Late Cretaceous Arctic Paleoenvironments from the Lower Cantwell and Prince Creek Formations, Alaska

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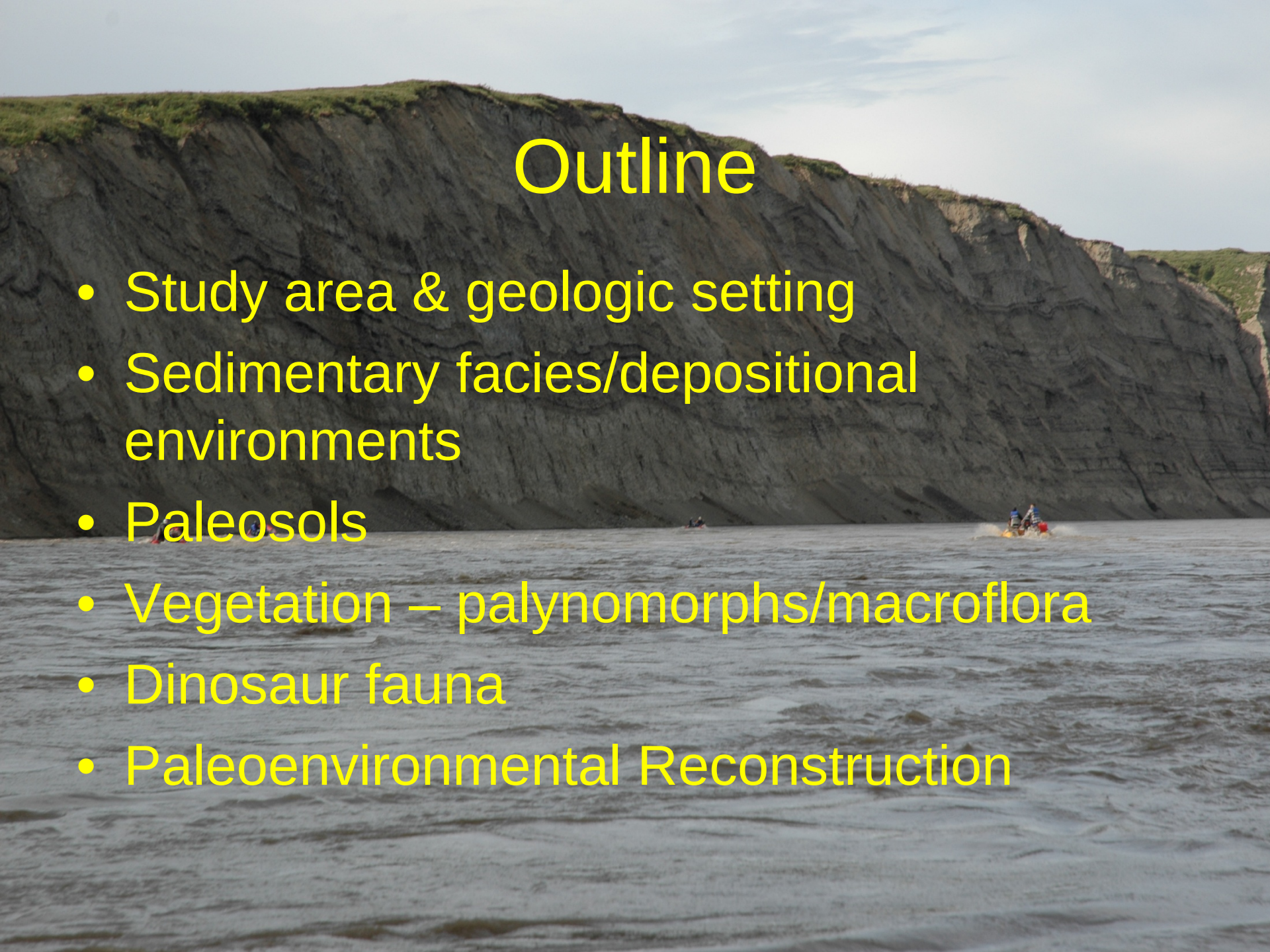
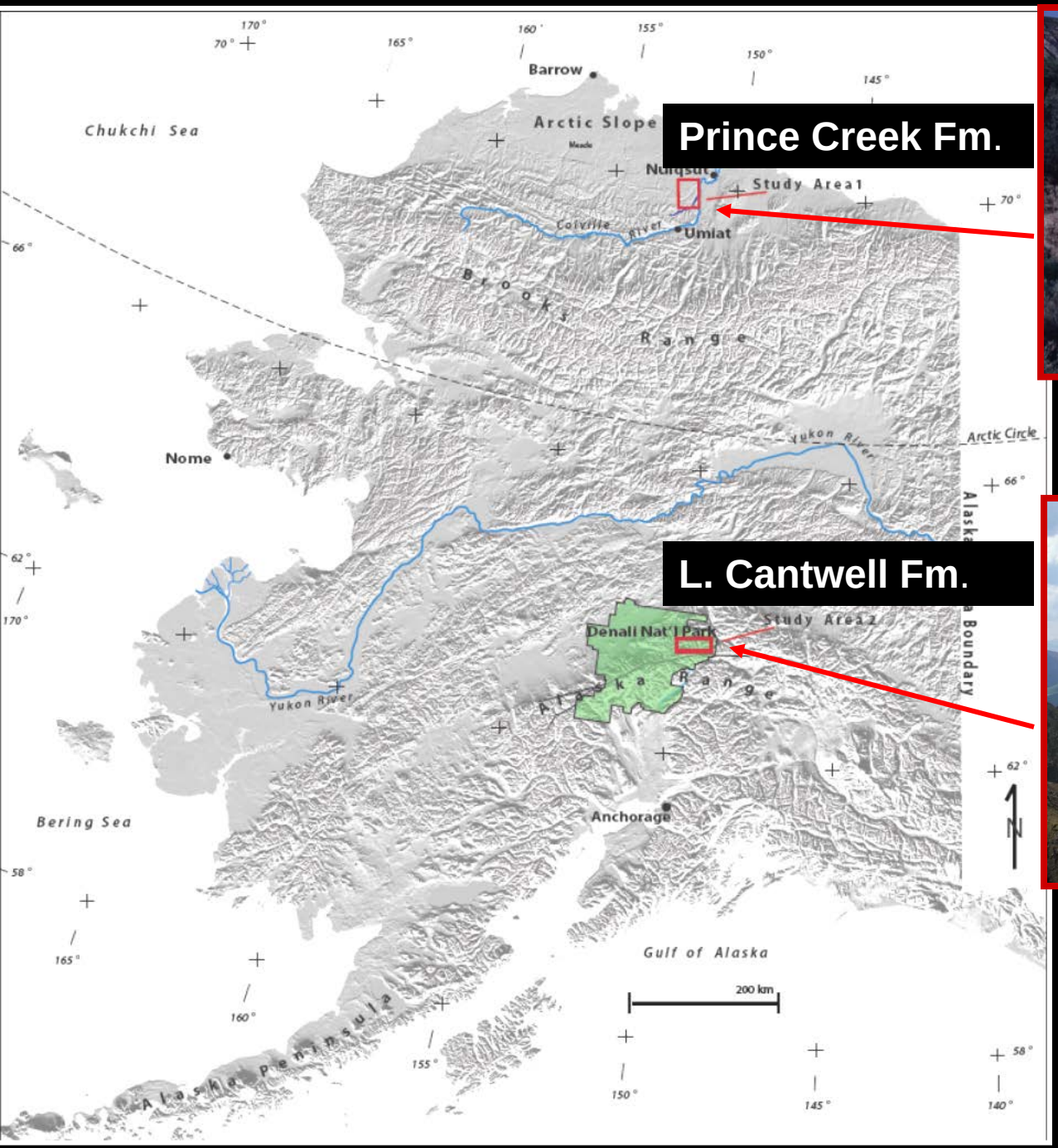
Per[o]t Museum of Nature and Science



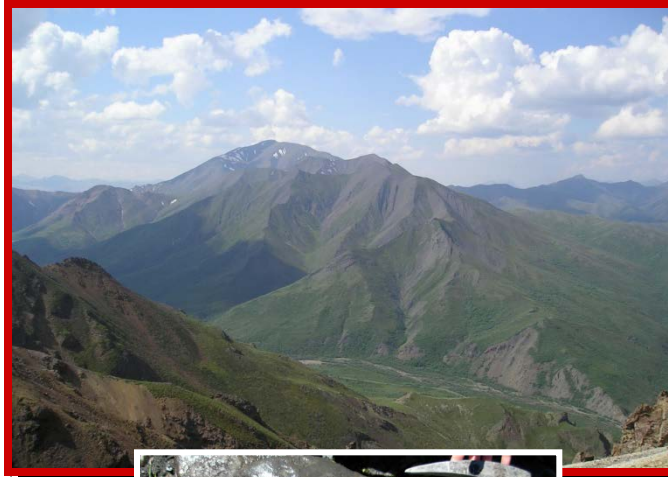
Outline

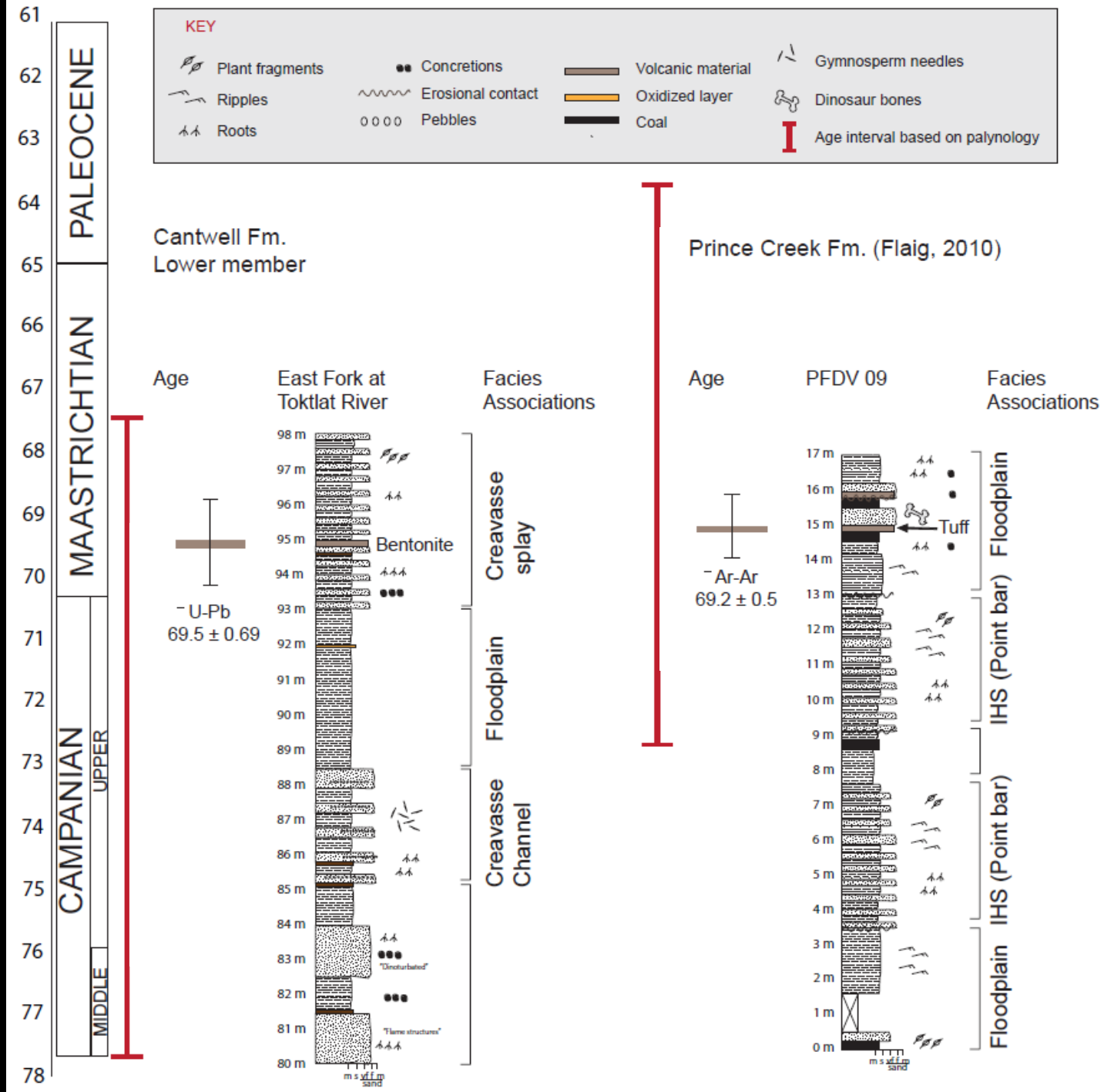
- Study area & geologic setting
- Sedimentary facies/depositional environments
- Paleosols
- Vegetation – palynomorphs/macroflora
- Dinosaur fauna
- Paleoenvironmental Reconstruction



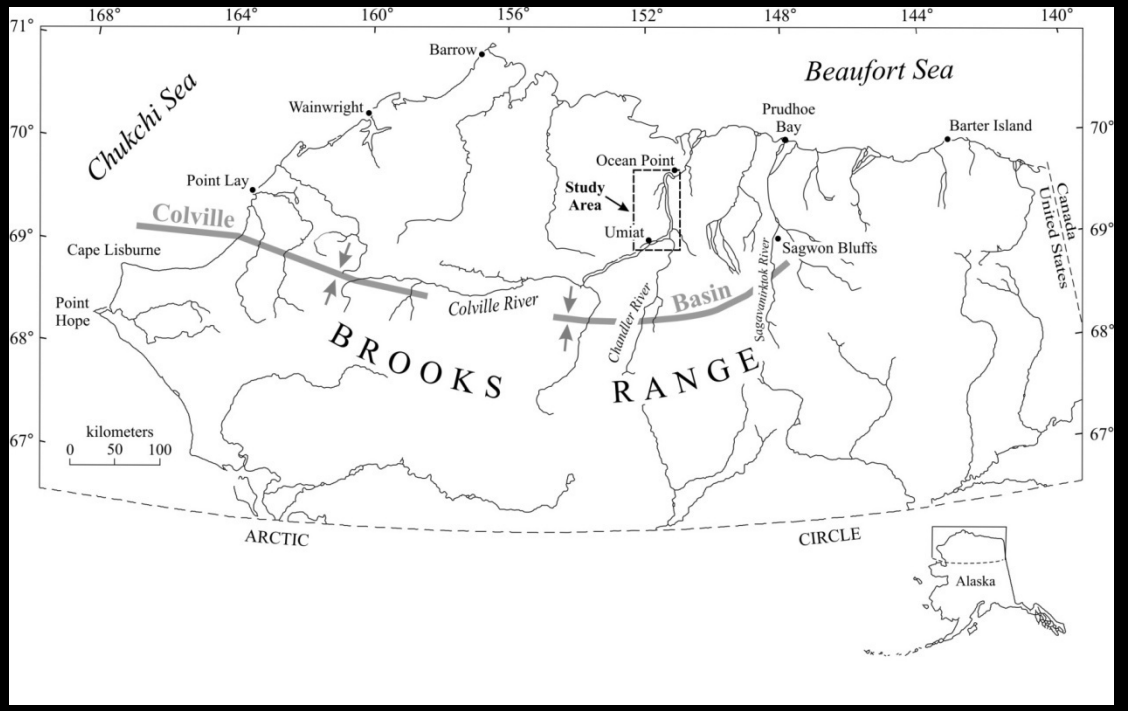
Prince Creek Fm.

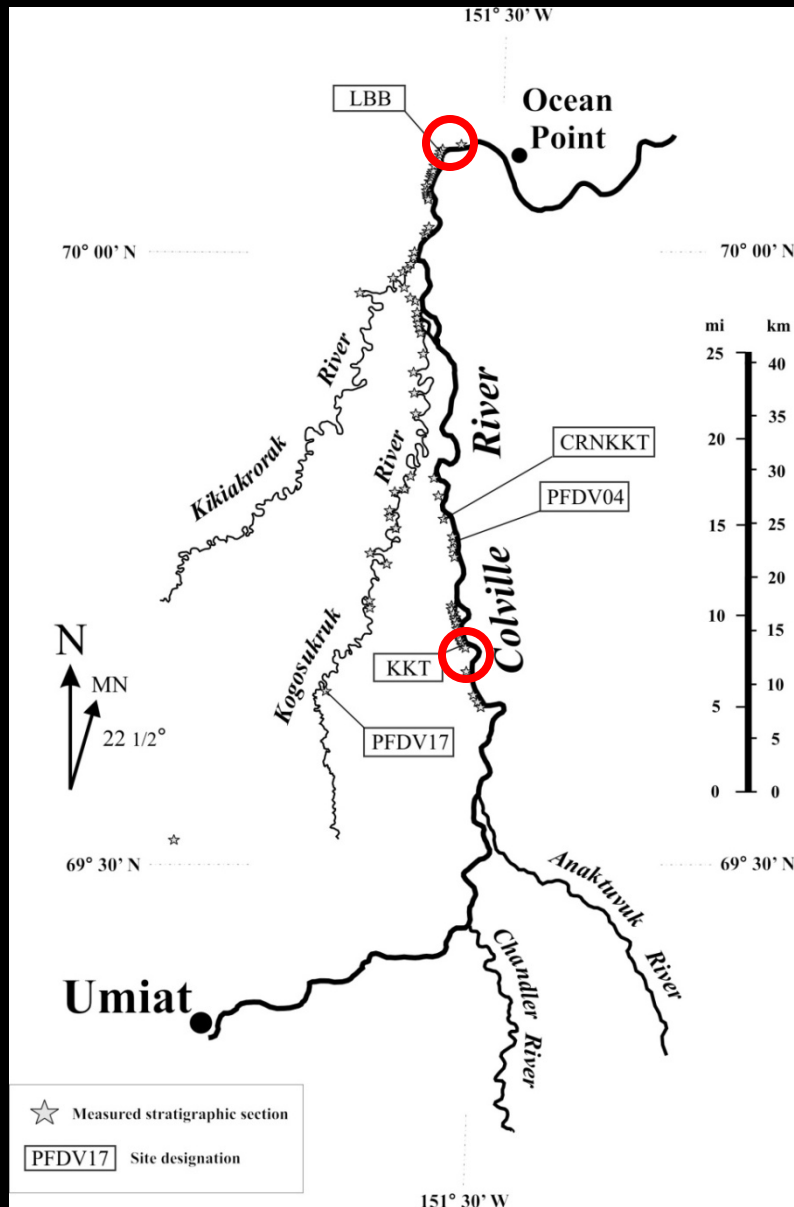
L. Cantwell Fm.



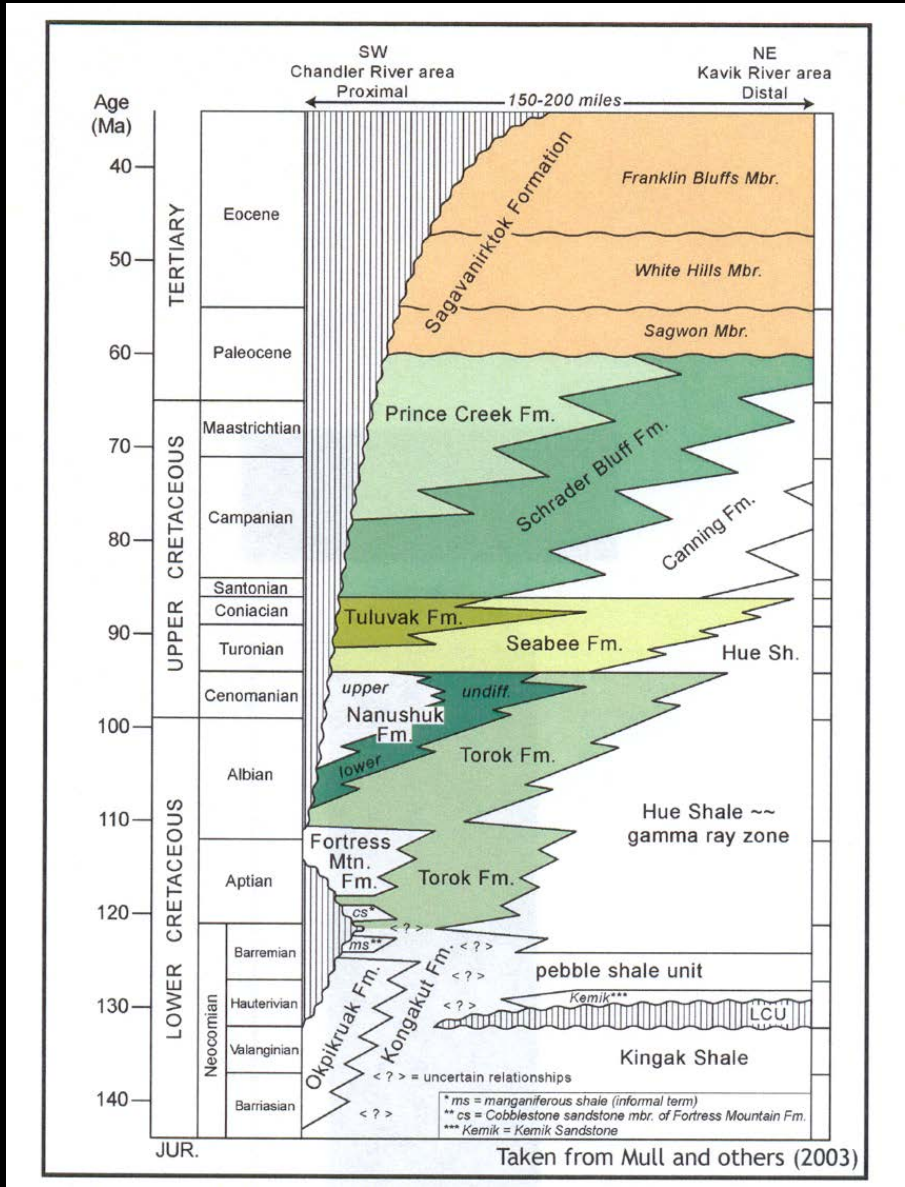

KEY
Plant fragments
Ripples
Roots
Concretions
Erosional contact
Pebbles
Volcanic material
Oxidized layer
Coal
Gymnosperm needles
Dinosaur bones
Age interval based on palynology
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
PALEOCENE
MAASTRICHTIAN
CAMPANIAN
UPPER
MIDDLE
Cantwell Fm.
Lower member
Age
U-Pb
69.5 ± 0.69
East Fork at
Toktlat River
98 m
97 m
96 m
95 m
94 m
93 m
92 m
91 m
90 m
89 m
88 m
87 m
86 m
85 m
84 m
83 m
82 m
81 m
80 m
Bentonite
"Dinoturbated"
"Flame structures"
m s vf f m
sand
Facies
Associations
Creavasse
splay
Floodplain
Creavasse
Channel
Prince Creek Fm. (Flaig, 2010)
Age
Ar-Ar
69.2 ± 0.5
PFDV 09
17 m
16 m
15 m
14 m
13 m
12 m
11 m
10 m
9 m
8 m
7 m
6 m
5 m
4 m
3 m
2 m
1 m
0 m
Tuff
m s vf f m
sand
Facies
Associations
Floodplain
IHS (Point bar)
IHS (Point bar)
Floodplain

Study Area – Prince Creek Fm.

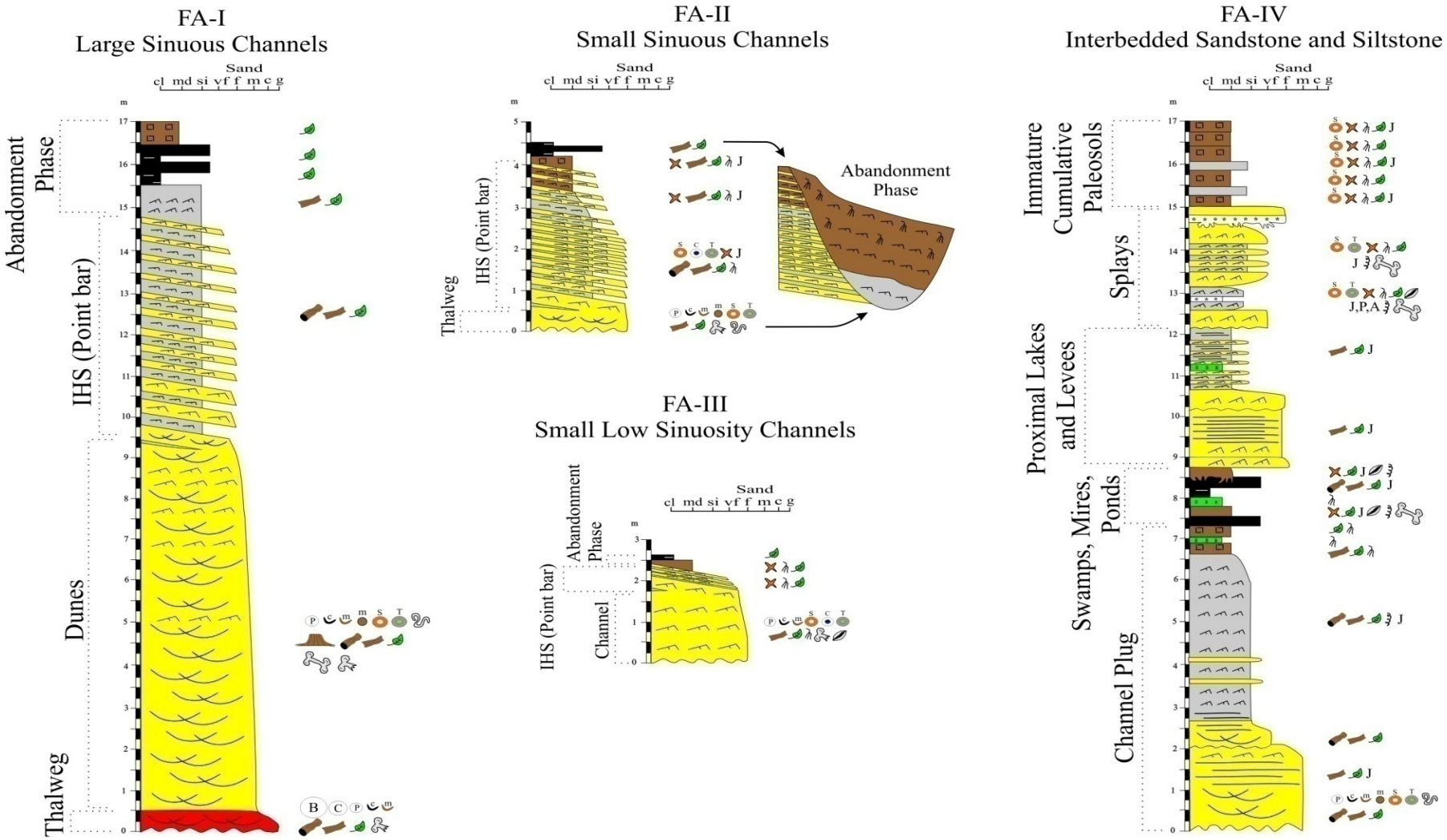




Stratigraphy

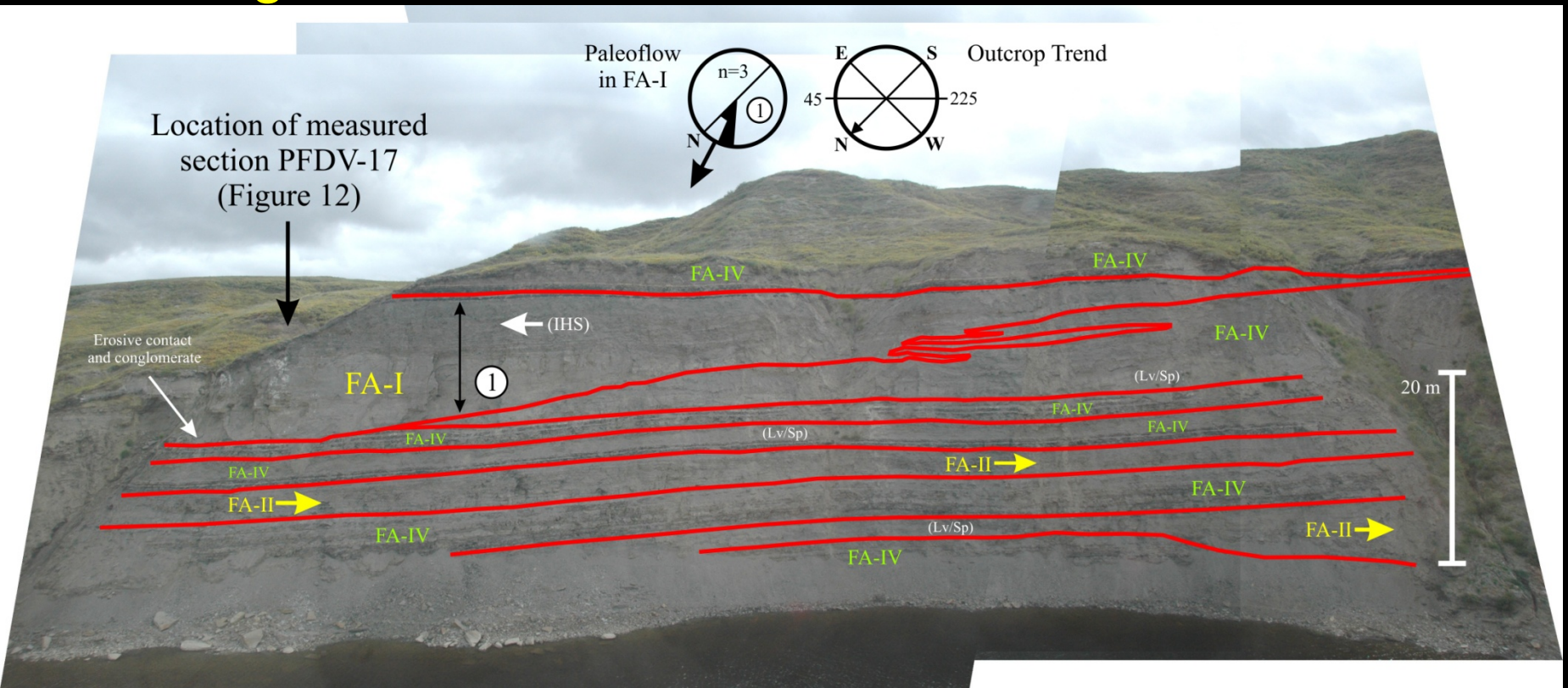


Sedimentary Environments



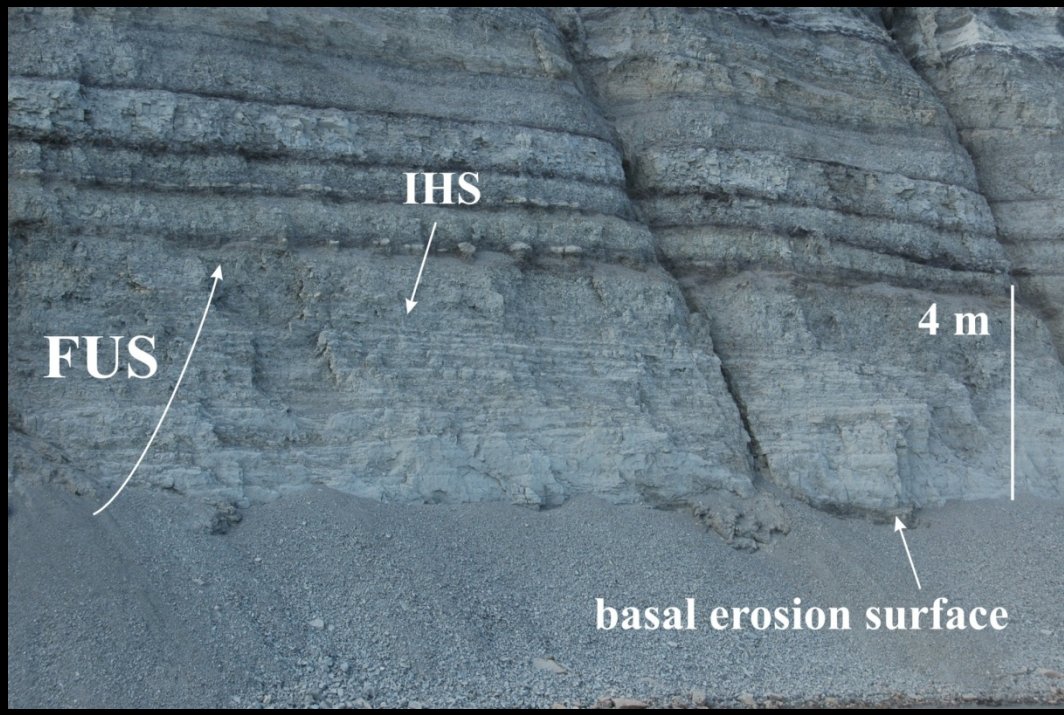
Large Sinuous Channels

- Up to 10 m thick
- Gravel lag
- Inclined heterolithic fill common
- Large lateral accretion surfaces



Small Sinuous Channels

- Sandstone lenses 2-5 m thick
- Sharp base
- No basal lag
- Dominated by ripple cross-lamination; some trough cross-bedding
- Rooted throughout



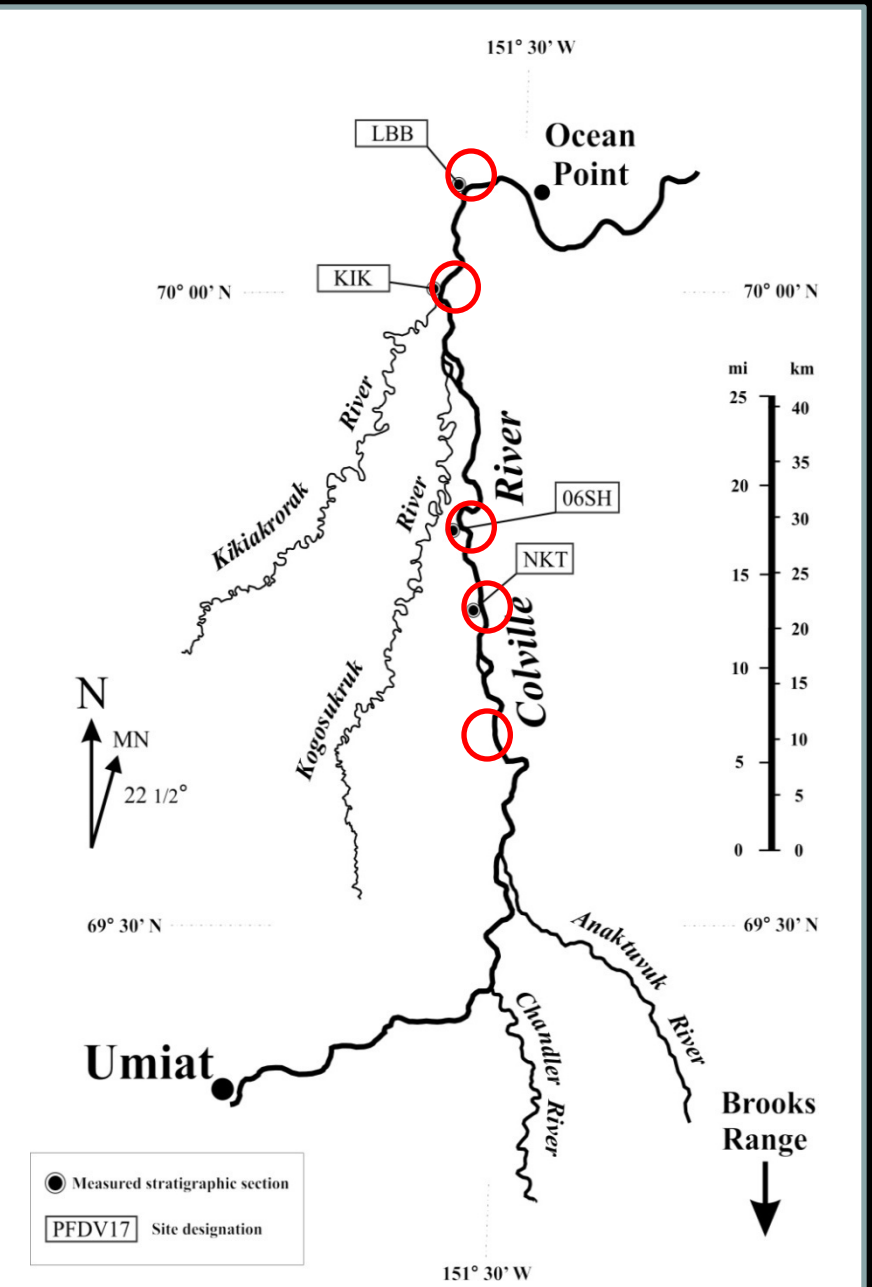
Small Low Sinuosity Channels

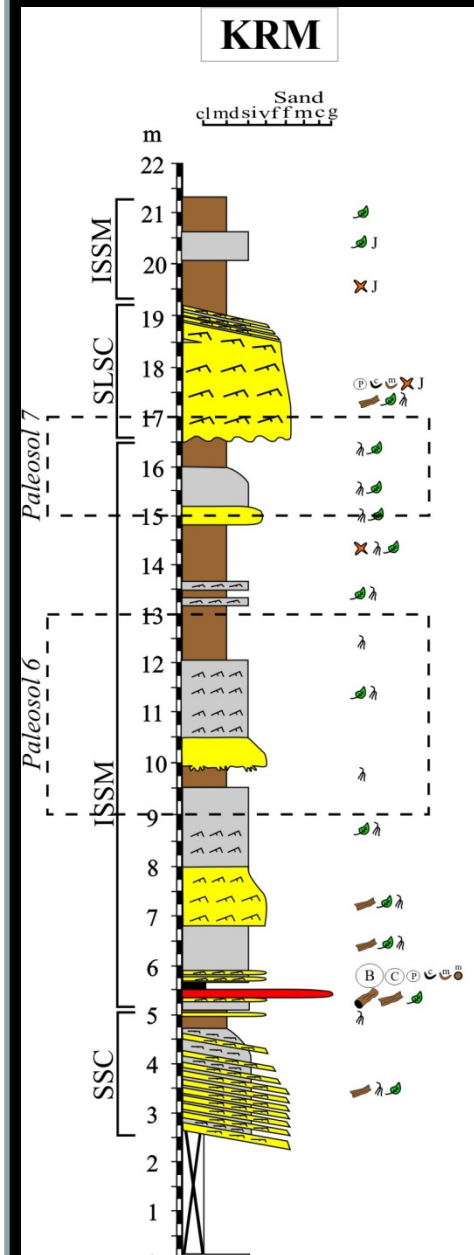
1-3 m-thick ribbon-form channel bodies
IHS may occur in top 0.5 m
Primarily vertical accretion – other sandbodies at same stratigraphic level

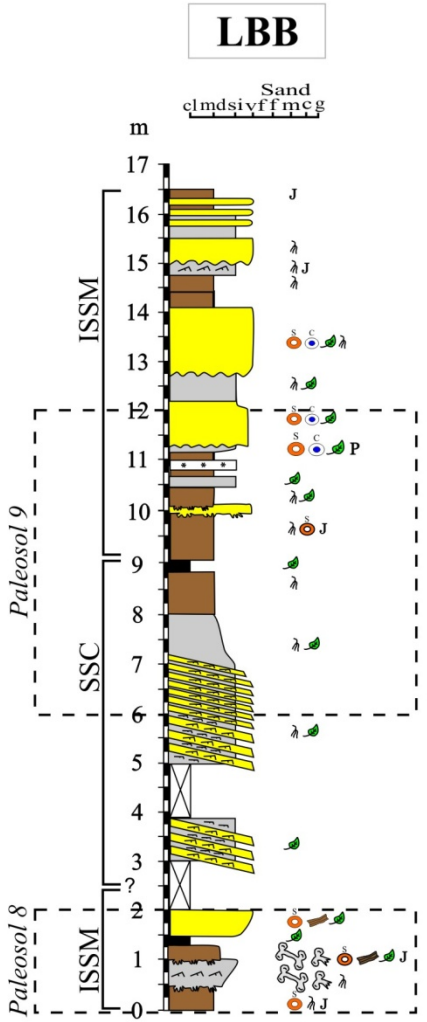
Floodplains

- Interbedded sands/muds
- Levees and crevasse splays
- Backswamps and wetlands
- Lakes
- Paleosols

Paleosols

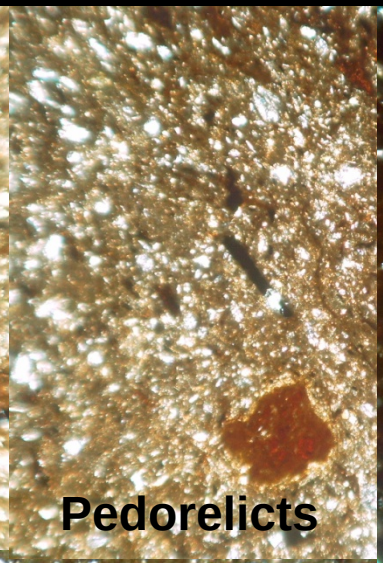

151° 30' W
LBB
Ocean Point
KIK
70° 00' N
70° 00' N
River
Kikiakrorak
River
Kogosukruk
River
Colville
06SH
NKT
mi
km
25
20
15
10
5
0
40
35
30
25
20
15
10
5
0
N
MN
22 1/2°
69° 30' N
69° 30' N
Anaktuvuk River
Chandler River
Umiat
Brooks Range
Measured stratigraphic section
PFDV17
Site designation
151° 30' W

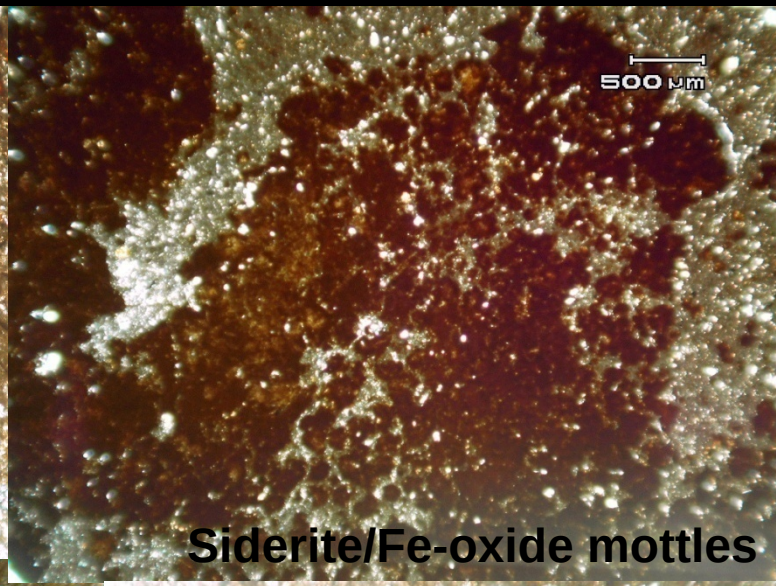

KRM
Sand
c l m d s i v f f m c g
m
ISSM
SLSC
ISSM
SSC
Paleosol 7
Paleosol 6


LBB
Sand
c l m d s i v f f m c g
m
ISSM
SSC
ISSM
Paleosol 9
Paleosol 8

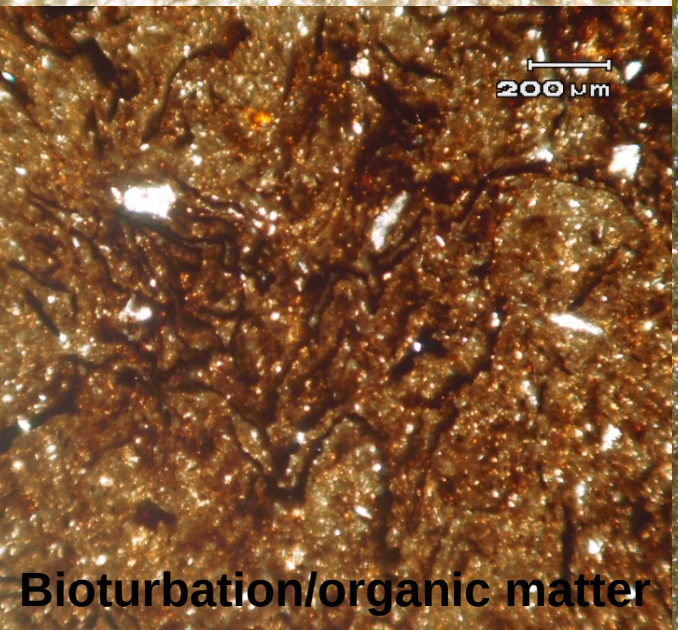
Micromorphology

Root traces

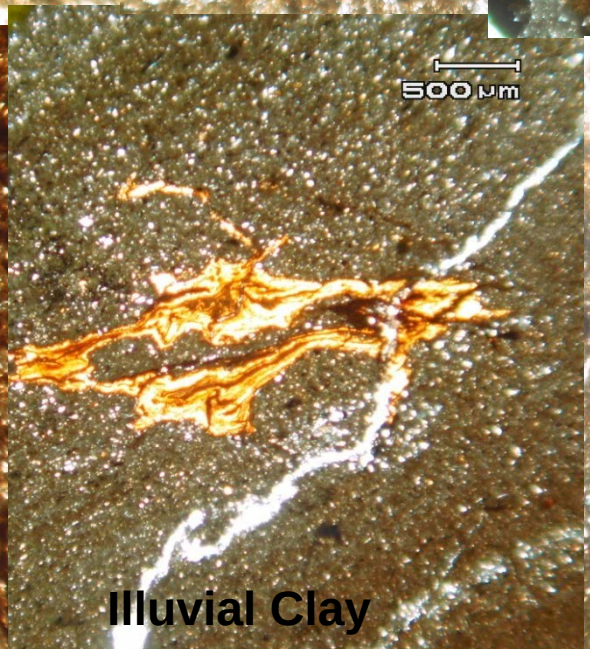

Pedorelicts



Siderite/Fe-oxide mottles



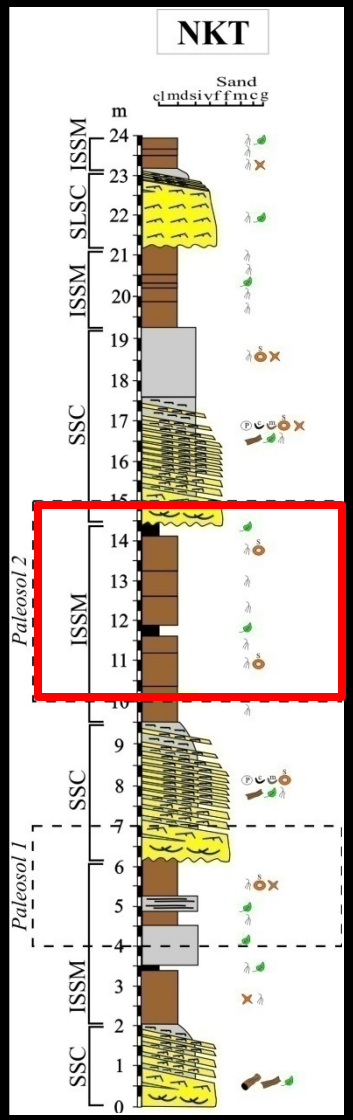
Bioturbation/organic matter

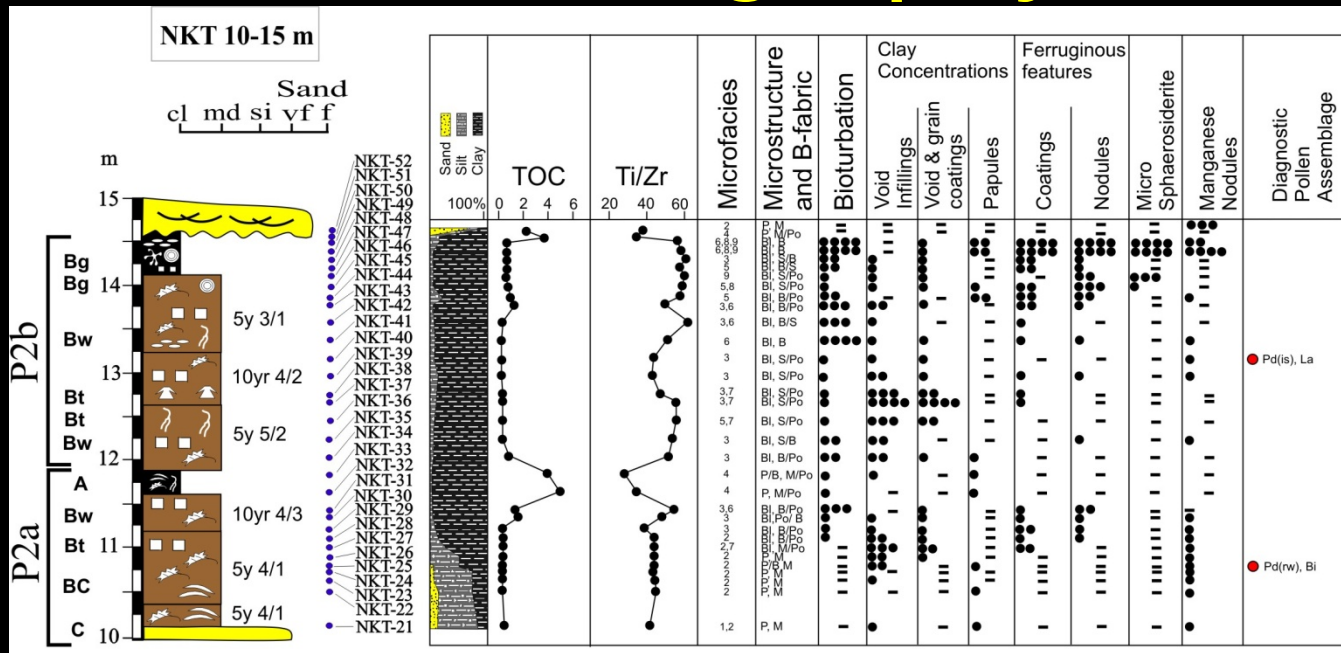


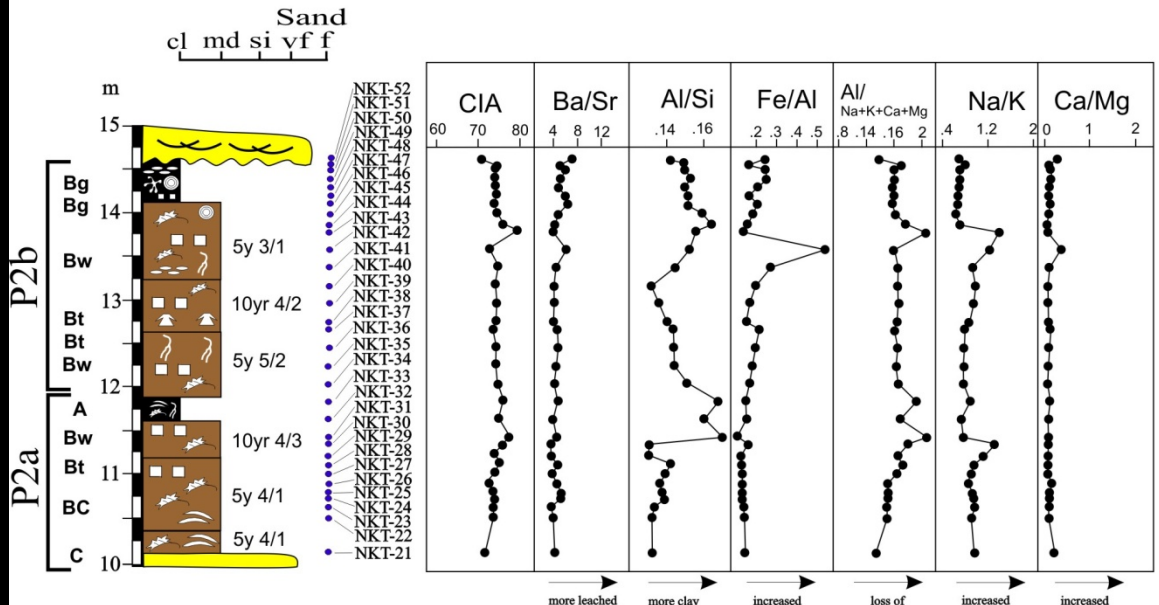
Illuvial Clay

Fe-oxide nodules

Paleosol Microstratigraphy







Paleosol Summary

- Compound/Complex and Cumulative soils
- Volcanic ash-charged alluvial parent material
- Unstable floodplains/frequent clastic influx
- Wet conditions but fluctuating water tables
- Periodic drying out of floodplains (seasonal?)
- Brackish influence at distal end of study area

Palynology

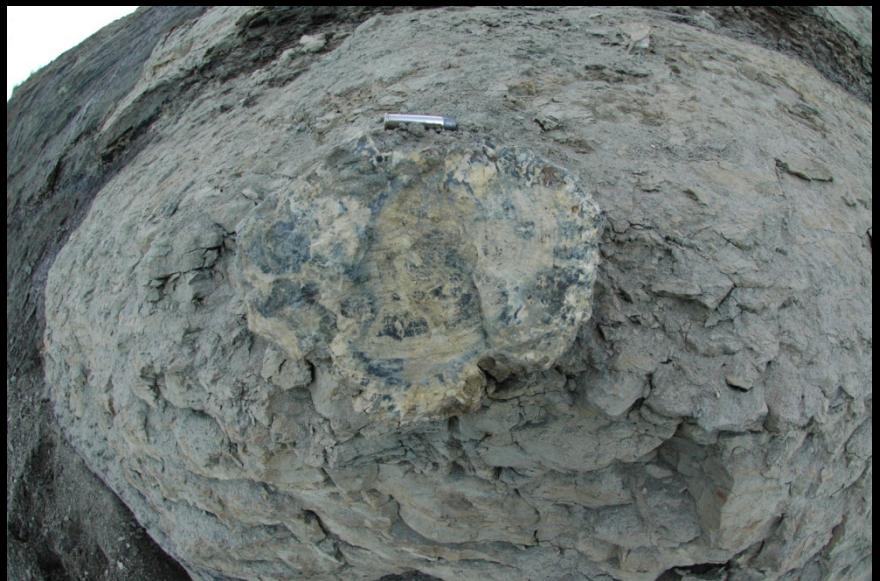
- Dominance of conifers and ferns suggests abundant wetlands
- Water levels probably fluctuated from shallow standing water to dry and subaerially exposed

		Sample[1]	Diagnostic Pollen/Dinoflagellates[2]	Background Average[3] (total count)	Sample[4] (total count)	Positive Deviation[5]	Palynofacies[6]
P7	KRM	KRM-27	*Bisaccate*	9	18	100%	Fluvial
			Peridinioid dinocysts (reworked)	Abundant			
P6	KRM	KRM-22	*Psilatriletes*	55	101	84%	Swamp/Mire
		KRM-16	*Aquilapollenites scabridus*	41	115	180%	Swamp/Mire
P5	06SH	06SH-16.8	*Peridinioid* dinocysts *(in situ)*	Abundant			Undiff. Lower Delta Plain
			Taxodiaceaepollenites	23	35	52%	
		06SH-14.8	*Pterospermella*	6	19	217%	Lacustrine
			Pediastrum	14	29	107%	
P4	06SH	06SH-9.2	*Psilatriletes*	43	68	58%	Swamp/Mire
		06SH-8.1	*Psilatriletes*	43	105	144%	Swamp/Mire
P3	06SH	06SH-3.6	*Bisaccate*	8	21	163%	Fluvial
			Peridinioid dinocysts (reworked)	Abundant			
			Taxodiaceaepollenites	23	44	91%	
		06SH-2.2	Fungal clusters	Abundant			Floodplain Paleosol
			Fungal hyphae	Abundant			
P2	NKT	NKT-40	*Peridinioid* dinocysts *(in situ)*	Present			Undiff. Lower Delta Plain
			Laevigatosporites	27	35	30%	
		NKT-25	*Peridinioid dinocysts (reworked)*	Abundant			Fluvial
			Bisaccate	18	45	150%	
P1	NKT	NKT-12	*Peridinioid* dinocysts *(in situ)*	Present			Overbank/ Swamp/Mire/ Lower Delta Plain
			Peridinioid dinocysts (reworked)	Present			
			Bisaccate	Abundant			
			Pediastrum	4	8	100%	
			Aquilapollenites scabridus	7	17	143%	
		NKT-7	*Peridinioid* dinocysts *(in situ)*	Present			Undiff. Lower Delta Plain
			Botryococcus braunii	37	90	143%	

1. Sample name
2. Type of diagnostic pollen/dinoflagellate found to be above the background average in the sample (Matthews and Lowe pers. comm.).
3. Background average is the arithmatic mean for all samples containing the diagnostic pollen in a measured section
4. Total count of diagnostic pollen found in sample
5. Deviation from the background average given as percent above the arithmatic mean
6. Palynofacies interpretation based on criteria described in the text

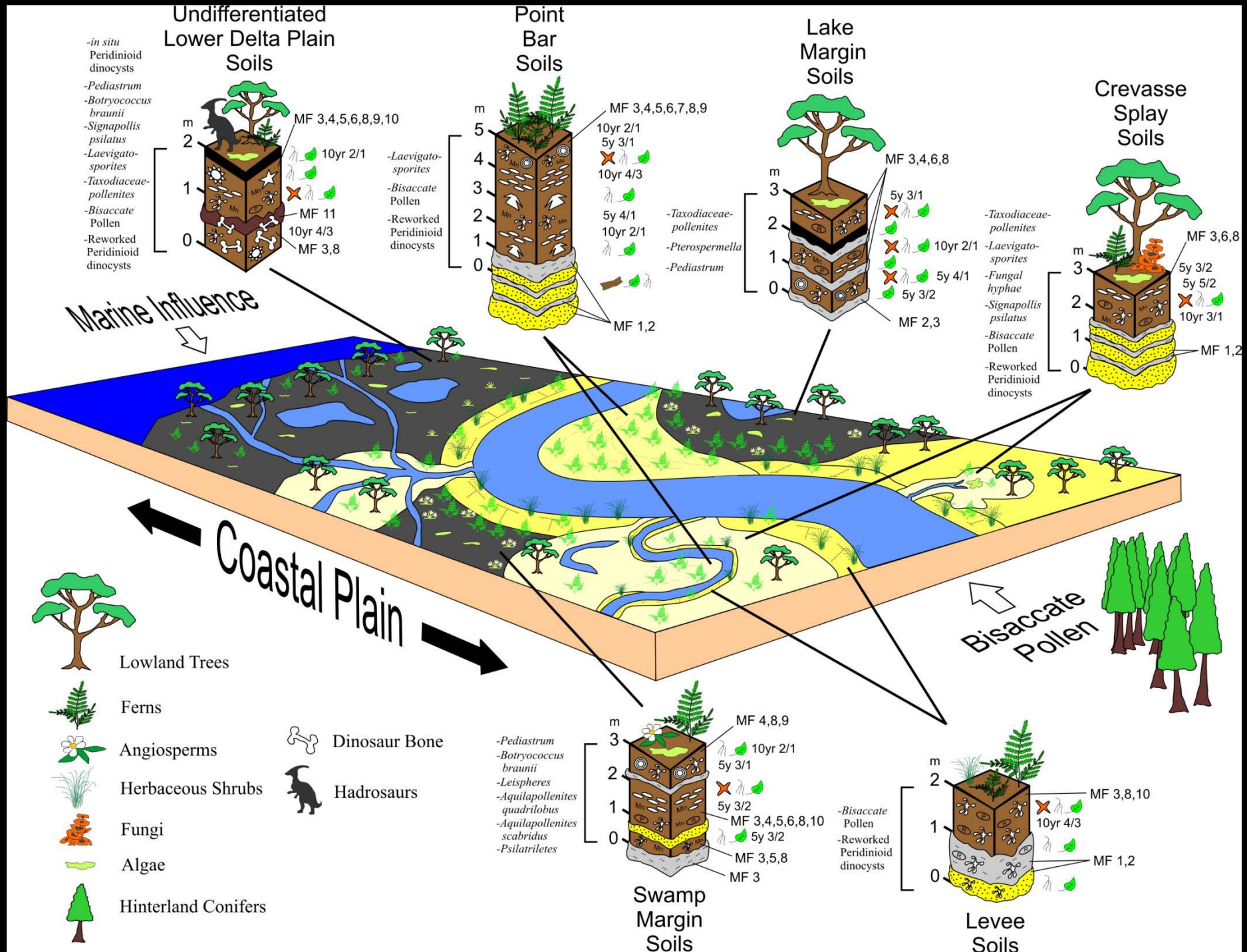
Macroflora

- Coals thinner, lower rank, higher ash content than earlier Cretaceous coals – dry or high sediment influx
- Charcoal relatively abundant – fires common
- Trees relatively small (max. diameter ~ 25 cm) -- dry or cold

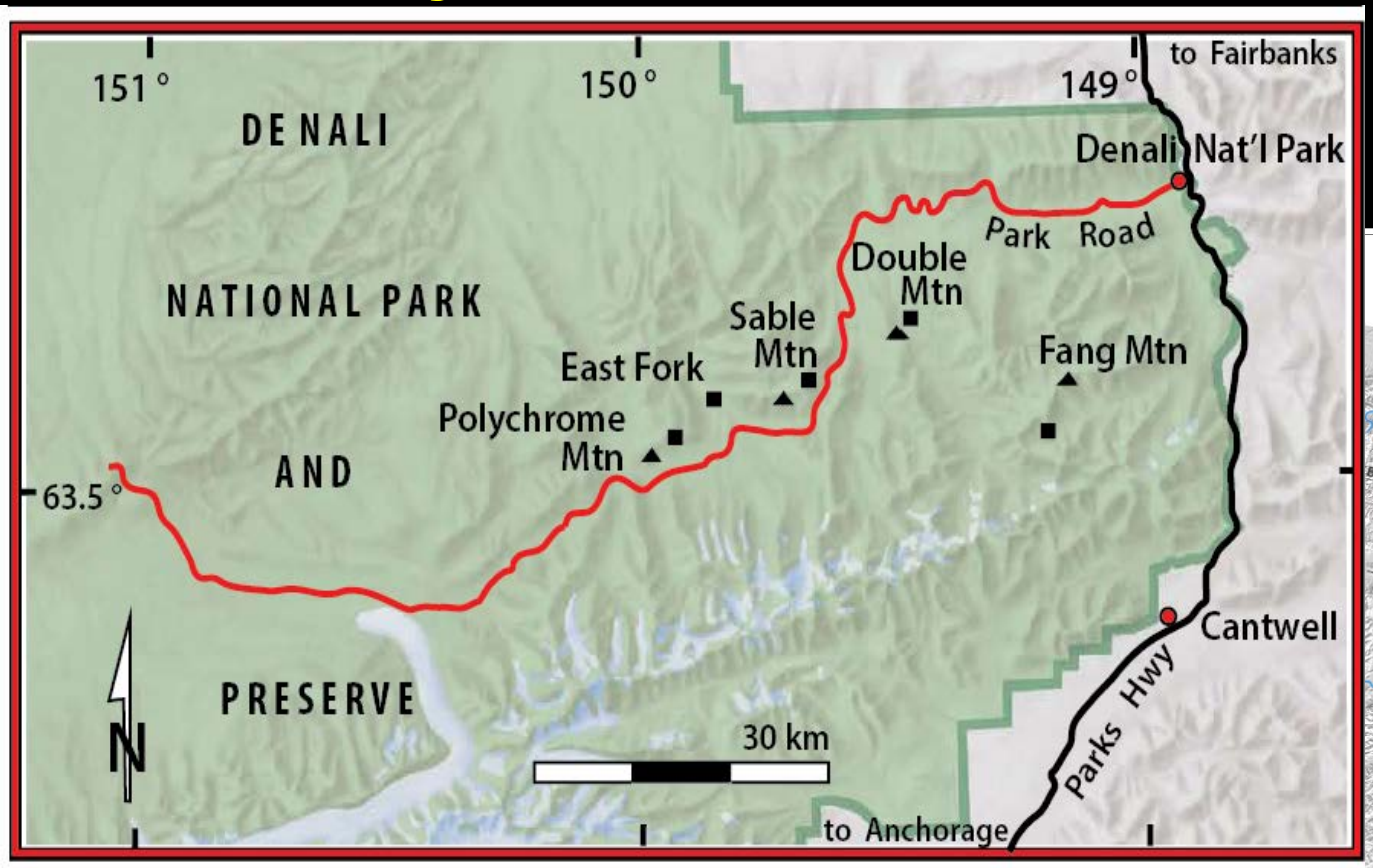


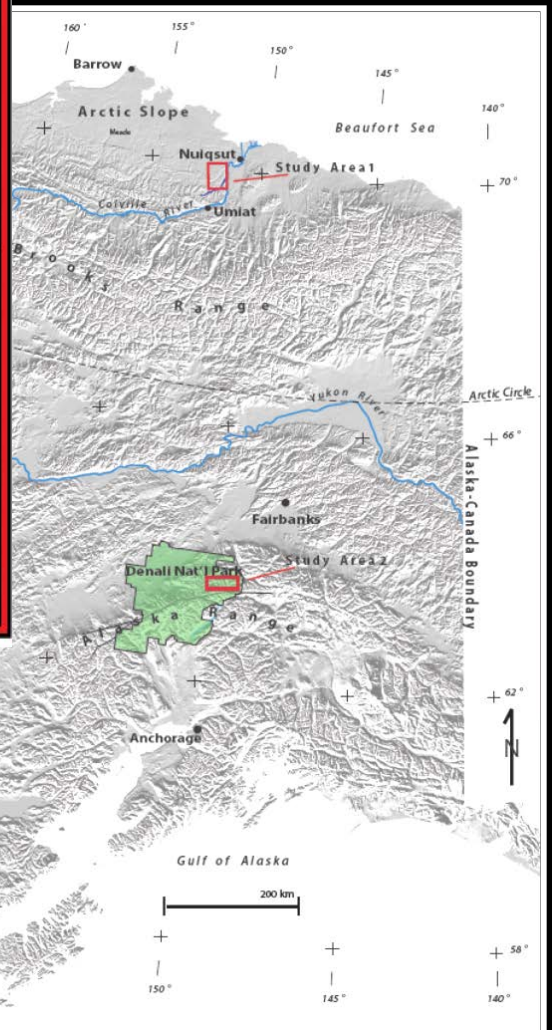
Prince Creek Formation Dinosaur Fauna

Edmontosaurus
Pachyrhinosaurus
Troodon
tyrannosaur


Undifferentiated Lower Delta Plain Soils
-in situ Peridinioid dinocysts
-Pediastrum
-Botryococcus braunii
-Signapollis psilatus
-Laevigato-sporites
-Taxodiaceae-pollenites
-Bisaccate Pollen
-Reworked Peridinioid dinocysts
m
2
1
0
MF 3,4,5,6,8,9,10
10yr 2/1
MF 11
10yr 4/3
MF 3,8
Point Bar Soils
-Laevigato-sporites
-Bisaccate Pollen
-Reworked Peridinioid dinocysts
m
5
4
3
2
1
0
MF 3,4,5,6,7,8,9
10yr 2/1
5y 3/1
10yr 4/3
5y 4/1
10yr 2/1
MF 1,2
Lake Margin Soils
-Taxodiaceae-pollenites
-Pterospermella
-Pediastrum
m
3
2
1
0
MF 3,4,6,8
5y 3/1
10yr 2/1
5y 4/1
5y 3/2
MF 2,3
Crevasse Splay Soils
-Taxodiaceae-pollenites
-Laevigato-sporites
-Fungal hyphae
-Signapollis psilatus
-Bisaccate Pollen
-Reworked Peridinioid dinocysts
m
3
2
1
0
MF 3,6,8
5y 3/2
5y 5/2
10yr 3/1
MF 1,2
Marine Influence
Coastal Plain
Bisaccate Pollen
Lowland Trees
Ferns
Angiosperms
Herbaceous Shrubs
Fungi
Algae
Hinterland Conifers
Dinosaur Bone
Hadrosaurs
-Pediastrum
-Botryococcus braunii
-Leispheres
-Aquilapollenites quadrilobus
-Aquilapollenites scabridus
-Psilatriletes
m
3
2
1
0
MF 4,8,9
10yr 2/1
5y 3/1
5y 3/2
MF 3,4,5,6,8,10
5y 3/2
MF 3,5,8
MF 3
Swamp Margin Soils
-Bisaccate Pollen
-Reworked Peridinioid dinocysts
m
2
1
0
MF 3,8,10
10yr 4/3
MF 1,2
Levee Soils

Study Area – L. Cantwell Fm.



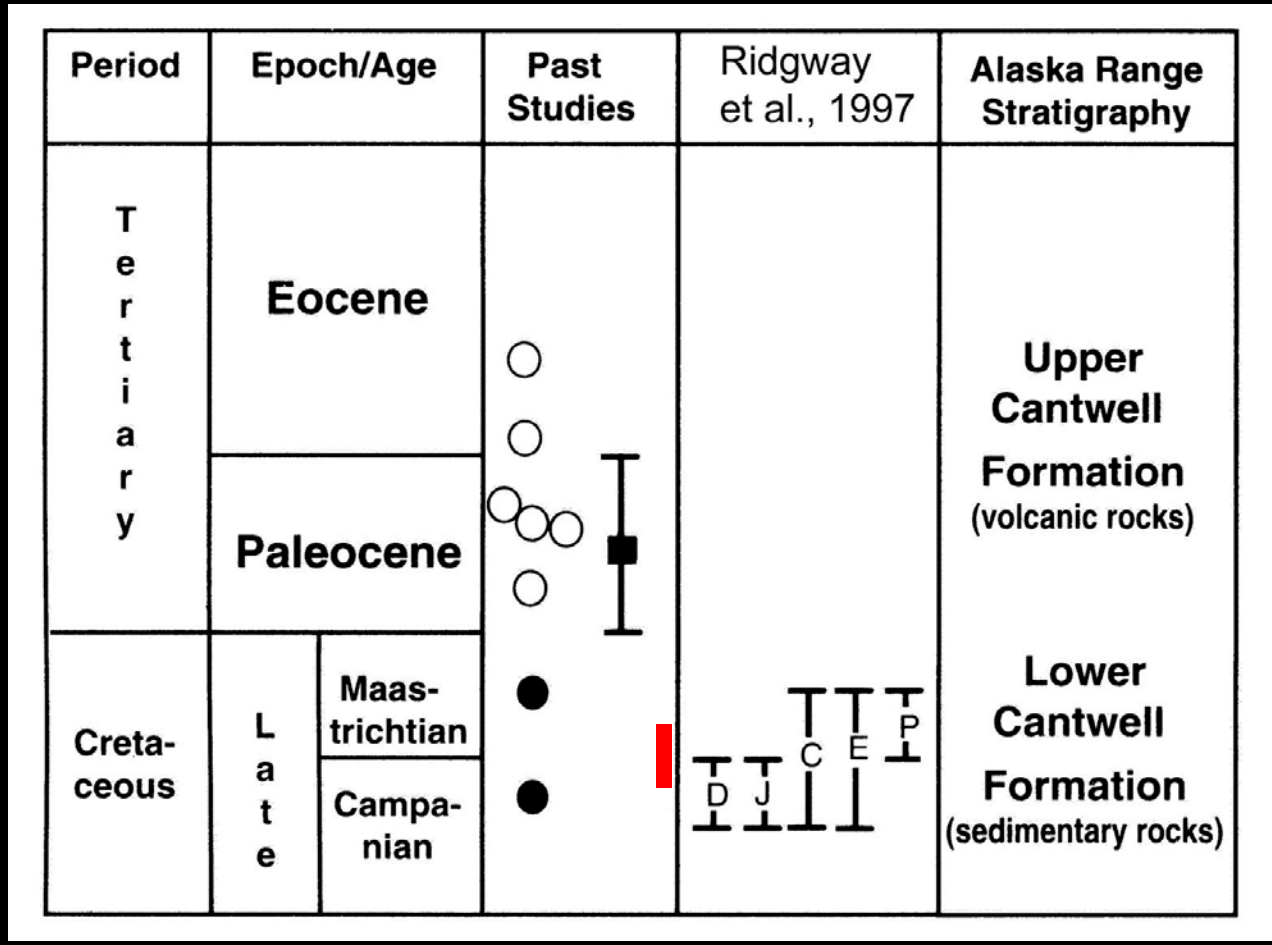


Stratigraphy

East Fork – 69.5+/-0.7 Ma

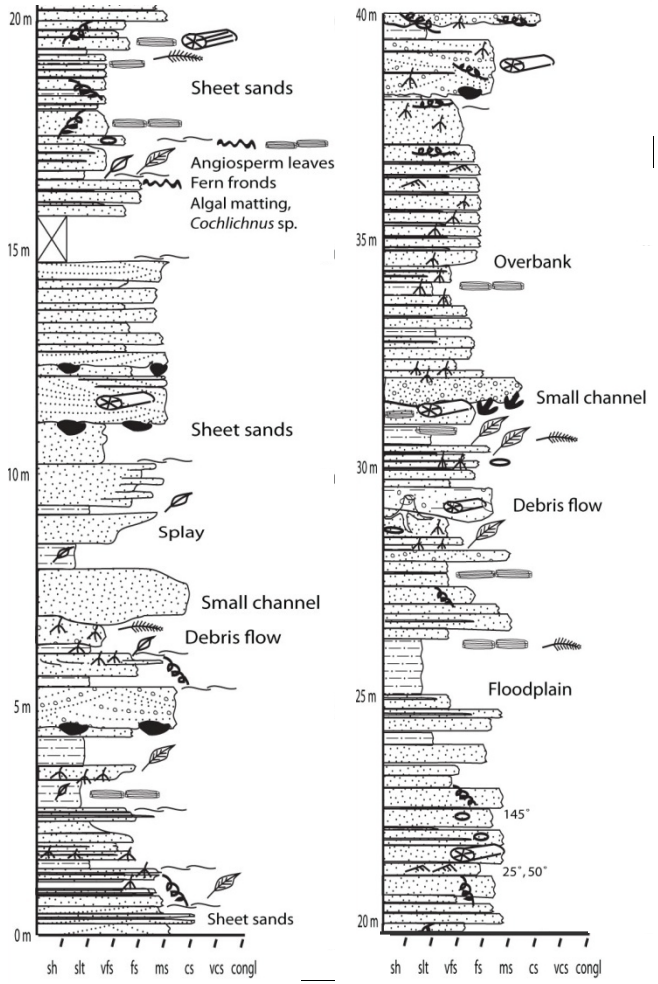
Tattler 1 – 71.5+/-0.9 Ma

Tattler 2 – 71.0+/-1.1 Ma

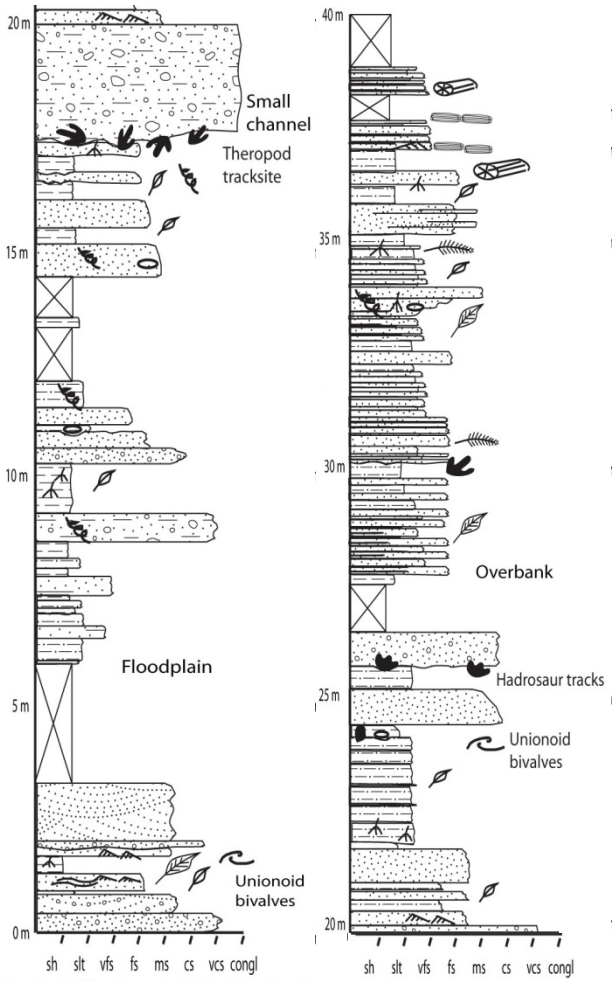


After Ridgway et al., 1997

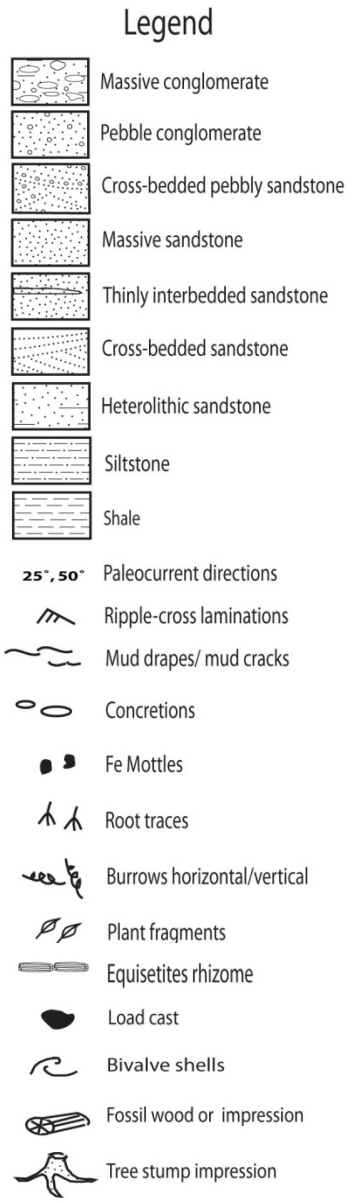
Sedimentary Environments



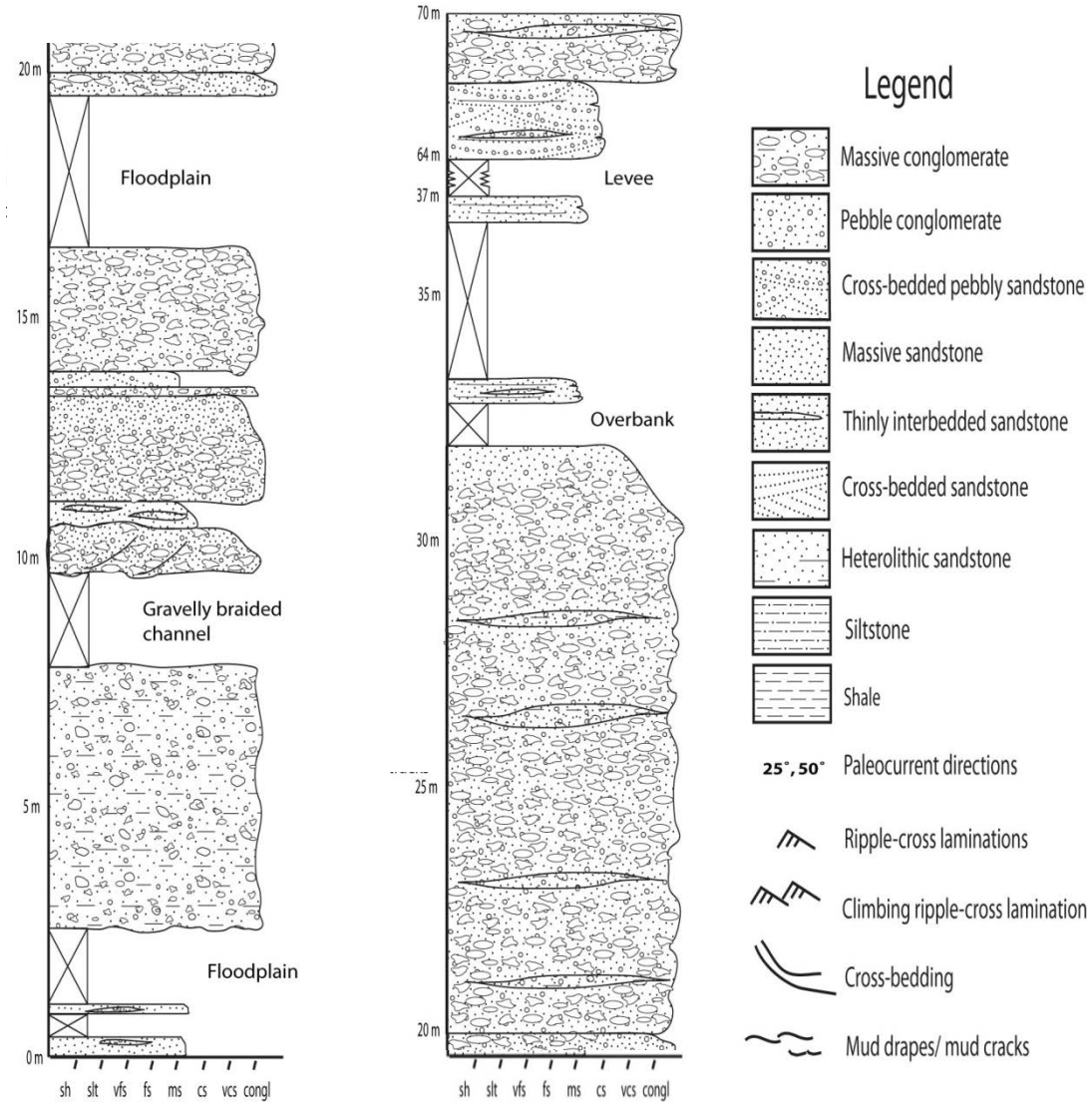
Sable Mtn. – south side



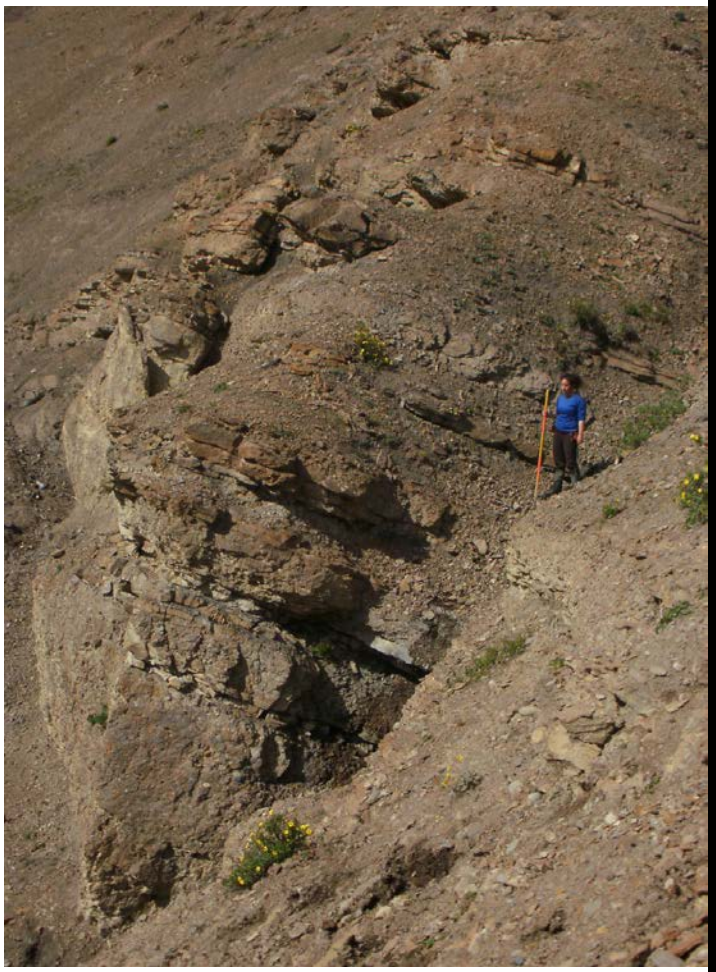
Sable Mtn. / Tattler Creek



Sedimentary Environments



Polychrome Mtn.



Conglomerate – gravel braided channel

Large Channels

6 m-thick tabular cross-bedded sand and gravel – braided trunk channel

Small channels, floodplains, lakes

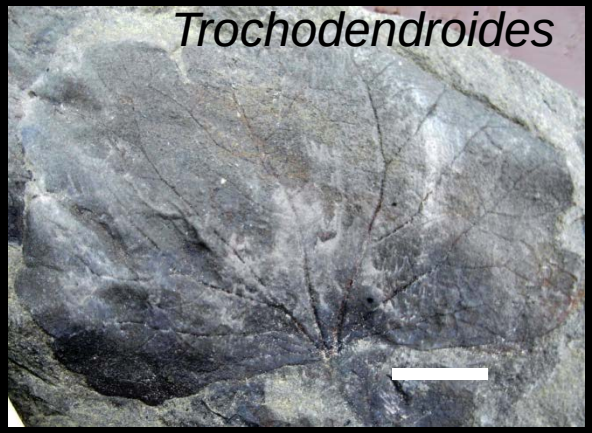
1-2 m-thick channel sandstones with tabular interbedded sandstones & mudstones – crevasse channels, splays, floodplain, swamp and lacustrine deposition

Interbedded tabular conglomerate sandstone & mudstone

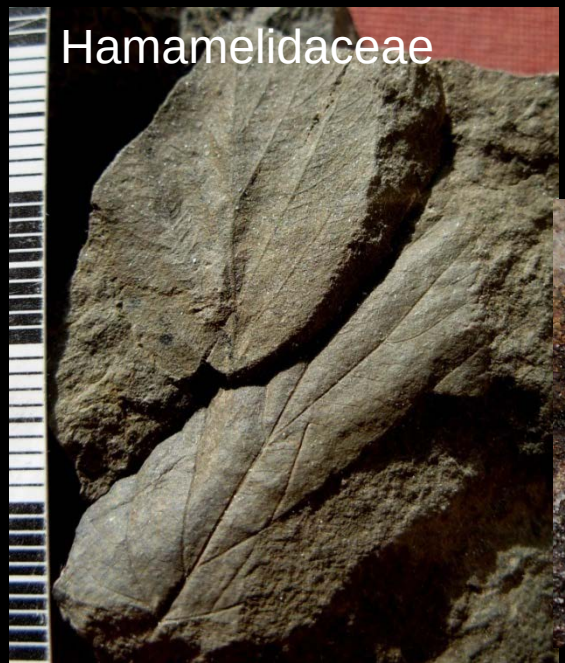
Small distributary channels and sheetflood deposits

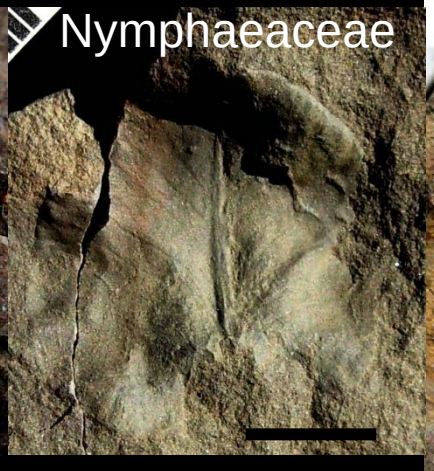
Breccia and Matrix-supported conglomerate

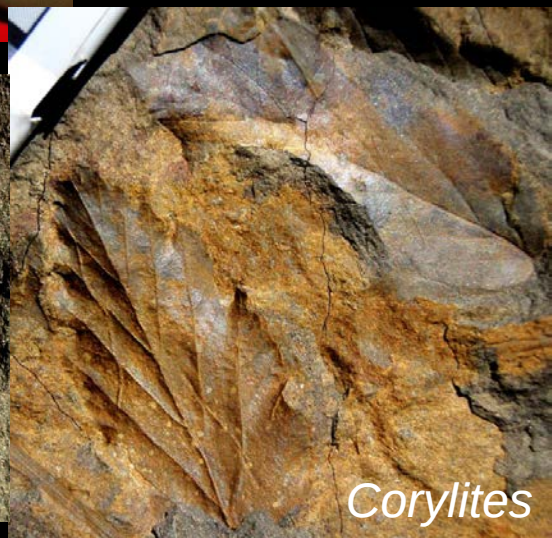
Angiosperm leaves and seeds



Scale bars are 1cm.







Gymnosperm plant fossils


Lithified wood


Torreya seeds


Metasequoia


Pinaceous seed cone. *Picea?*


Sequoia shoots

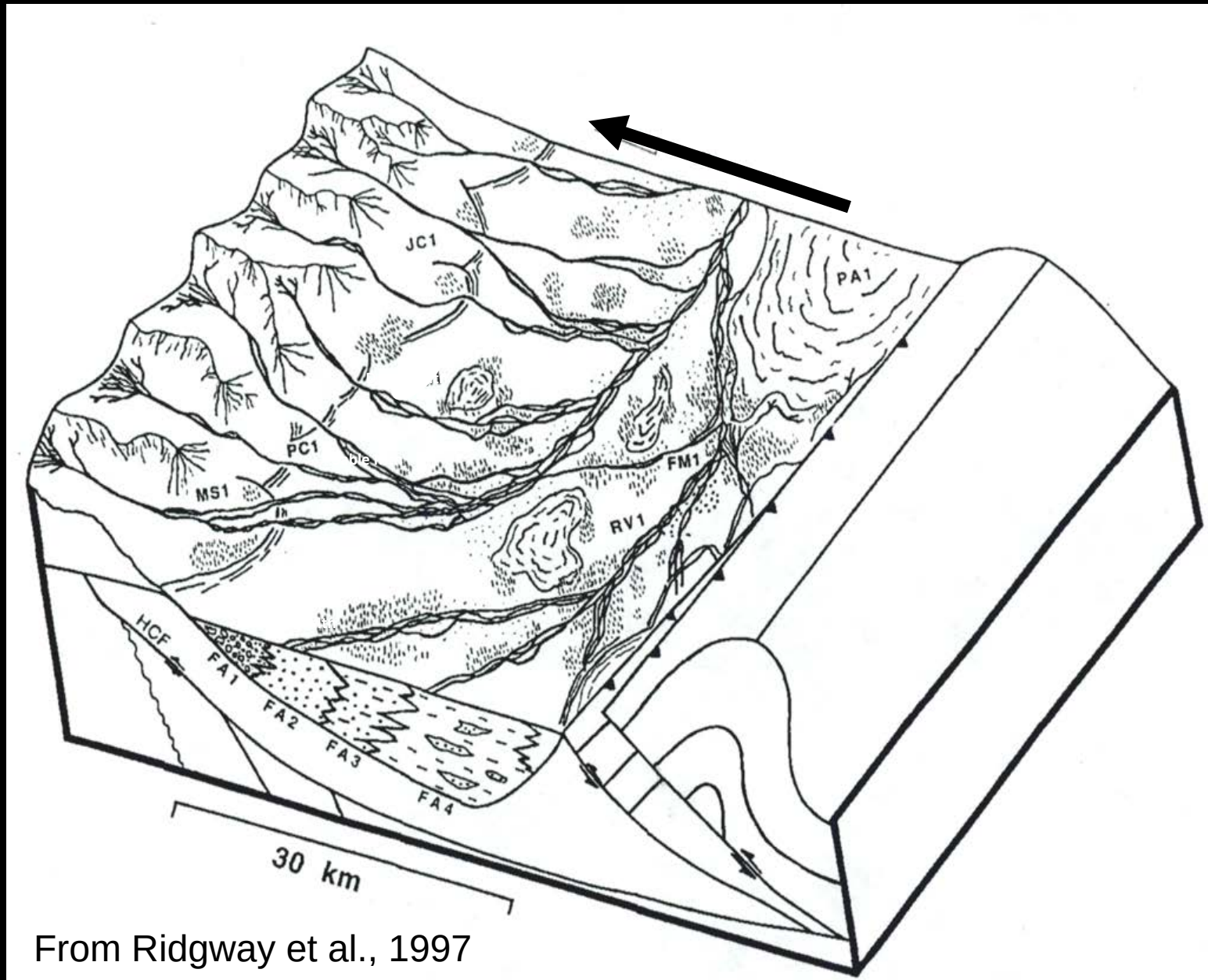
Cantwell Dinosaur Fauna

Edmontosaurus
Pachyrhinosaurus
Troodon
tyrannosaur

Cantwell Dinosaur (and others) Fauna

Pterosaurs
Birds
Therizinosaurs
Ankylosaurs

Cantwell Depositional Environments



From Ridgway et al., 1997

Paleoclimate

Temperature (°C)

	MAT	WMMT	CMMT	
Prince Creek Fm.	5-6	10-12	2-4	(Spicer & Parrish, 1990)
	6.7+/- 2.2	n/a	na	(Spicer & Herman, 2010)
	12 +/-2.2	n/a	n/a	(paleosol geochem. – Salazar, unpub.)
L. Cantwell Fm.	7.4 +/-2.4	17 +/-3.2	-2 +/-3.8	(CLAMP – Tomsich et al., 2010)
	4.4 +/-2.2	n/a	n/a	(LMA – Tomsich, unpub.)

Paleoclimate

Precipitation (mm/yr)

	MAP	3WM	3DM	
Prince Creek Fm.	1427+/-253	n/a	n/a	(C stable isotopes – Salazar, unpub.)
	745+/- 256	n/a	na	(C stable isotopes - Salazar, unpub.)
	1254 +/-181	n/a	n/a	(paleosol geochem. – Salazar, unpub.)
L. Cantwell Fm.	230 +/-670	177 +/-282	141+/-186	(CLAMP – Tomsich et al., 2010)
	530 +/-233	n/a	n/a	(C stable isotopes – Salazar, unpub.)

Conclusions

Prince Creek Formation

- 75-85 N paleolatitude
- Alluvial /coastal plain
- Wet & dry (seasonal?)
- Abundant vegetation
- Diverse dinosaur fauna
- Cool temperate/humid
- Warmer & wetter

L. Cantwell Formation

- 65-75 N paleolatitude
- Alluvial fan/alluvial plain
- Wet (high water table?)
- Abundant vegetation
- Diverse dinosaurs & birds
- Cool temperate/subhumid
- Greater temp. range/drier

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