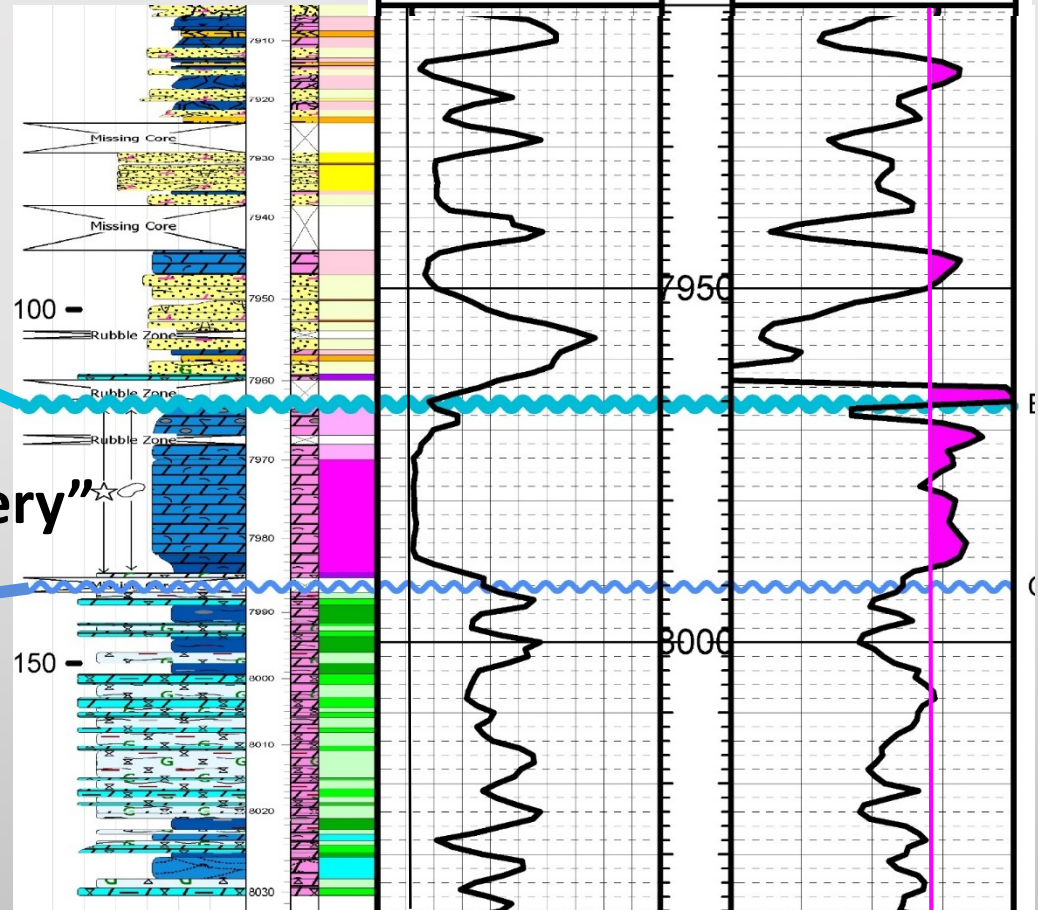
69%
Thalassinoides
 Burrowed
 Skeletal Dolo-
 Wkst Facies

Darby

Facies

"Mystery"

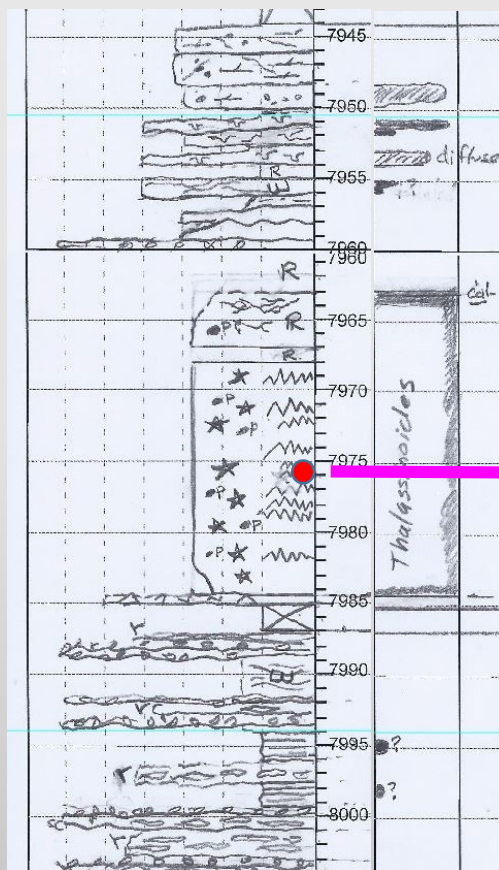
Gallatin



USGS Core Photos Across Darby-Gallatin Interval



7970-7995.8 ft MD: *Thalassinoides*-burrowed echinoderm, peloidal dolowackstone



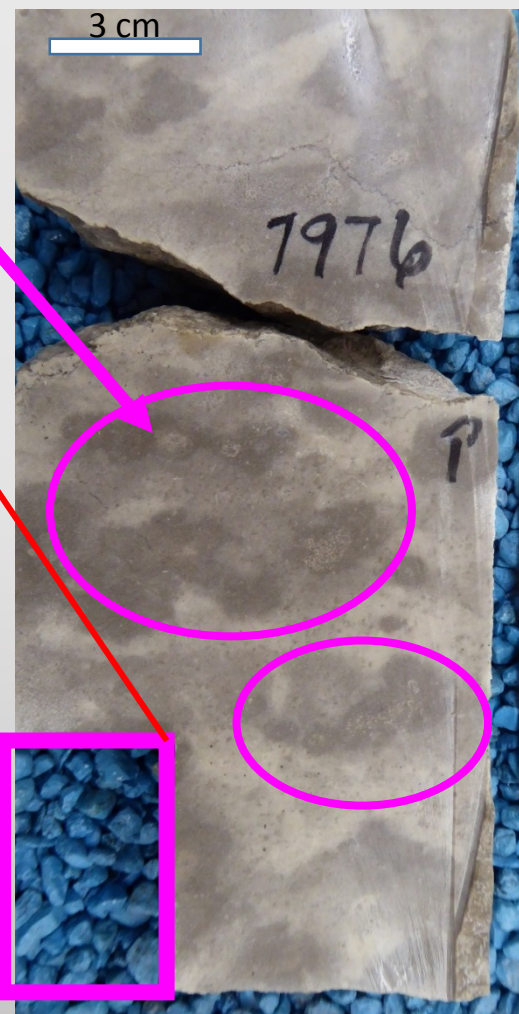
Burrow wall

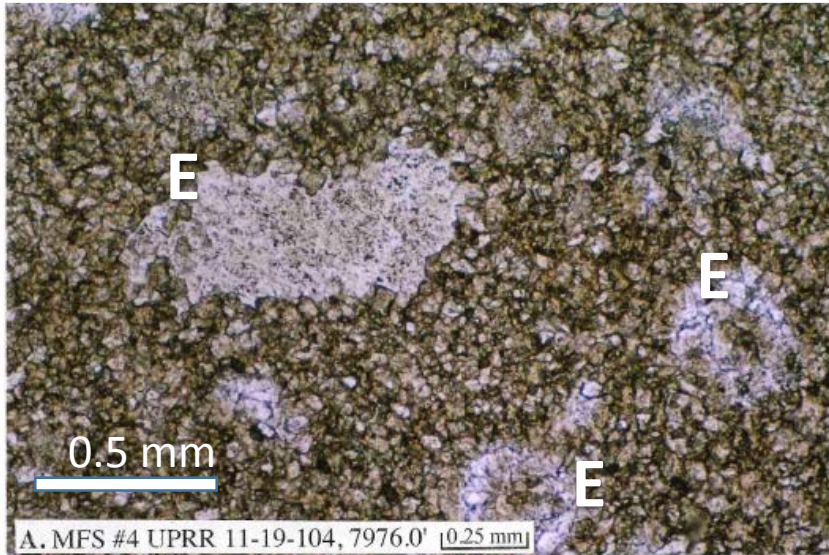
2.7 cm



Crinoid fragments

Note "burrow-in-burrow" texture



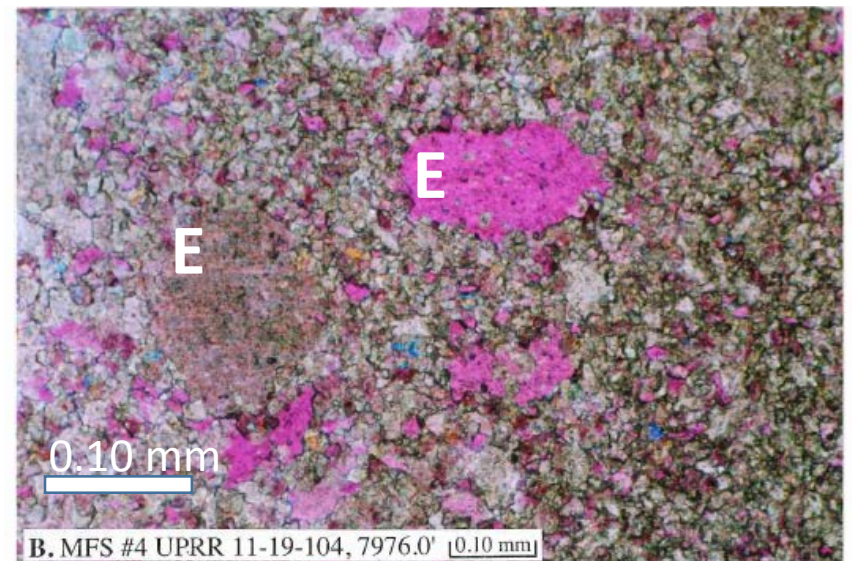


Plane light

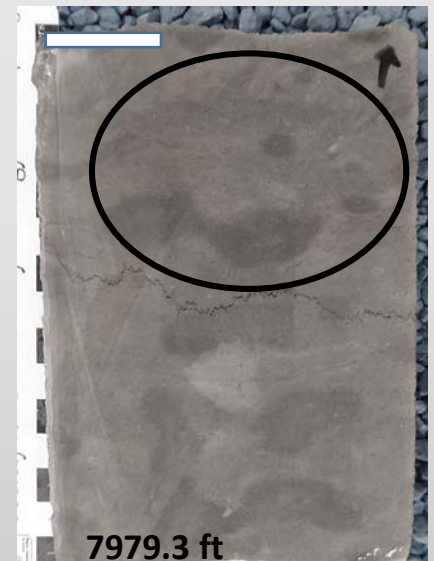
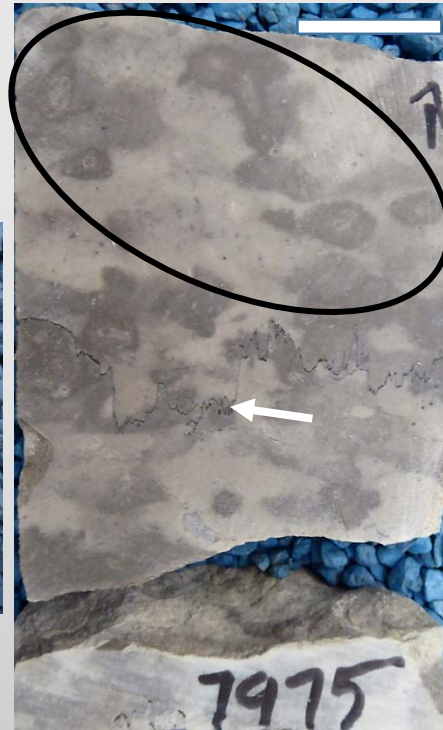
Finely crystalline dolomite with scattered coarse dolomite crystals that replaced former echinoderm fragments (E)

7976 ft MD: *Thalassinoides*-burrowed dolo-wackstone with scattered echinoderms (E)

Crossed Polarizers, Gypsum Plate



Thalassinoides-Bioturbated Facies with Interlocking Stylolites



All Scale Bars
are 3 cm

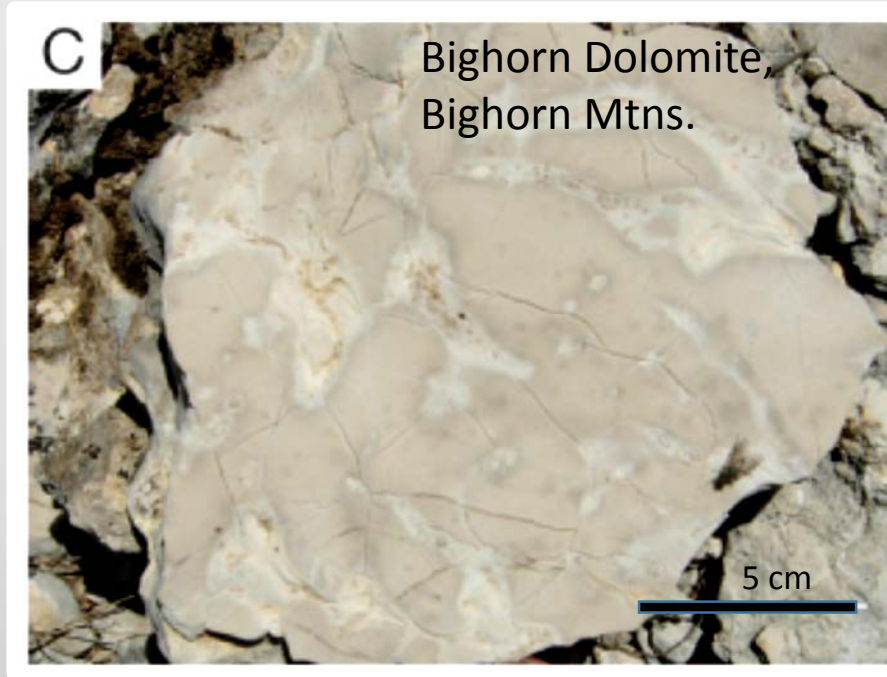
Late Ordovician Burrowed Facies of Laurentia

- Late Ordovician massive-bedded *Thalassinoides* ichnofacies along the palaeoequator of Laurentia
 - Excellent article by Jin et al., 2012, in *Palaeogeog.*, *Palaeoclim.*, *Palaeoecol.*
- Pervasive in widely separated areas on the vast Upper Ordovician carbonate platforms from North Greenland to the eastern Great Basin USA (Ely Springs Dolomite and equivalent strata)
 - Consistent characteristics suggest a paleo-geographically homogenous and temporally stable depositional environment along the paleo-equator
 - First phase of mega-scale invasion of burrowers into relatively deep water platform and shelf environments: part of Great Ordovician Biodiversification Event
 - Generally considered an environment below wave-base

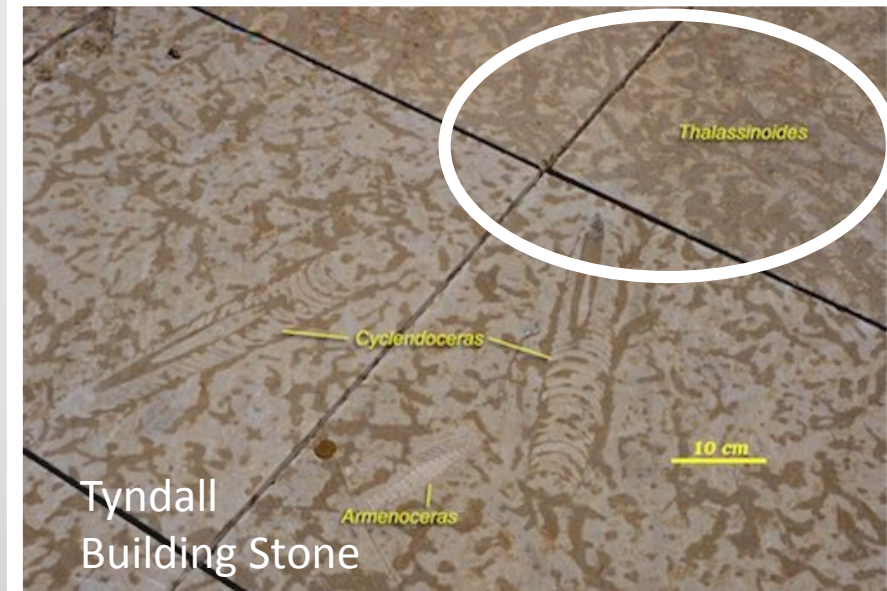
Physical Characteristics

- Long-recognized (early 1900s) as a widespread (since 1950s) facies
- Zenger (1996) suggests five macro/microscopic criteria for recognition:
 - *Thalassinoides*-like burrow patterns
 - Small burrows within burrows
 - Megafauna including receptaculitids, macluritid gastropods, orthoconic nautiloids
 - Common matrix of partly dolomitized (mud-selective) skeletal (primarily echinoderm) wackstone & packstone
 - Fine-centimicron-size, nonplanar, unimodal dolomite completely or nearly completely replacing burrow fills
- Complex, 3-D anastomosing or multi-level galleries (Jin et al., 2102)
 - Consistent in size pattern and density with preserved depth up to 1 m.

Bighorn Dolomite in Bighorn Mtns. & Tyndall Building Stone



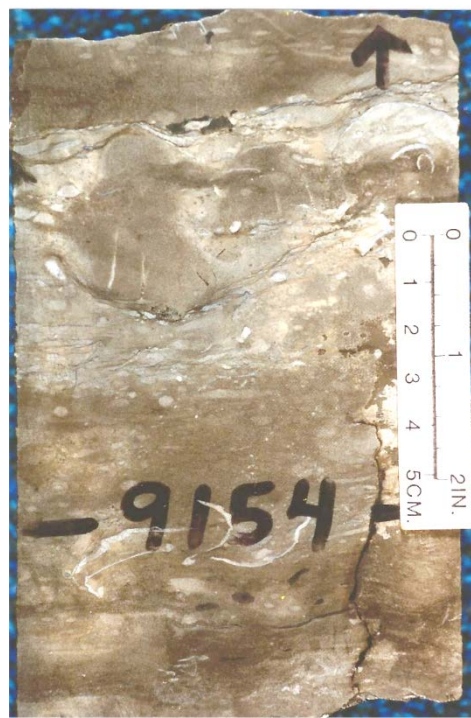
Zoned dolomitization around *Thalassinoides* burrows, “Open shallow subtidal” facies of *Holland & Patzkowsky, 2012, JSR, Figure 4C*.



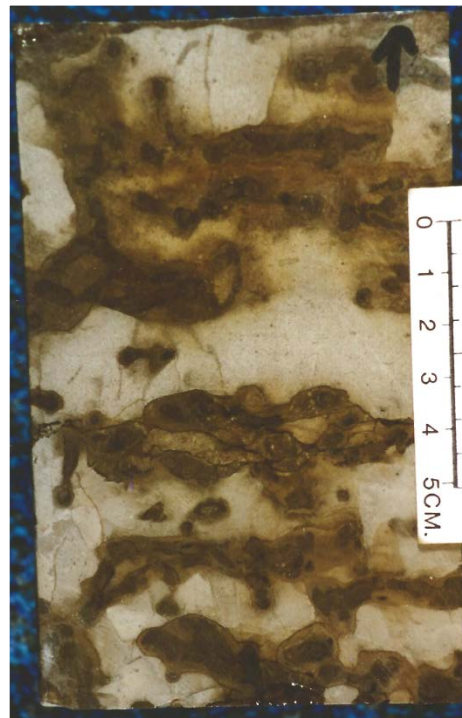
Thalassinoides burrows and nautiloid fossils in polished Tyndall Building Stone, Manitoba, Canada: Selkirk Mbr., Red River Fm.
Image from web

Thalassinoides-Burrowed Red River C: Core Williston Basin

3 cm



Shell fragments,
basal C burrowed
interval



Oil stain in
burrows



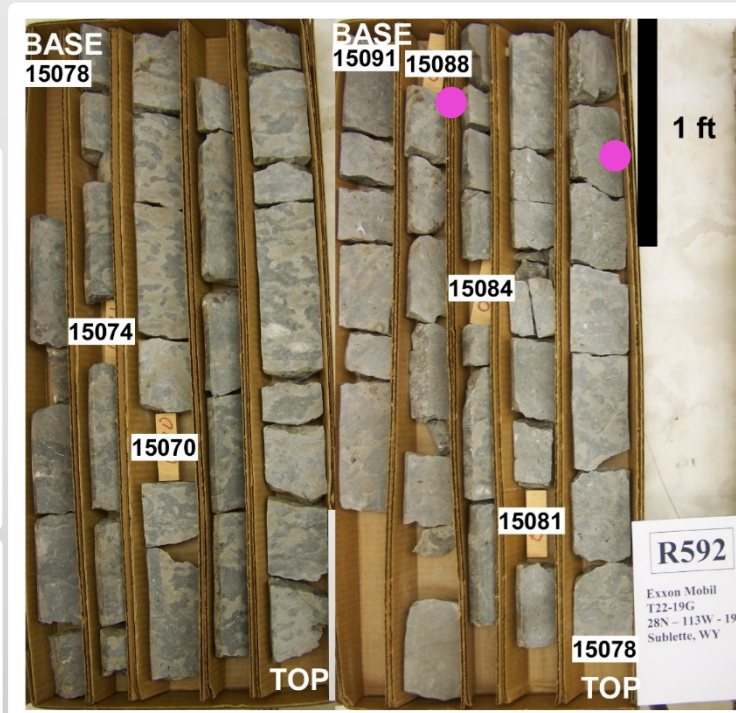
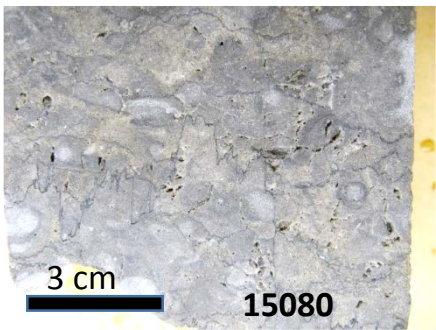
Oil stain between
burrows

Bighorn Core: La Barge Platform

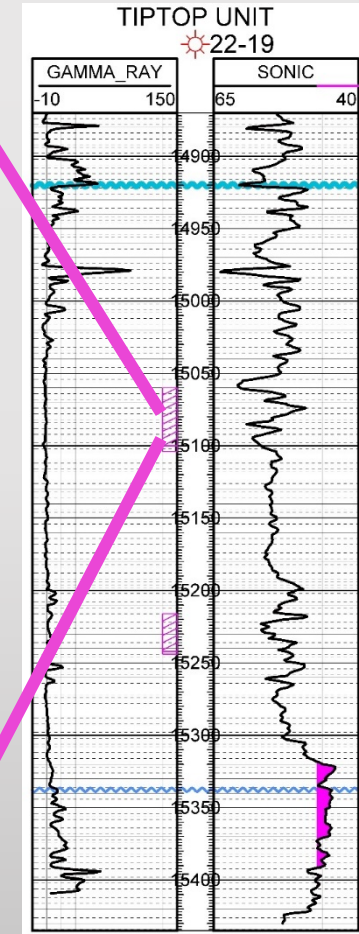
Pervasive

Thalassinoides

“burrow-in-burrow”
texture



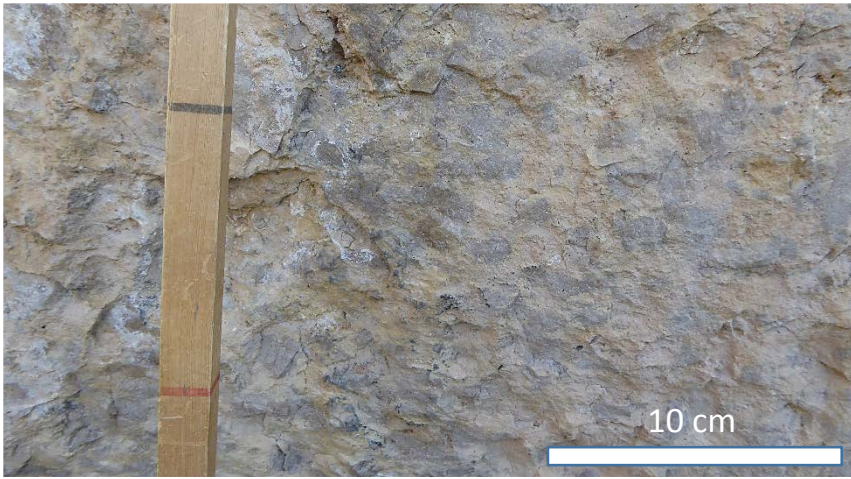
Note: Depth labels correct as per core box labels



Darby
Bighorn

Gallatin

Bighorn Dolomite Outcrops at Sinks Cyn & Rocky Ridge: Outcrops closest to the Rock Springs Uplift



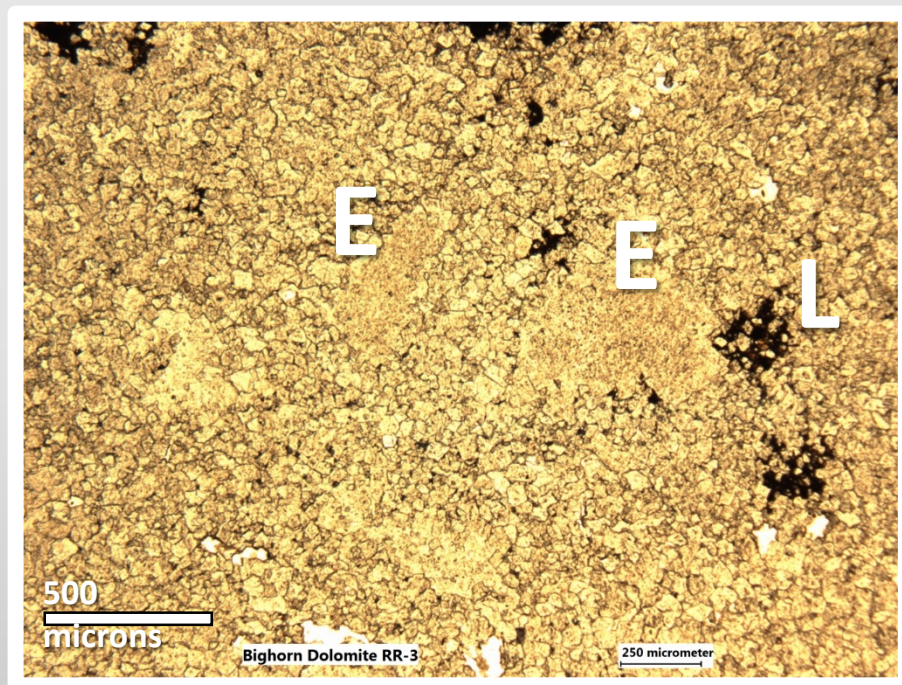
Fresh outcrop, Sinks Canyon, Wyoming



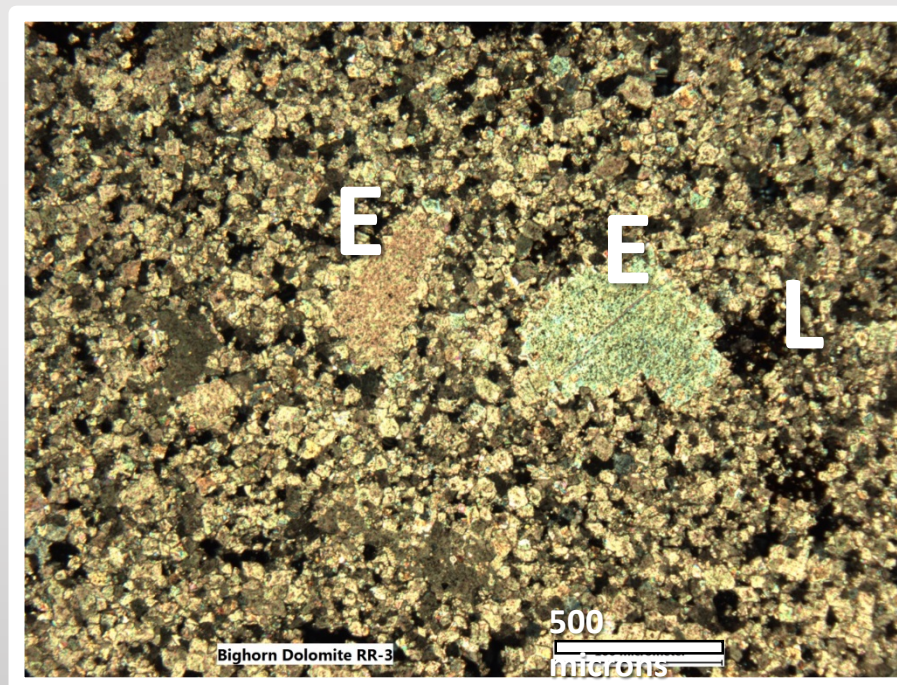
Weathered outcrop, Rocky Ridge, Wyoming

Massive-bedded *Thalassinoides* burrowed dolo-wackestone

Photomicrograph of Bighorn Dolomite, Rocky Ridge Outcrop



Plane light

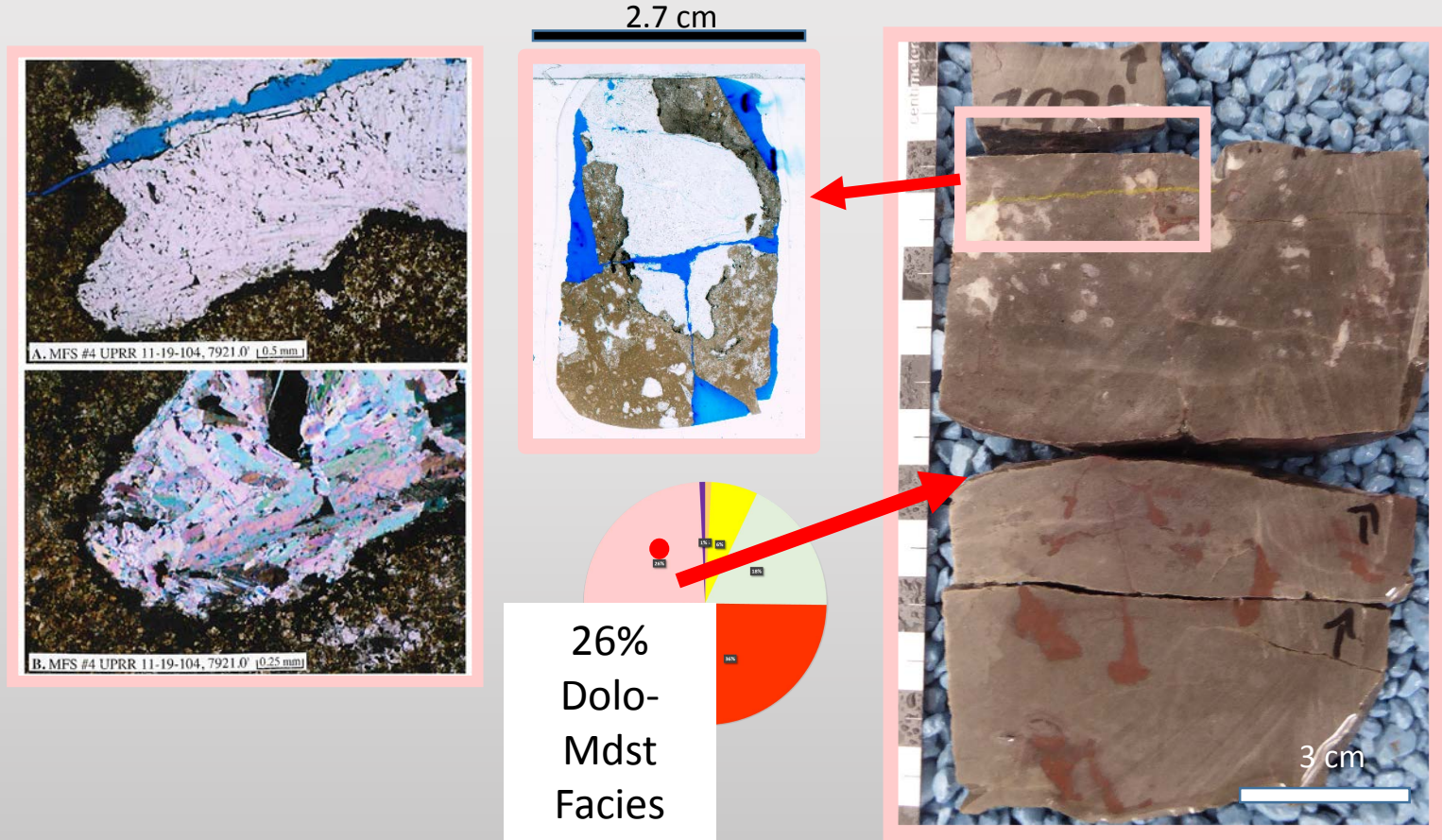
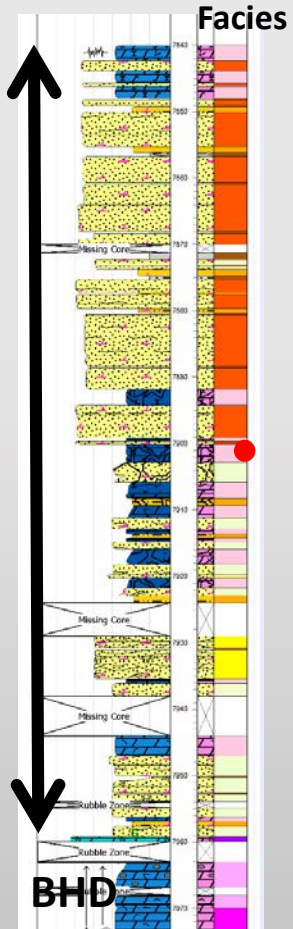


Crossed Polarizers

Echinoderm fragments (E) and limonite (L) in dolomitized skeletal wackestone

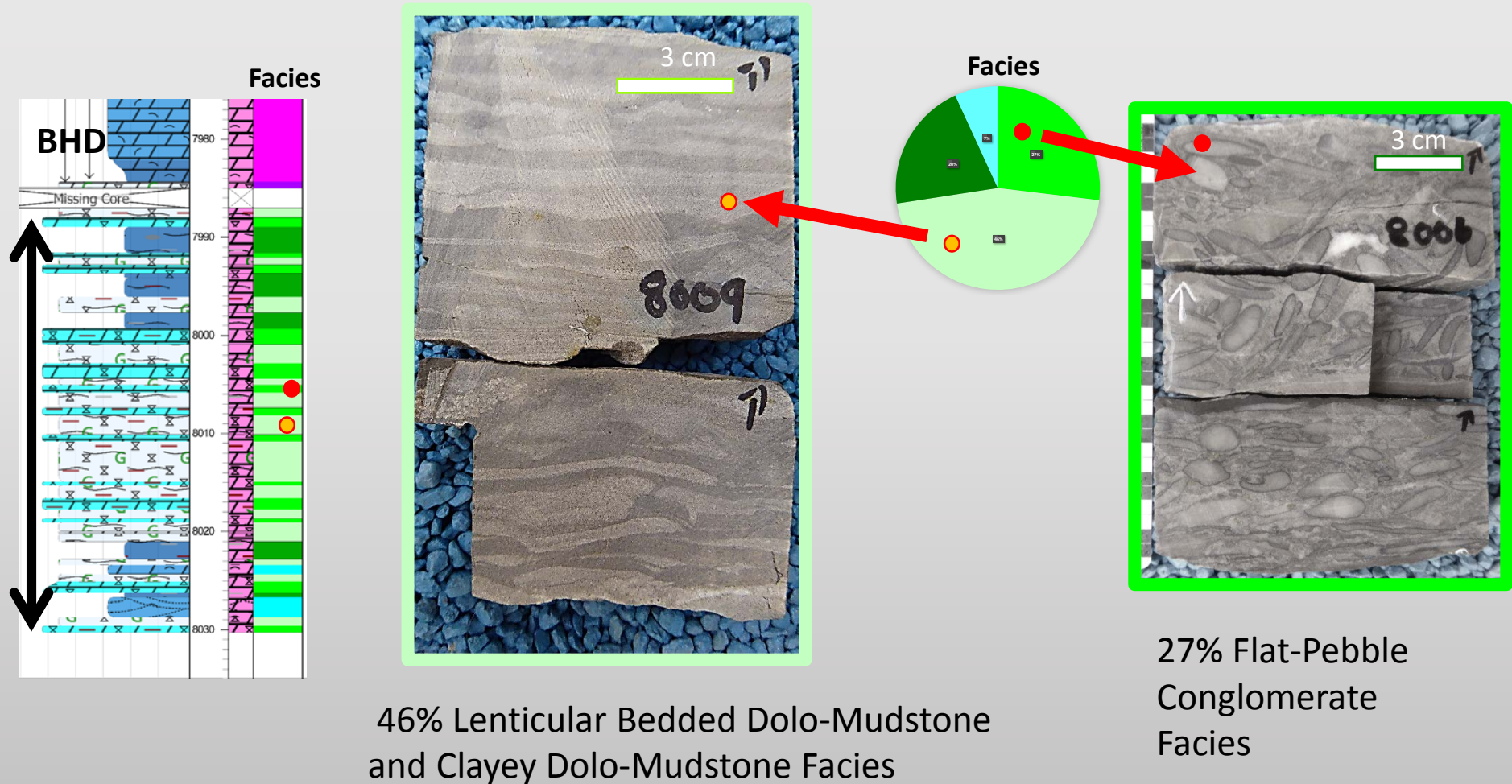
Other dolostone facies from the
Darby and Gallatin Intervals in the
Mountain Fuel core
are entirely different

Typical Dolostone Facies in Darby Formation



Recrystallized (peloidal) dolo-mudstone with anhydrite and red siltstone filling brecciated intervals (exposure surface)

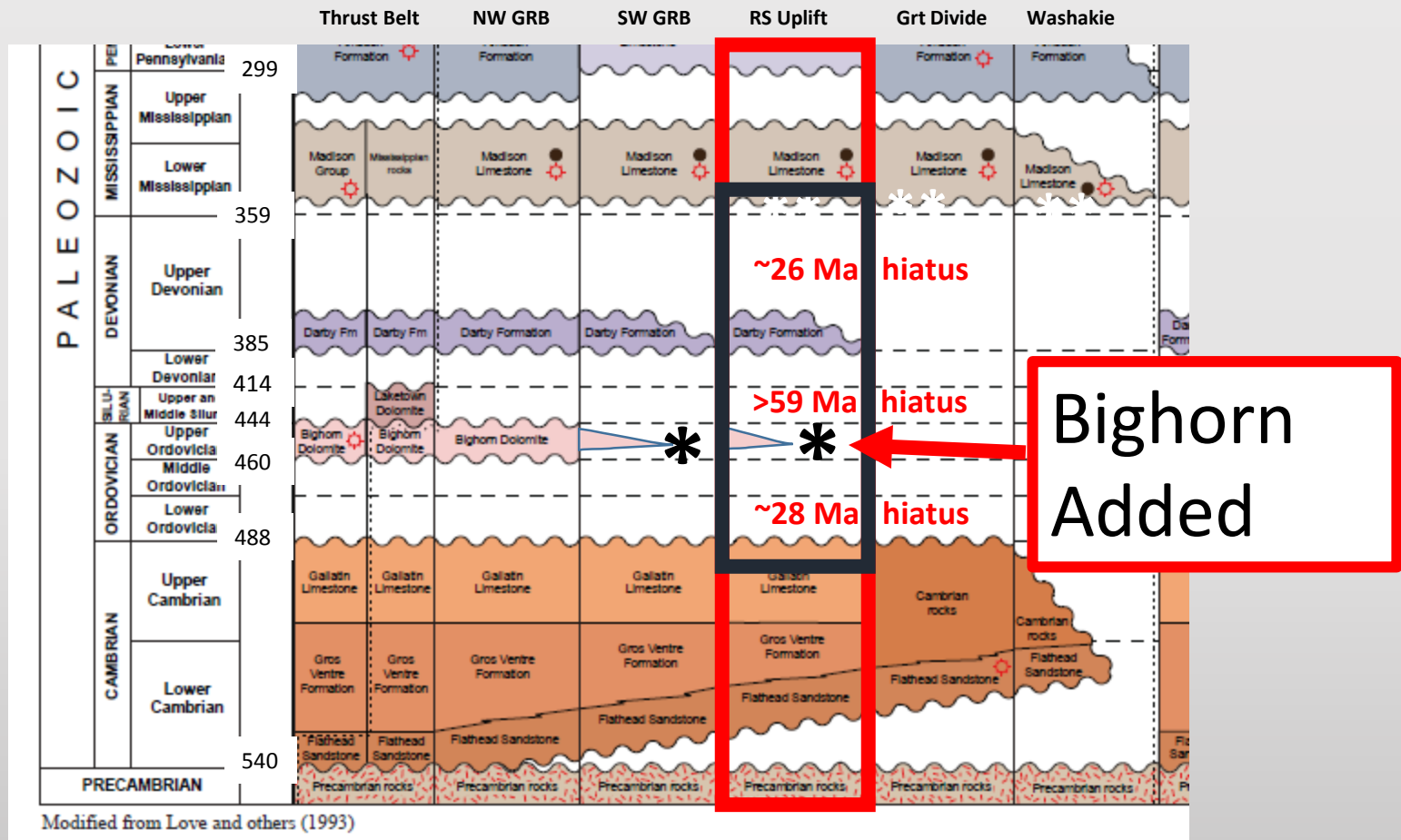
Typical Dolostone Facies in upper Gallatin Formation



We are convinced that the interval
from 7963 to 7985 ft MD in the core
is the Bighorn Dolomite

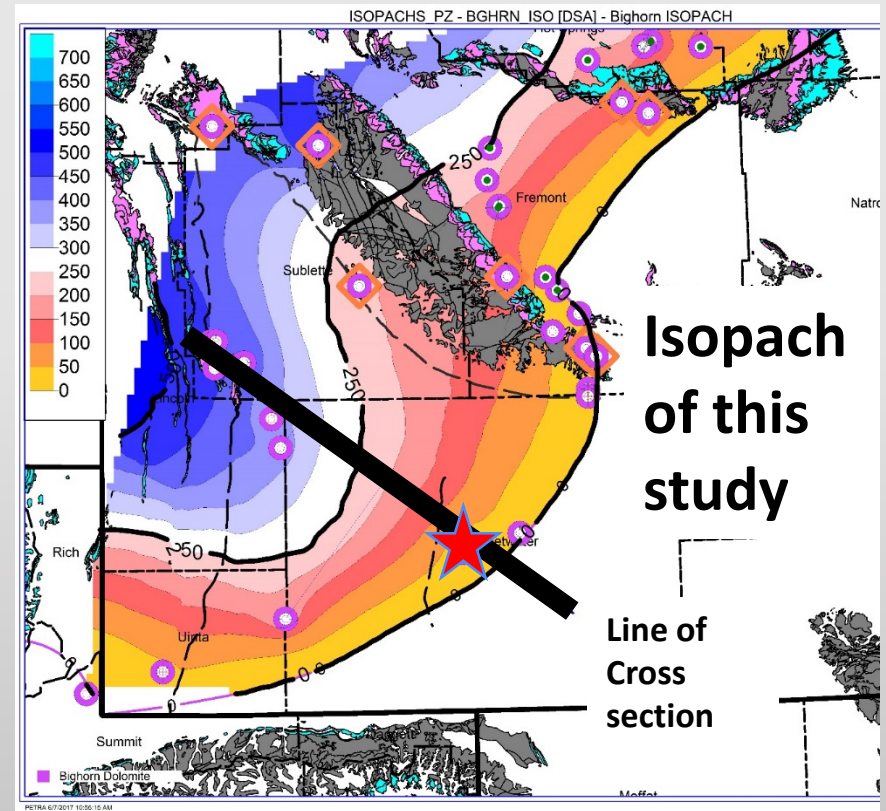
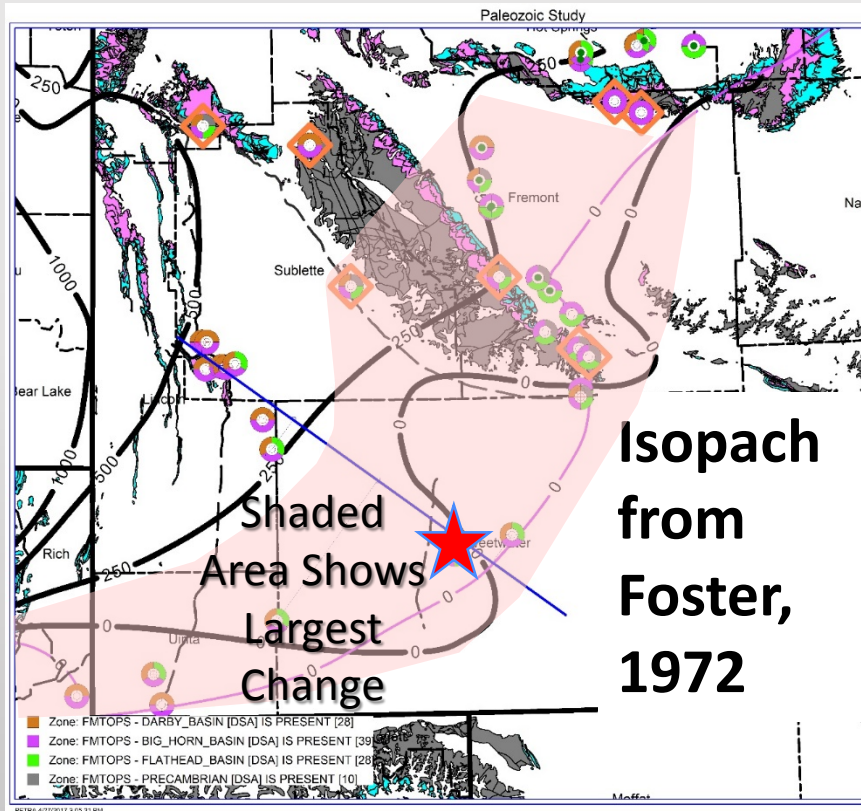
So.... Some things need revision

Revised Stratigraphy

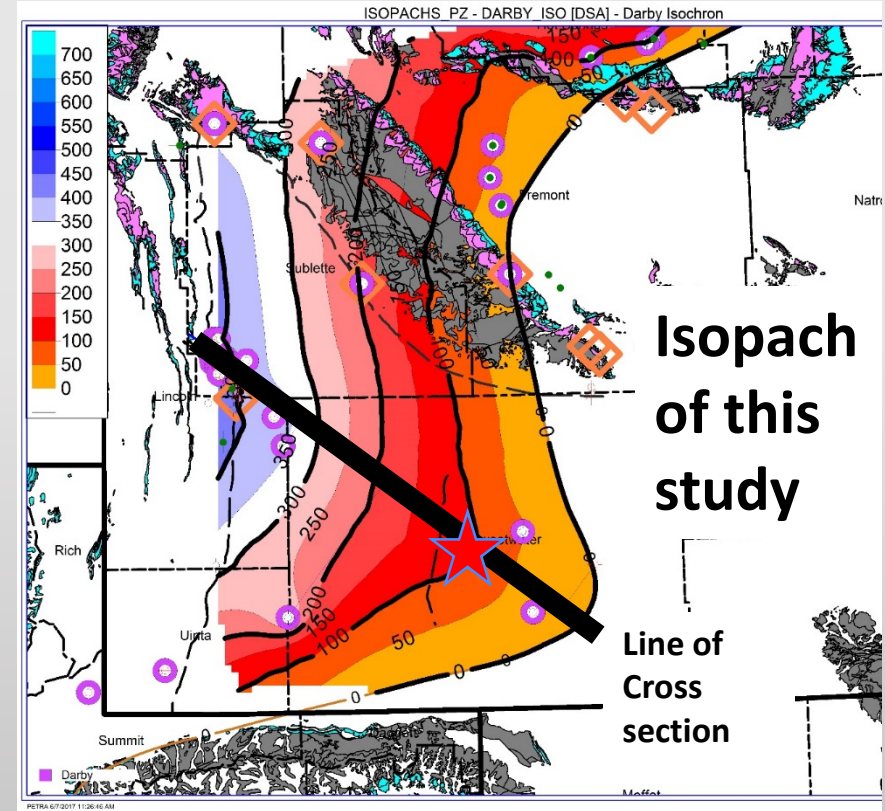
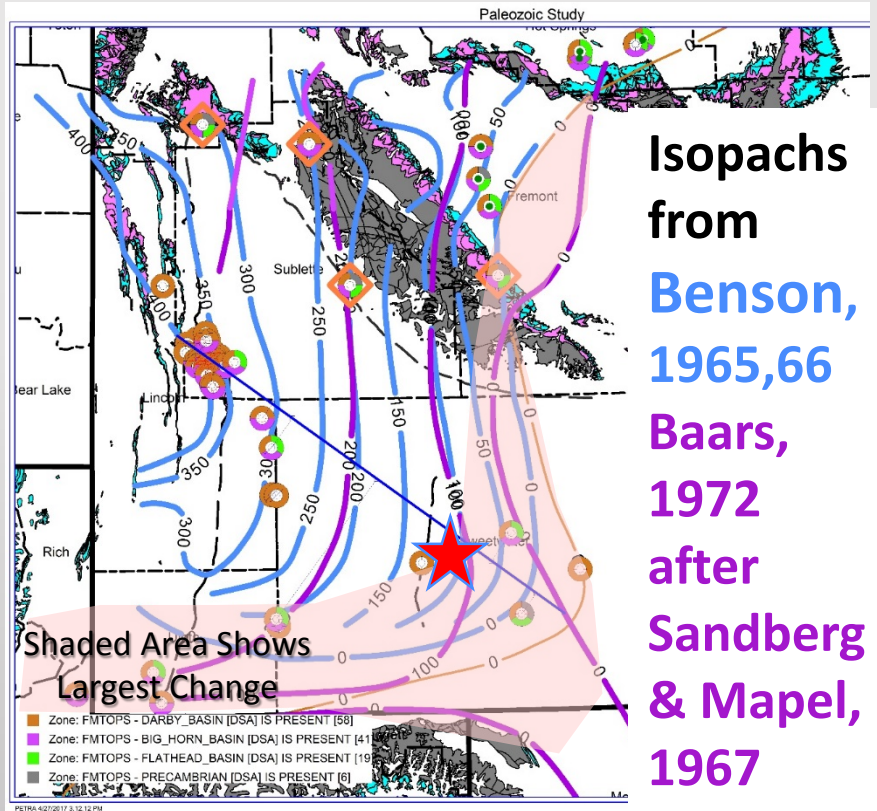


Period age-boundaries from Ogg et al., 2004

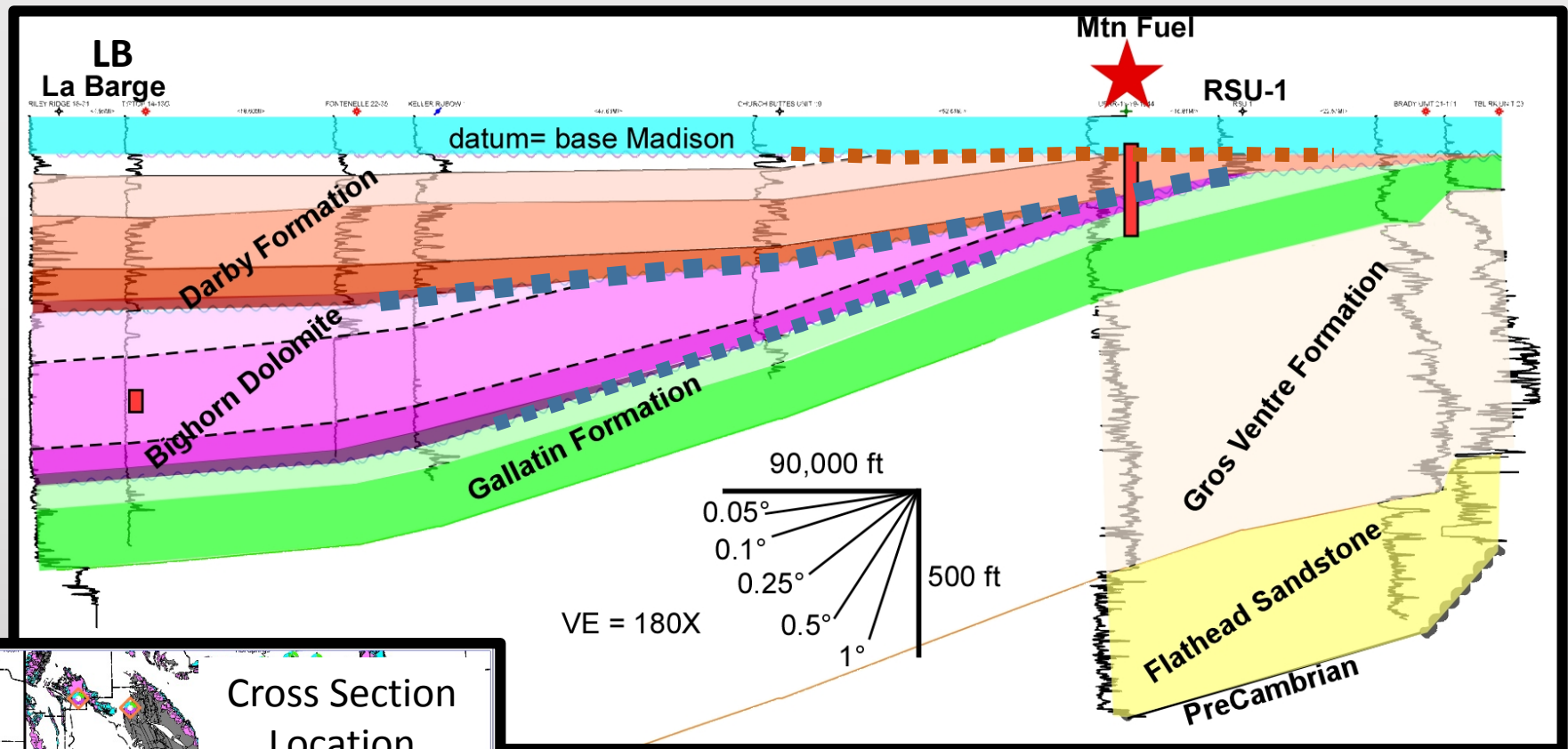
Bighorn Dolomite Isopach: Then-Now



Darby Formation Isopach: Then-Now



Unconformity Relationships



Darby: Onlap > Top Truncation
 Bighorn: Onlap << Top Truncation
 Gallatin: Onlap <<<< Top Truncation

Summary

- Mtn Fuel Core contains a 21-ft thick interval of Bighorn Dolomite
 - The RSU-1 well to the east contains a 9-ft thick interval of BHD
- The BHD is more extensive across the SW Green River Basin than previously mapped.
 - The Darby Formation overlaps the Bighorn Dolomite in the Green River Basin, unlike in the Wind River Basin.
- Variable proportions of onlap vs. top truncation between formations reflect distinct tectonic tilting episodes across the northern flank of the Transcontinental Arch.
 - Major tilting between Latest Ordovician and Middle Devonian.

Acknowledgments

- The following organizations and persons greatly aided this study:
 - USGS Core Research Center, Lakewood, Colorado, where the Mtn. Fuel core and all associated data are archived
 - John Rhoades and staff patiently laid out core and retrieved data.
 - Wagner Petrographic & Jae Erickson, CSM, for thin section preparation.
 - L. Anderson for field assistance
 - EasyCore™ software for core-description drafting, display & analysis.
 - IHS Energy Petra™ software.
 - Wyoming Oil & Gas Conservation Commission well & log database.

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