

Finishing what Don Winston started

Preliminary correlations of the Appekunny formation

LONG LIVE
DON WINSTON

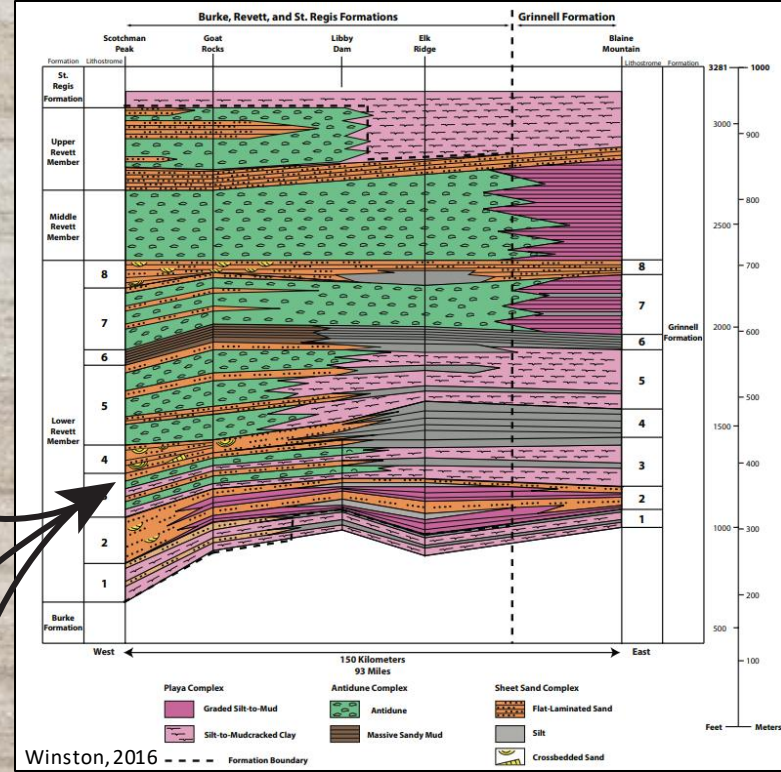
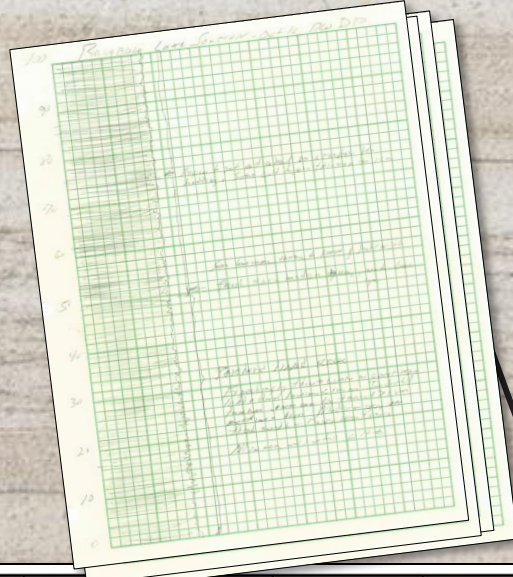
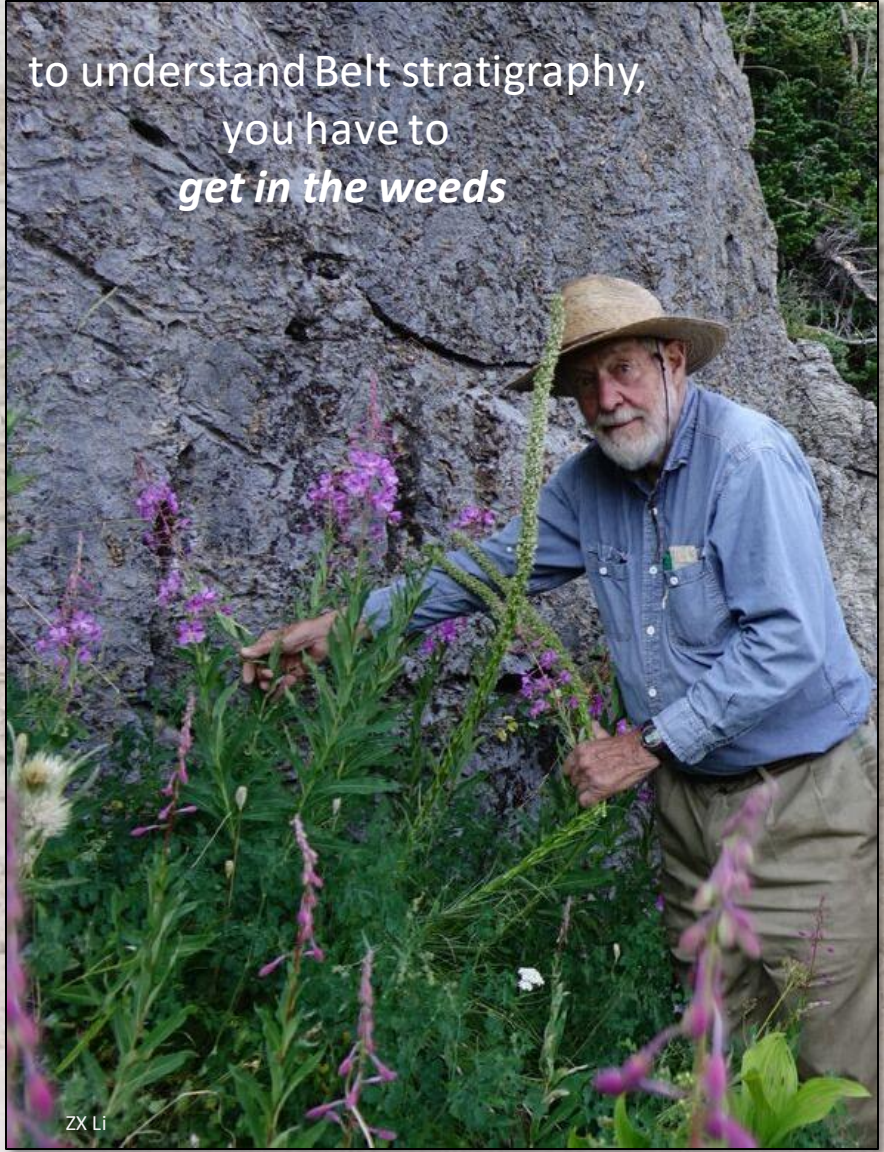
1931-2022

Stuart Parker

*Montana Bureau
of Mines and Geology*

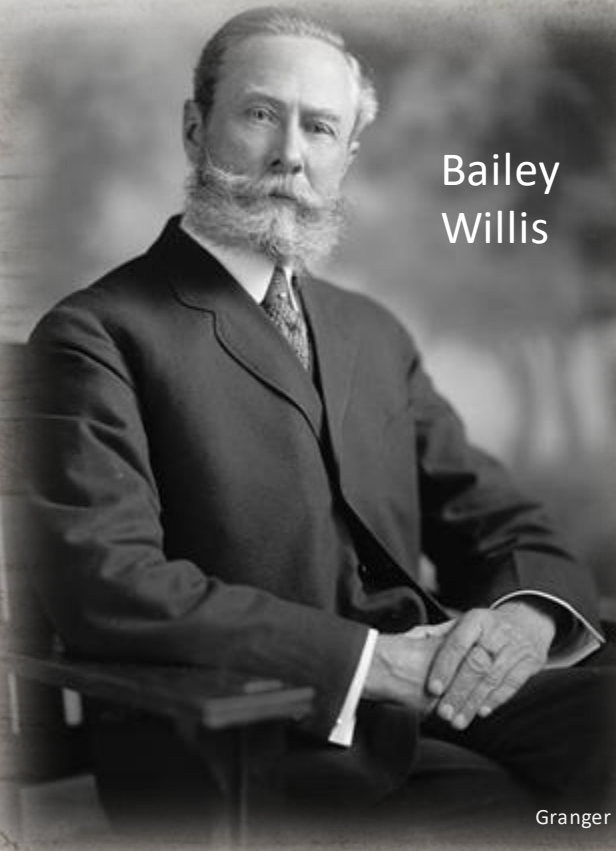
The Winston approach to stratigraphy

to understand Belt stratigraphy,
you have to
get in the weeds



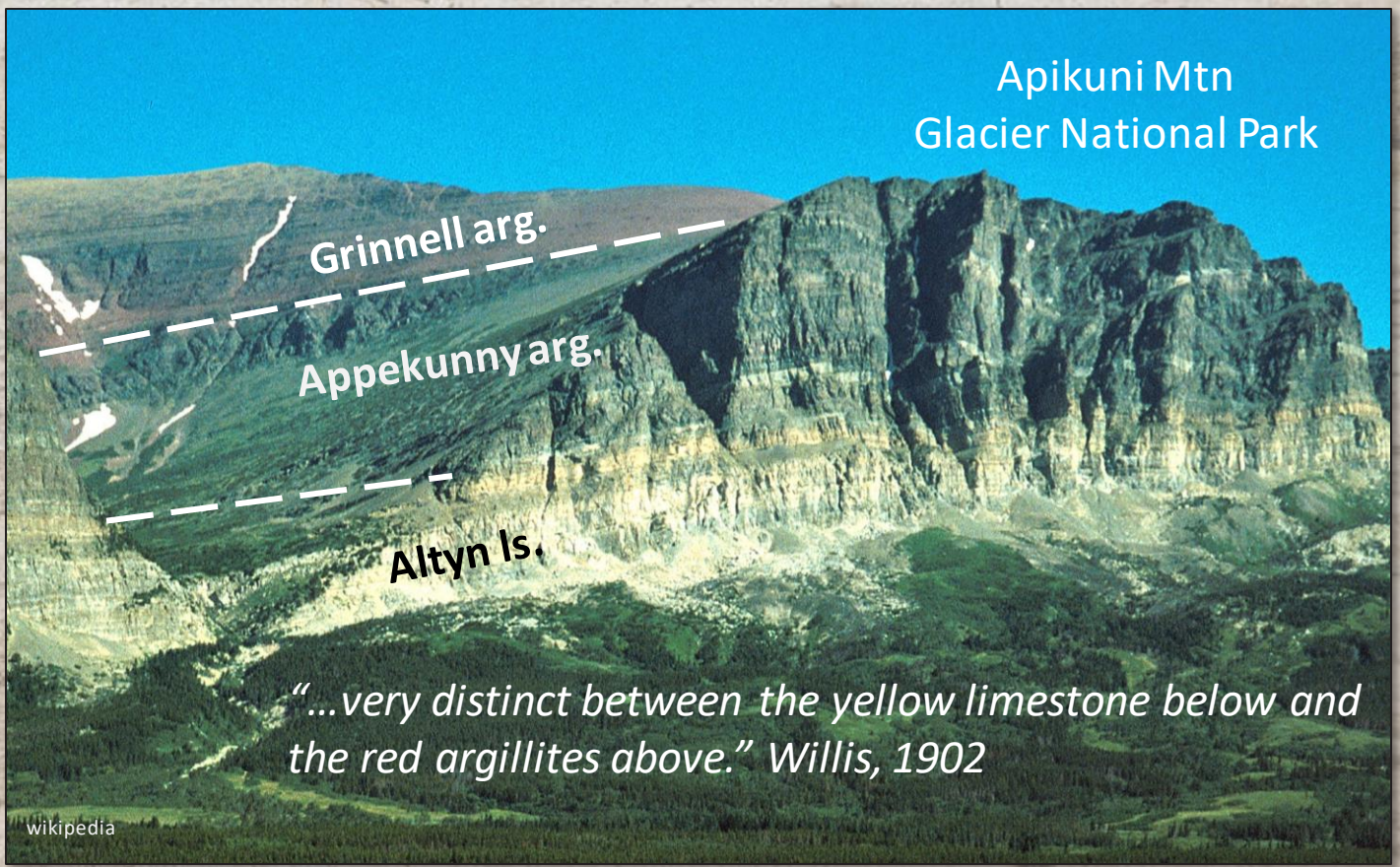
Sedimentary Structures	Sediment Type	Description	Depositional Processes	Depositional Environments
	Gravel	Crossbedded pebble quartzite and feldspathic conglomerate.	Flood transport in braided channels.	Mid-alluvial apron.
	Crossbedded Sand	Coarse- to fine-grained crossbedded feldspathic sand.	Sheetflood and channelled transport and deposition in the upper part of the lower flow regime.	Sandy alluvial apron.
	Flat-Laminated Sand	Medium- to fine-grained, flat-laminated sand with occasional climbing ripples and mudchips.	Sheetflood transport and deposition in the upper flow regime.	Sandflats at the toes of alluvial aprons.
	Discontinuous Layer	Fine sand-to-silt lenses interbedded with silty mud layers, rare mudchip concentrations.	Decelerating flood and prolonged flow transport and deposition the lower flow regime.	Sandflats at the toes of alluvial aprons.
	Even Couplet	Even, mudcracked graded fine sand and silt-to-mud layers.	Sheetflood transport and deposition.	Sandflats
	Mudcracked Even Couplet	Mudcracked, graded, even, fine sand-to-mud layers.	Sheetflood flow across exposed mudflats followed by deceleration, suspension settleout, & desiccation.	Exposed playa mudflats.
	Mudcracked Lenticular Couplet	Oscillation-rippled fine sand and silt lenses, capped by clay laminae, cut by mudcracks.	Wave transport of fine sand and silt, followed by clay settleout and desiccation.	Submerged & exposed playa mudflats.
	Mudcracked Mud	Mud layers up to 2 cm thick, cut by mud-filled mudcracks.	Suspended load transport across dried playa floors, followed by submergence and desiccation.	Dry playa mudflats.
	Microlamina	Interlayered and graded silt and clay laminae.	Alternating silt and clay suspension settleout.	Lake margin wind setup flats.
	Coarse Sand and Intraclast	Coarse- to fine-grained, quartz and oolite sand and planar clasts, cross-bedded and imbricated at various angles.	Transport of coarse grains and scoured clasts by breaking waves.	Beaches, shoals, and lake margin oolitic sandflats.
	Carbonate Mud	Micrite and dolomitic without detectable siliciclastic laminations.	Aragonite or calcite precipitation, in places followed by dolomitization.	Carbonate-saturated perennial lake bottom.
	Uncracked Lenticular Couplet	Non-cracked oscillation-rippled, fine sand and silt lenses, capped by clay laminae.	Wave accumulation of fine sand and silt into ripples, followed by suspension settleout.	Shallow submerged playa and perennial lake margin.
	Hummocky Silt	Hummocky and plane-laminated silt and fine sand layers.	Storm transport of fine sand and silt, and deposition from oscillatory flow.	Perennial lake bottom within reach of storms.
	Pinch-and-Swell Couplet	Graded, medium gray, fine sand with undulating scoured and loaded bases to dark gray mud layers.	Episodic scour and transport of fine sand, silt and clay by storm waves and deposition by oscillatory flow, followed by suspension settleout.	Perennial lake bottom swept by storms and turbidity flows.
	Bouldery Sand and Mud	Matrix-supported angular to round boulders in poorly stratified sand and mud.	Slump and debris flow transport and deposition.	
	Muddy Graded Sand	Graded structureless or plane-laminated dark muddy sand beds.	Turbidity flow transport and deposition.	Perennial lake bottom below storm base.
	Uncracked Even Couplet	Even, uncracked graded silt-to-clay couplets.	Episodic suspension transport and settleout.	
	Plane-Laminated Silt and Clay	Even, sharply bounded silt and clay interlaminae.	Alternating silt and clay transport and settleout.	

Defining the Appekunny argillite



Bailey Willis

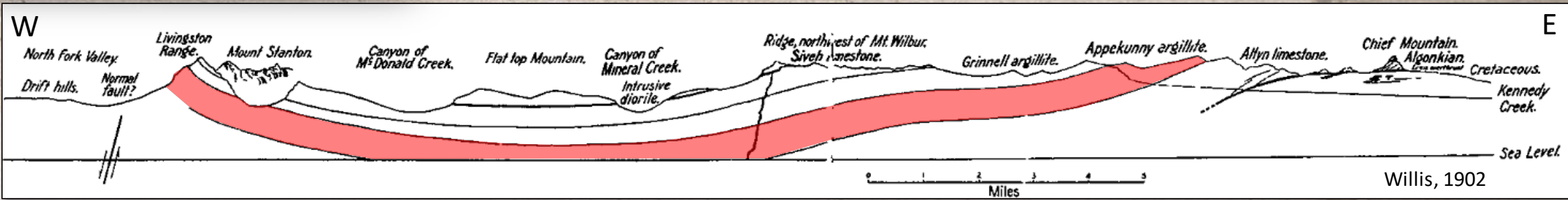
Granger



Apikuni Mtn
Glacier National Park

"...very distinct between the yellow limestone below and the red argillites above." Willis, 1902

wikipedia



Willis, 1902

Defining the Prichard and Burke

GEOLOGY AND ORE DEPOSITS
OF THE
CCEUR D'ALENE DISTRICT, IDAHO
Ransome and Calkins, 1908

"Burke...sun cracks and ripple marks...in almost every outcrop...frequently exposed to air" -Ransome, 1905

"regularly banded argillite [of the Prichard] ...easily recognized...can hardly be confused...with any other"

"gradual transition...causes difficulty in fixing the Burke-Prichard boundary"

-Ransome and Calkins, 1908



Frank Calkins

USGS



Frederick Ransome

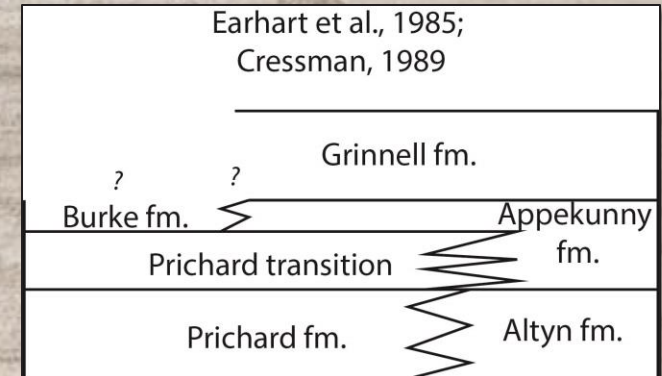
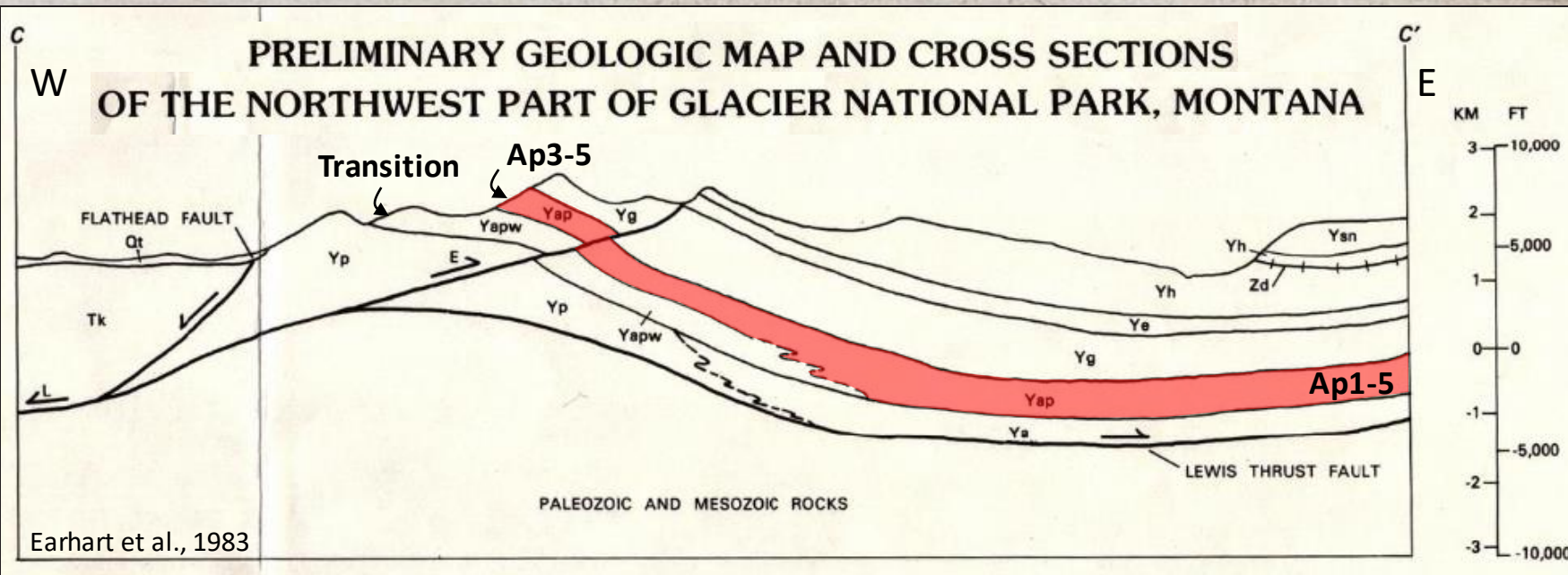
USGS

Ransome, 1905; Ransome and Calkins, 1908	Willis, 1902
	Grinnell argillite
	Appekunny argillite
	Altyn limestone
----- ~6,000' of section ?	
Burke fm.	
Prichard slate	

Making the transition

“...informally subdivided [Appekunny] into five members..., on the west side of park only parts of members 5, 4, and 3 are present.”
-Whipple, 1992

“Transition member ...contact with overlying Burke... is difficult to locate consistently.”
-Cressman, 1989



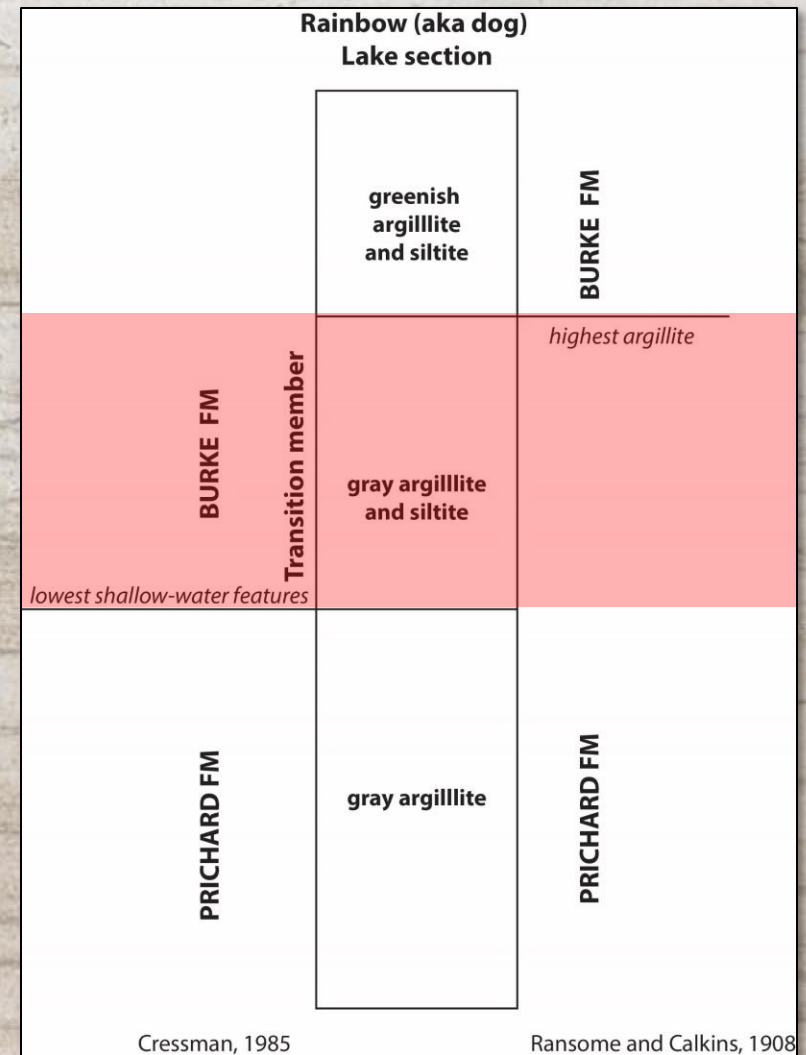
Contested contacts

“Transition zone between lowest occurrence of rocks typical of the Burke and the highest occurrence of rocks typical of the Prichard...”

Ransome and Calkins assign the transition zone to the Prichard Formation....

[Cressman] placed the top of the Prichard at the base...of the transitional sequence.”

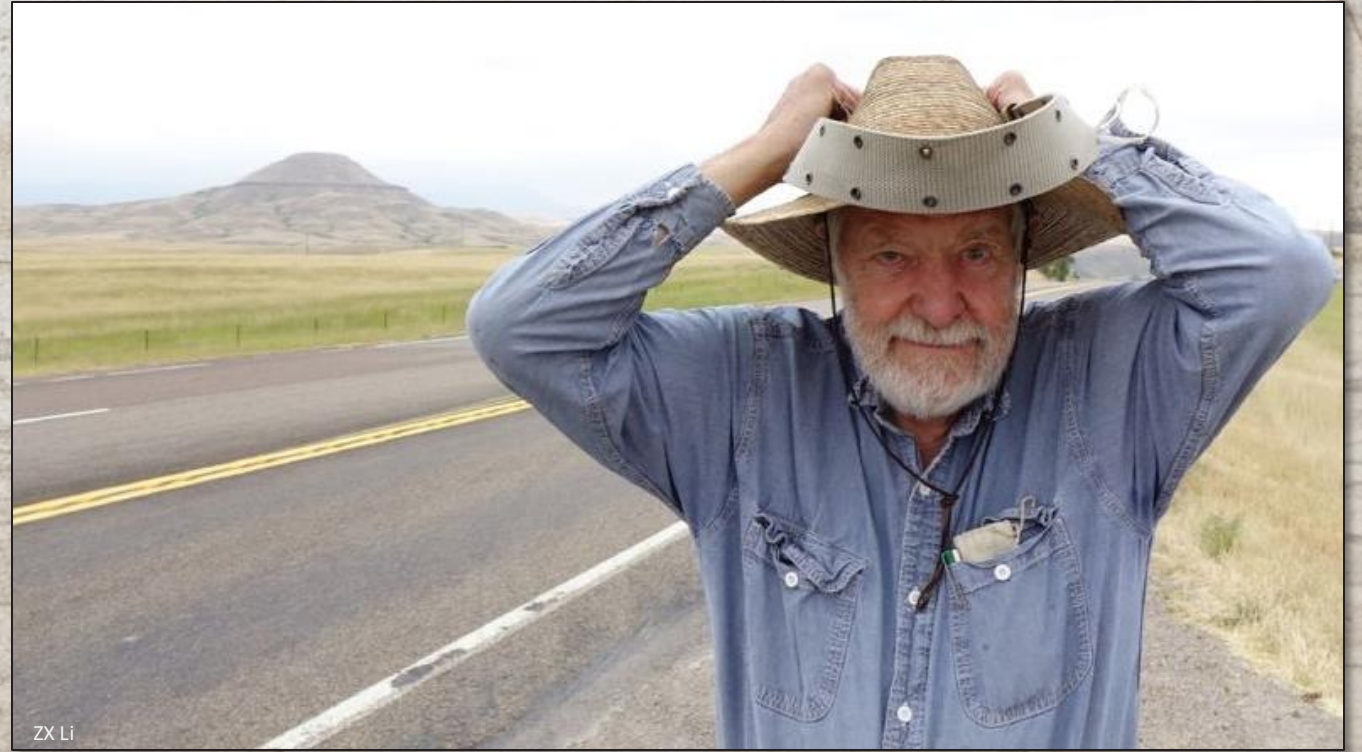
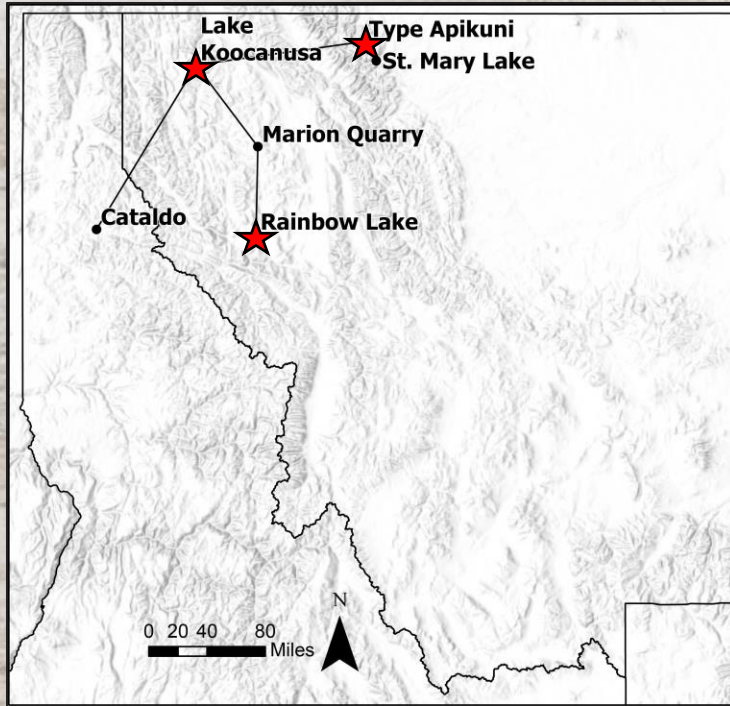
-Cressman, 1985



“...one of the most troublesome stratigraphic problems in the Belt”

–Winston, 1989

What Don started



This Study; Winston, 2016	
St. Regis fm.	Grinnell fm.
Revett fm.	
Burke fm.	
Apeekunny fm.	
Prichard fm.	Altyn fm.

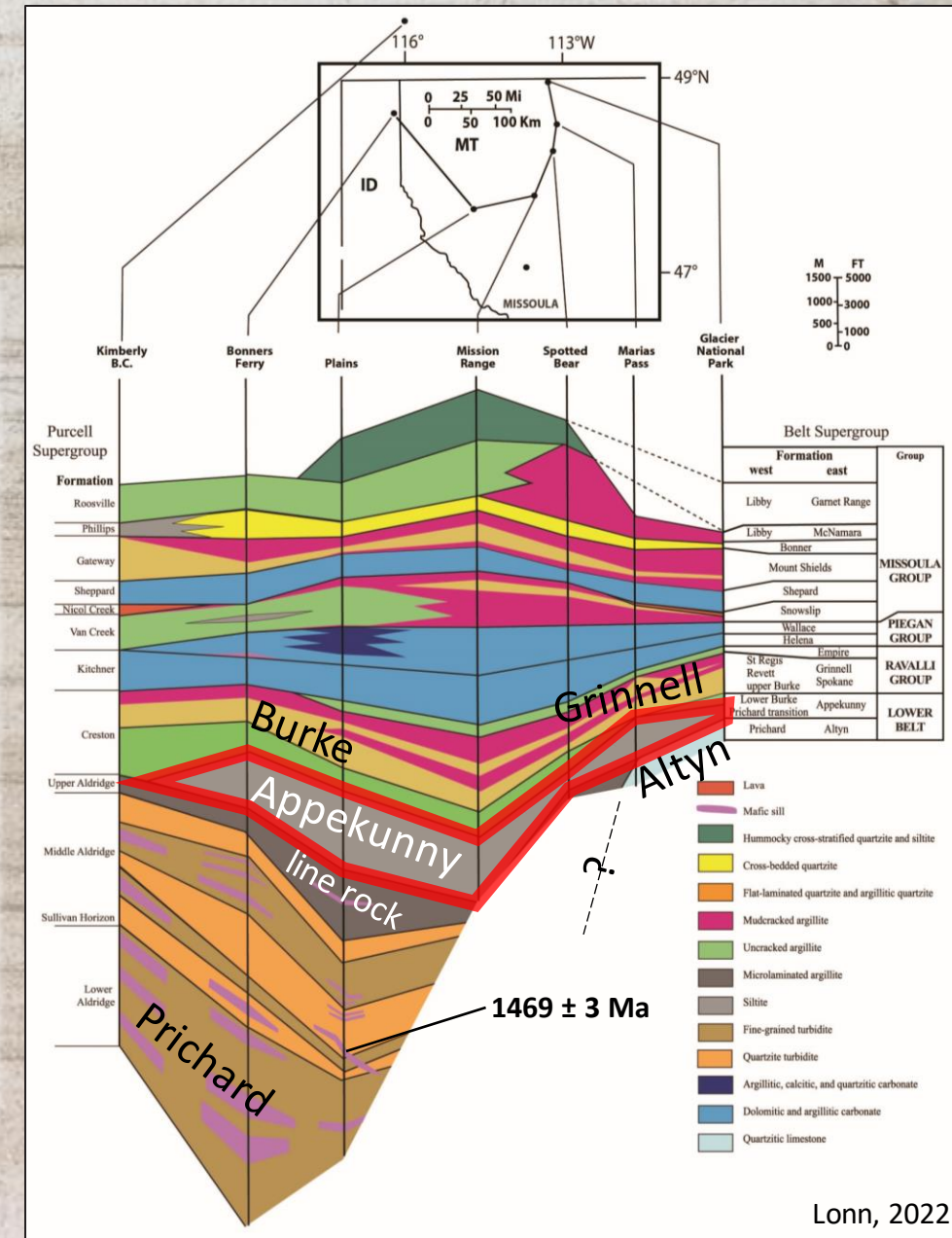
Data sources

- 5 unpublished partial sections
 - Don and others, since ~2013
 - Archived at MBMG in 2023
- 3 field checked, complete sections

General description of Appekunny



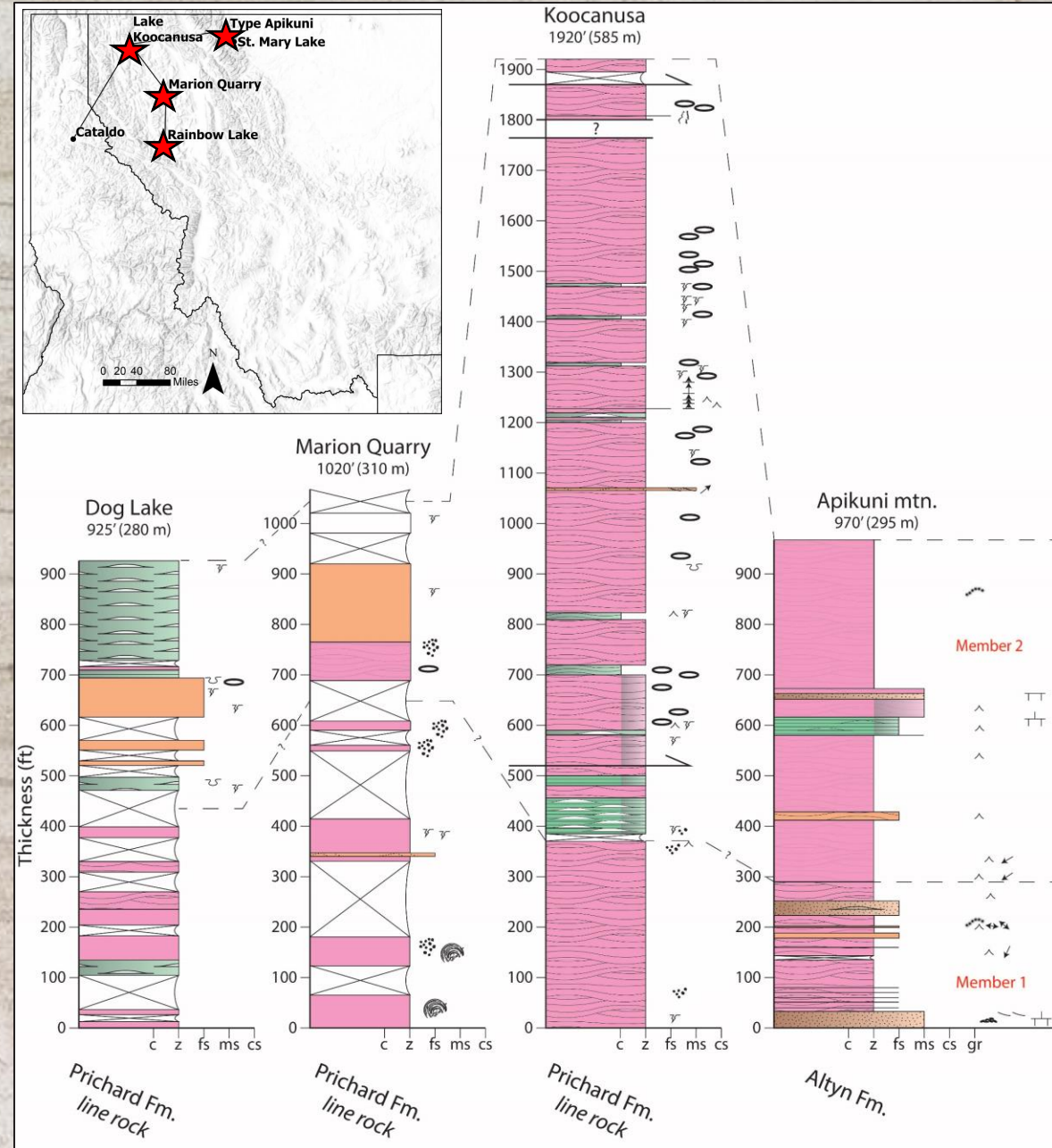
- Siltite to very fine quartzite
- 1855 – 3200' (565 – 975m)
- Flat-laminated to hummocky
- Above Prichard (deep, rift fill) and Altyn (shallow, carbonate bank)
- Below Grinnell and Burke (subaerial)
- May record first complete filling, and drying-up of the basin



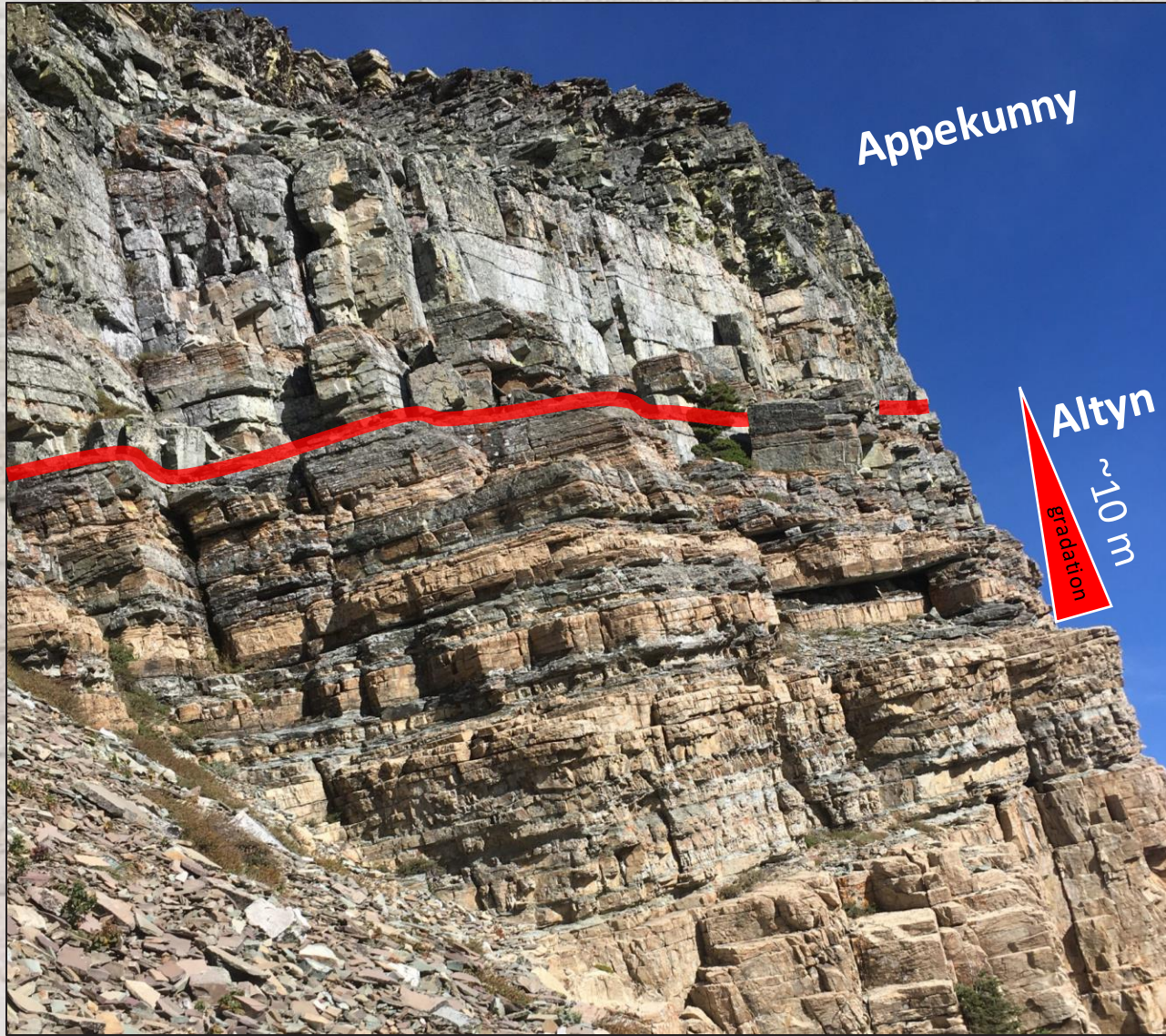
Lon, 2022

Lower Appekunny Sediment types

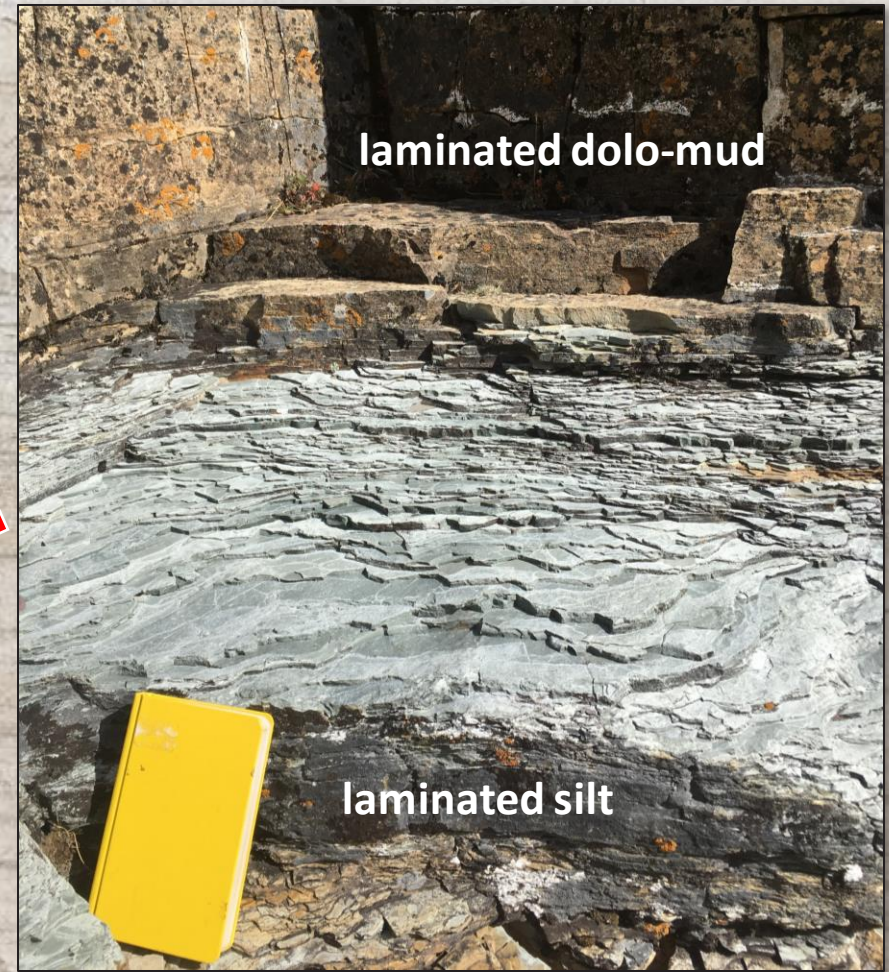
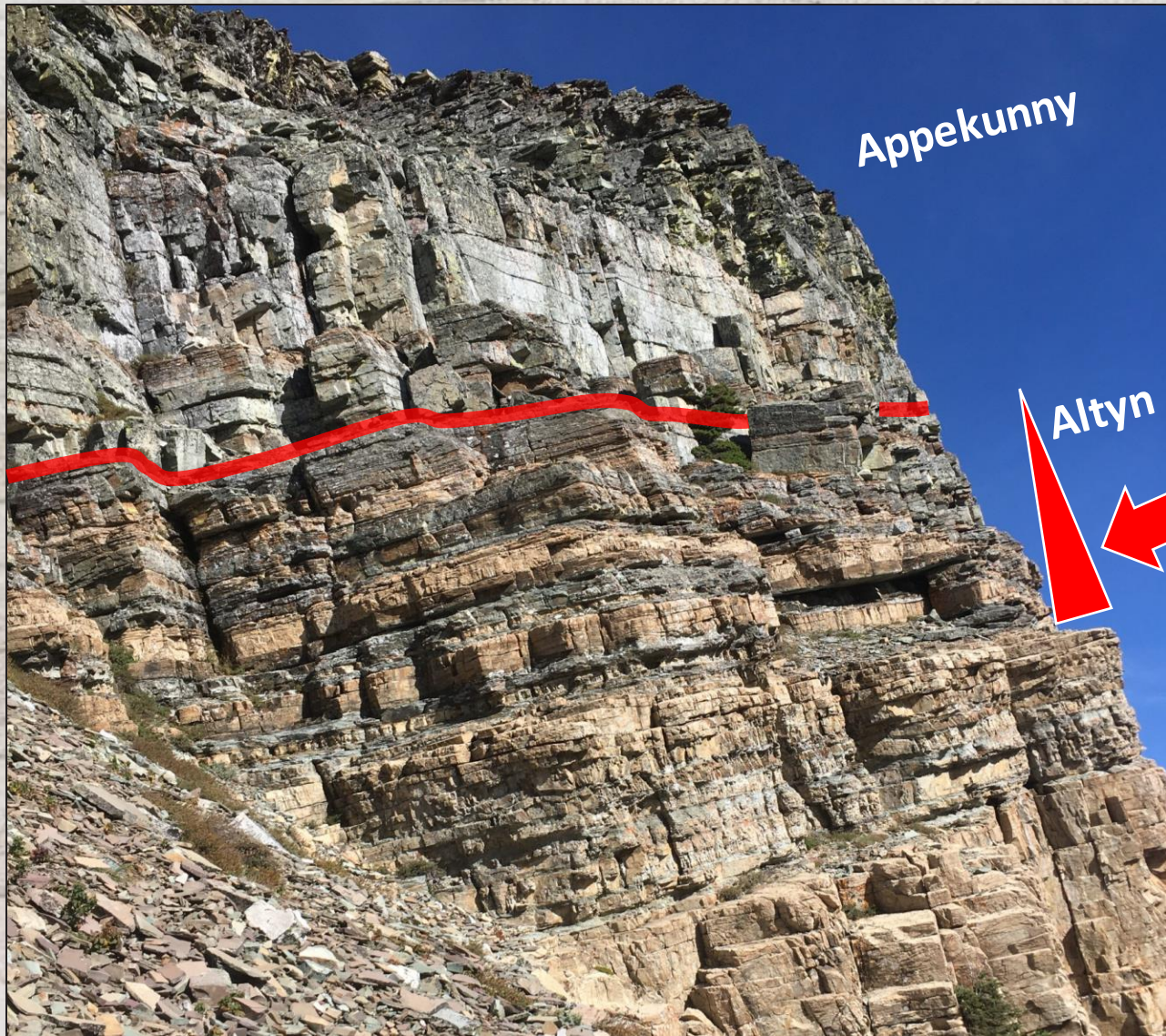
- **Hummocky cross-stratified (HCS)**
 - *Laminated silt sub type*
- **Tabular sand**
 - *Graded sand sub type*
- **Pinch and swell couple/t**



Basal contact, Type section

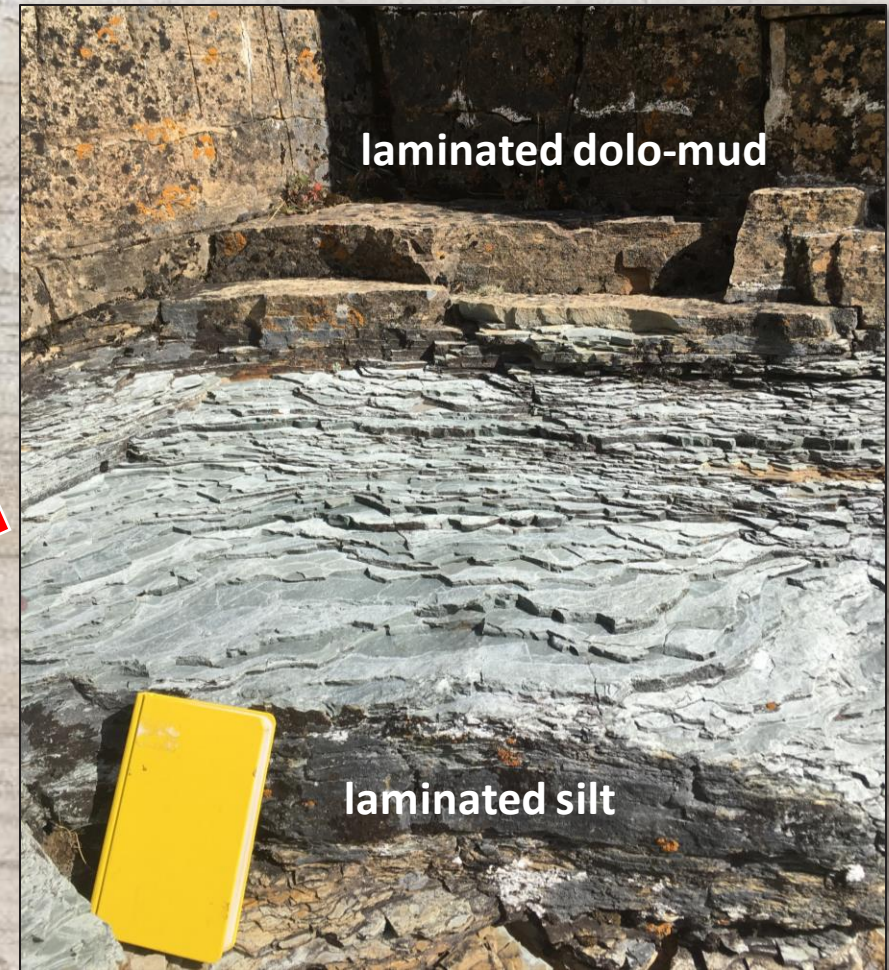
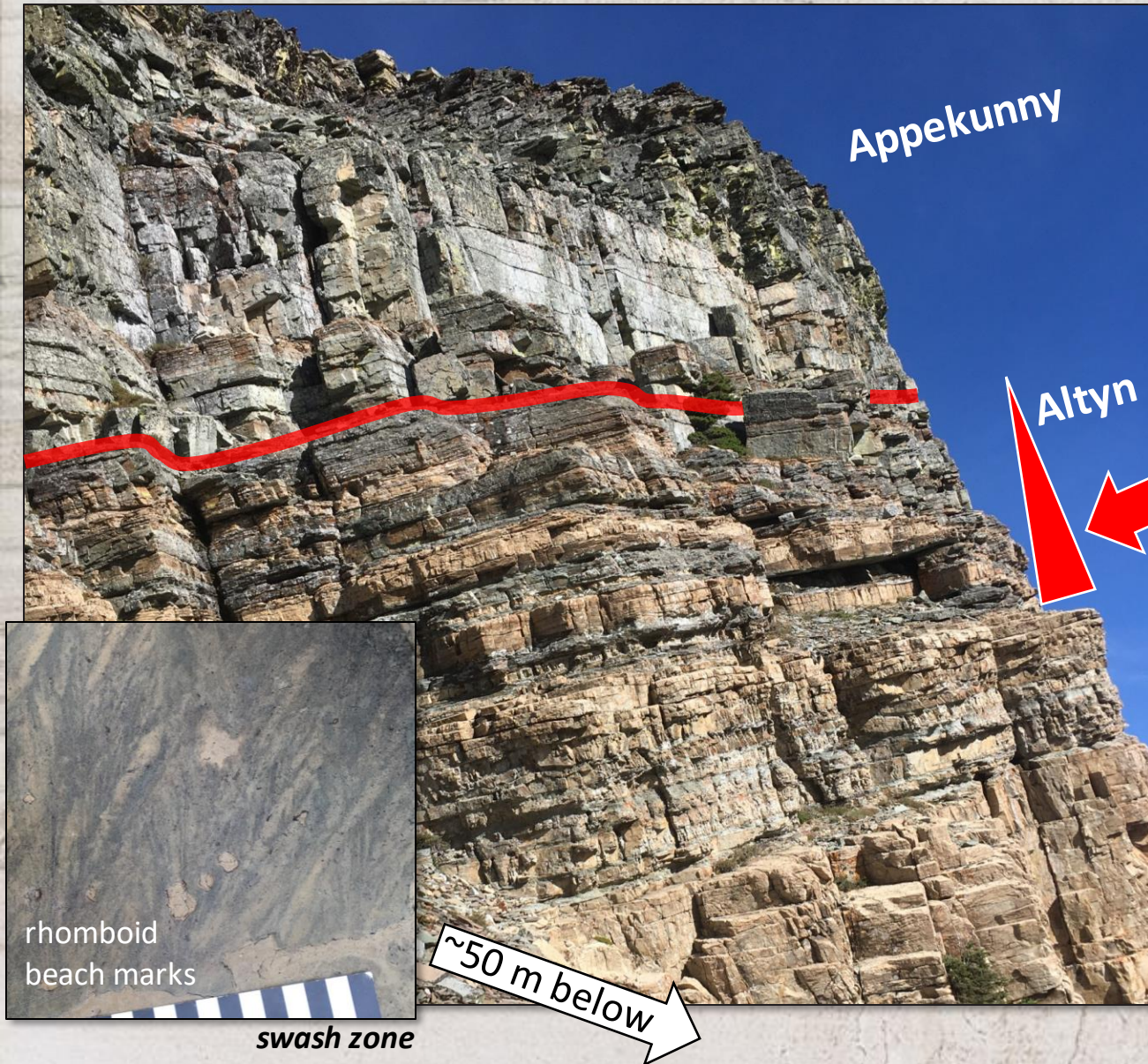


Basal contact, Type section



mm-scale, even, laminae, alternating silt and dolo-mud

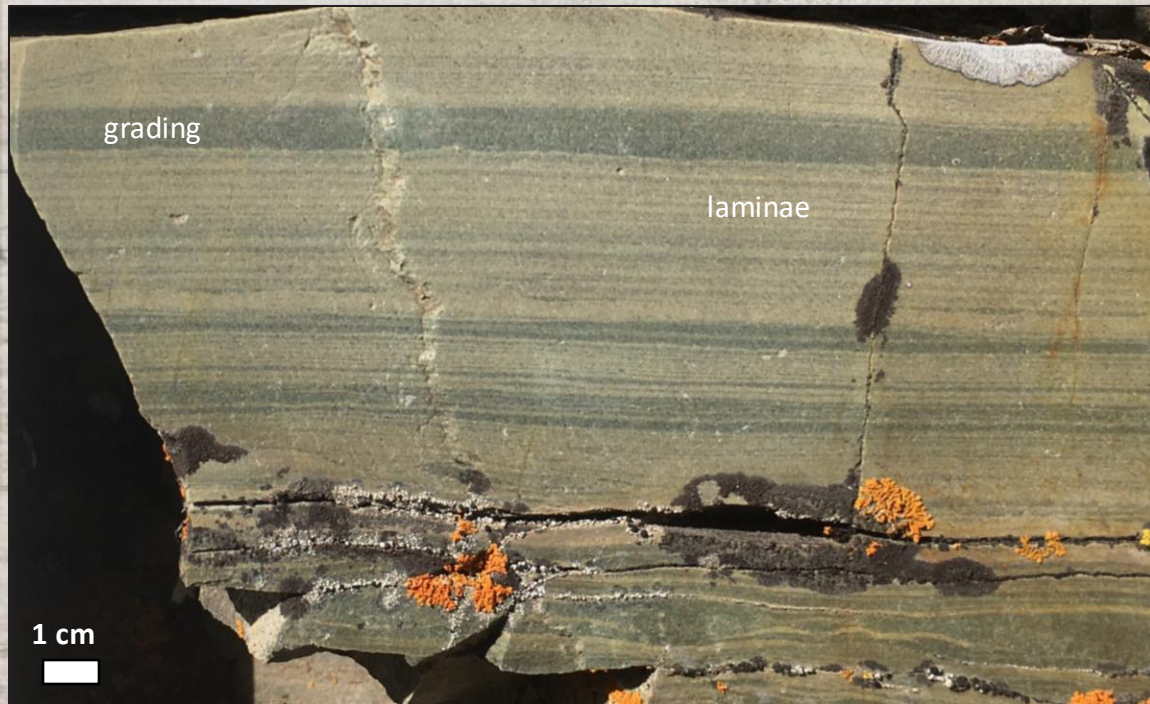
Basal contact, Type section



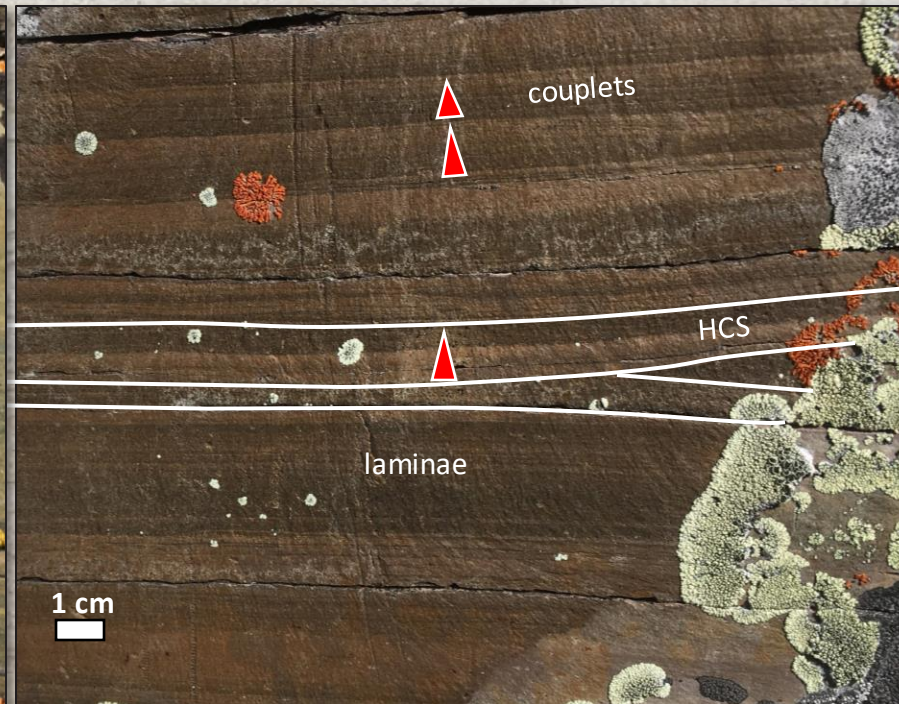
mm-scale, even, laminae, alternating silt and dolo-mud

Episodic suspension settle out in calm [shallow?] water, with or without carbonate precipitation (Winston, 1989)

Laminated silt sub type



even silt laminae,
uncommon grading to clay

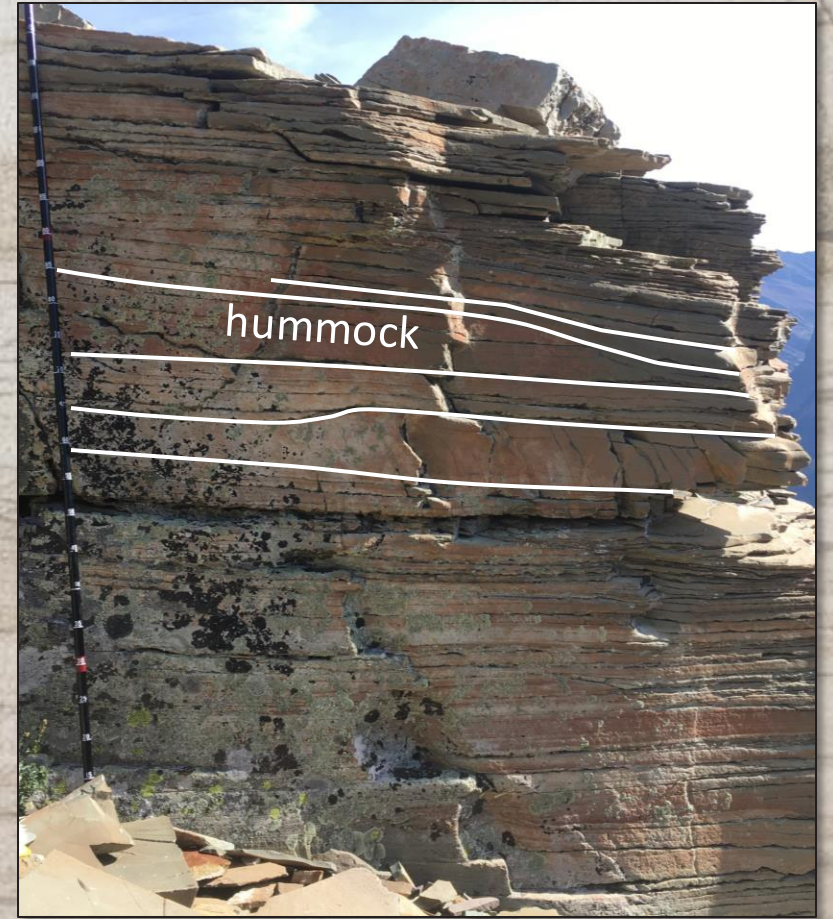
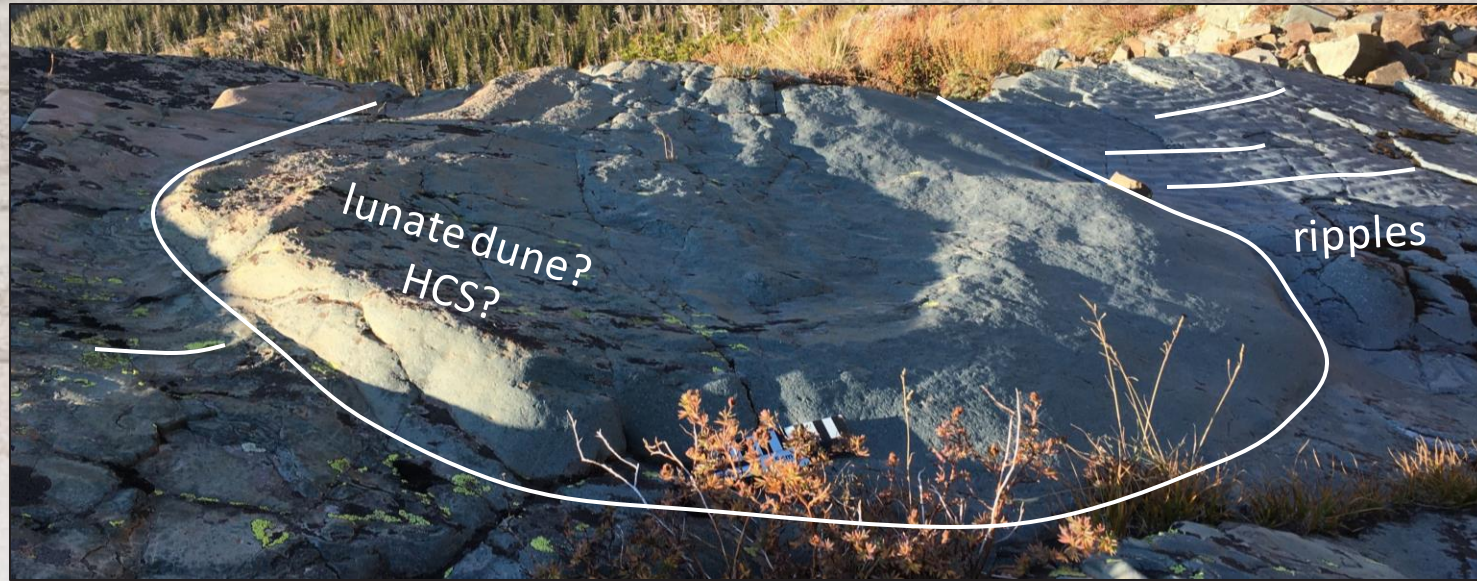


interlayered with silt-clay couplets
and hummocky cross-stratification (HCS)

***Suspension settle out of silt (\pm clay),
 \pm oscillatory storm waves***

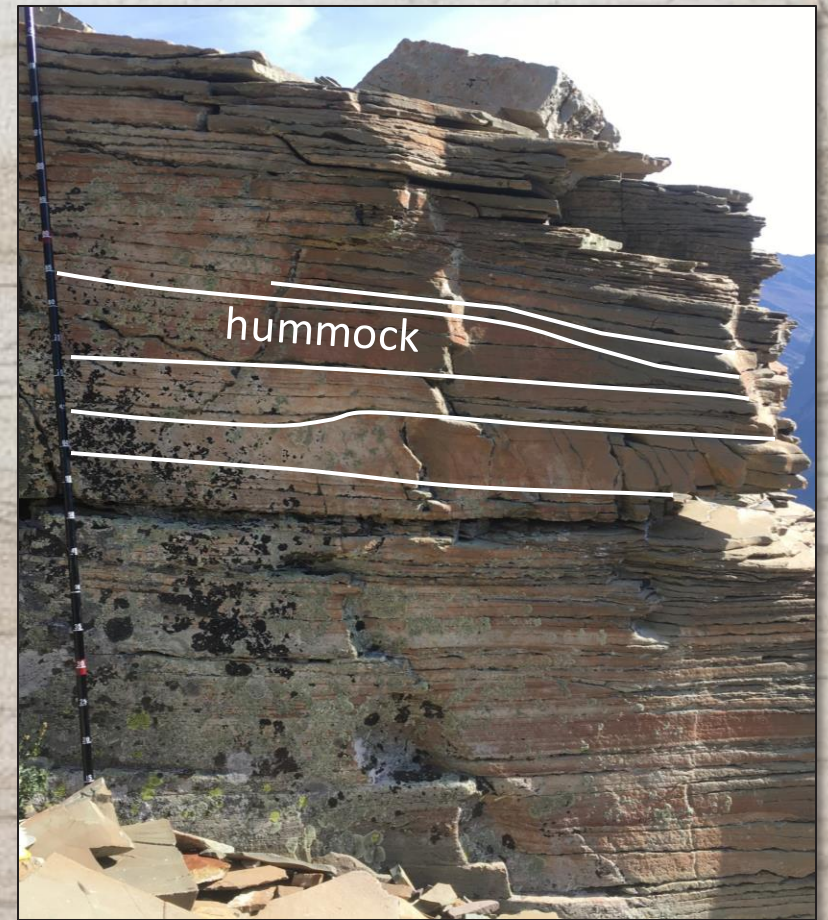
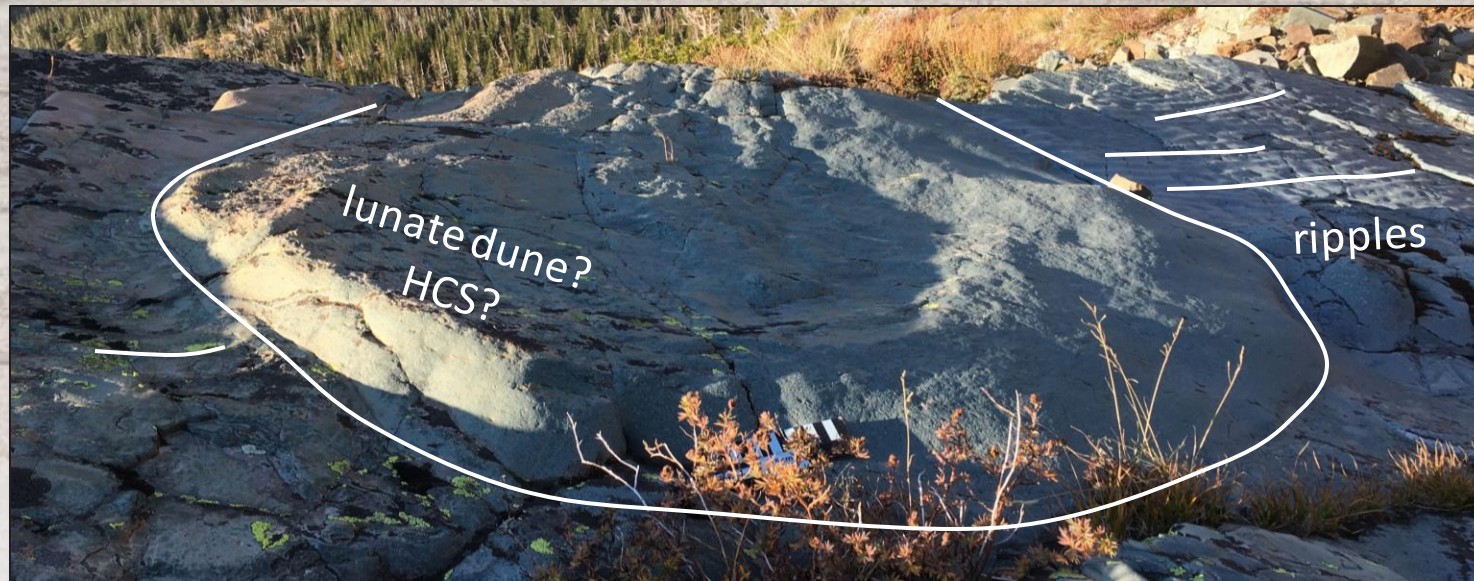
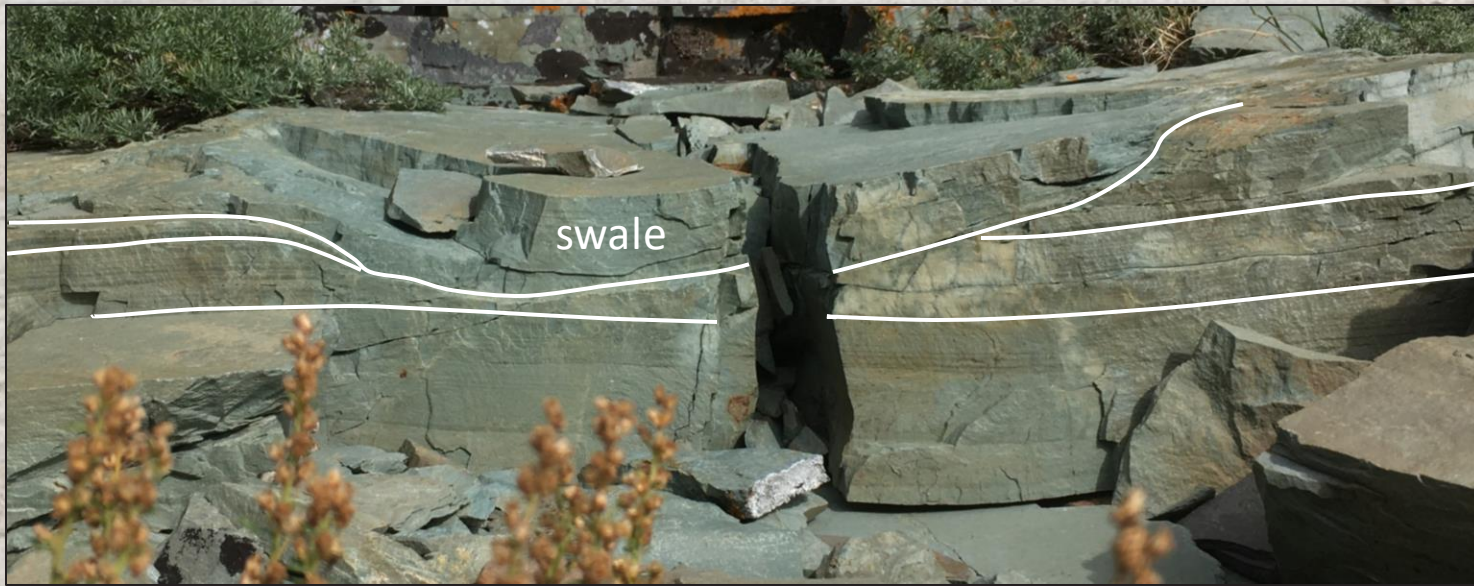


HCS sediment type



even/wavy continuous silt/vf sand laminations,
low-angle truncations,
dm-scale hummocks and swales, rippled tops

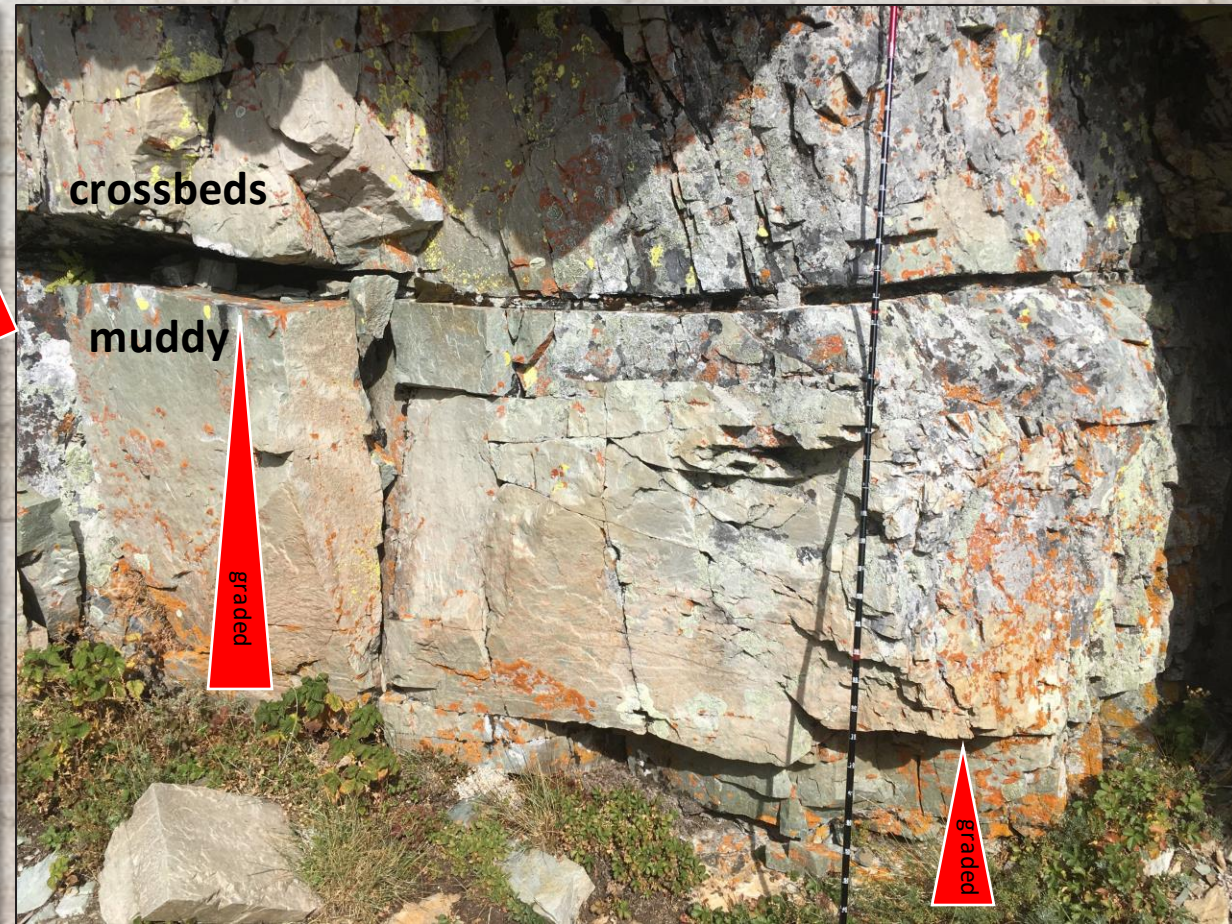
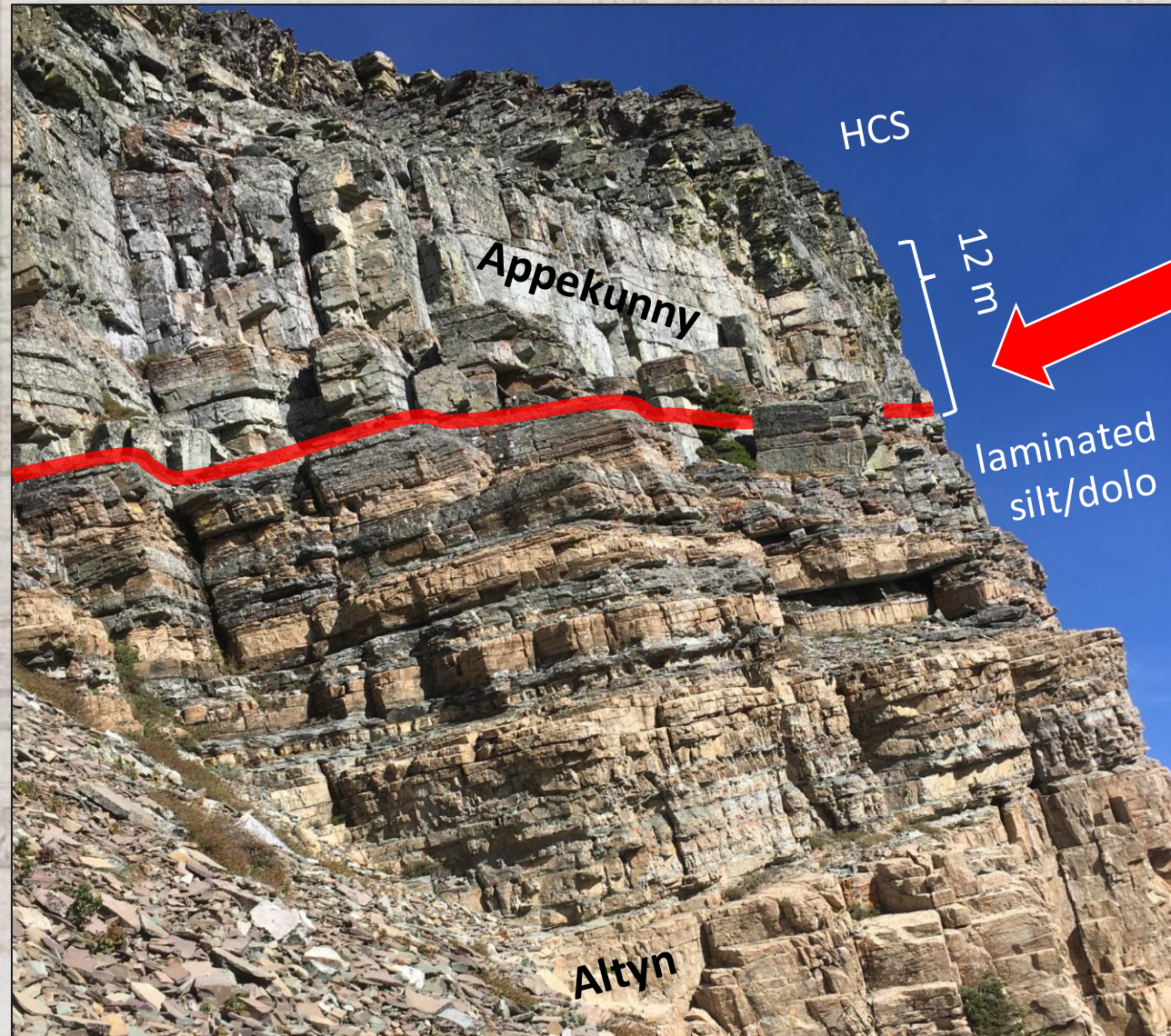
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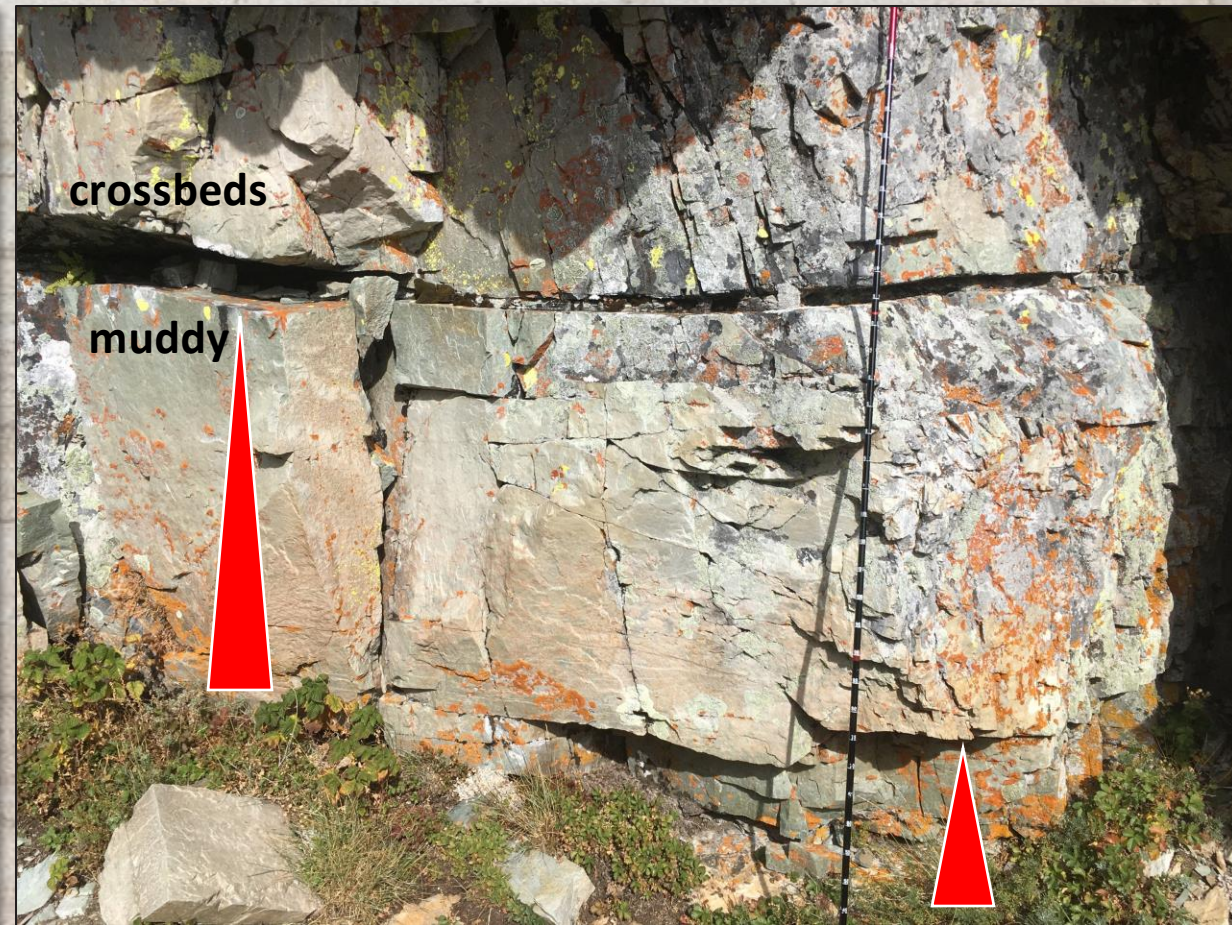
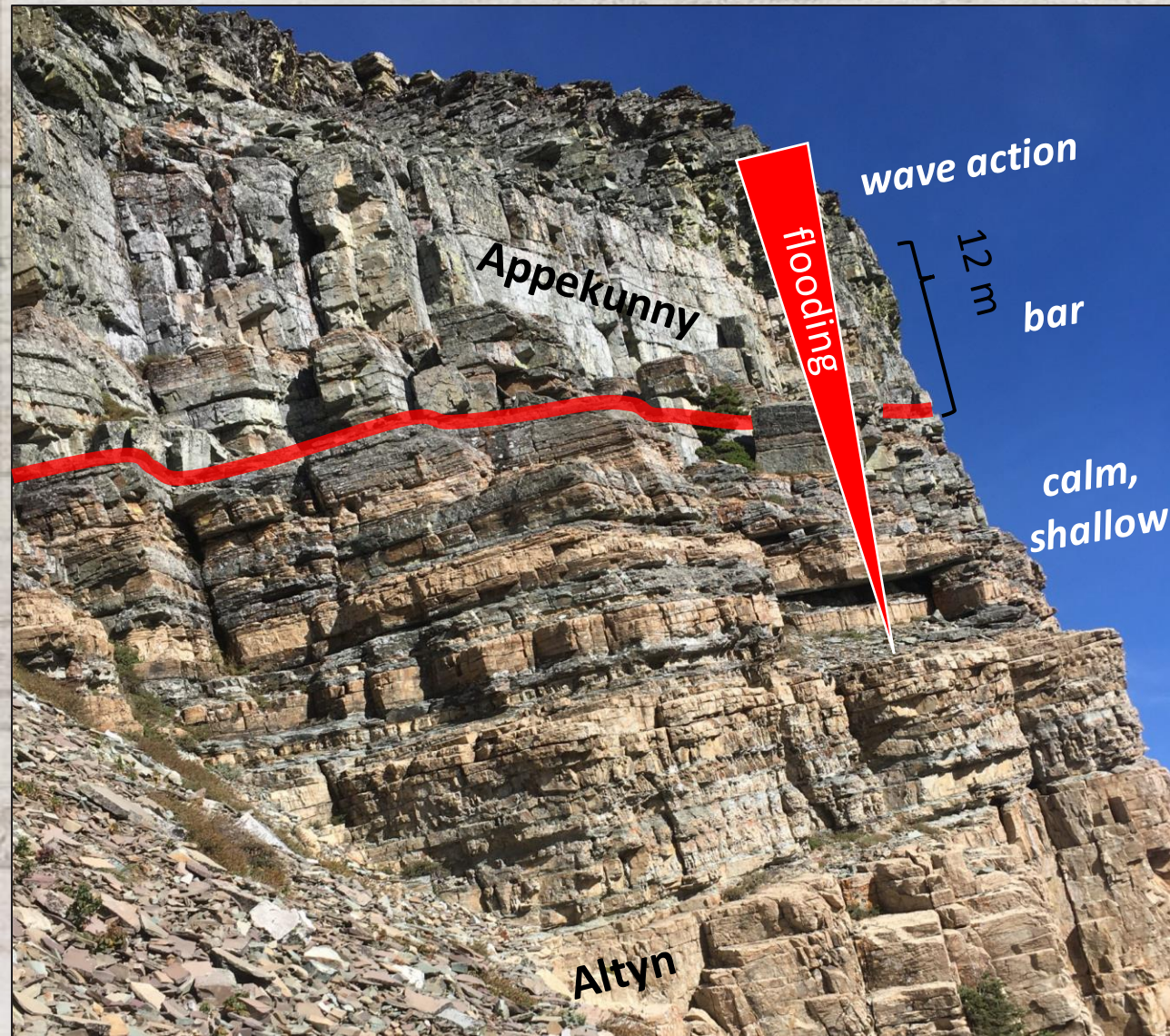
***Reworking of silt bedload
by oscillatory storm (and fair weather?) waves***

Graded sand sub type



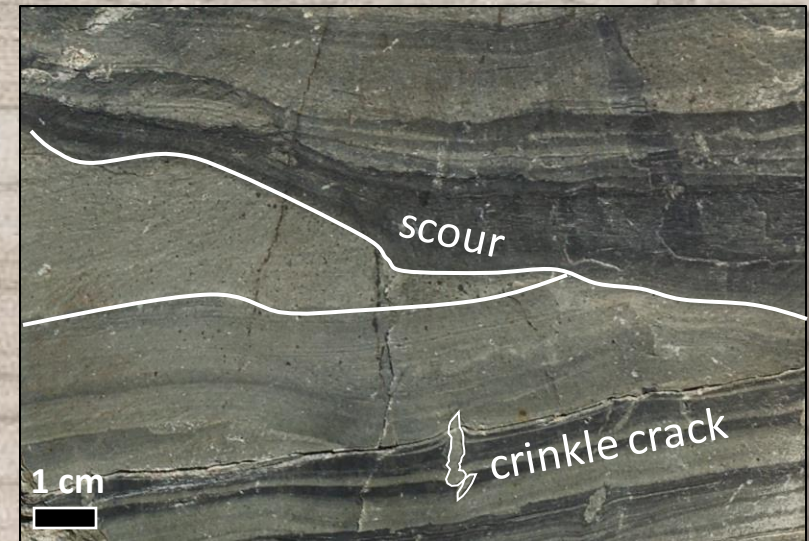
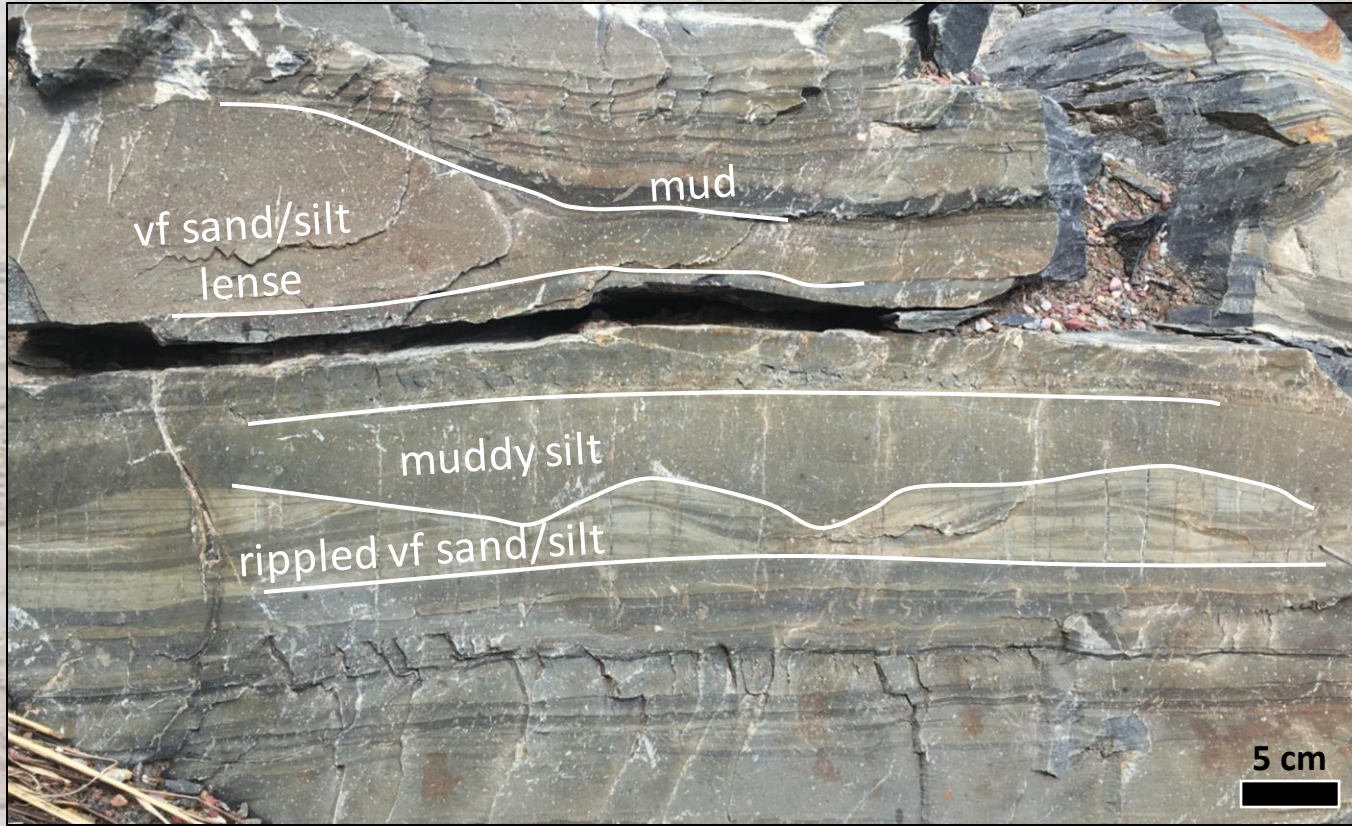
m-scale crossbedded, massive to graded muddy sand beds
rare dolomite mudchips at base

Graded sand sub type



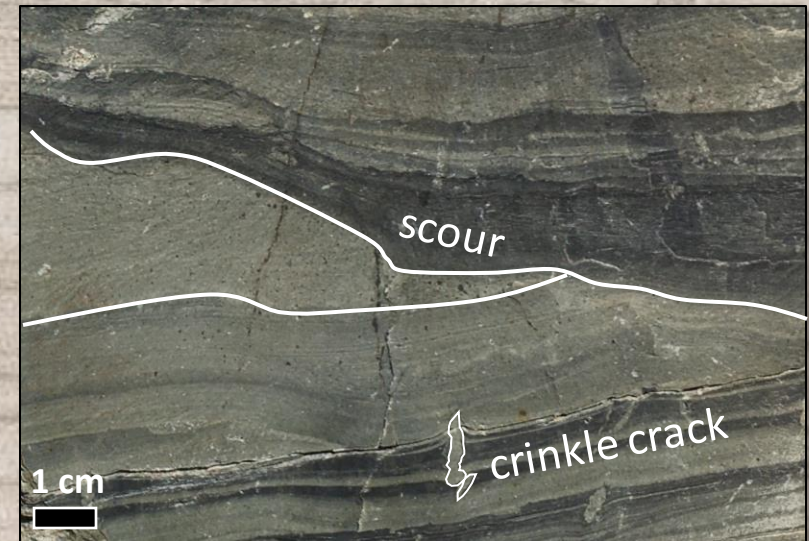
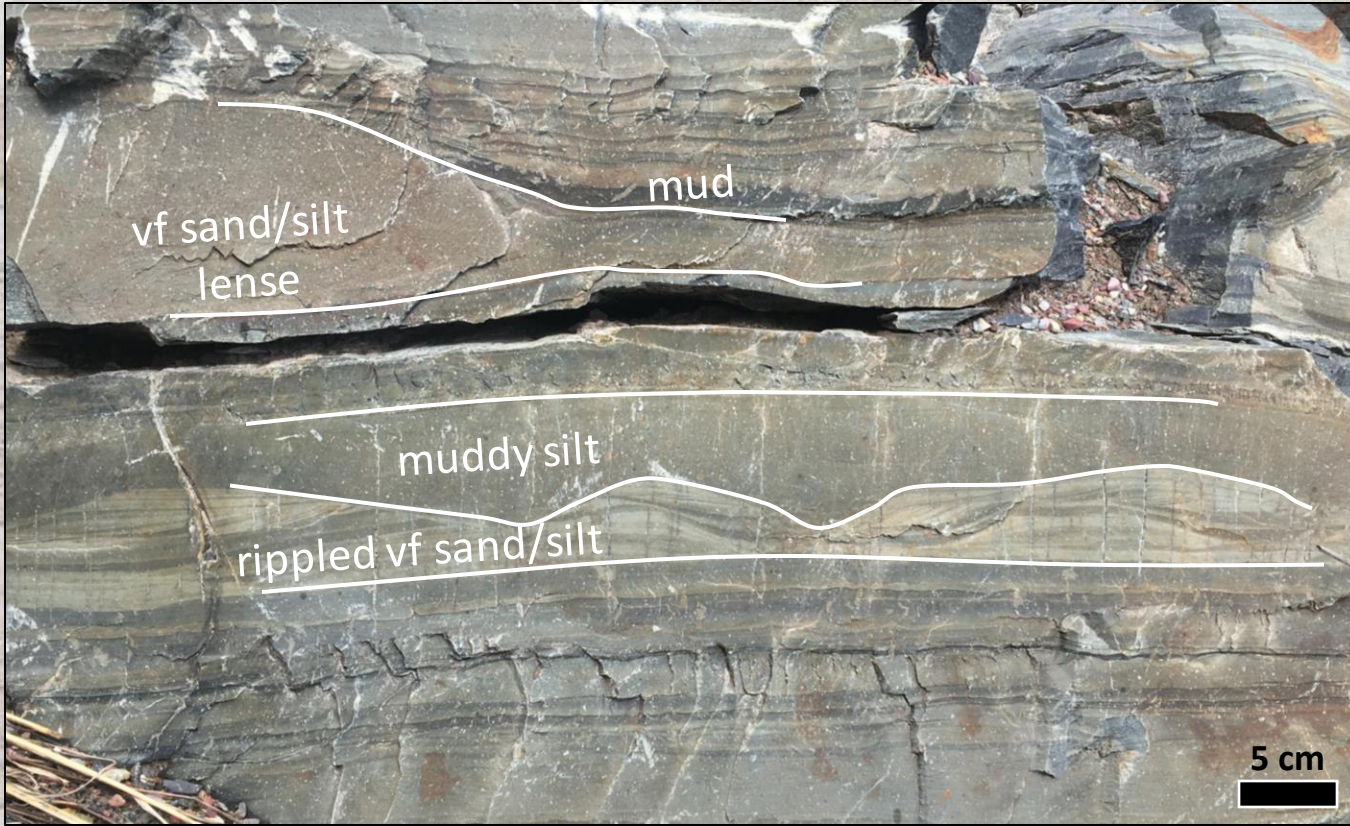
m-scale crossbedded, massive to graded muddy sand beds
rare dolomite mudchips at base

Pinch and swell couplet sediment type



Wavy, continuous to discontinuous silt/vf sand - clay couple/ts

Pinch and swell couplet sediment type



Wavy, continuous to discontinuous silt/vf sand - clay couple/ts

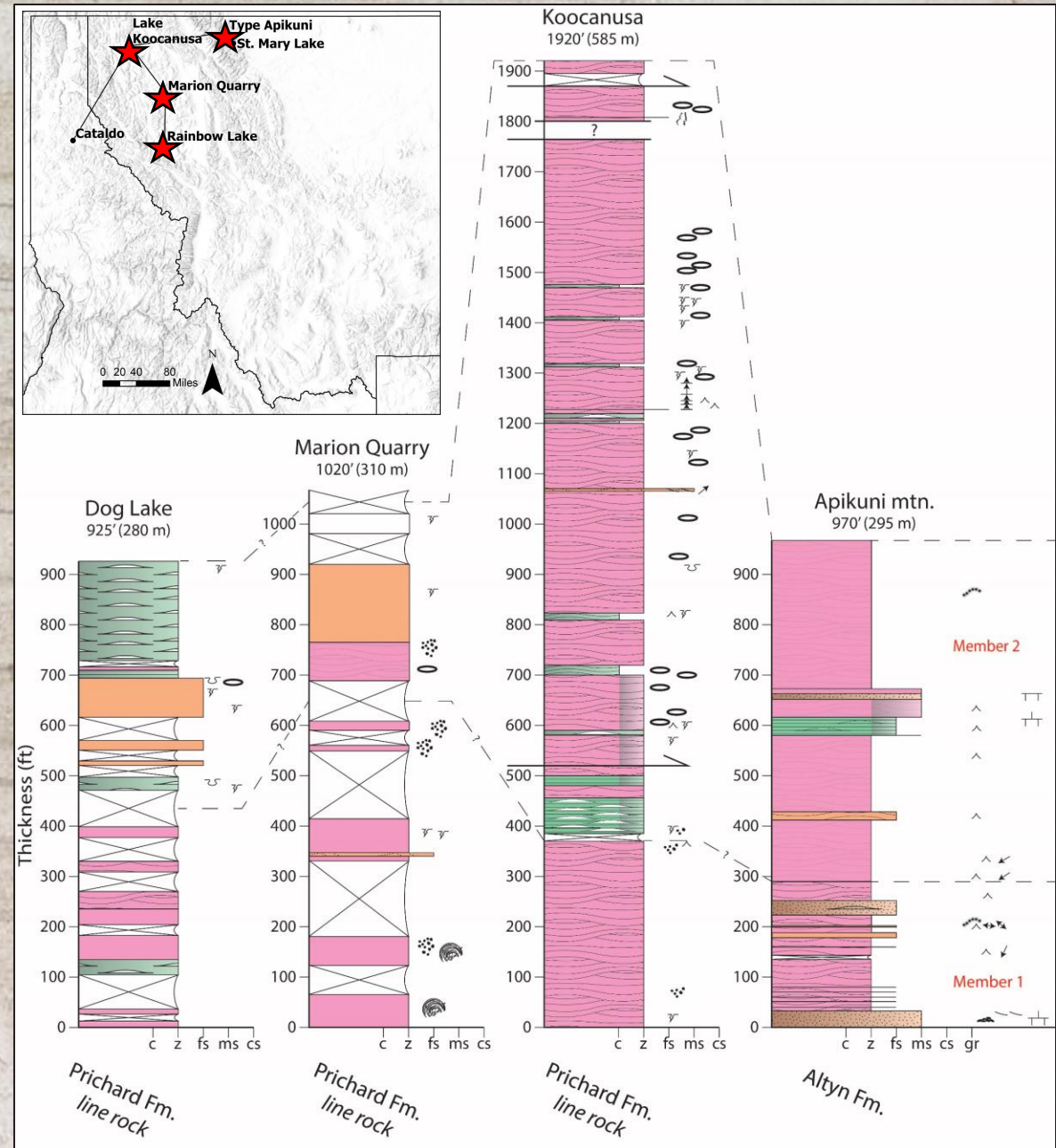
Scour, transport of vf sand/silt bedload by storm waves, suspension settle out of silt and clay, compaction

Lower Appekunny summary

- **Hummocky cross-stratified (HCS)**
 - *Laminated silt sub type*
- **Tabular sand**
 - *Graded sand sub type*
- **Pinch and swell couple/t**

-Distinct and predictable basal contact
 -lowest laminated silt

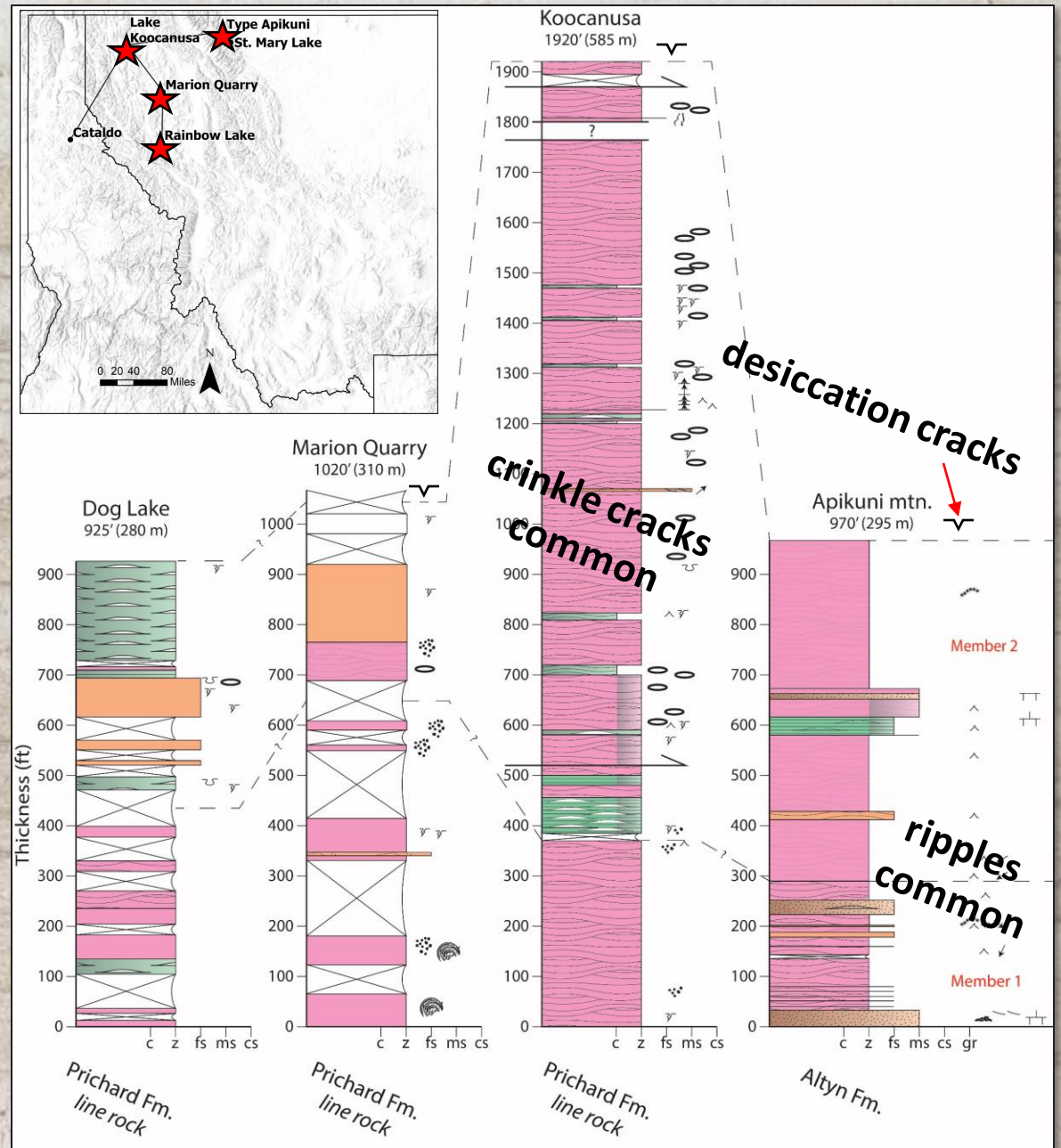
-HCS is defining sediment type
 -mostly silt bedforms, within storm wave base



Middle Appekunny transition



desiccation cracks mark the base of member 3 in most places

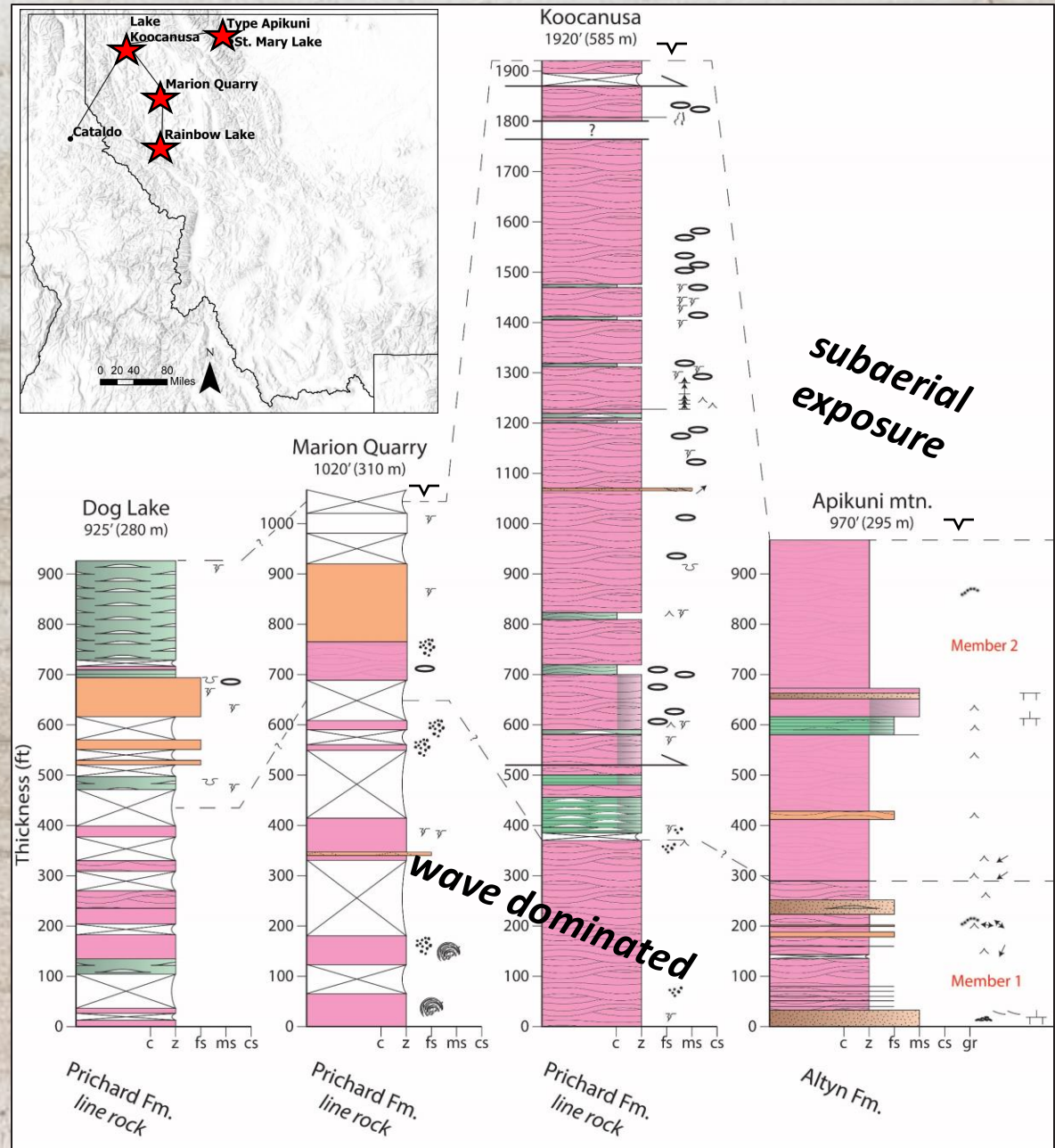


Middle Appekunny transition



desiccation cracks mark the base of member 3
in most places

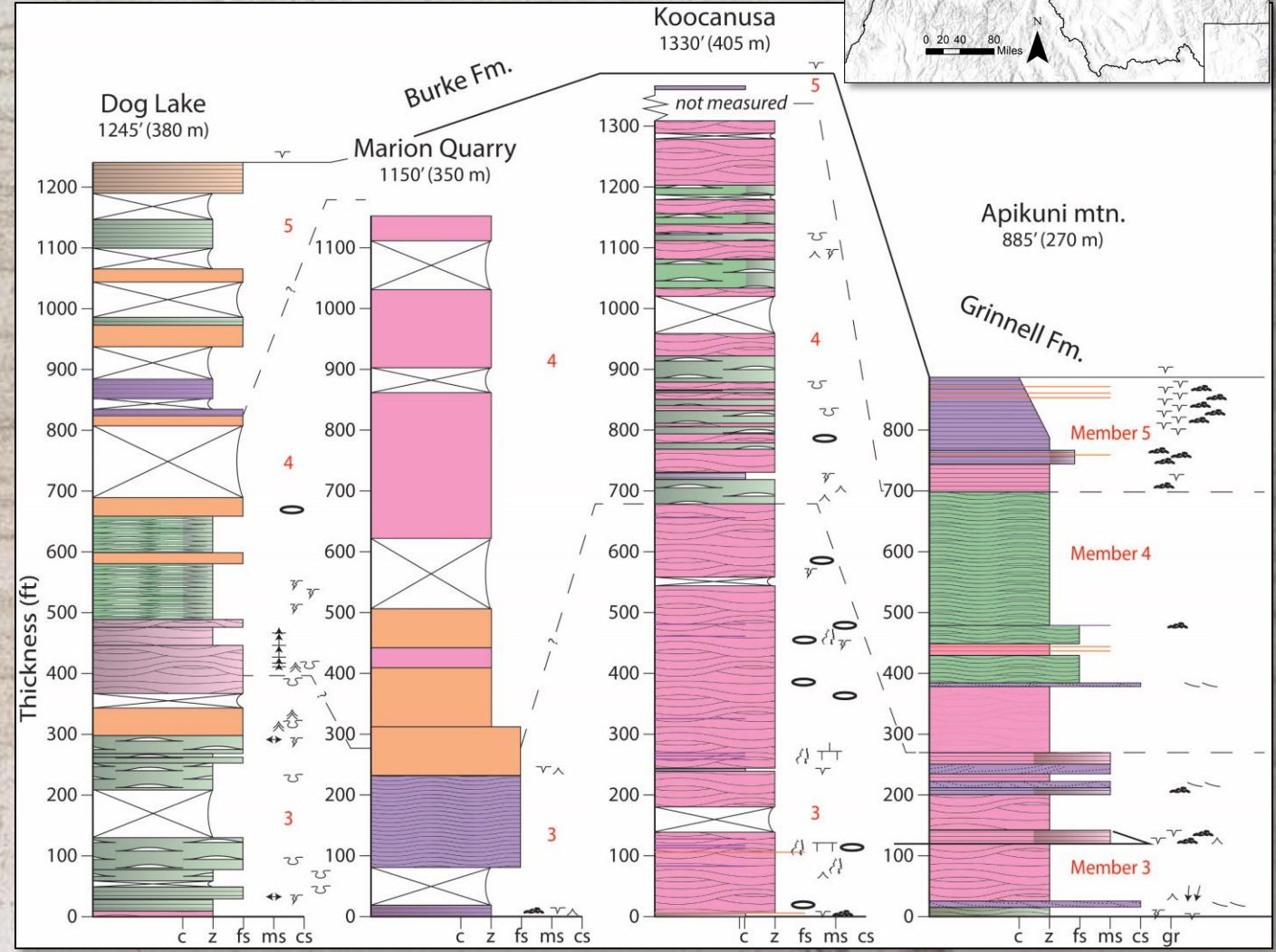
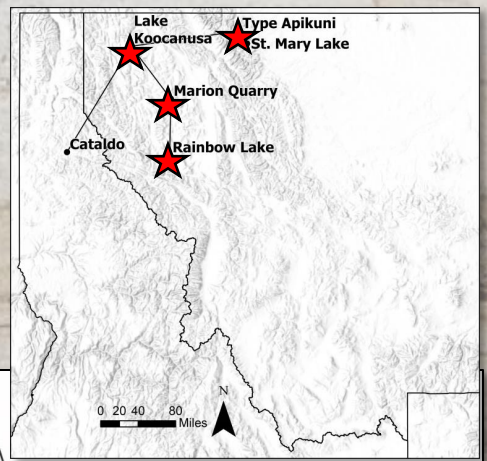
widespread subaerial exposure



Upper Appekunny sediment types

- **Hummocky cross-stratified (HCS)**
 - *Laminated silt sub type*
- **Tabular sand**
 - *Graded sand sub type*
- **Pinch and swell couplet**
- **Cracked couplet**
 - *Crossbedded sand sub type*
- **Microcouplet**

NEW →



Cracked couplet sediment type



continuous fine sand to clay couplets,
mudchip base, asymmetric ripples, desiccation cracks

***(distal) sheetflood across dry playa,
flow deceleration, settle out, desiccation***

Cross bedded sand sub type



Tabular beds of cross bedded sand, mud chips and desiccation cracks

(proximal) sheetflood across dry playa, scour and transport of mud chips, desiccation

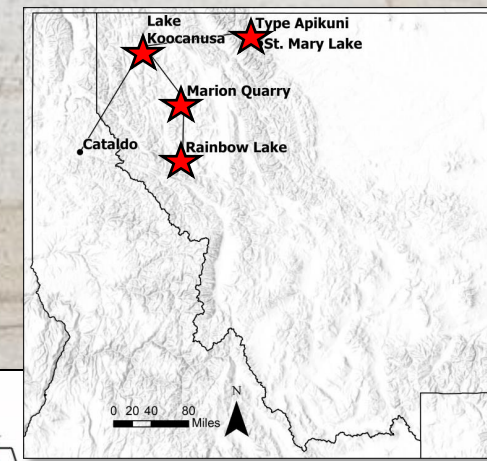
Microcouplet sediment type



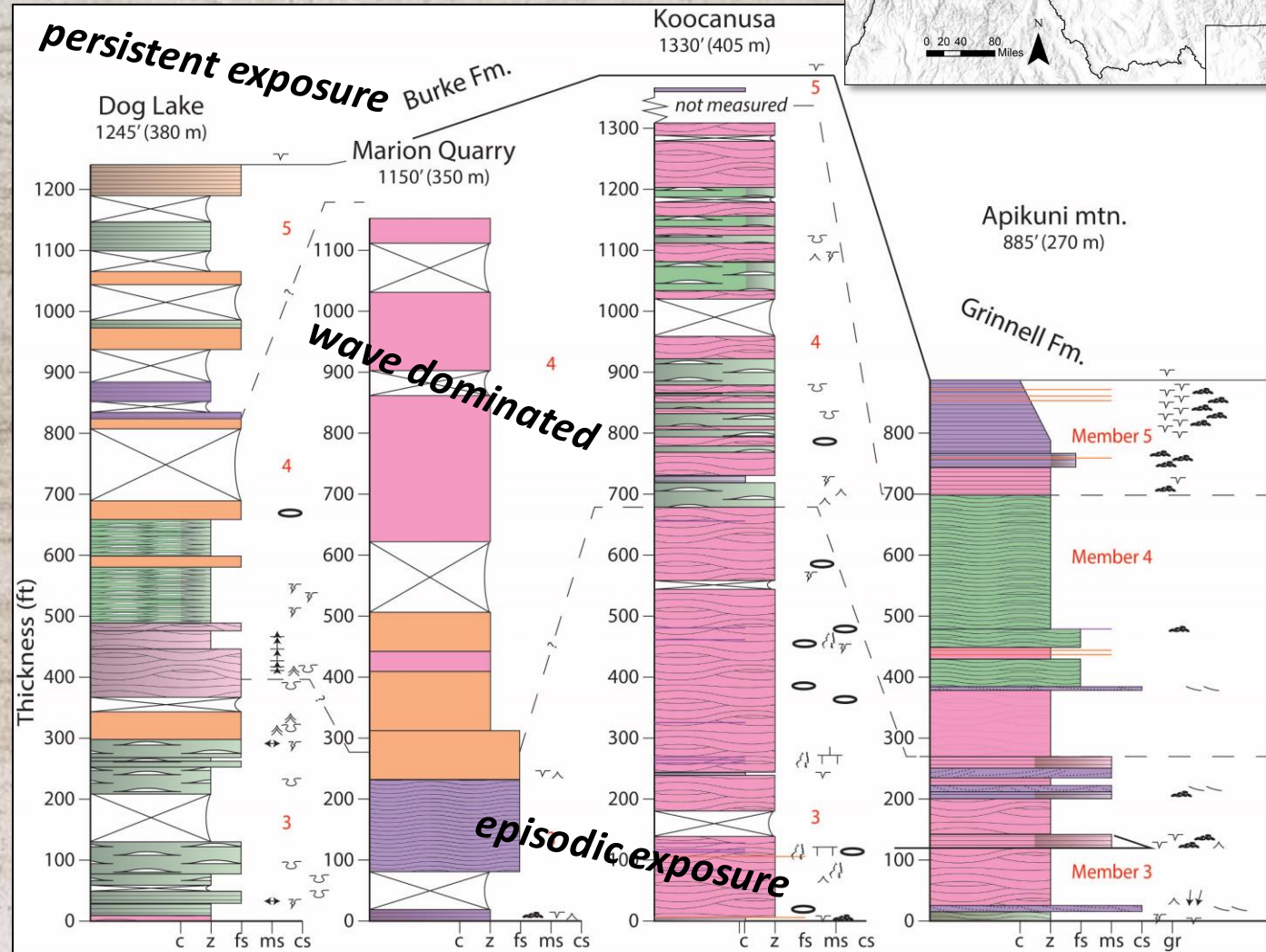
Even continuous silt to clay microcouplets, with mud chips, rare desiccation cracks and ripples

*Influxes of turbid water into calm, protected water.
Suspension settle out,
minimal bedload transport.*

Upper Appekunny summary

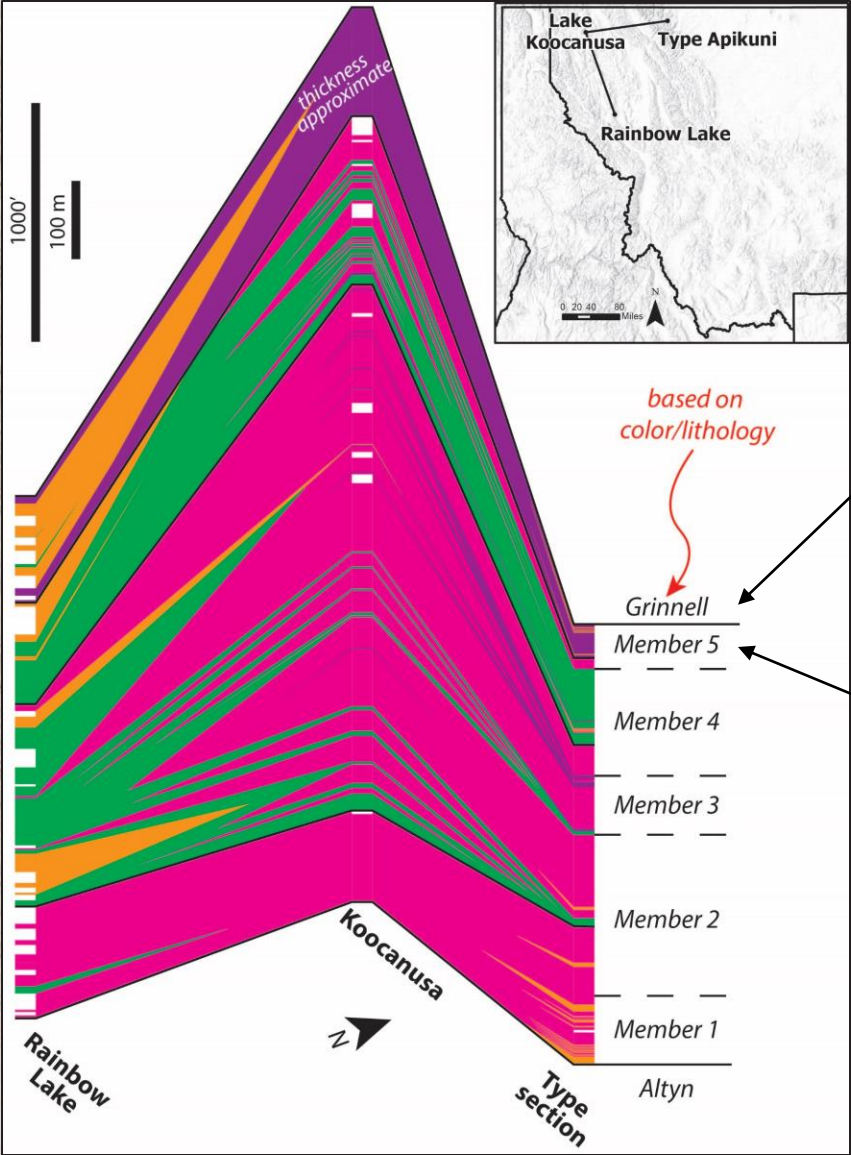


- Distinct and predictable upper contact
- lowest cracked microcouplet
- various sediment types
- within storm wave base
- sporadically exposed



Misleading colors

- member distinction is largely based on color
- limits the usefulness of member distinction (on regional scale)



Predictable sediment types

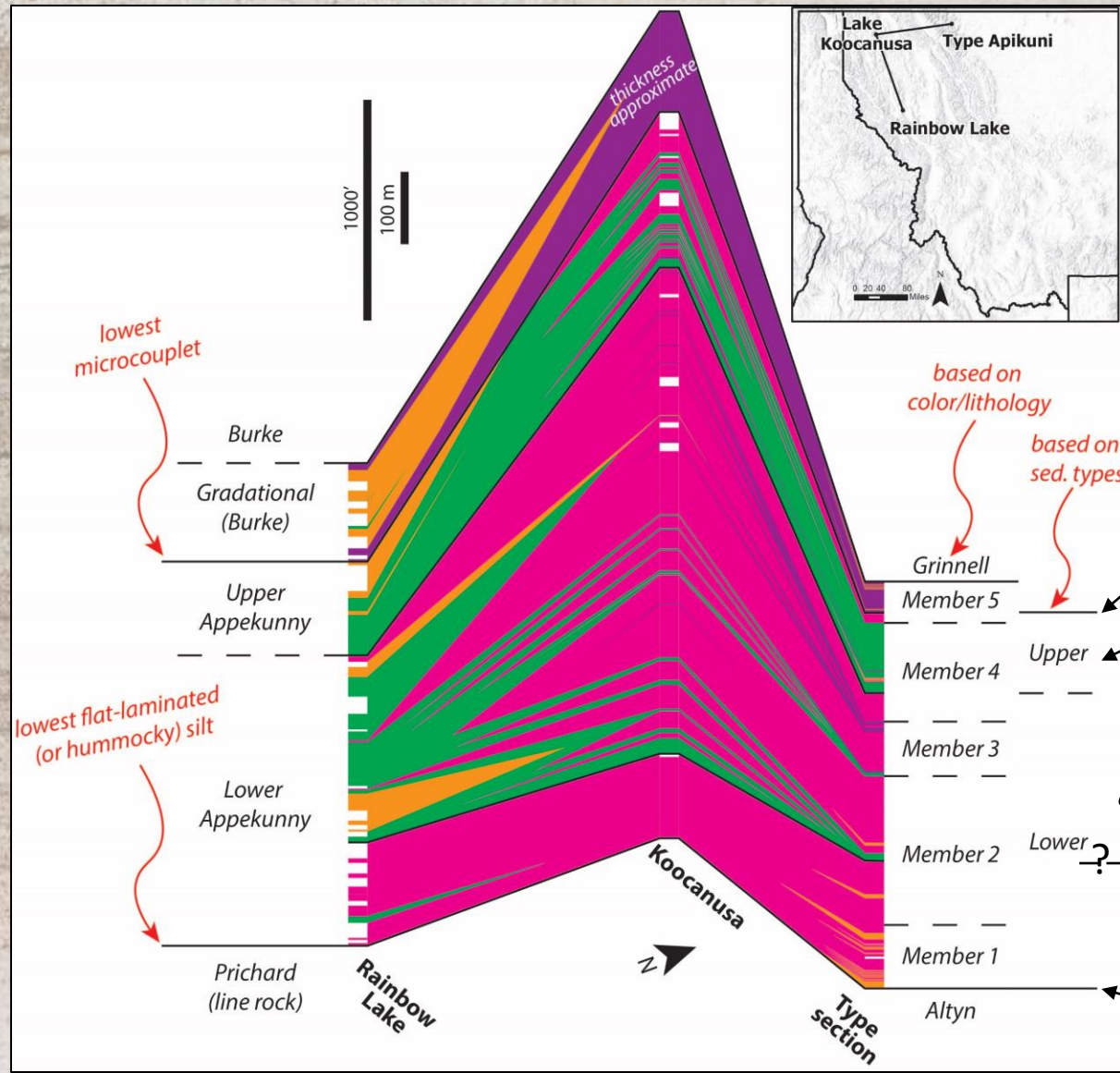
-Appekunny formation, as defined by sediment types, is mappable unit

-distinct and extensive contacts

-simple 2 (or 3)-part subdivision

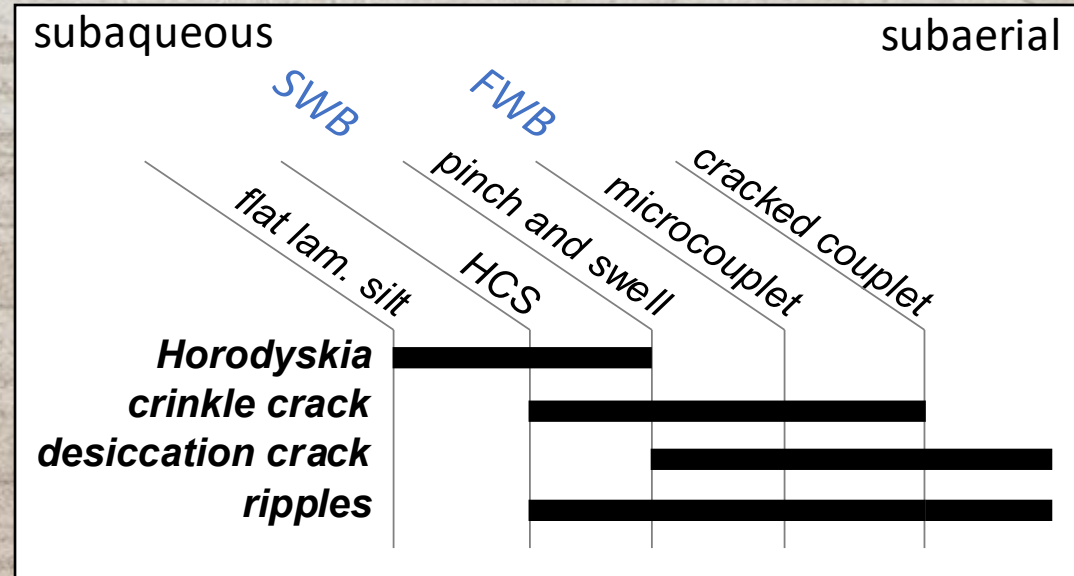
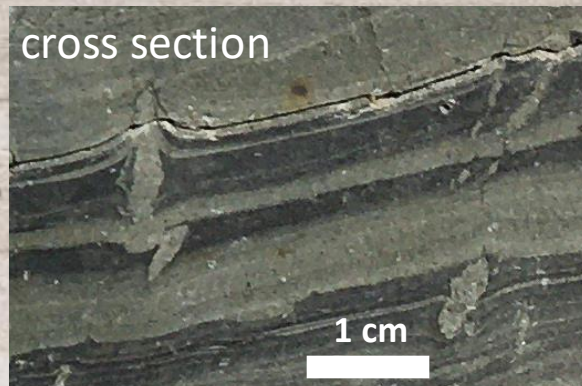


...now some sedimentology



Crinkle crack depositional model

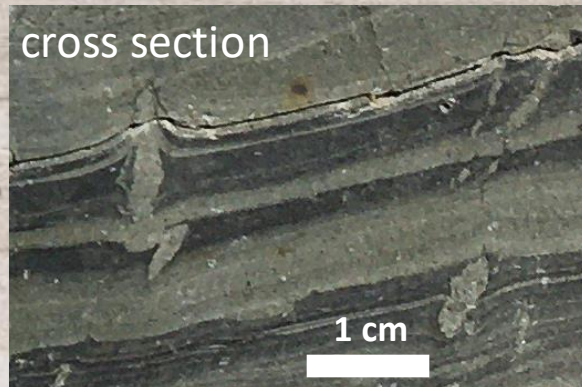
Rock record



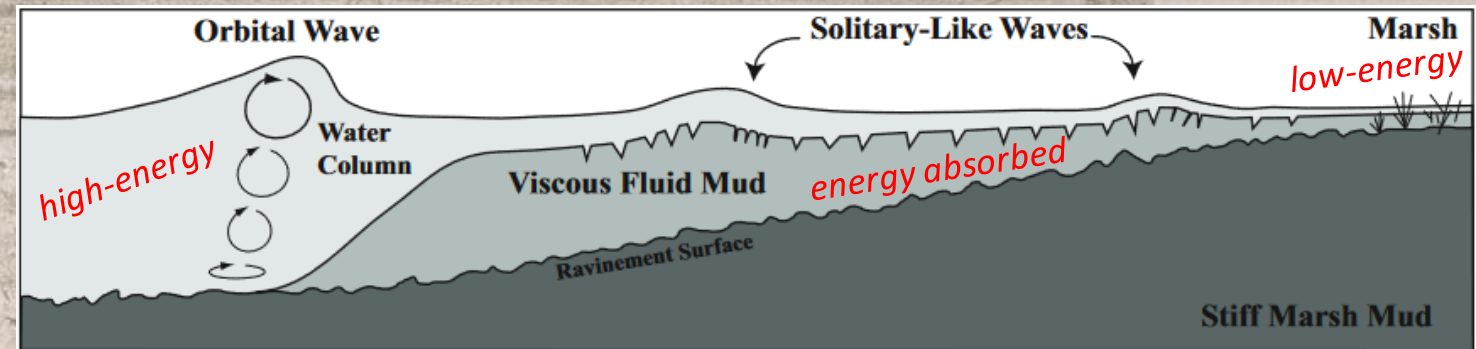
- aligned to en-echelon in plane view, filled from above
- crinkled in cross section (compaction)
- common in sediment types of intermediate depth (wave base)

Crinkle crack depositional model

Rock record



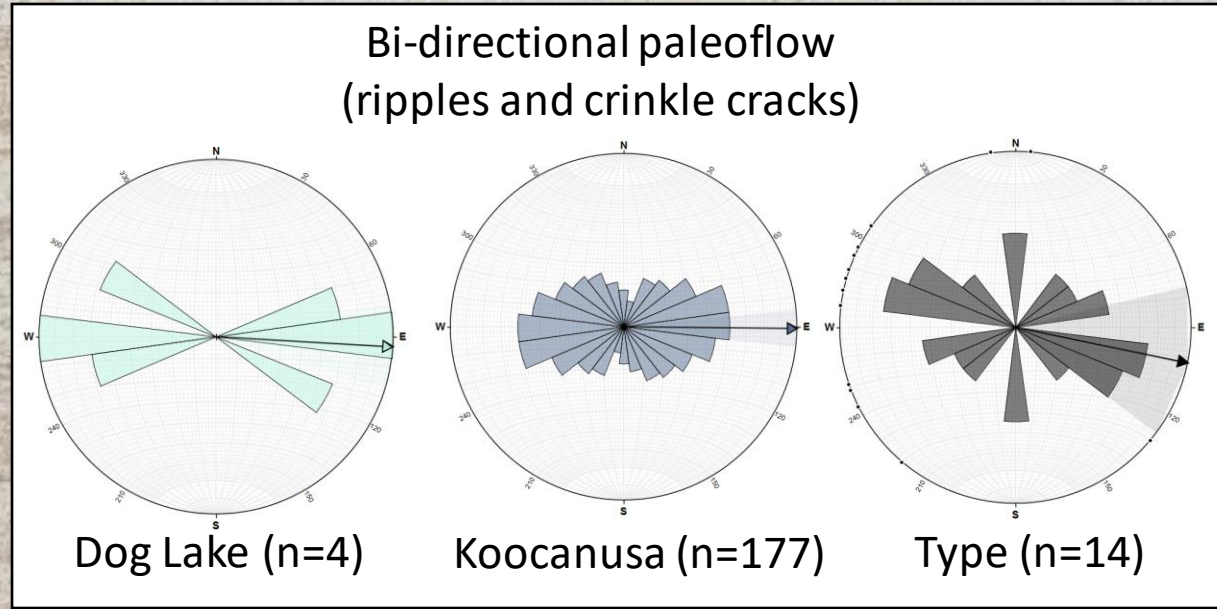
Modern analog



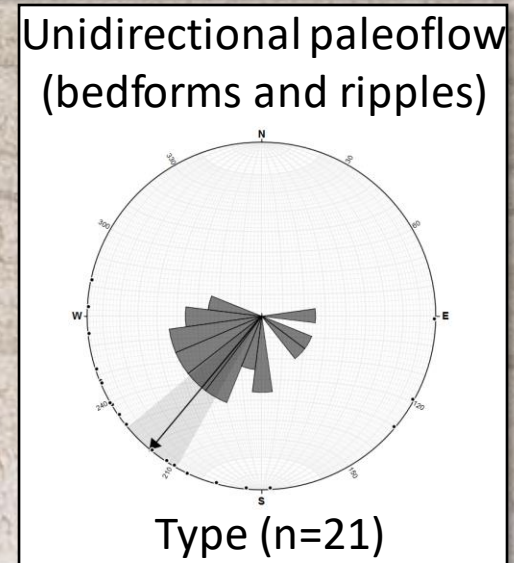
*Tension cracks formed by waves through fluid mud,
filled by sand bedload, crinkled by compaction
(Winston and Smith, 2016)*

Paleoflow

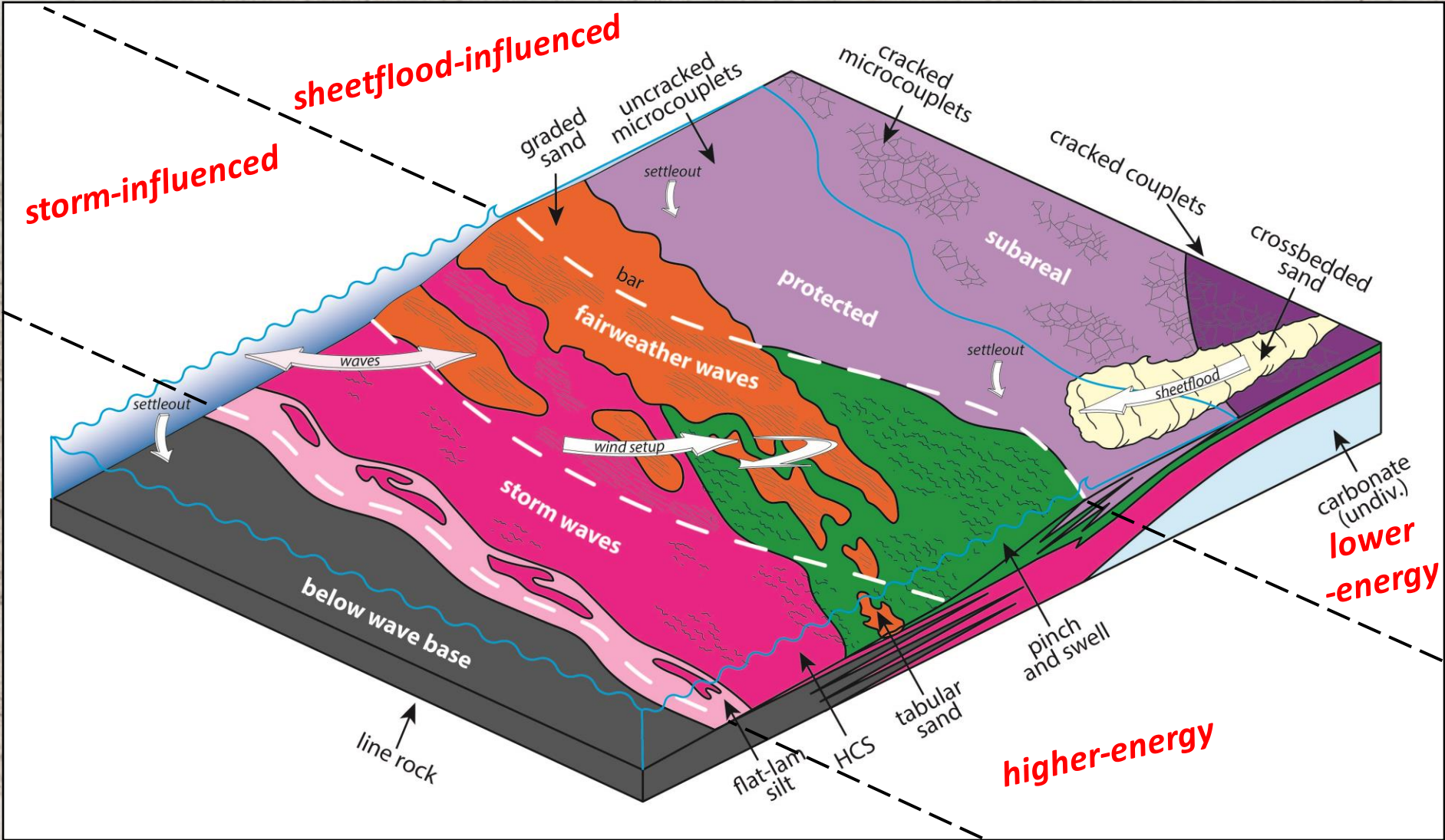
*~ E-W wave action,
throughout Appekunny Fm.*



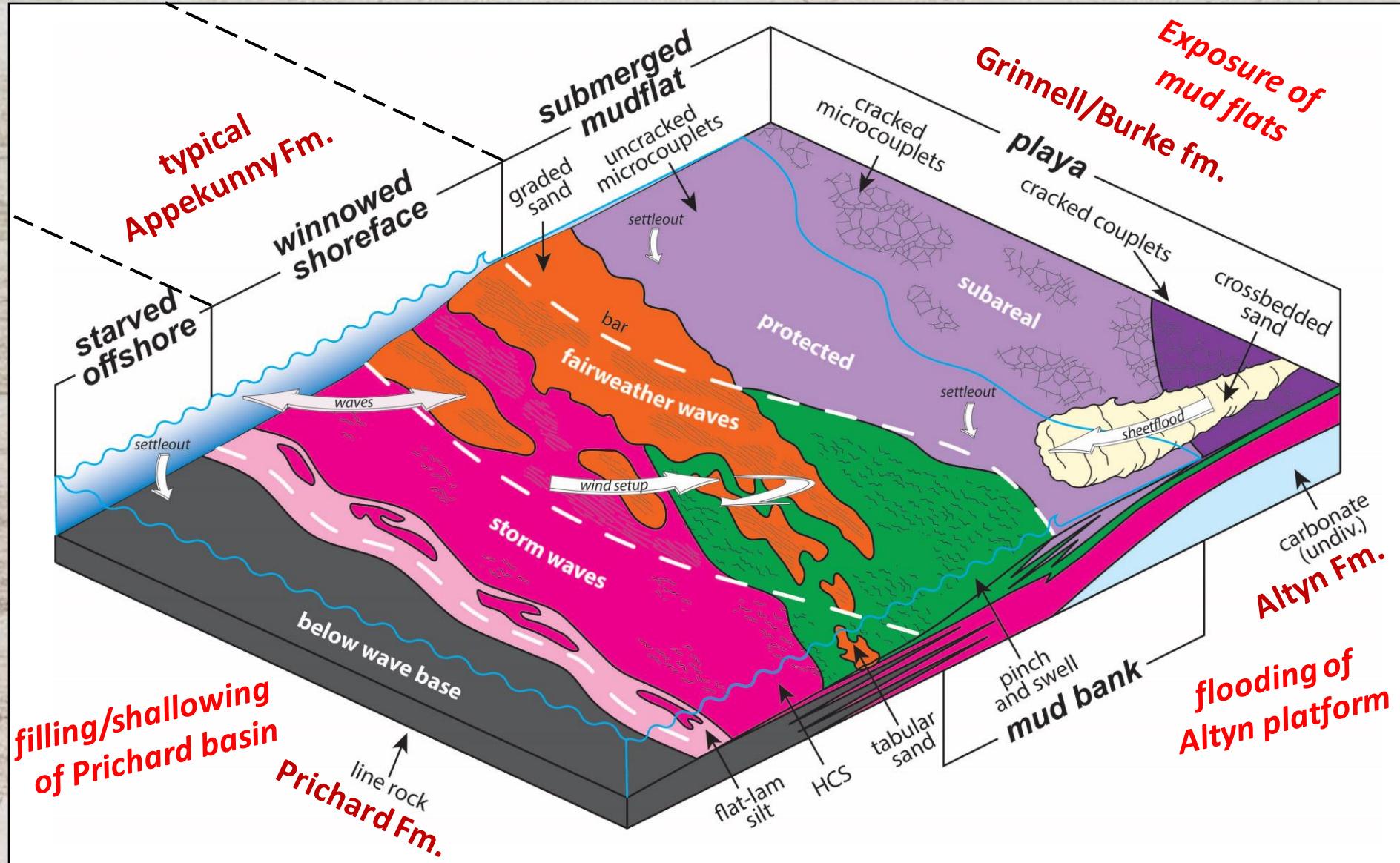
*SW-directed (offshore) flow
at Type section*



Depositional model



Depositional model



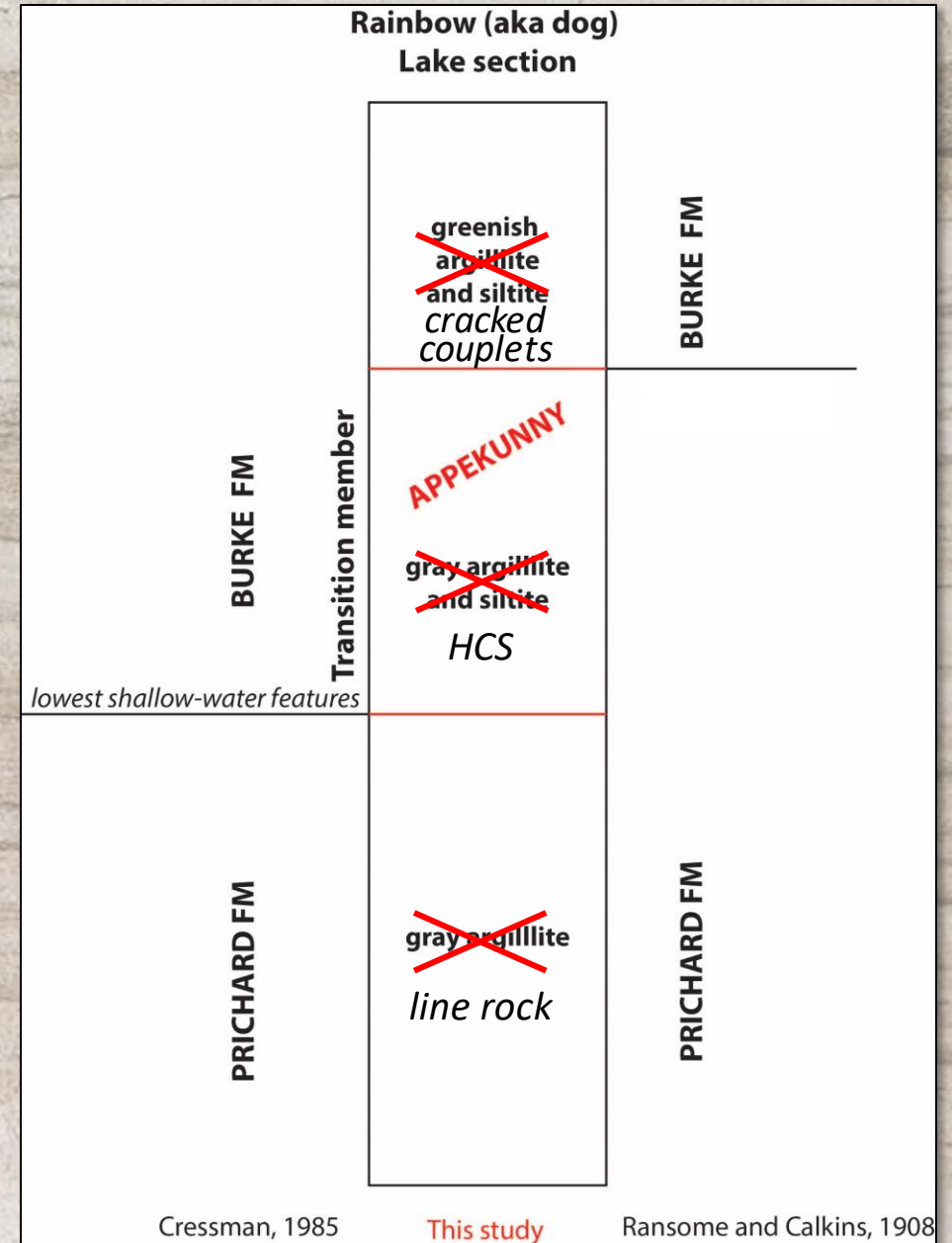
Conclusions

-Appekunny fm is mappable unit, defined by sediment types (hummocky silt)

-resolves competing models of the *transition member*

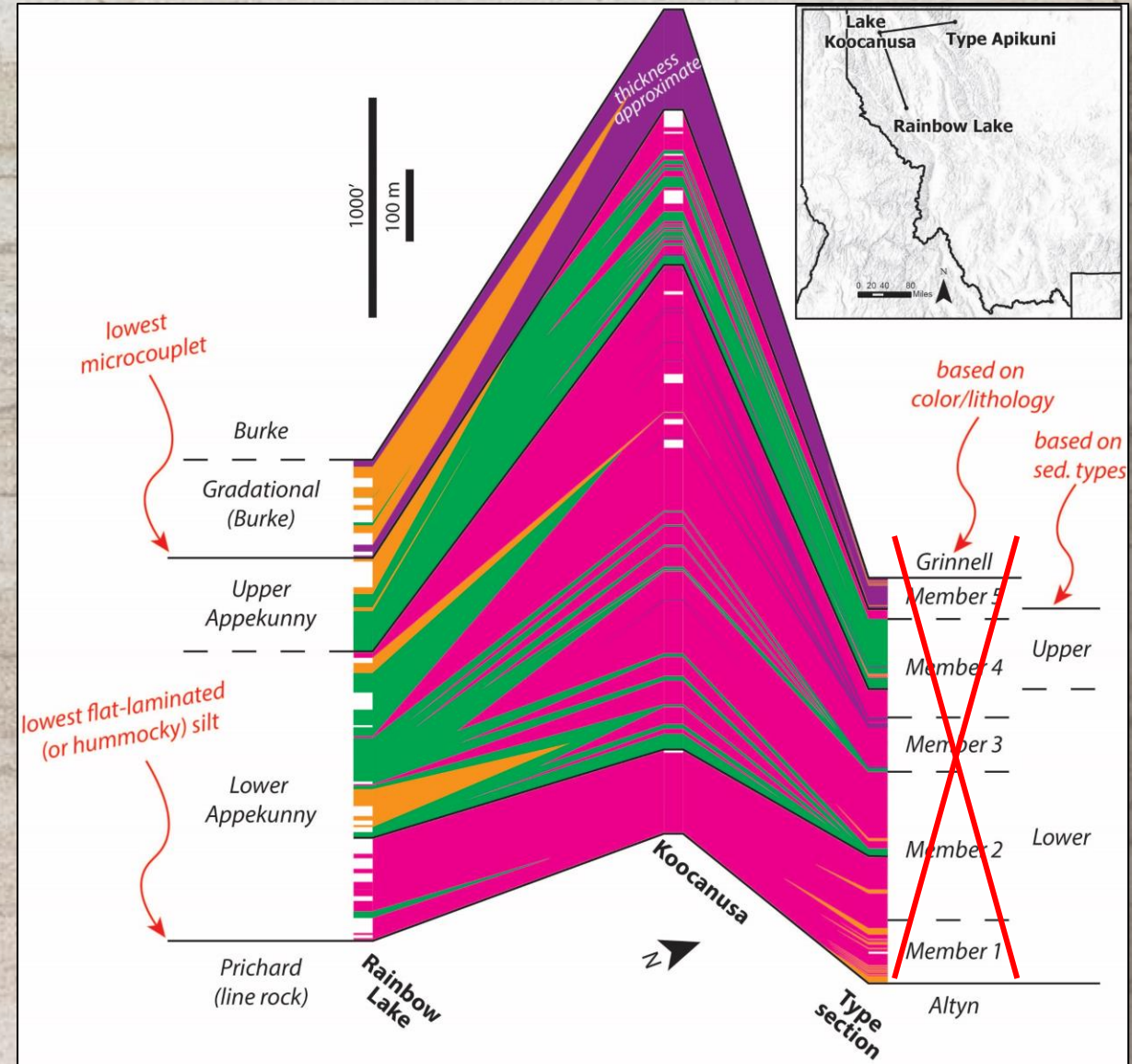
-draws attention to a basin-wide shift in depositional environments

...flooding of the carbonate bank, filling of the Prichard basin, west-to-east wave-driven silt bed load, transition to playa.

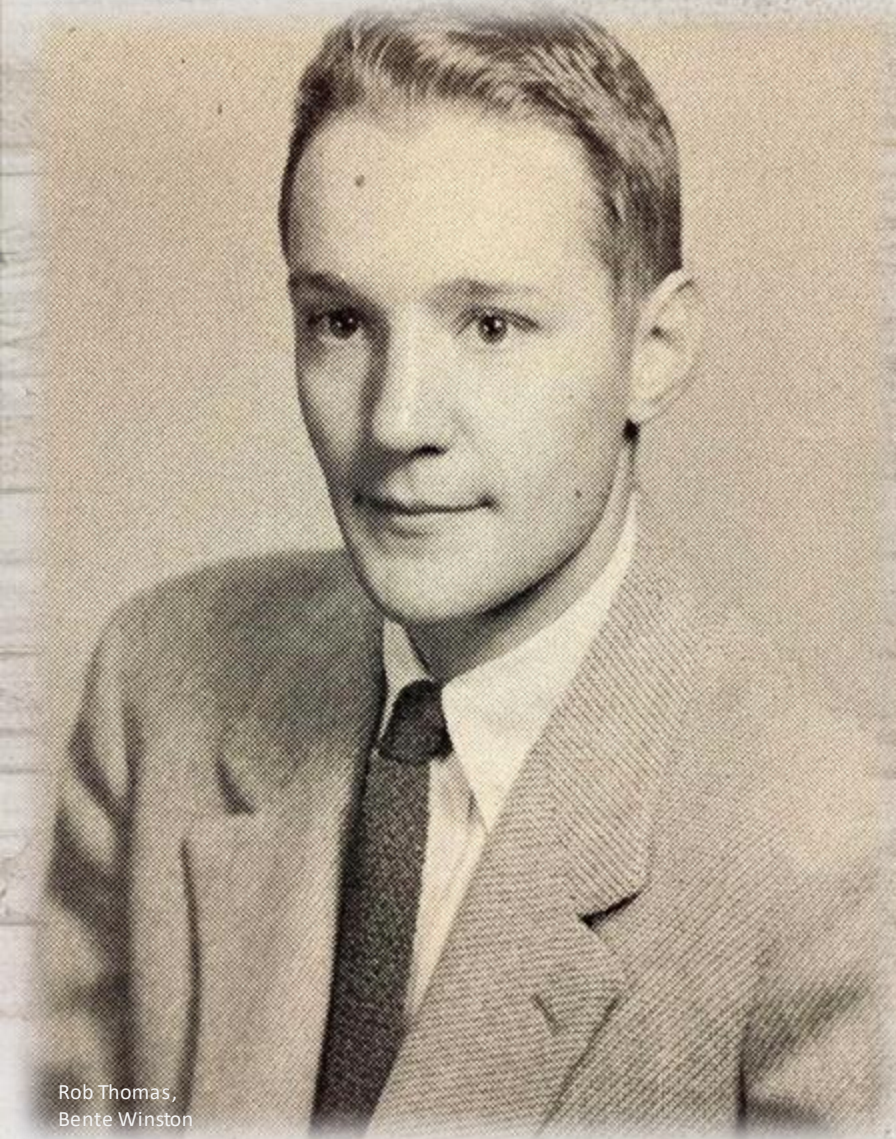


Recommendations

- map based on sediment type, not color/lithology
- apply *Appekunny* name to units below Burke/Grinnell and above Prichard/Altyn fms.
- place basal contact below lowest flat-laminated/hummocky-cross-stratified silt (or above highest line rock/laminated dolostone)
- place upper contact below lowest microcouplet (or above highest flat-laminated/hummocky-cross-stratified silt)

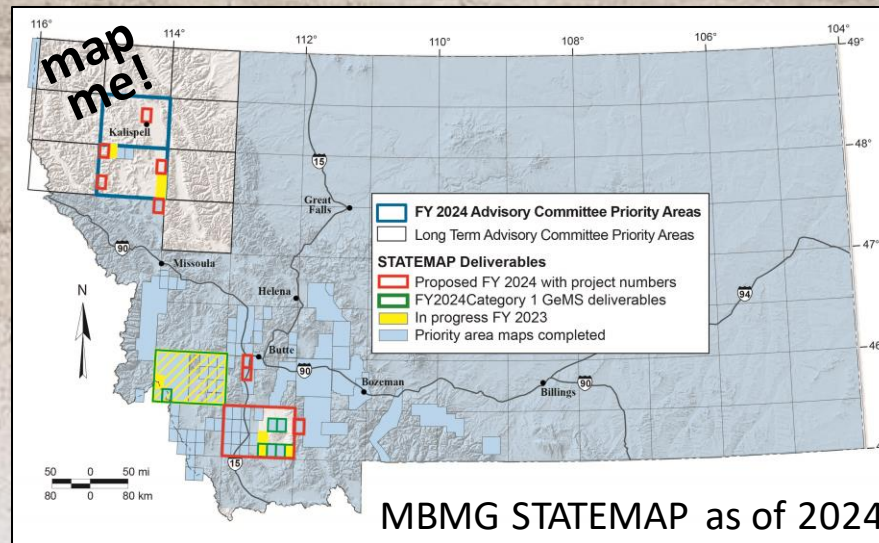


Finishing what Don Winston started



Rob Thomas,
Bente Winston

- measure sections of potential Appekunny, across the basin
 - in Coeur d'Alene district and Helena Embayment
- test and refine stratigraphy
 - upper and lower contacts
 - develop internal members (if useful regionally)
 - expand/refine sediment types/depo models
- map (1:100,000) using Appekunny stratigraphy
- make Winston Collection more accessible to public



Rob Thomas

Winston
Collection

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LONG LIVE
DON WINSTON

1931-2022

