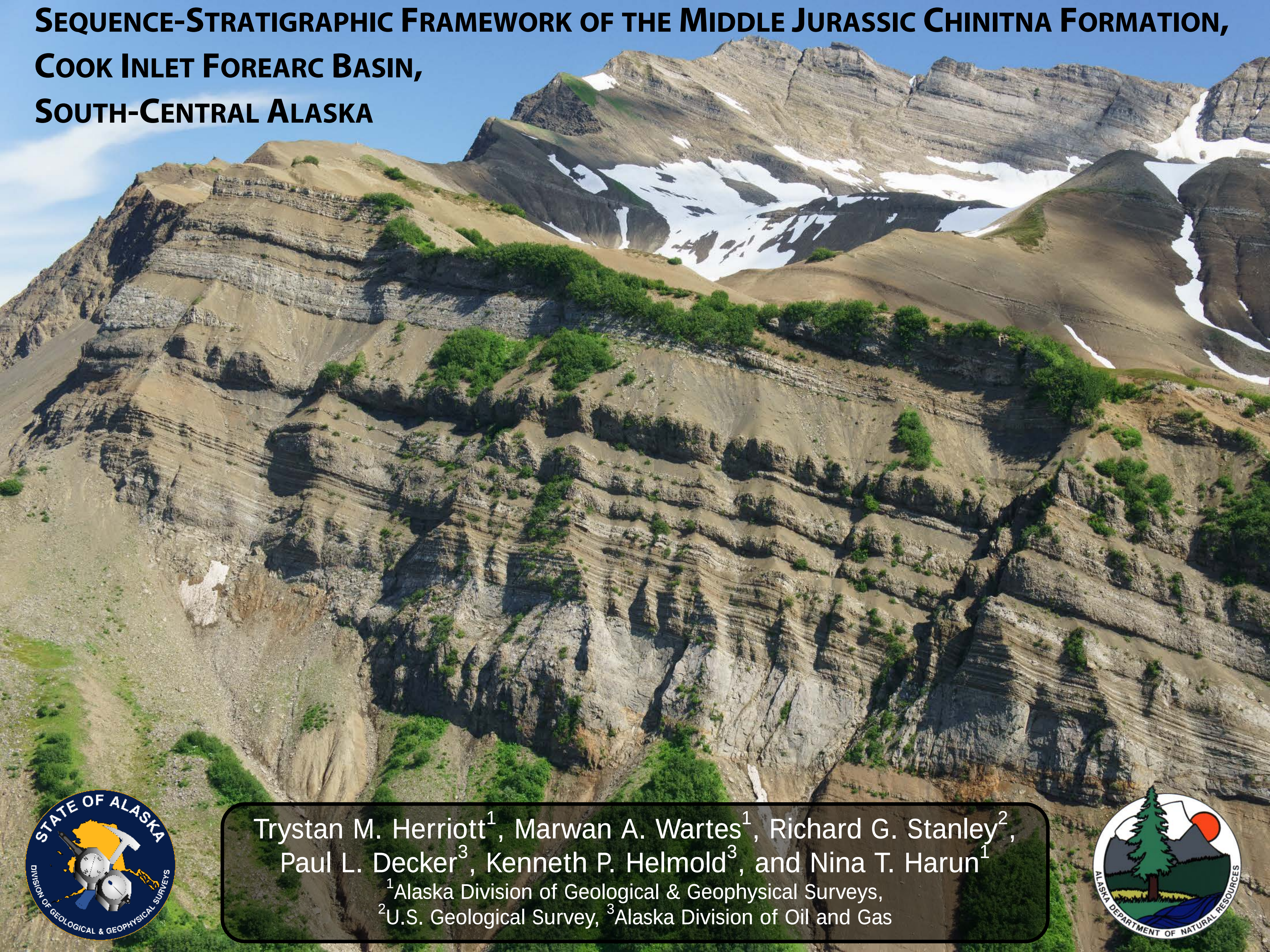
Sequence-Stratigraphic Framework of the Middle Jurassic Chinitna Formation, Cook Inlet Forearc Basin, South-Central Alaska



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Abstract

The Chinitna Formation is the latest Middle Jurassic forearc basin record of the Talkeetna oceanic island arc. Recent work along the arc-proximal Iniskin Bay–Tuxedni Bay outcrop trend on the northwest side of lower Cook Inlet provides new insights into the Chinitna, which comprises the Tonnie Siltstone (Bathonian–Callovian) and Paveloff Siltstone (Callovian) Members. Outcrop-based observations, process–response sedimentology, 1:63,360-scale geologic mapping, and architectural analysis of mountain-scale exposures are the foundation of a sequence-stratigraphic interpretation for the Chinitna, which lies between the Middle Jurassic Tuxedni Group and Upper Jurassic Naknek Formation.

The Chinitna in outcrop is commonly ca. 700 m thick, with each member representing approximately half of this total thickness. Successions of bioturbated siltstone with subordinate, sharp-based, graded sandstone are common in the middle and upper parts of each member. Abundant fossils (e.g., ammonites, pelecypods, belemnites), discrete trace fossils (e.g., *Thalassinoides*, *Planolites*, *Phycosiphon*), and woody debris are present in these lithostratigraphically characteristic exposures of the Chinitna. These observations suggest that mud-prone sedimentation was intermittently punctuated by higher energy sediment gravity flow events that transported sand to shelfal environments, including prodelta settings. However, thick, coarse-grained basal successions in each member impart prominent member-scale stratigraphic cyclicity to the Chinitna. These basal units principally comprise tabular-bedded and channelized sandstone and conglomerate that sharply overlie surfaces varying from planar to exhibiting several tens of meters of erosional relief. We also observe convolute stratification and very thick, texturally structureless beds and infer that the basal successions record deposition in high energy deltaic and associated shoreline-proximal settings.

The Tonnie and Paveloff are each interpreted as third-order (i.e., 10^6 years duration) stratigraphic sequences. The coarse-grained basal units are regressive deposits of lowstand systems tracts (LSTs) that mark base-level fall and early rise associated with onset of each cycle. Overlying, fine-grained, fining-upward successions in each member reflect waning deltaic influences as near-shore environments were transgressed by landward/northwestward-shifting shorelines of transgressive systems tracts (TSTs) during continued base-level rise, transitioning into mud-prone shelfal settings. TST deposits are overlain by coarsening- and thickening-upward successions in the upper parts of each member, recording normal regressions of highstand systems tracts (HSTs) as probable clinoforms of delta- to slope-scale relief prograded basinward/southeastward during later stages of base-level rise. Each Chinitna member HST was terminated by base-level fall associated with establishment of an overlying sequence boundary.

This sequence-stratigraphic interpretation delineates timing for transport of coarse, LST detritus into the basin, which bears on the potential distribution of hydrocarbon reservoir facies in the underexplored Jurassic stratigraphy. We also discovered oil-stained outcrops in the Chinitna—one in each of the two LSTs—neither of which are associated with outcrop-scale fractures, suggesting that the migrated oils occur in intergranular porosity. Furthermore, the size and context of the Tonnie Siltstone Member LST oil-stained locality provides a potential outcrop analogue for a stratigraphically trapped conventional hydrocarbon accumulation of oil field scale. These outcrop-based insights are positive indications for continued exploration in Cook Inlet, further challenging the paradigm that Mesozoic units have low potential as conventional oil and gas reservoirs.

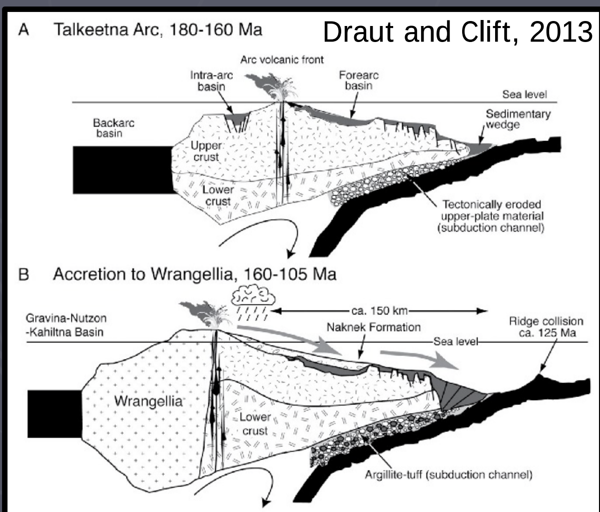
*Authors' note: these slides were presented at the Alaska Geological Society monthly luncheon on 20 March 2018, as well as at the University of Alaska Fairbanks Department of Geosciences Friday seminar on 1 December 2017. Abstract also available at: http://www.alaskageology.org/newsletters.html (see March 2018)

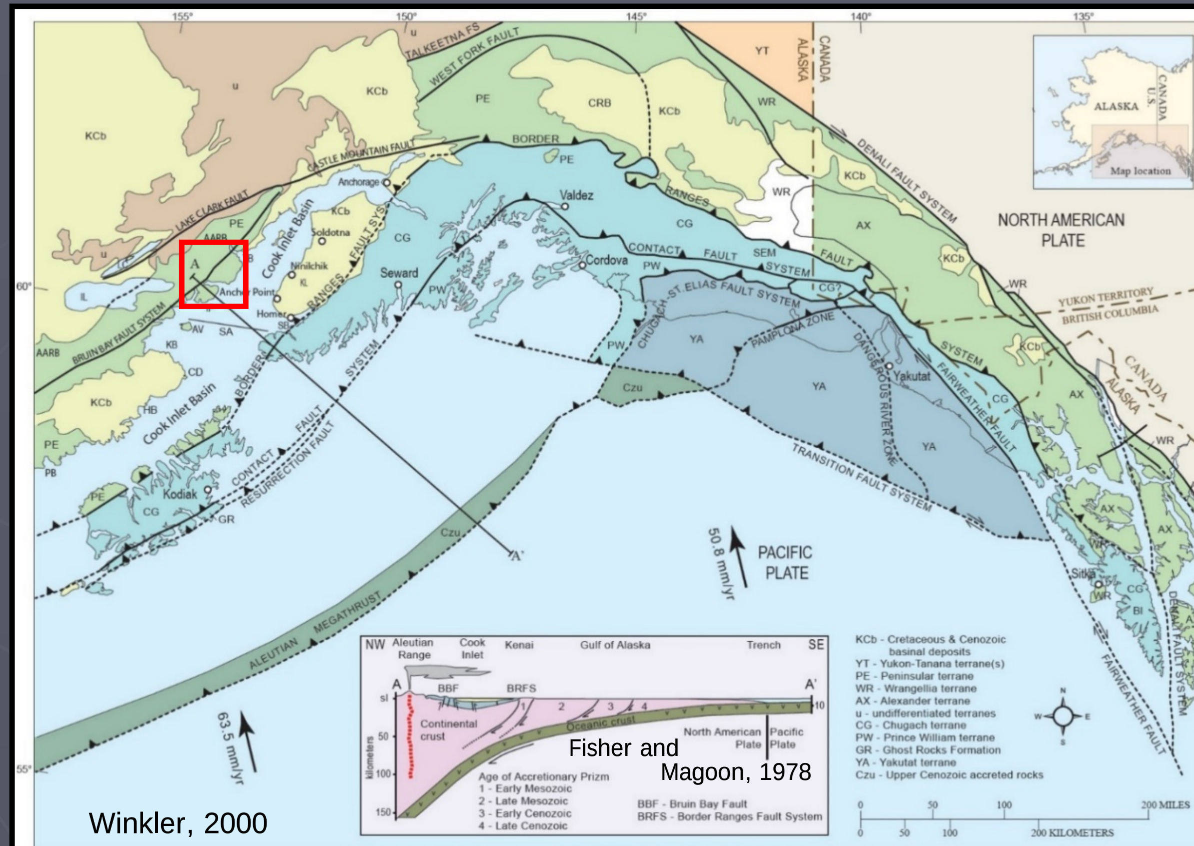
Presentation Outline

- Geologic Setting—Cook Inlet Forearc Basin
- Chinitna Formation—Stratigraphic Overview
- Sedimentologic Character of Typical Chinitna
  - Observations and process–response studies
  - Depositional environment interpretations
- Stratigraphic Character of Basal Successions
  - Observations and photogeologic mapping
  - Depositional environment interpretations, again
- Stratigraphic Architecture of the Chinitna
- Sequence-Stratigraphic Framework of the Chinitna
  - Surfaces, systems tracts, and sequences
  - Depositional environments, once again
- Petroleum Systems Context, Oil-stained Outcrops, and Reservoir Quality Considerations
- Summary and Conclusions

Geologic Setting—Cook Inlet Forearc Basin

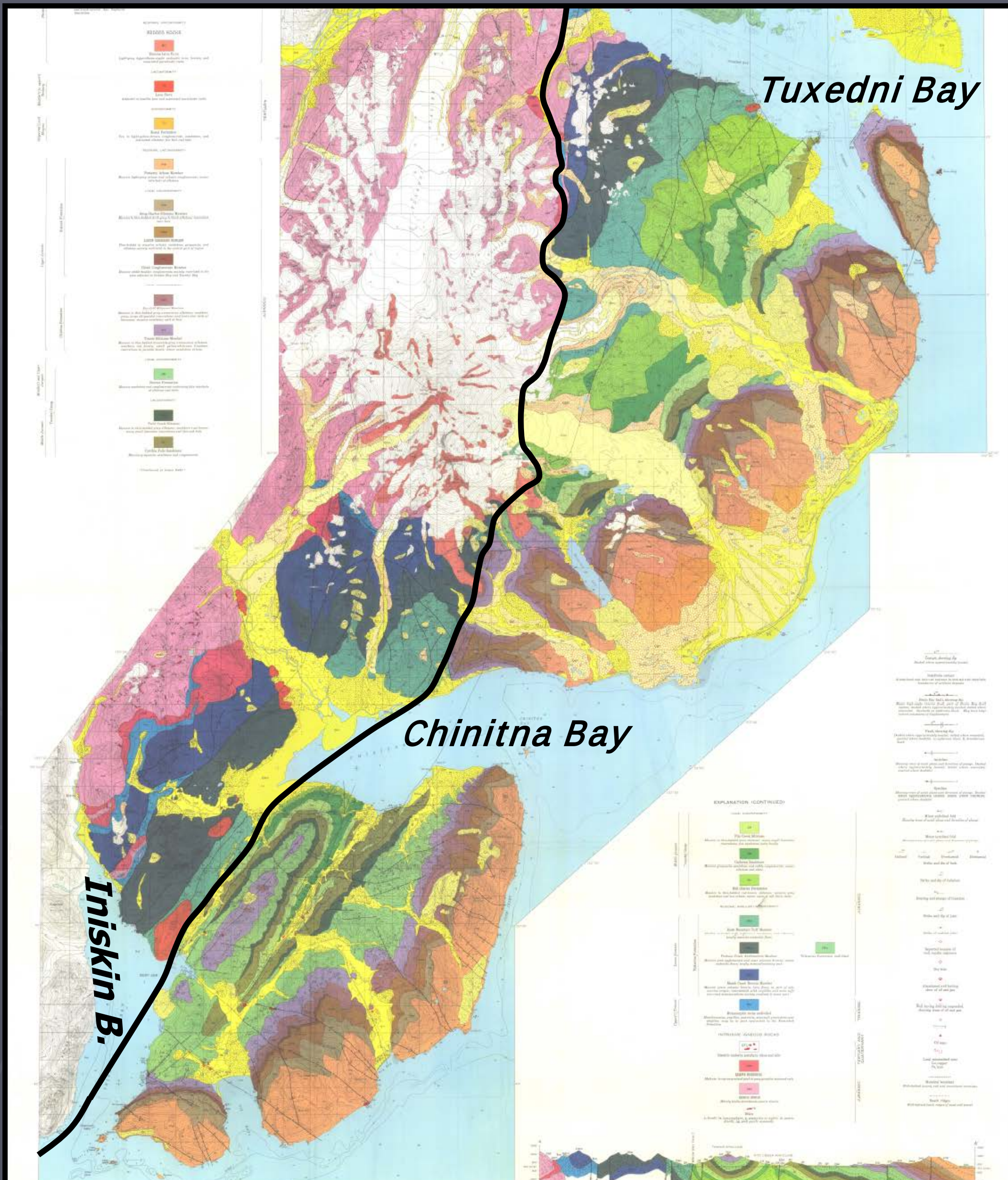
- Arc–forearc–accretionary wedge
- Cook Inlet forearc basin between BBFS and BRFS
  - Nearly 200 m.y. history
- Jurassic Talkeetna oceanic island arc coupled to Cook Inlet forearc (e.g., Clift et al., 2005)



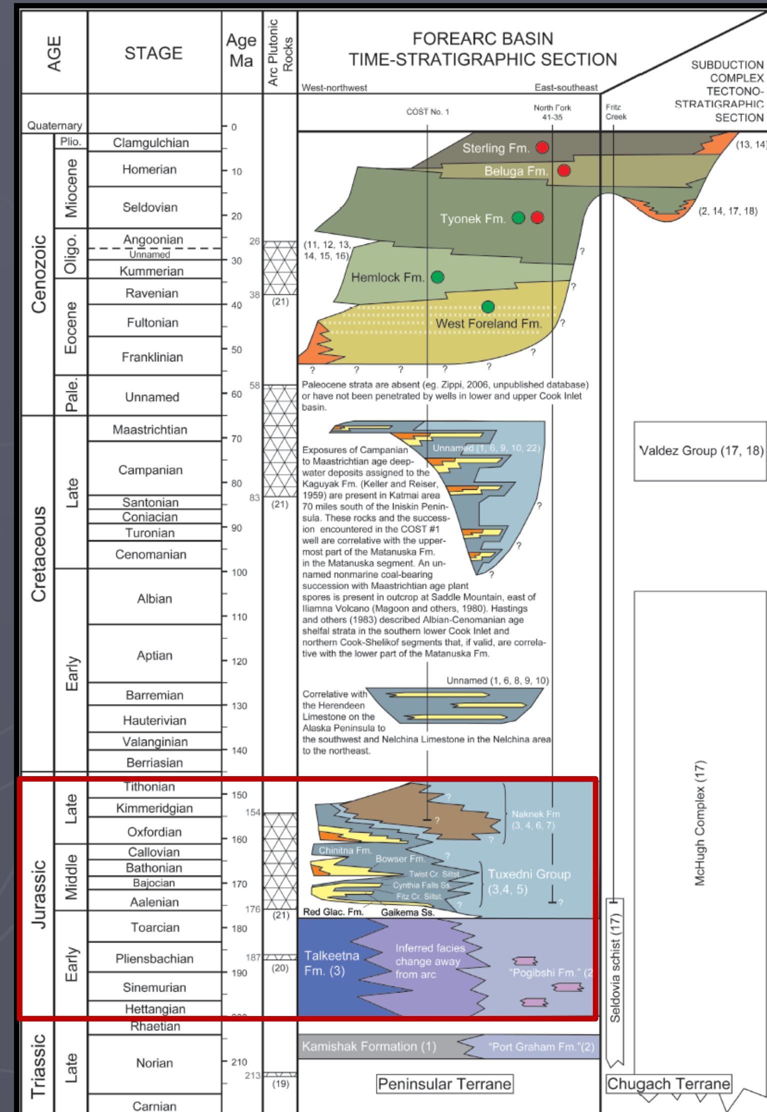


- Jurassic stratigraphy exposed in Iniskin–Tuxedni bays area:
  - Naknek Formation
  - Chinitna Formation
  - Tuxedni Group
  - Talkeetna Formation

Iniskin–Tuxedni Bays Region: Study Area

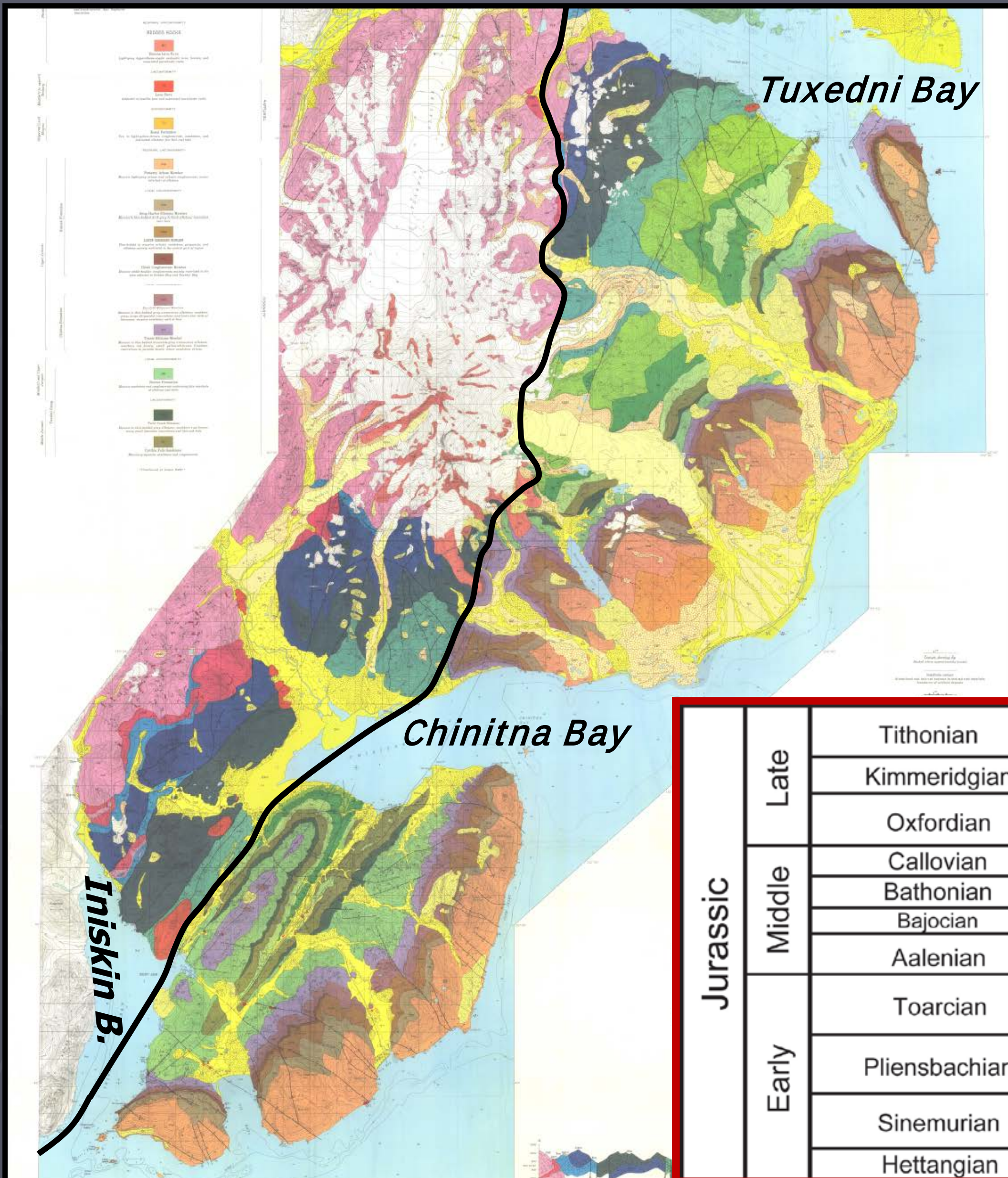


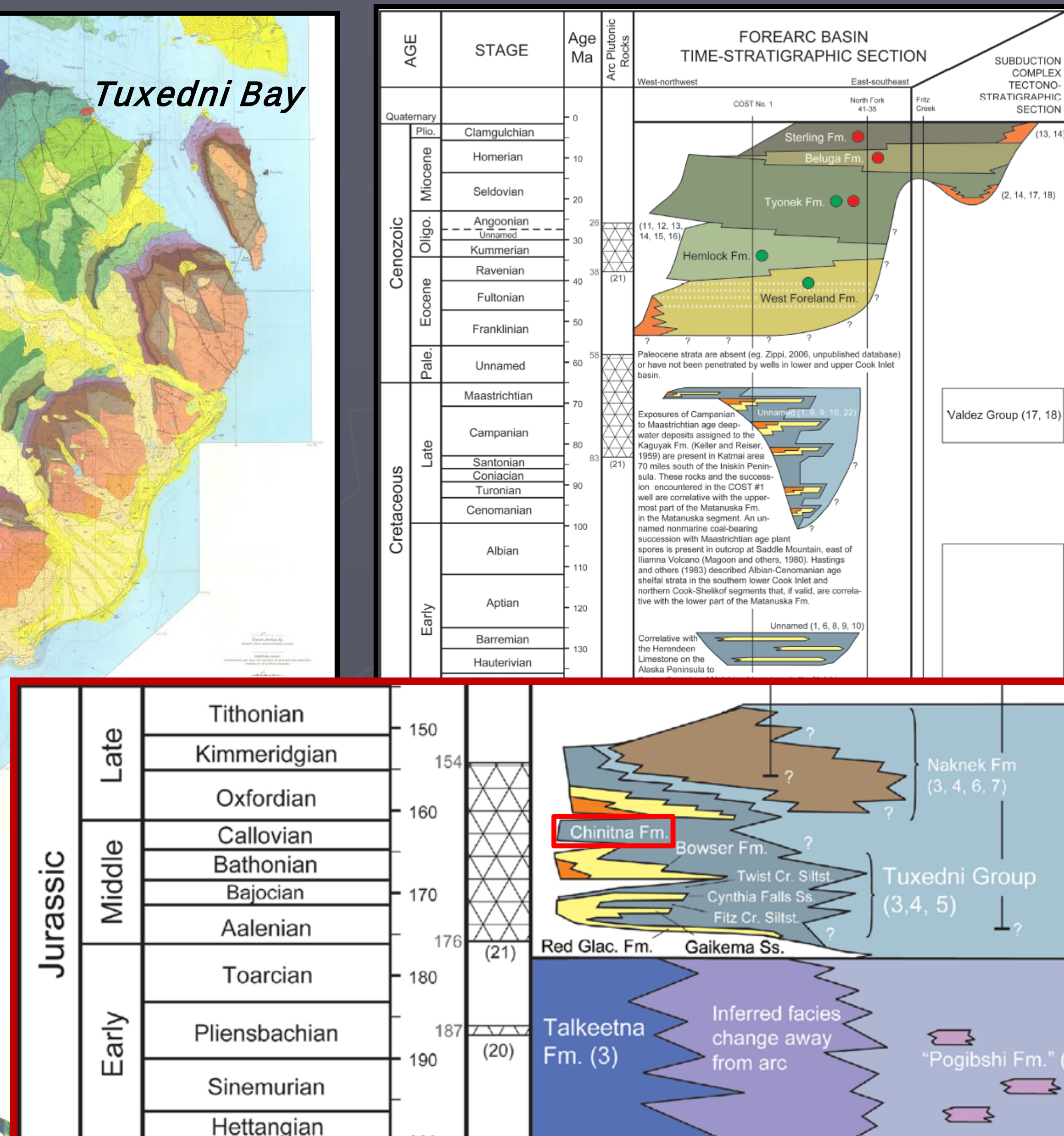
Detterman and Hartsock, 1966



LePain et al., 2013

Iniskin–Tuxedni Bays Region: Study Area





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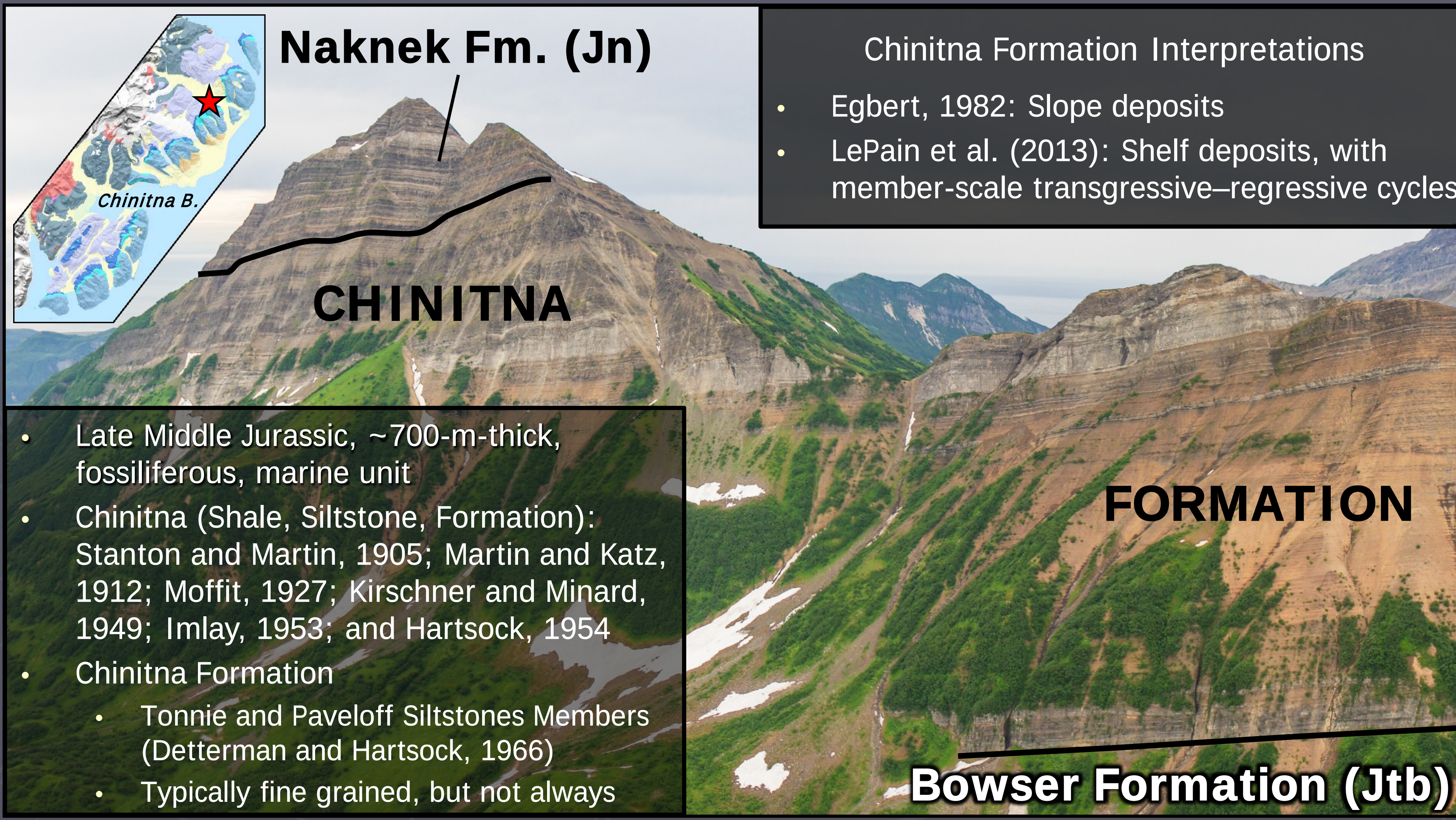
Chinitna Formation—Stratigraphic Overview

Triangle Peak Reference Exposure



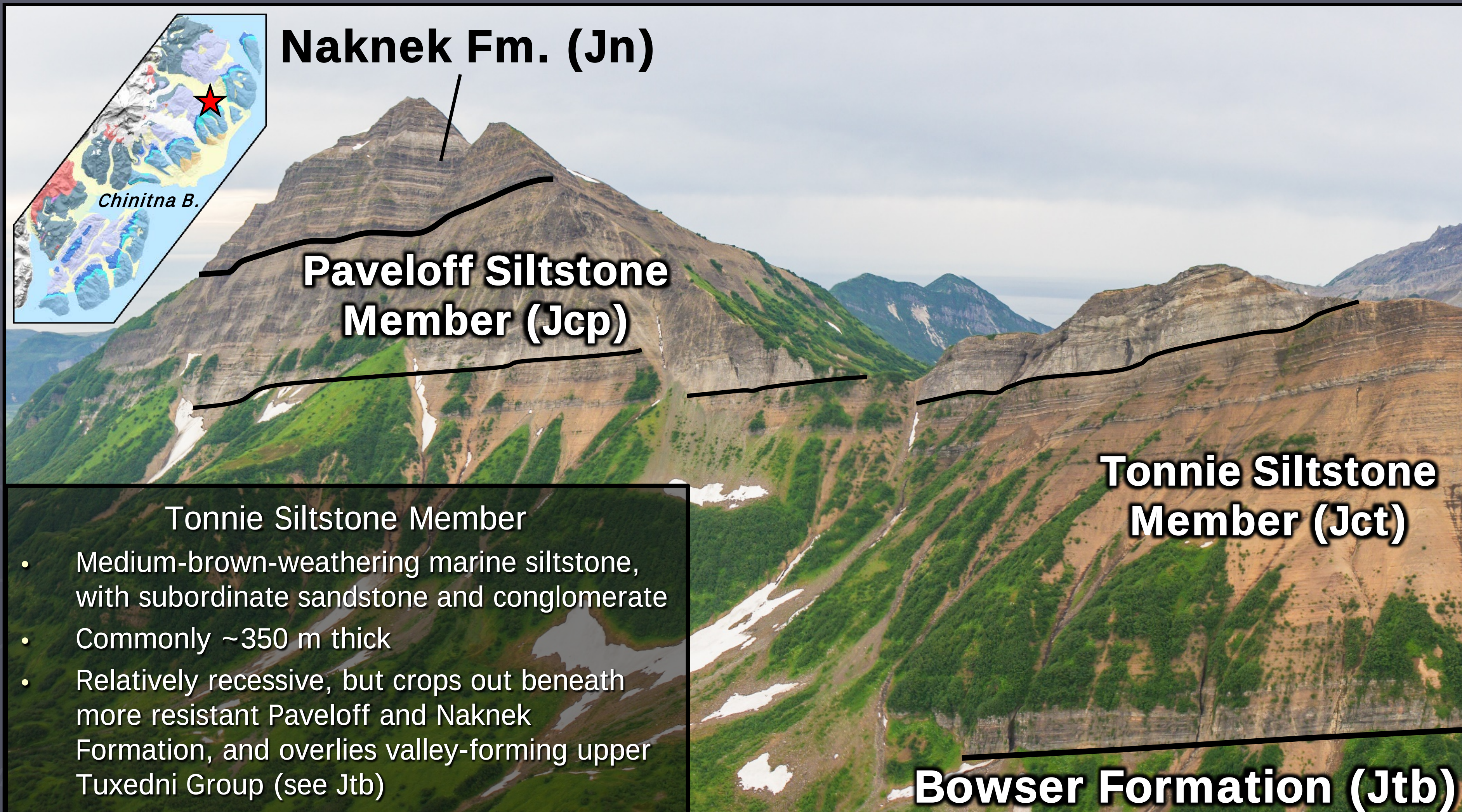
Chinitna Formation Interpretations

- Egbert, 1982: Slope deposits
- LePain et al. (2013): Shelf deposits, with member-scale transgressive–regressive cycles

- Late Middle Jurassic, ~700-m-thick, fossiliferous, marine unit
- Chinitna (Shale, Siltstone, Formation): Stanton and Martin, 1905; Martin and Katz, 1912; Moffit, 1927; Kirschner and Minard, 1949; Imlay, 1953; and Hartsock, 1954
- Chinitna Formation
  - Tonnie and Paveloff Siltstones Members (Detterman and Hartsock, 1966)
  - Typically fine grained, but not always

Chinitna Formation—Stratigraphic Overview

Triangle Peak Reference Exposure

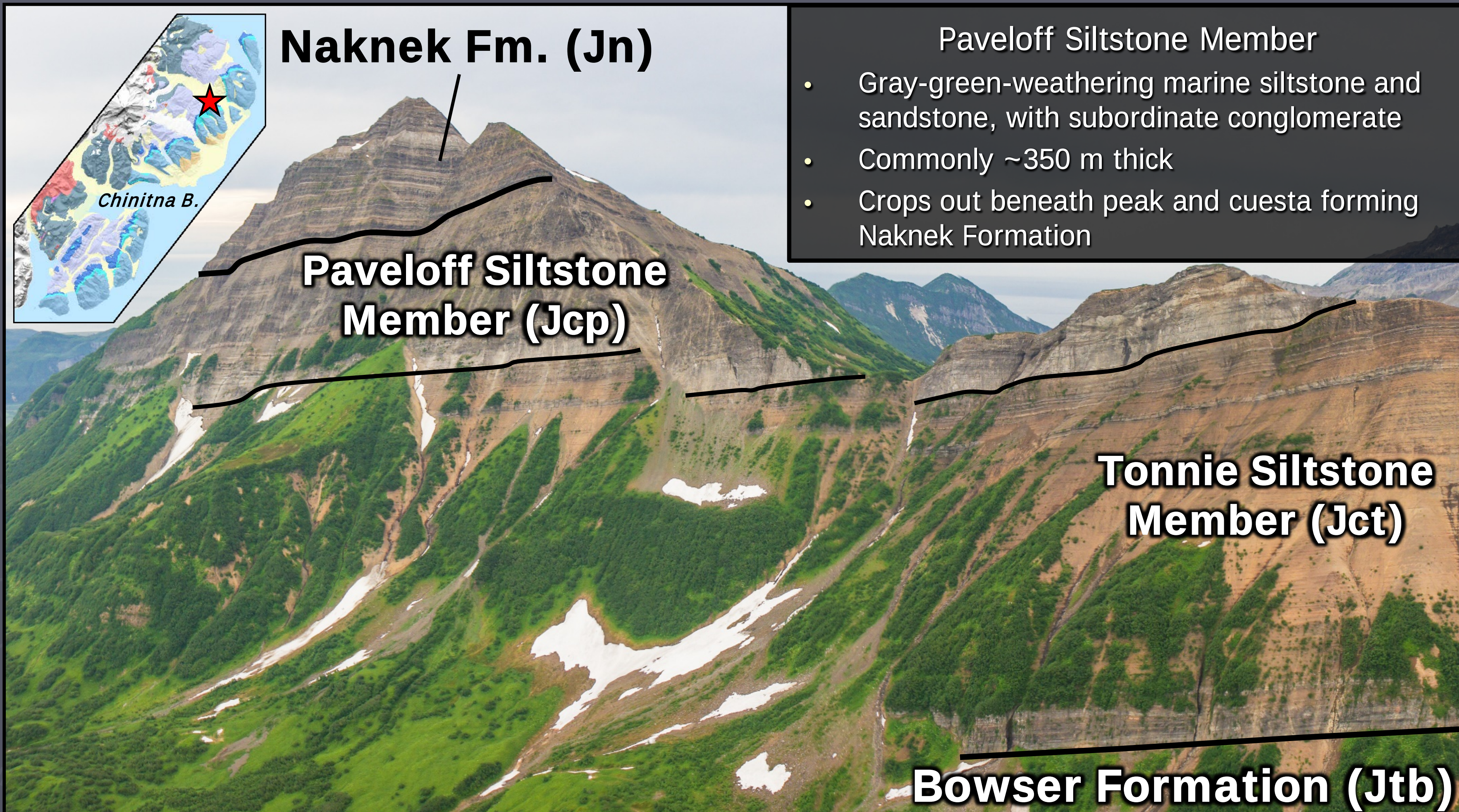


Tonnie Siltstone Member

- Medium-brown-weathering marine siltstone, with subordinate sandstone and conglomerate
- Commonly ~350 m thick
- Relatively recessive, but crops out beneath more resistant Paveloff and Naknek Formation, and overlies valley-forming upper Tuxedni Group (see Jtb)

Chinitna Formation—Stratigraphic Overview

Triangle Peak Reference Exposure



Paveloff Siltstone Member

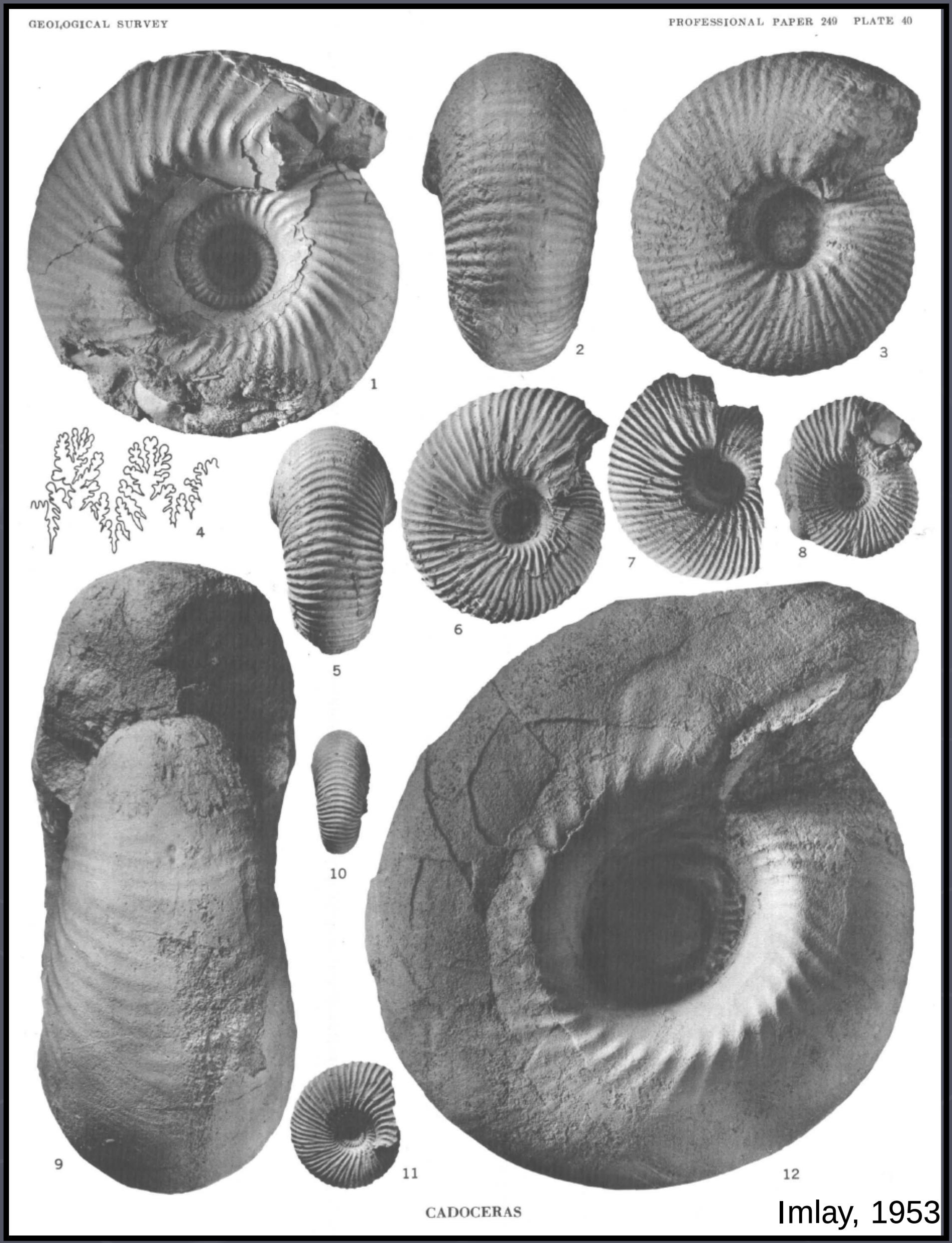
- Gray-green-weathering marine siltstone and sandstone, with subordinate conglomerate
- Commonly ~350 m thick
- Crops out beneath peak and cuesta forming Naknek Formation

Chinitna Formation—Stratigraphic Overview

Age? Ammonites and Zircons

- Biostratigraphy indicates late Middle Jurassic
  - Tonnie is Upper Bathonian(?)–Lower Callovian; Paveloff is Lower to Middle Callovian (Imlay, 1953, 1975, 1981)
  - ~166–164 Ma (see Gradstein et al., 2012)
- Paveloff detrital zircon sample:
  - Many grains are slightly younger than the ammonites; this work is ongoing

- Paveloff palynology (n=32), too:
  - Callovian



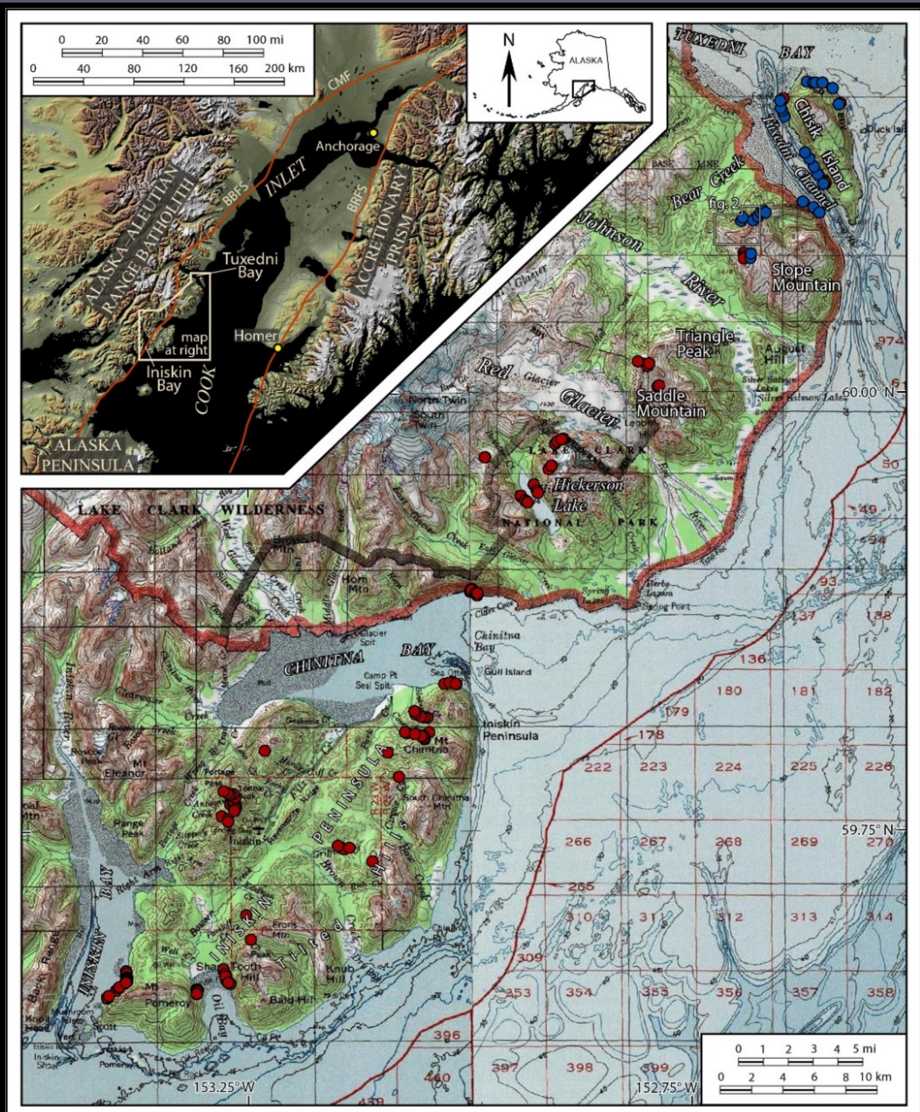
Imlay, 1953

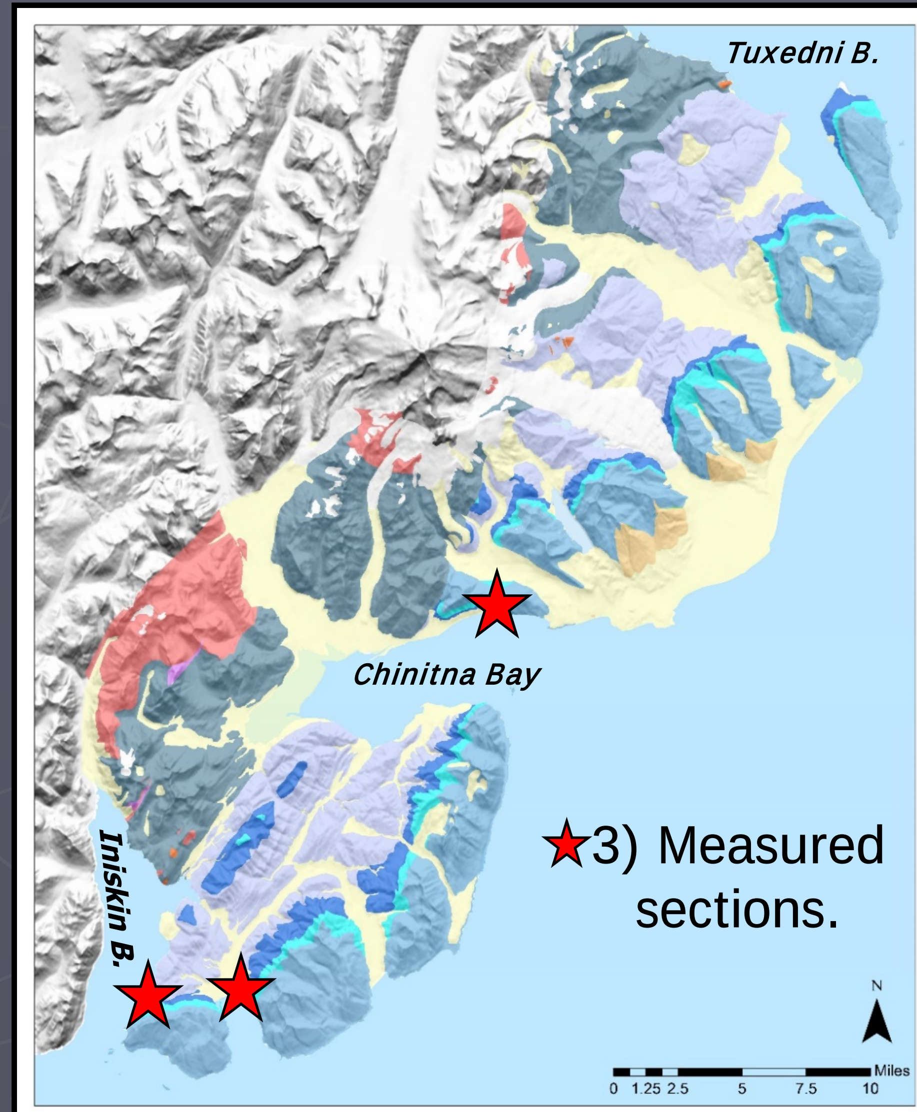
Chinitna Formation—Stratigraphic Overview: Methods

How did we learn what we think we know about the Chinitna?

1) Outcrop observations.

2) Geologic mapping.

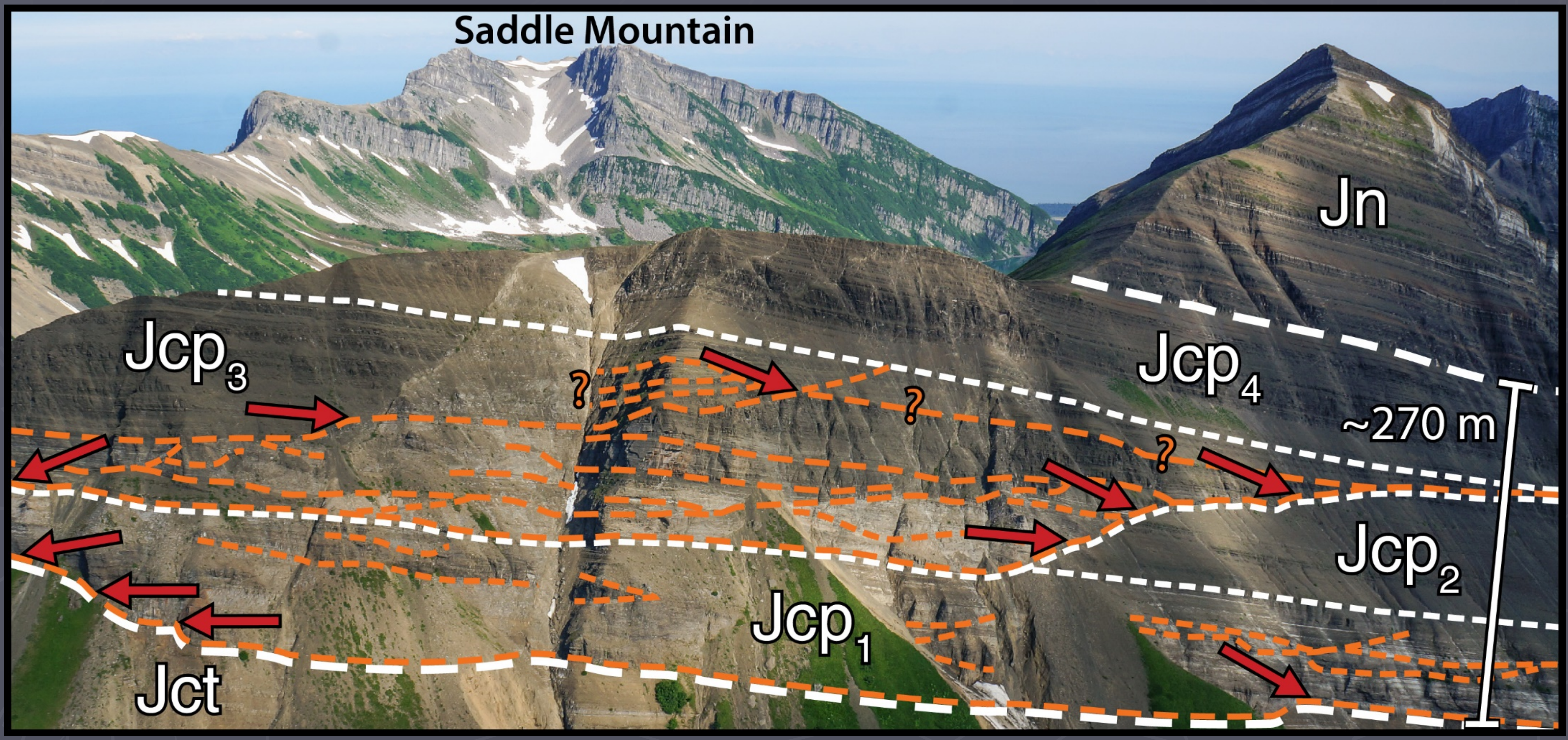




Chinitna Formation—Stratigraphic Overview: Methods

How did we learn what we think we know about the Chinitna?

4) Stratigraphic architecture.



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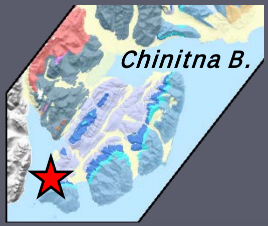
Sedimentologic Character of the Chinitna

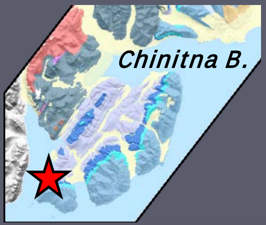
Tonnie Siltstone Member in Outcrop, Typical



- Tabular, thinly to thickly bedded siltstone and silty sandstone, with thinly bedded and sharp-based sandstone
- Poorly to moderately well indurated
- Hackly weathering
- Fossiliferous—ammonites, fewer pelecypods, belemnites, gastropods, brachiopods
- Ellipsoidal to tabular concretions

Sedimentologic Character of the Chinitna

Tonnie Siltstone Member in Detail, Typical



Sedimentologic Character of the Chinitna

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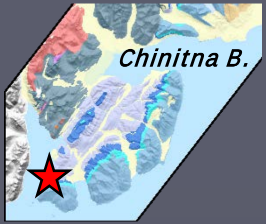


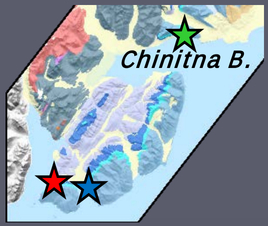
Summary

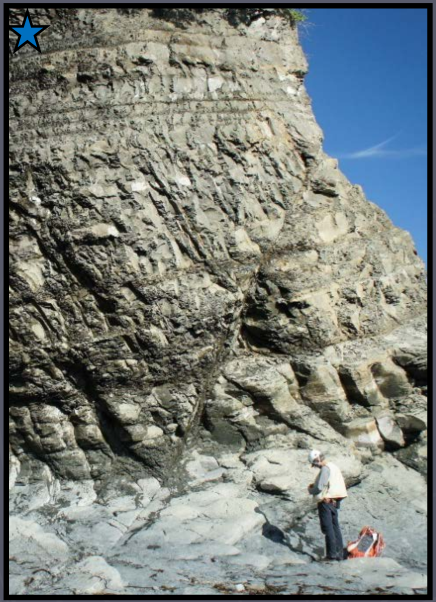
- Siltstone intervals most common
- Sharp-based, normally graded sandstones
  - Sediment gravity flow deposits
- Bedding plane parallel and vertical burrows
- Abundant marine fossils
- Potcasts or biogenic collections?
- Woody debris locally observed
  - Deltaic sediment routing
- Storm-influenced sedimentation?

Shallow-marine deposits of
<u>shelfal and prodelta settings</u>

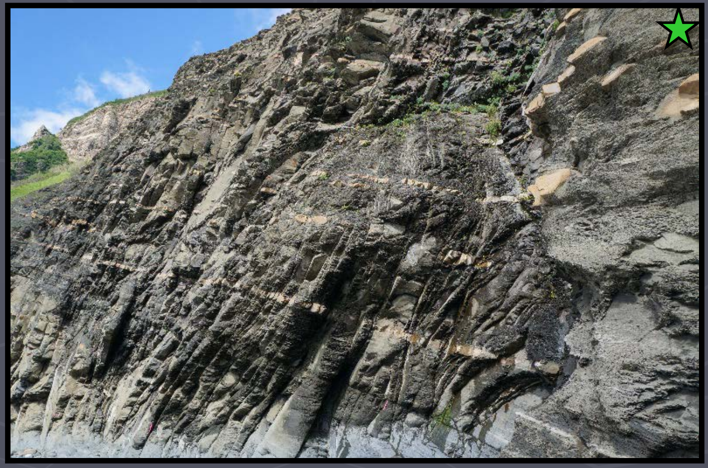
Sedimentologic Character of the Chinitna

Paveloff Siltstone Member in Outcrop, Typical



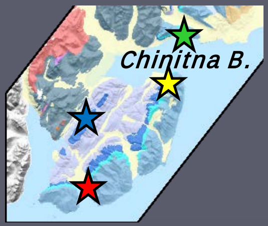


- Tabular, thinly to thickly bedded sandy siltstone and very-fine-grained sandstone, with thicker, coarser sandstone beds
- Moderately well to well indurated
- Massive to hackly weathering
- Bedding obscured by weathering and thorough bioturbation
- Fossiliferous—ammonites, pelecypods, belemnites, brachiopods, gastropods
- Tabular to ellipsoidal concretions



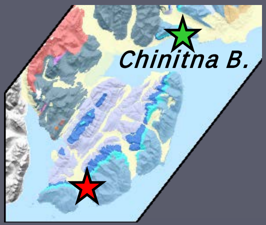
Sedimentologic Character of the Chinitna

Paveloff Siltstone Member in Detail, Typical



Sedimentologic Character of the Chinitna

Paveloff Siltstone Member in Detail, Typical



Summary

- Structureless siltstone intervals are bioturbated and probably much thicker than sedimentation units
- Sharp-based, normally graded sandstones
  - Sediment gravity flow deposits
- Trace fossils commonly observed
- Abundant marine fossils
- Woody debris locally observed
  - Deltaic sediment routing
- Storm-influenced sedimentation?

Shallow-marine deposits of
shelfal and prodelta settings

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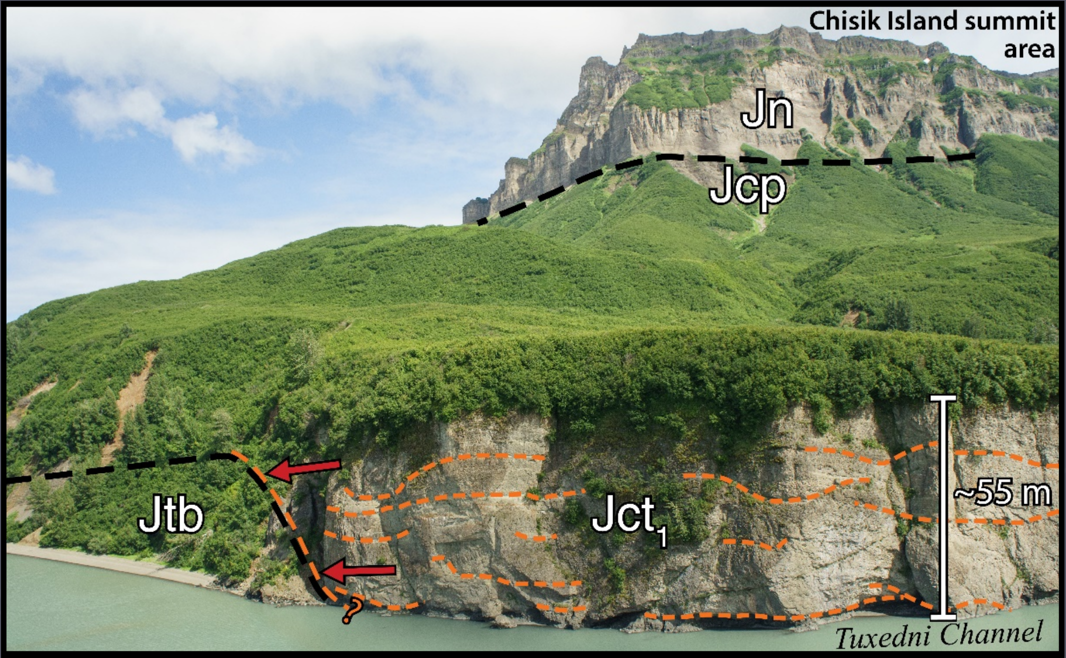
Stratigraphic Character of Basal Successions

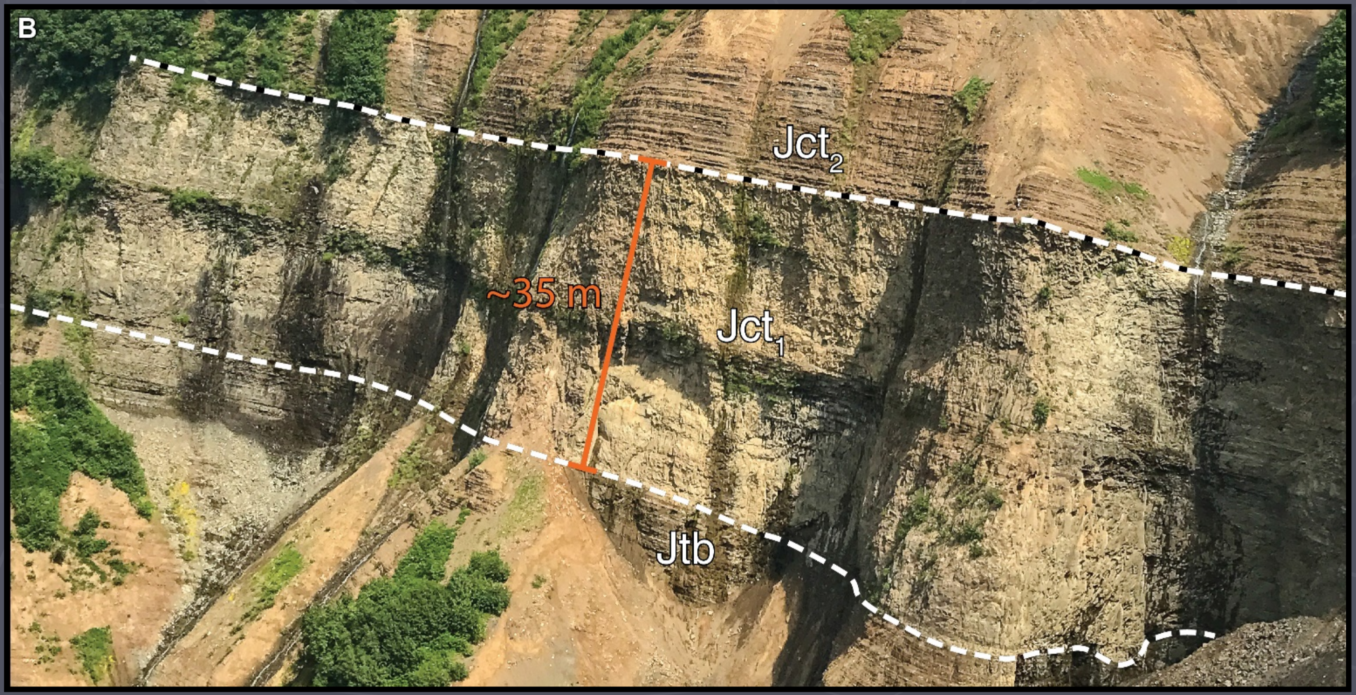
Tonnie Siltstone Member, **Jct₁**—Chisik Island NW



- ~70-m-thick channelized conglomerate and sandstone hosted within stratigraphic incision
- Clast to matrix supported
- Structureless sandstone
- Marine-fossil fragments reported (Egbert, 1982)

Stratigraphic Character of Basal Successions

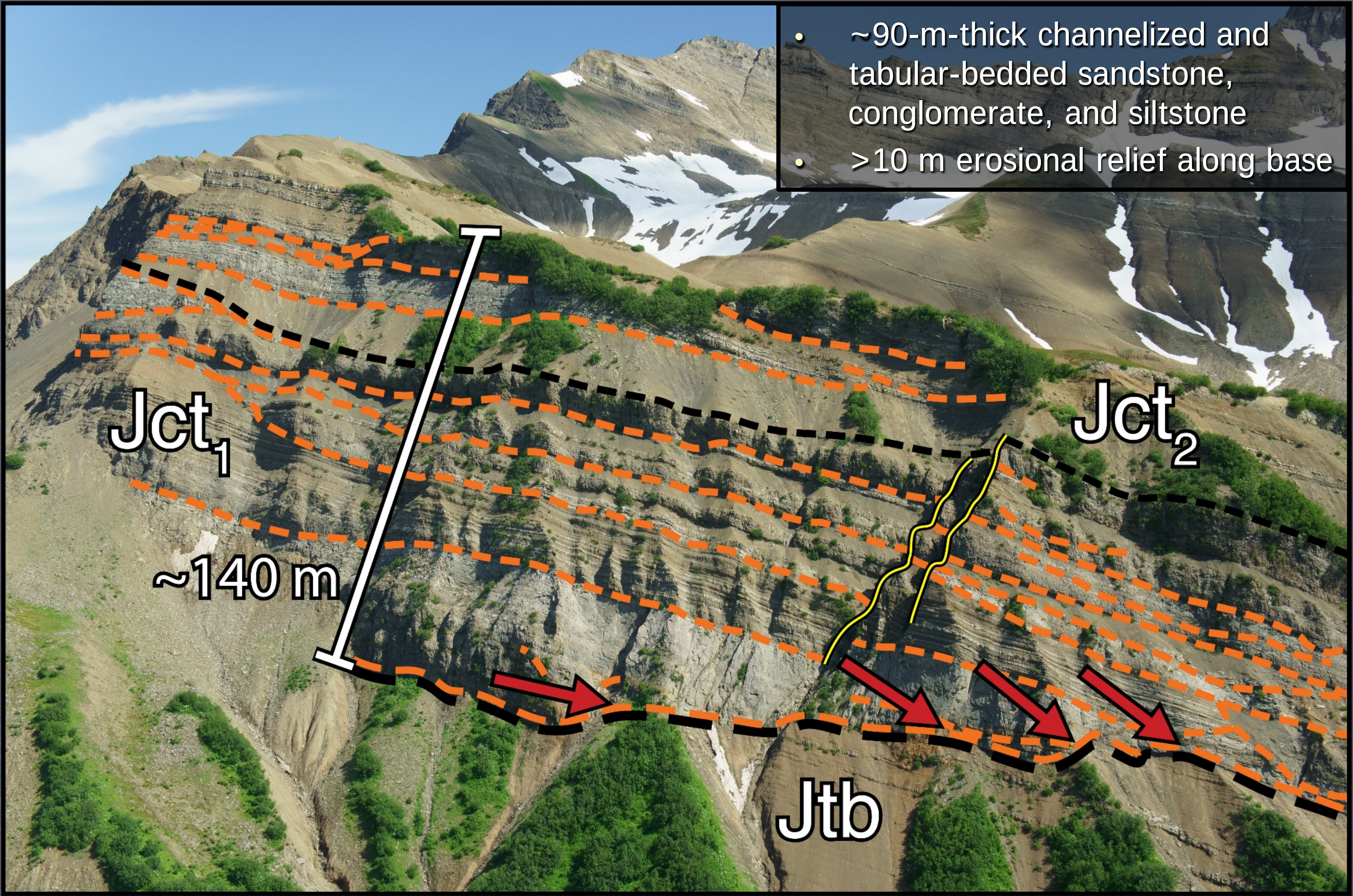
Tonnie Siltstone Member, Jct_1—Amphitheater



- ~35-m-thick, tabular-bedded, fine-grained sandstone succession
- Well sorted
- Laterally extensive
- Sharp, planar contacts
- Oil-stained outcrop
- Herriott and Wartes, 2017

Stratigraphic Character of Basal Successions

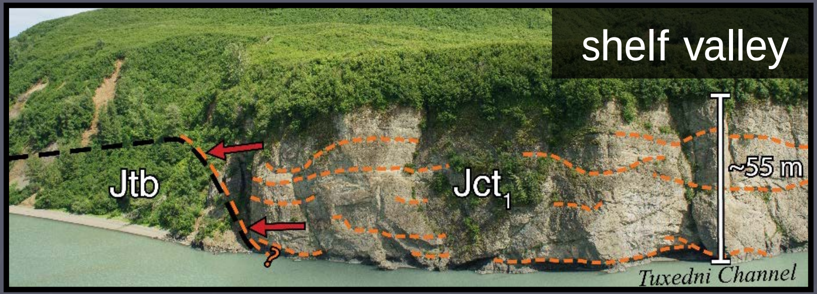
Tonnie Siltstone Member, Jct_1—Red Glacier

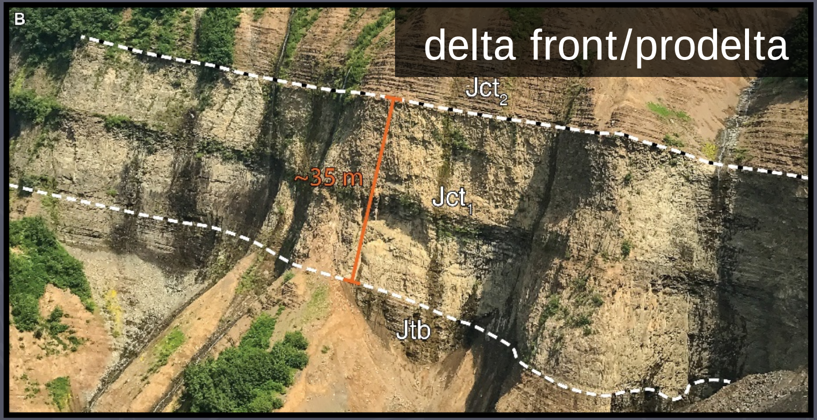


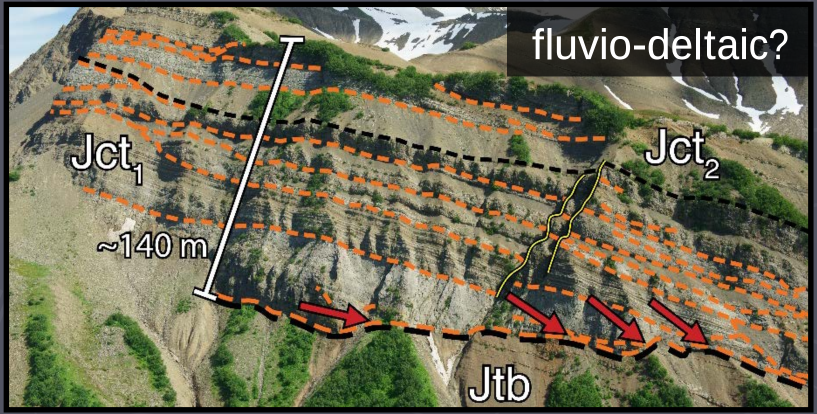
- ~90-m-thick channelized and tabular-bedded sandstone, conglomerate, and siltstone
- >10 m erosional relief along base

Stratigraphic Character of Basal Successions

Tonnie Siltstone Member, Jct_1—Summary





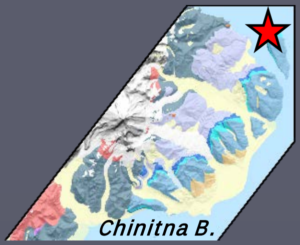


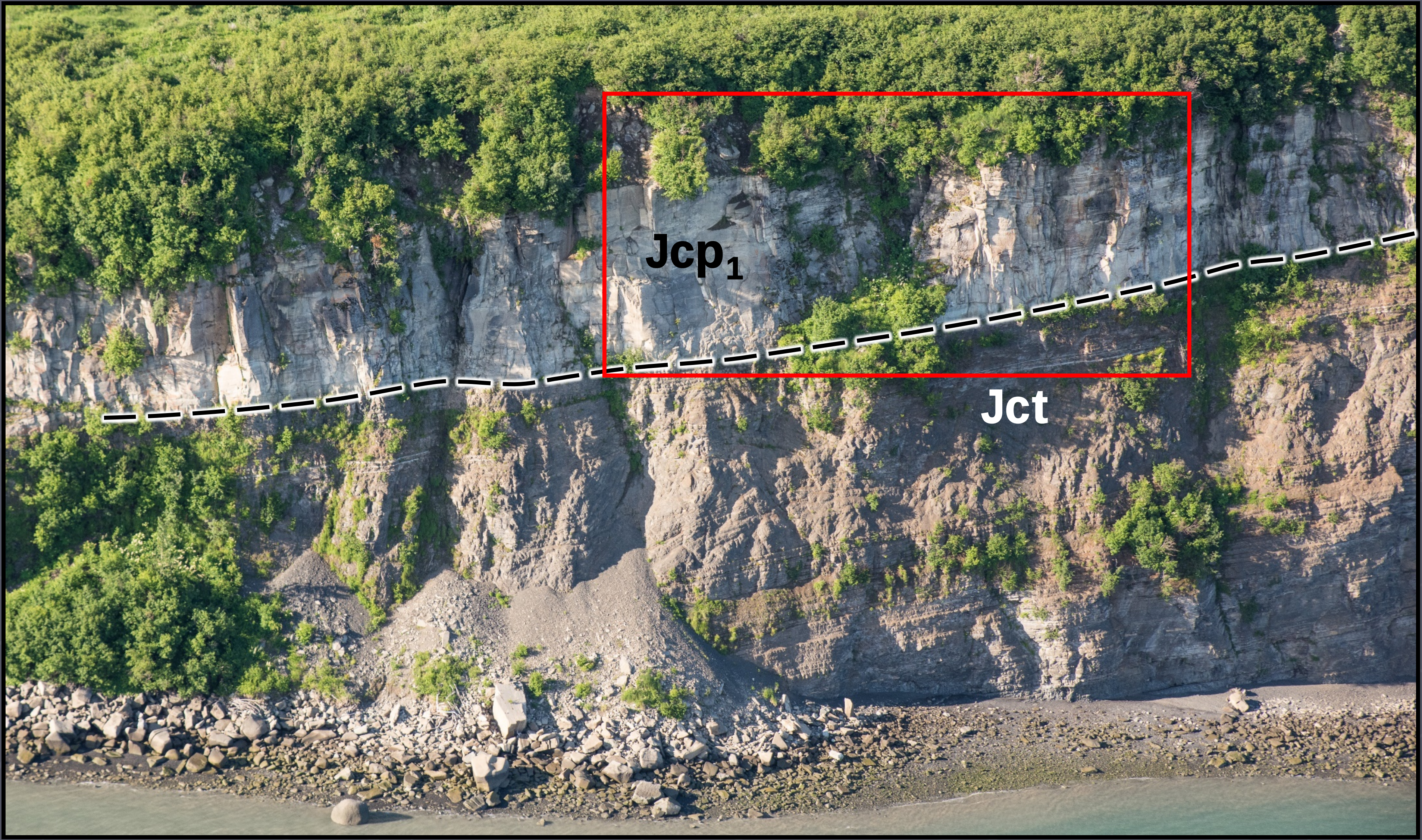
- Contact with Jtb is sharp and planar to erosional with relief up to 10s of m
- Thick, tabular and channelized successions of sandstone and conglomerate, locally siltstone
- Marine-fossil fragments locally observed
- Abundant supply of coarse detritus to high energy marine environments
  - Turbulent to non-turbulent sediment gravity flow processes likely common

Shallow-marine deposits of
<u>deltas and associated settings</u>

Stratigraphic Character of Basal Successions

Paveloff Siltstone Member, Jcp_1—Chisik Island NE





Stratigraphic Character of Basal Successions

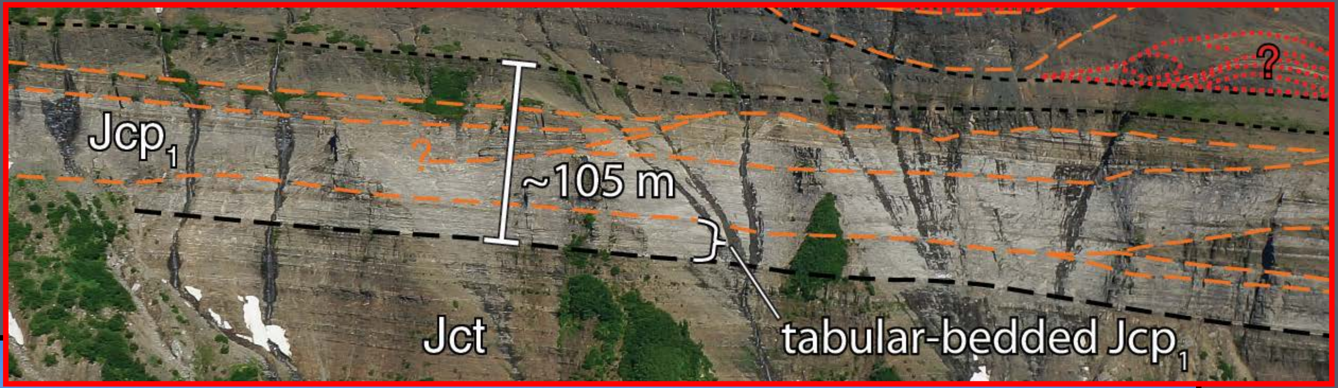
Paveloff Siltstone Member, Jcp_1—Chisik Island NE

- ~20-m-thick tabular, channelized, and convolute-stratified sandstone
- Sharp, planar base

Stratigraphic Character of Basal Successions

Paveloff Siltstone Member, Jcp_1—Battleship

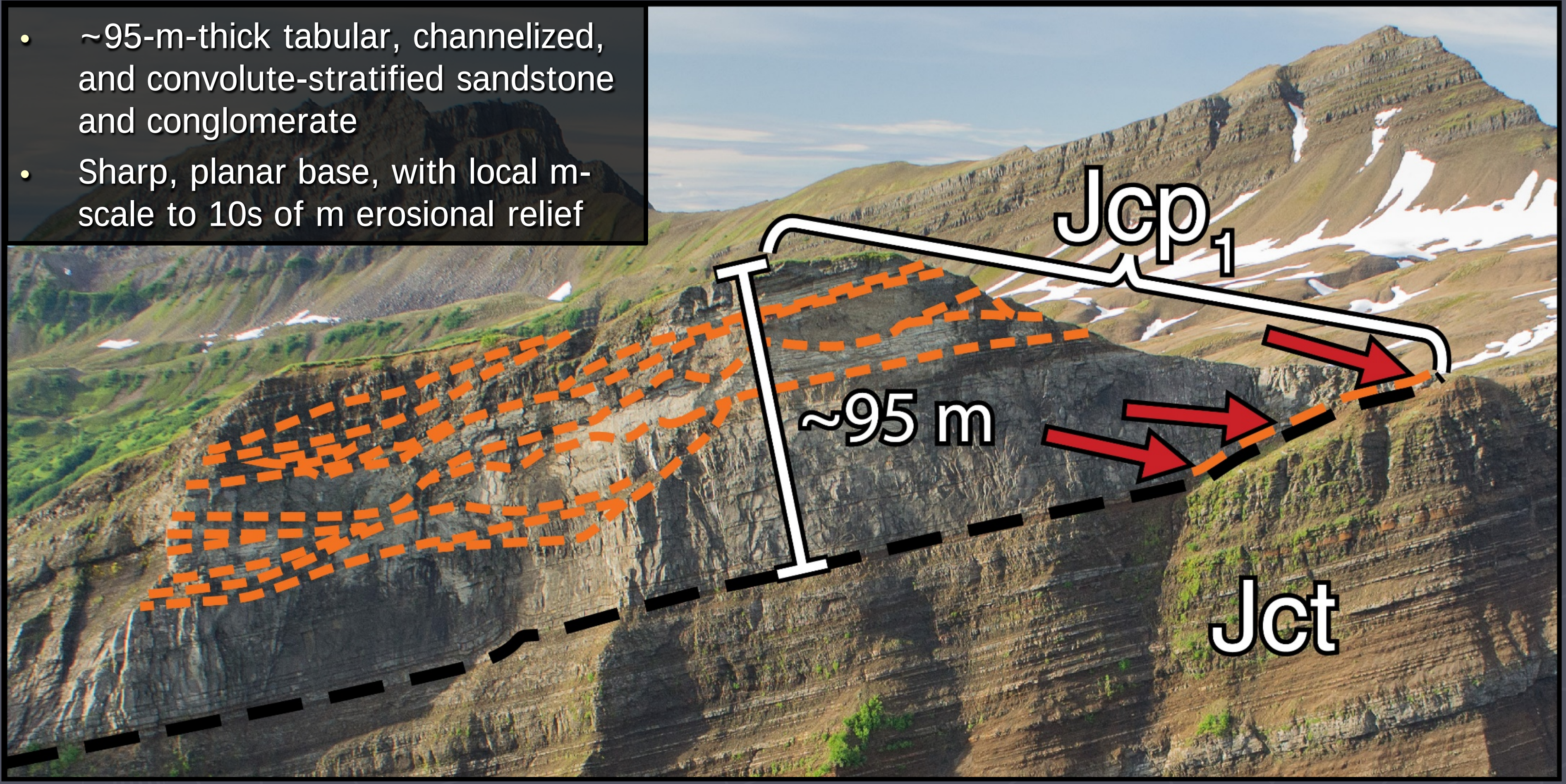
- ~105-m-thick tabular-bedded and channelized sandstone and siltstone
- Sharp, planar base



Stratigraphic Character of Basal Successions

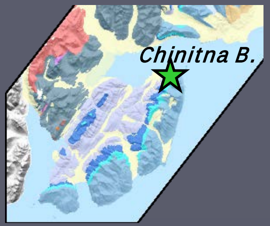
Paveloff Siltstone Member, Jcp_1—Triangle West

- ~95-m-thick tabular, channelized, and convolute-stratified sandstone and conglomerate
- Sharp, planar base, with local m-scale to 10s of m erosional relief



Stratigraphic Character of Basal Successions

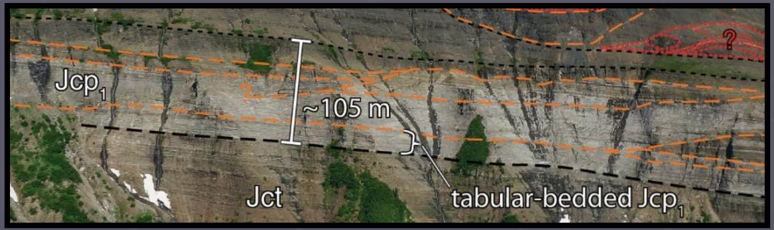
Paveloff Siltstone Member, Jcp_1—Chinitna Bay

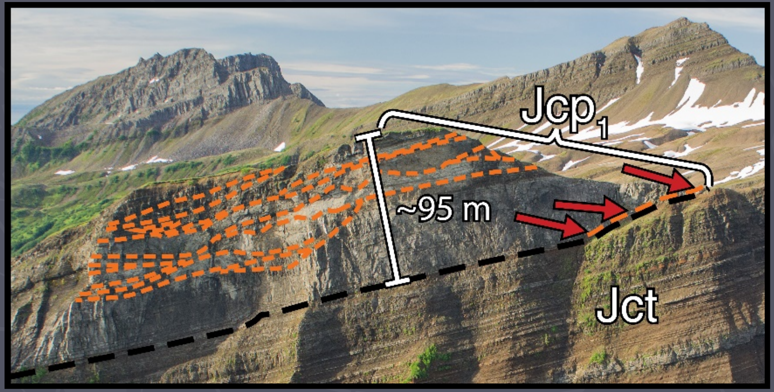


- Very-thick-bedded, structureless to faintly stratified, coarse-grained sandstone
- Poorly sorted
- Floating granules are common
- Oil-stained outcrop
- Wartes and Herriott, 2015

Stratigraphic Character of Basal Successions

Paveloff Siltstone Member, Jcp_1—Summary





- Contact with Jct is sharp and planar to erosional with relief of m-scale to 10s of m
- Thick, tabular and channelized successions of sandstone and conglomerate, locally siltstone
- Convolute stratification common
- Marine fossils
  - Pelecypods, belemnites, brachiopods, gastropods (Detterman and Hartsock, 1966)
- Abundant supply and high (instantaneous) sedimentation rates of coarse detritus in high energy marine environments
  - Turbulent to non-turbulent sediment gravity flow processes likely common

Shallow-marine deposits of
deltaic settings

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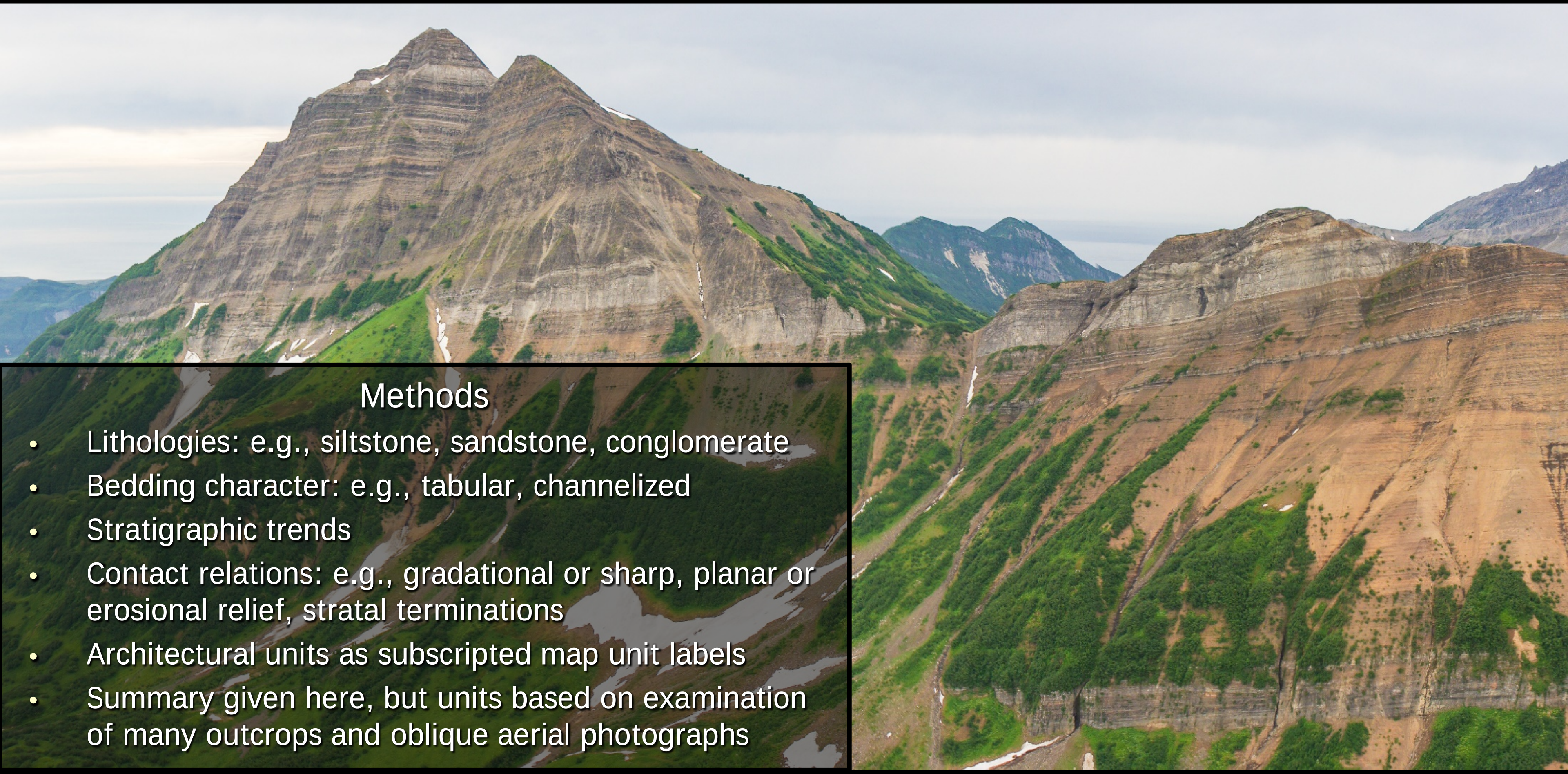
Stratigraphic Architecture of the Chinitna Formation—Architectural Units

Triangle Peak Reference Exposure

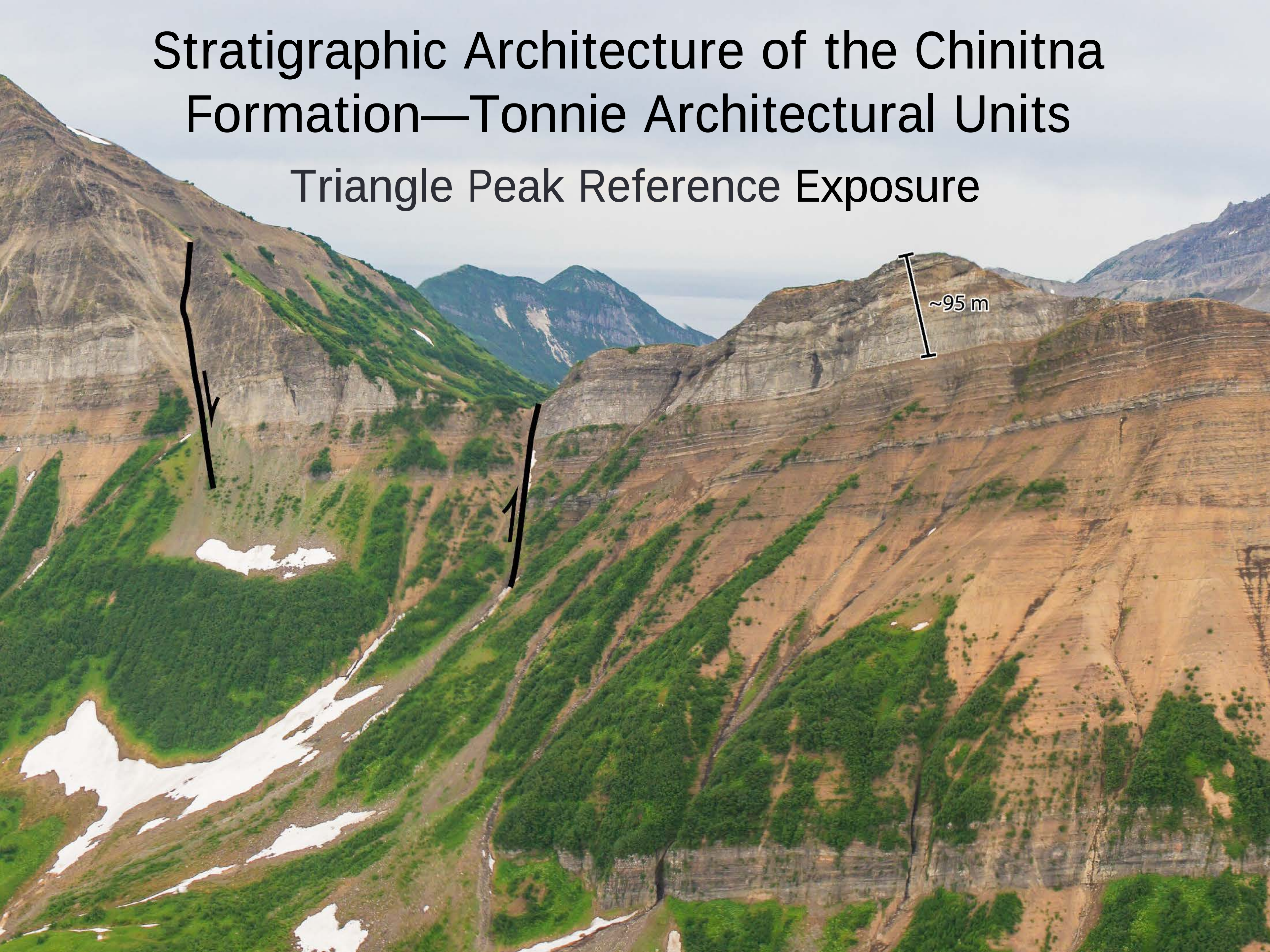


Methods

- Lithologies: e.g., siltstone, sandstone, conglomerate
- Bedding character: e.g., tabular, channelized
- Stratigraphic trends
- Contact relations: e.g., gradational or sharp, planar or erosional relief, stratal terminations
- Architectural units as subscripted map unit labels
- Summary given here, but units based on examination of many outcrops and oblique aerial photographs

Stratigraphic Architecture of the Chinitna Formation—Tonnie Architectural Units

Triangle Peak Reference Exposure



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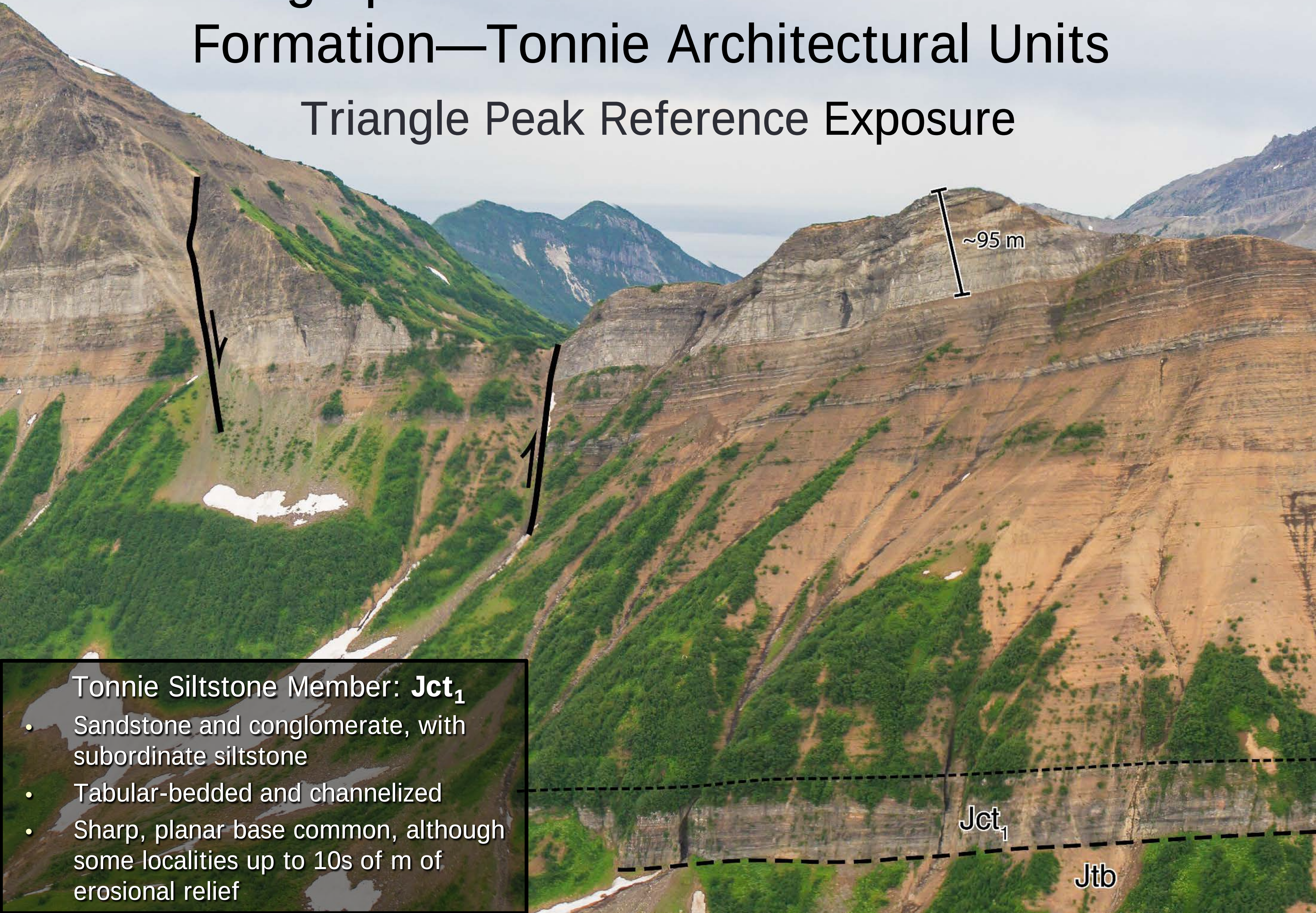


Tonnie Siltstone Member: **Jct$_1$**

- Sandstone and conglomerate, with subordinate siltstone
- Tabular-bedded and channelized
- Sharp, planar base common, although some localities up to 10s of m of erosional relief

Stratigraphic Architecture of the Chinitna Formation—Tonnie Architectural Units

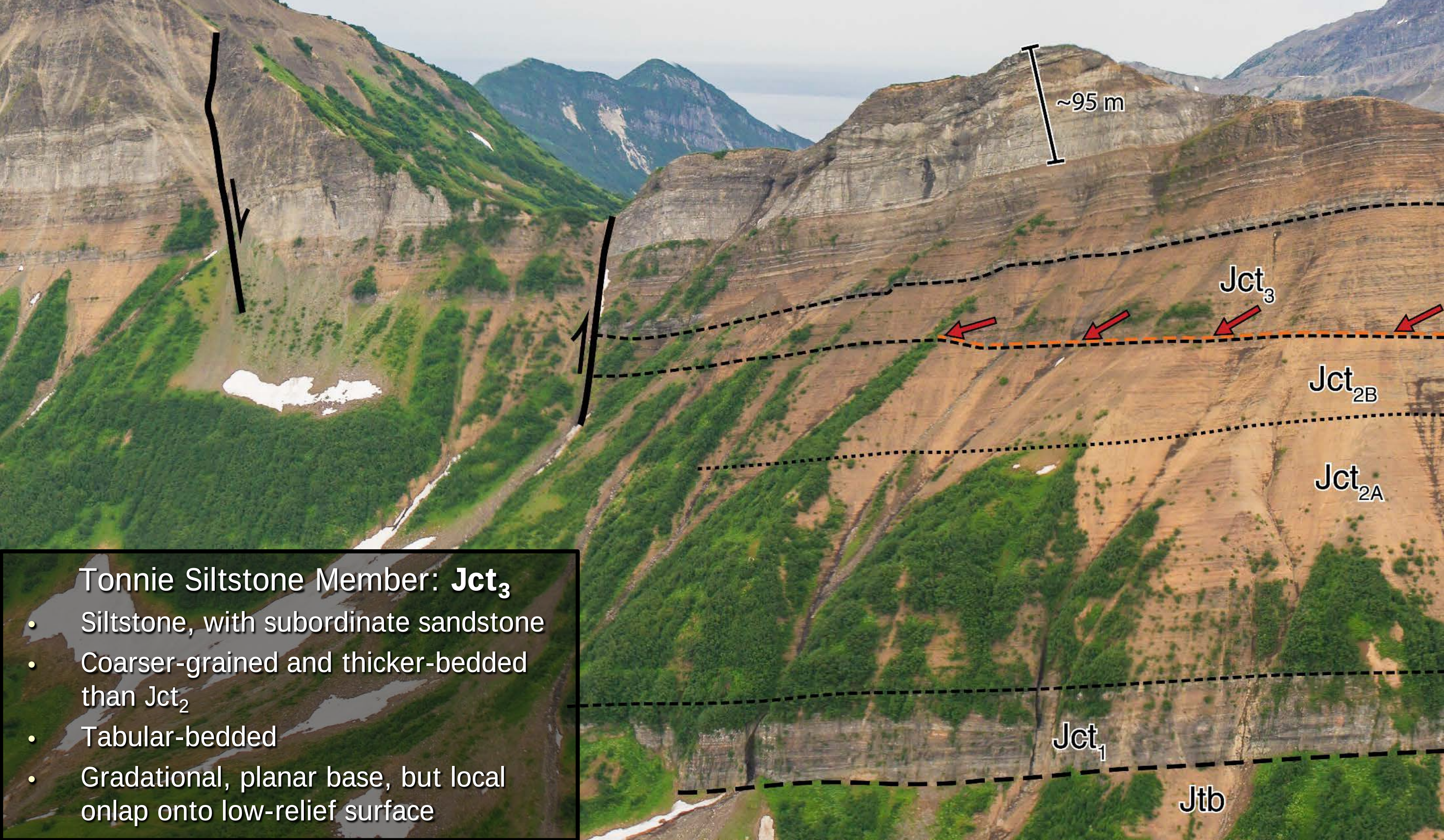
Triangle Peak Reference Exposure

Tonnie Siltstone Member: **Jct$_2$**

- Fining-upward (Jct$_{2A}$) and coarsening-upward (Jct$_{2B}$) successions of thinly bedded siltstone
- Tabular-bedded
- Gradational or sharp, planar base

Stratigraphic Architecture of the Chinitna Formation—Tonnie Architectural Units

Triangle Peak Reference Exposure

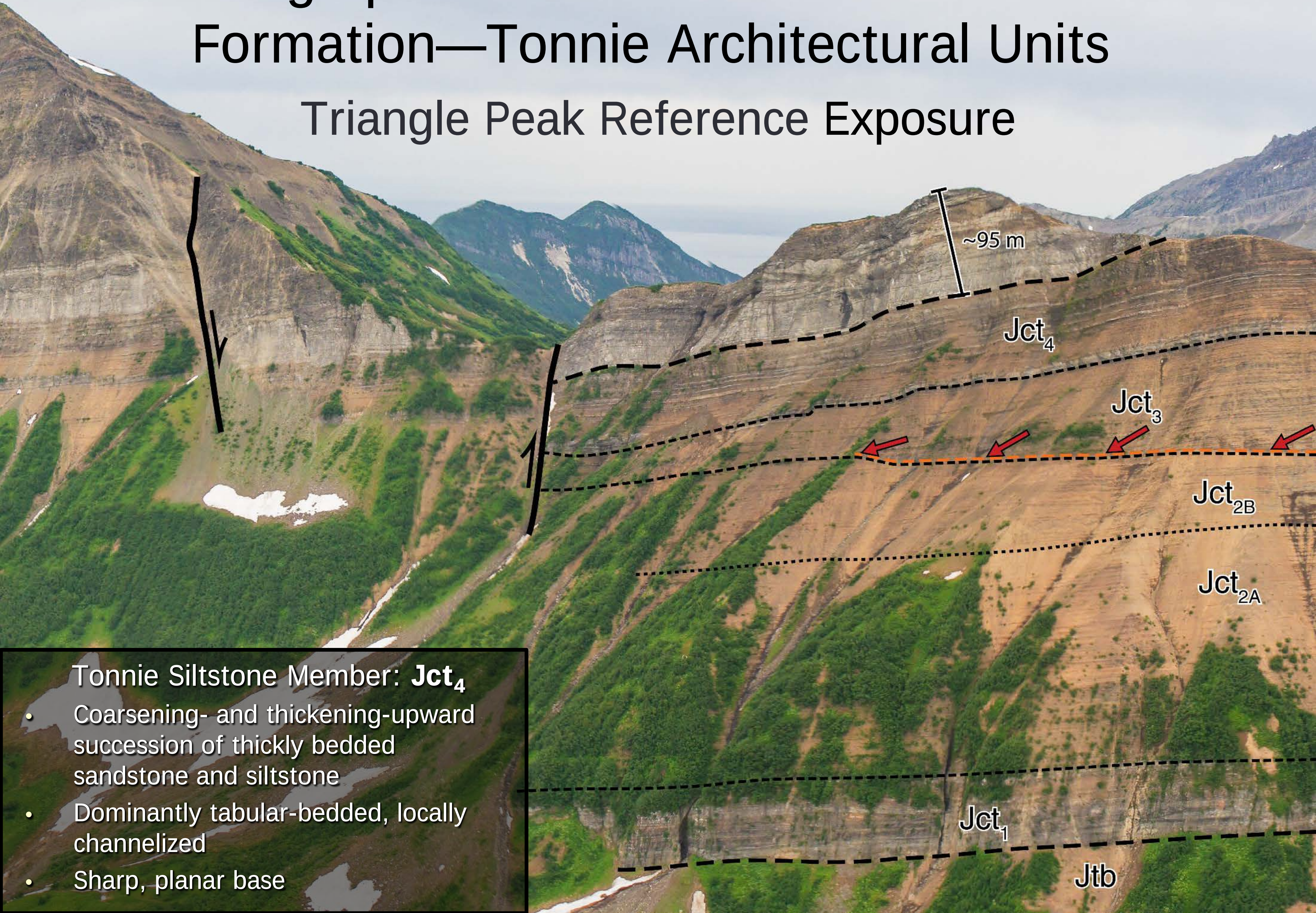


Tonnie Siltstone Member: **Jct$_3$**

- Siltstone, with subordinate sandstone
- Coarser-grained and thicker-bedded than Jct$_2$
- Tabular-bedded
- Gradational, planar base, but local onlap onto low-relief surface

Stratigraphic Architecture of the Chinitna Formation—Tonnie Architectural Units

Triangle Peak Reference Exposure

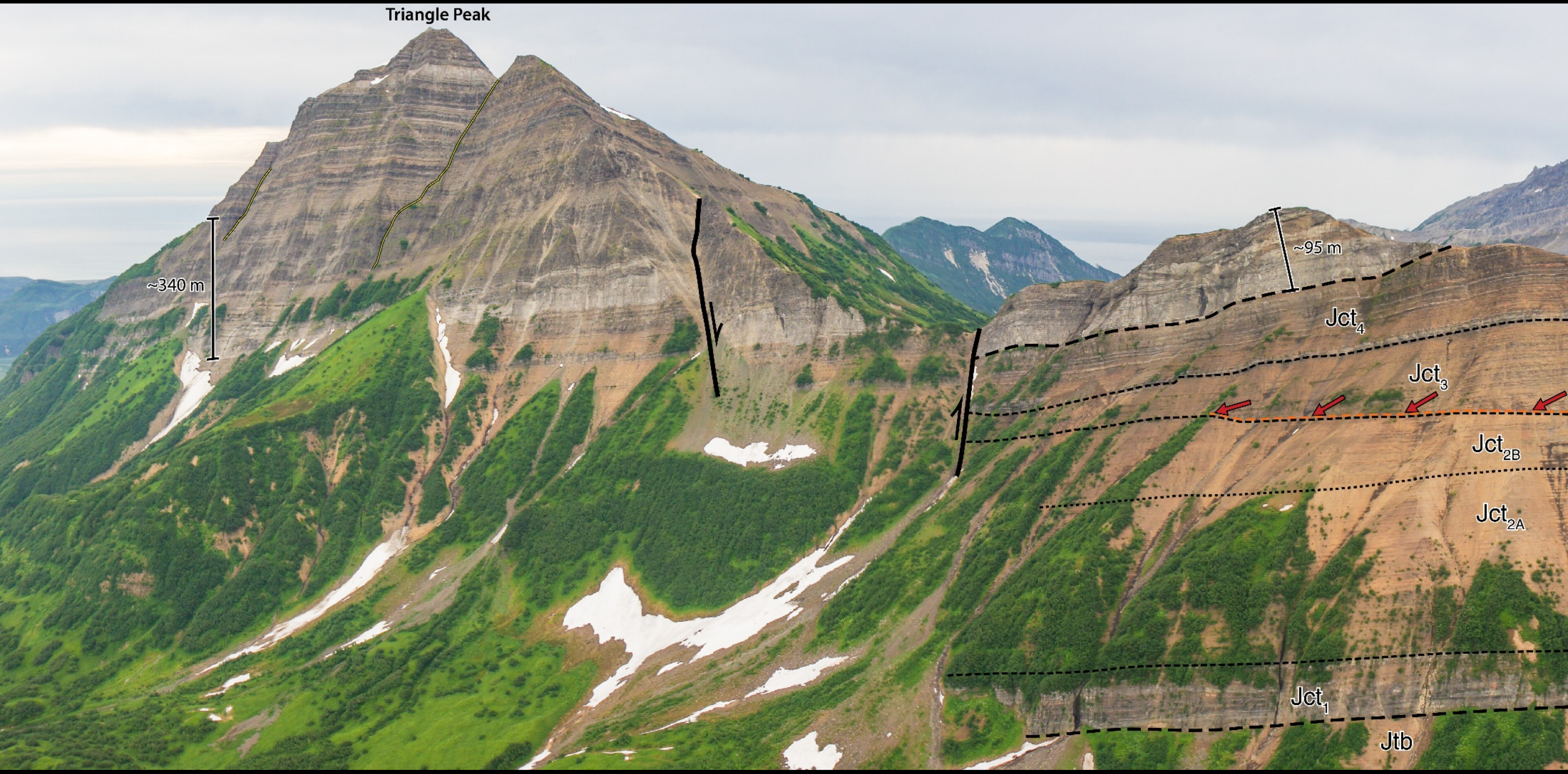


Tonnie Siltstone Member: **Jct$_4$**

- Coarsening- and thickening-upward succession of thickly bedded sandstone and siltstone
- Dominantly tabular-bedded, locally channelized
- Sharp, planar base

Stratigraphic Architecture of the Chinitna Formation—Architectural Units

Triangle Peak Reference Exposure

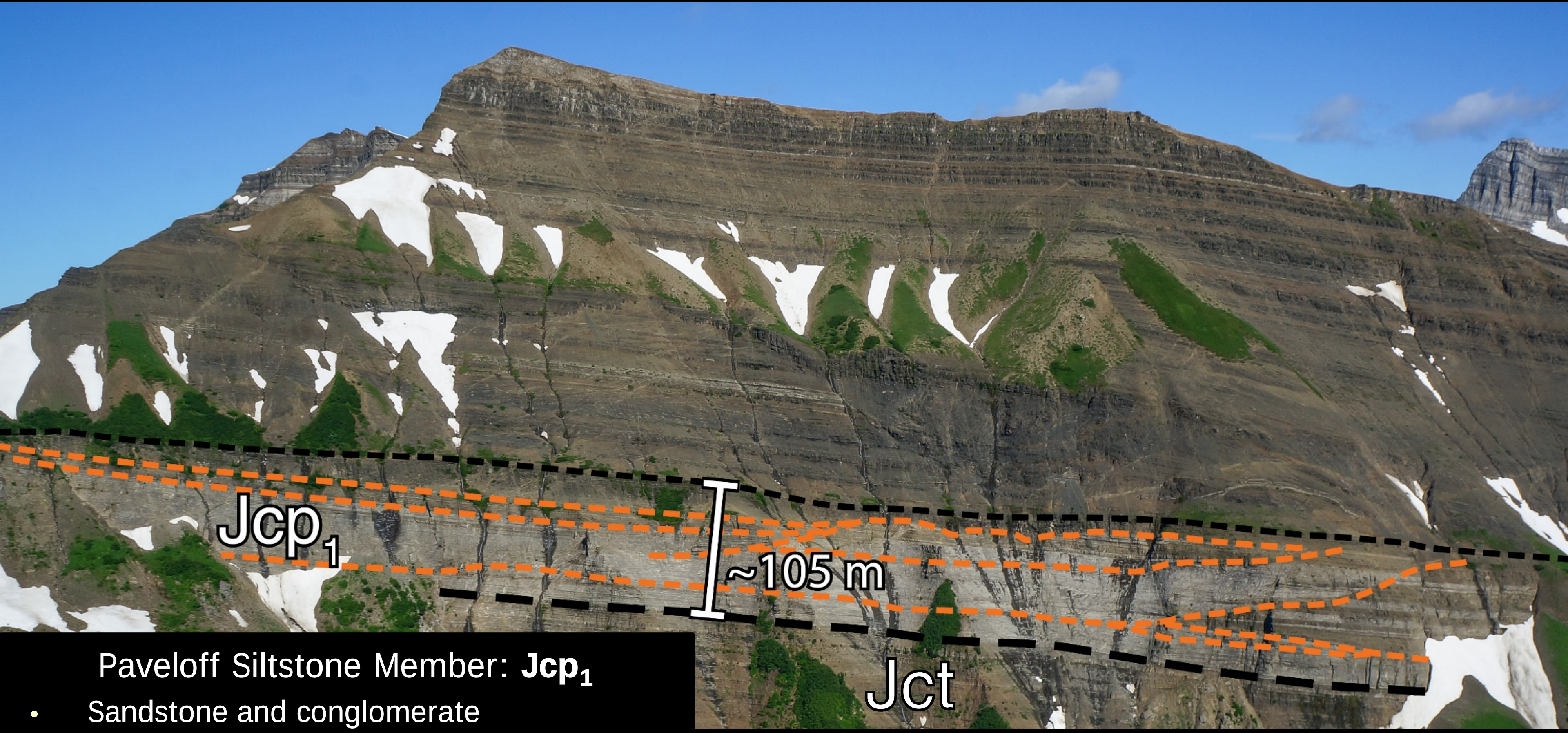


Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Detour to the Battleship Locality

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Detour to the Battleship Locality

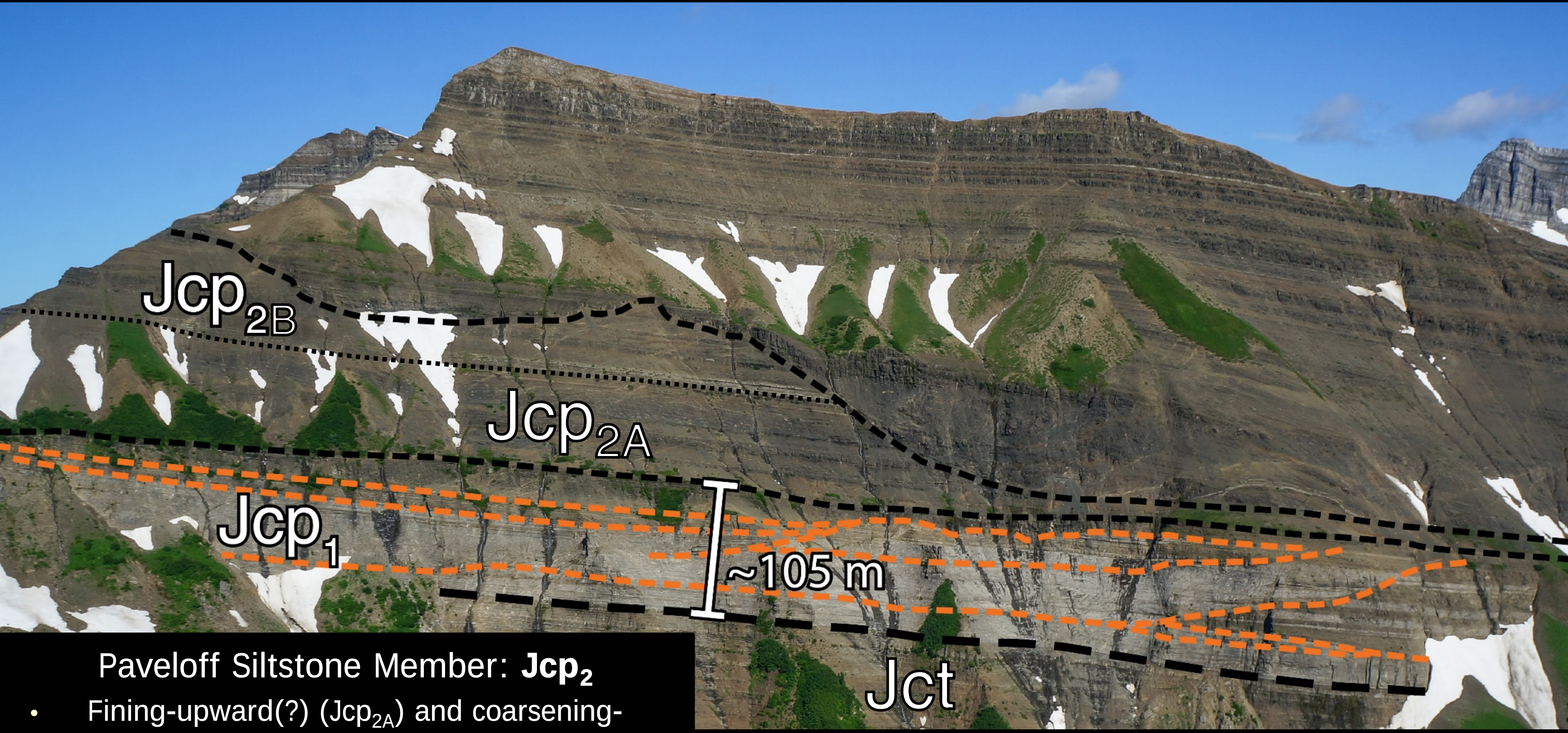


Paveloff Siltstone Member: **Jcp$_1$**

- Sandstone and conglomerate
- Tabular-bedded and channelized
- Typically sharp, planar base; locally m-scale to 10s of m erosional relief

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Detour to the Battleship Locality

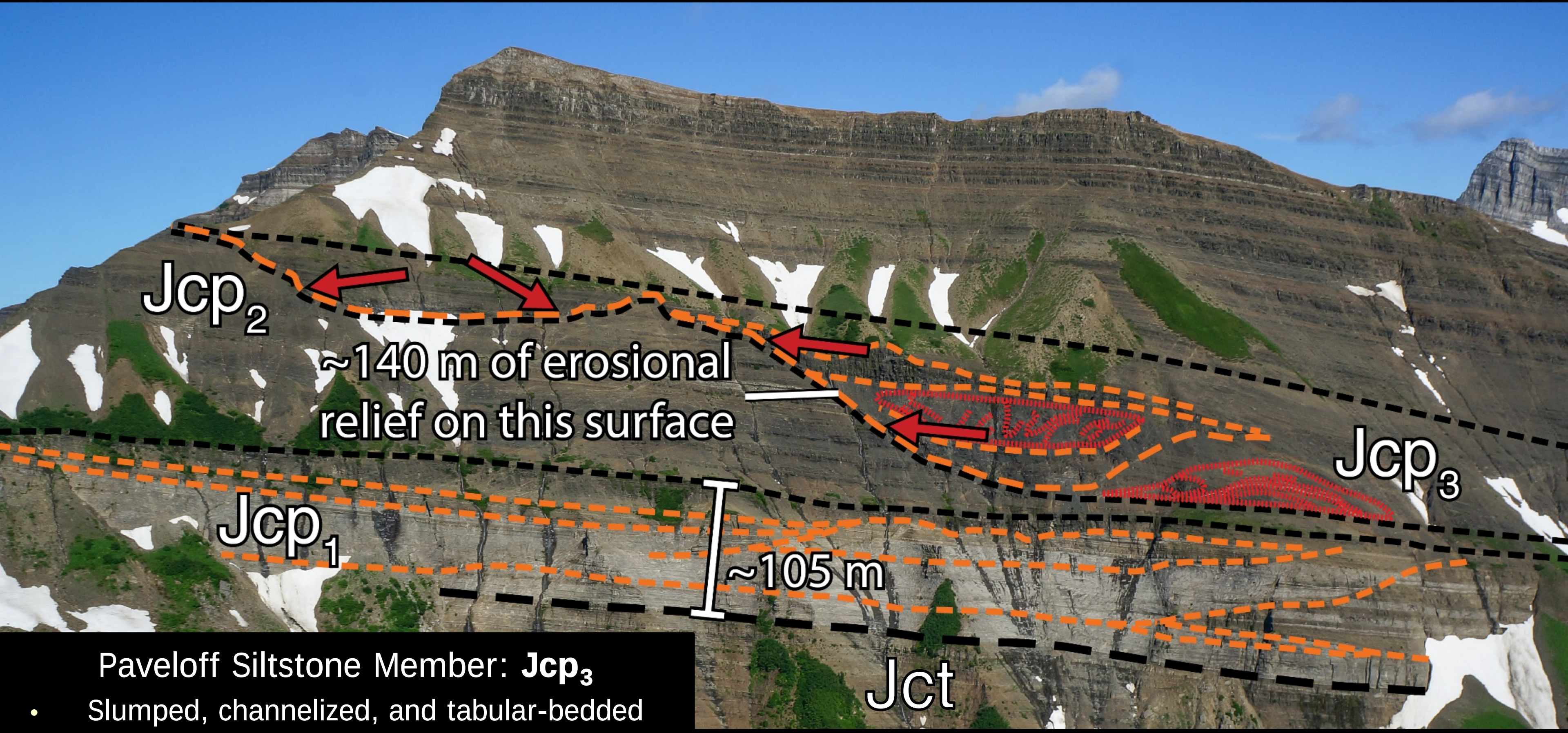


Paveloff Siltstone Member: **Jcp$_2$**

- Fining-upward(?) (Jcp$_{2A}$) and coarsening-upward(?) (Jcp$_{2B}$) successions of tabular-bedded siltstone and sandstone
- Gradational, planar base

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Detour to the Battleship Locality

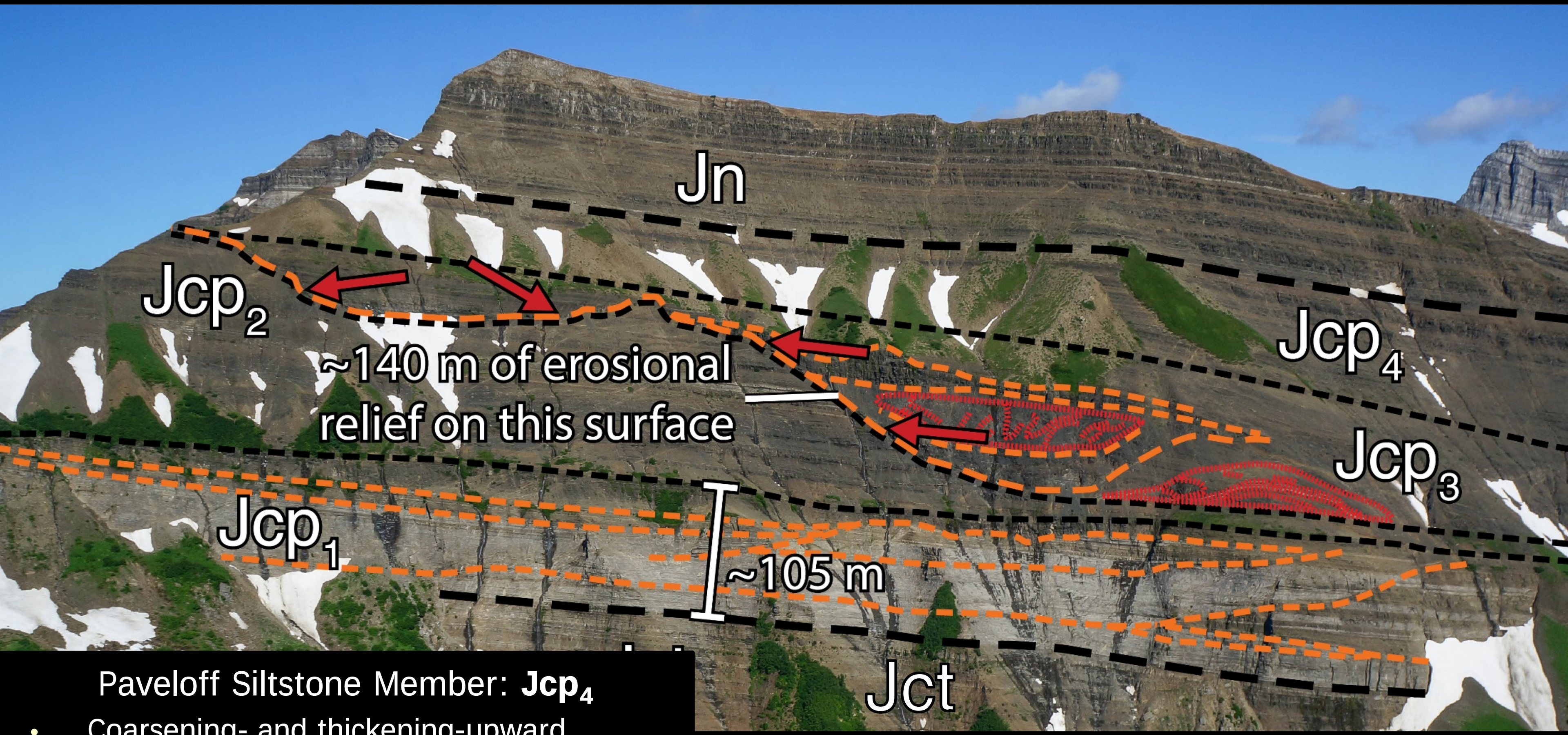


Paveloff Siltstone Member: **Jcp3**

- Slumped, channelized, and tabular-bedded siltstone and sandstone
- Succession onlaps and fills 100+ m erosional relief at base that cuts into and locally through Jcp_2

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Detour to the Battleship Locality

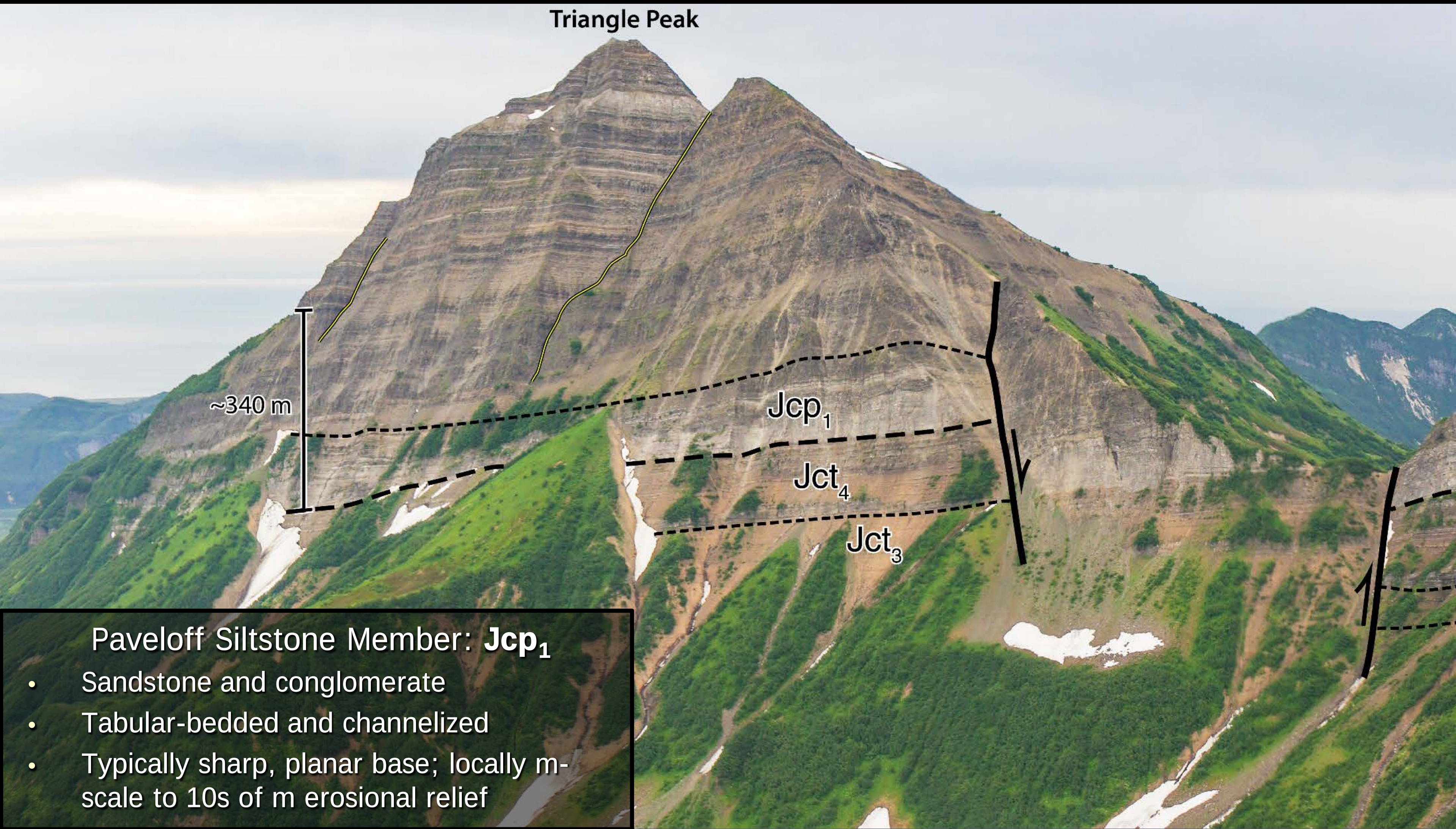


Paveloff Siltstone Member: **Jcp$_4$**

- Coarsening- and thickening-upward succession of siltstone and sandstone
- Tabular-bedded
- Gradational, planar base

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Triangle Peak Reference Exposure



Paveloff Siltstone Member: **Jcp$_1$**

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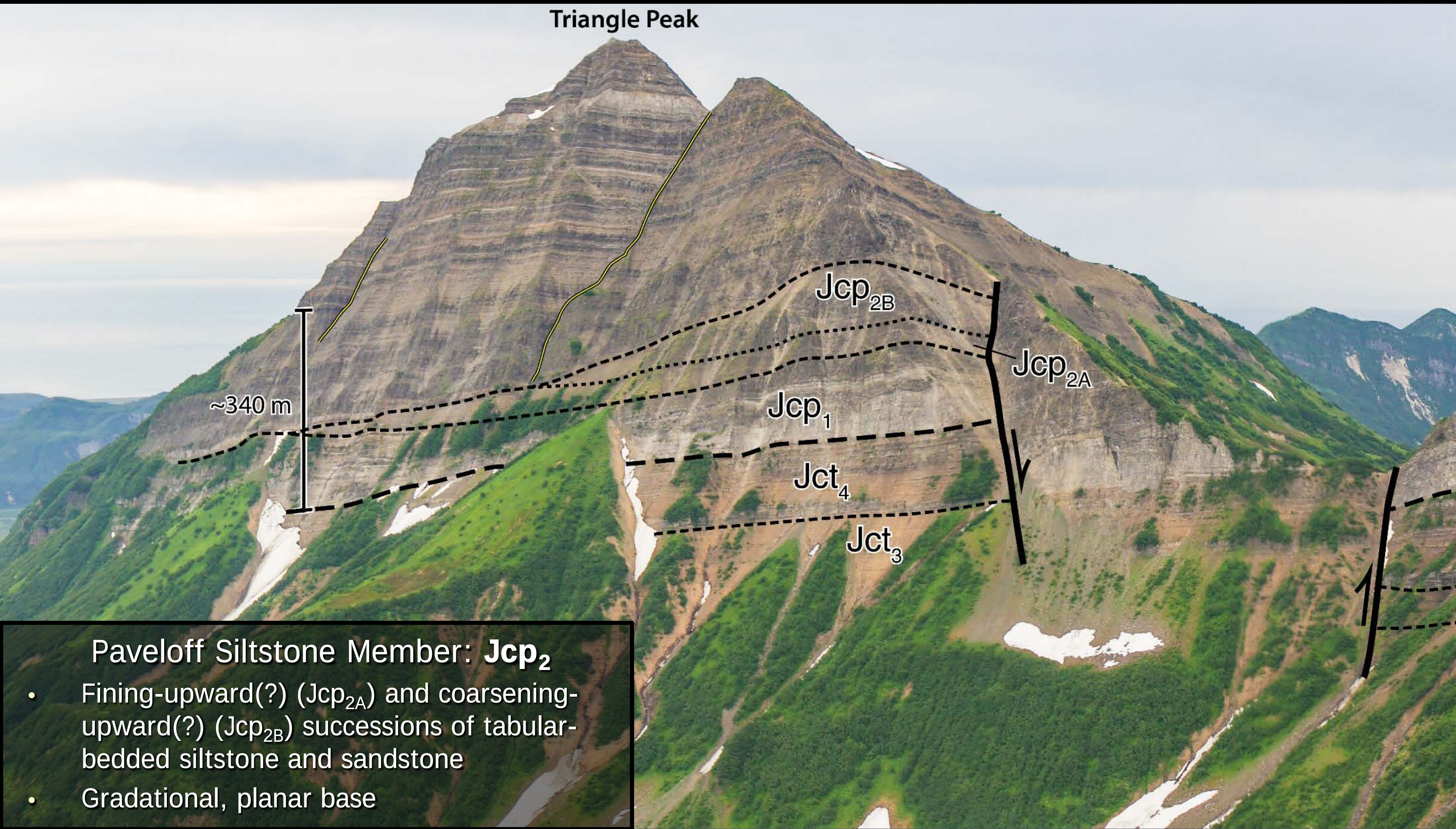
- Tabular-bedded and channelized
- Typically sharp, planar base; locally m-scale to 10s of m erosional relief

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Triangle Peak Reference Exposure

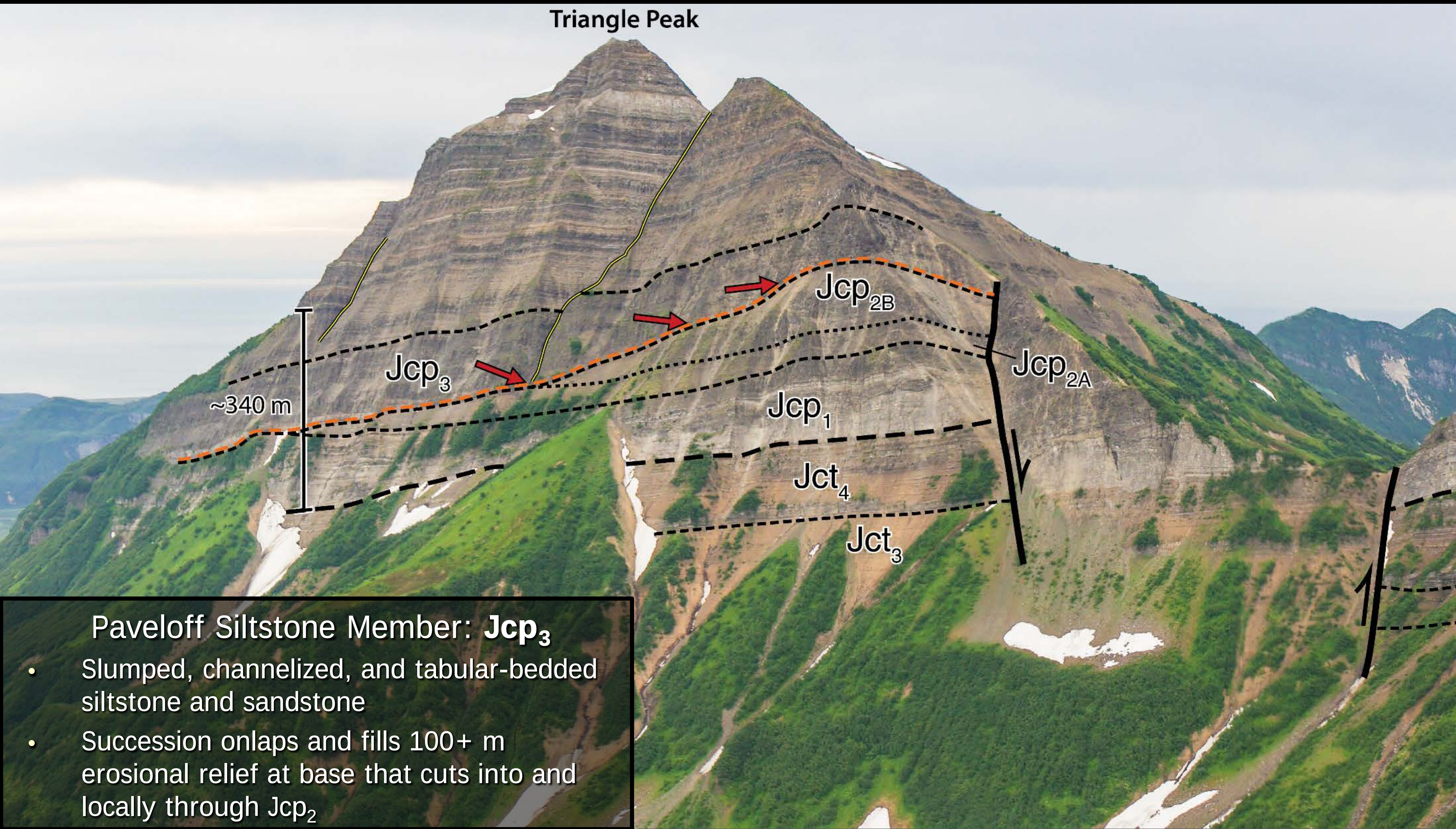


Paveloff Siltstone Member: **Jcp₂**

- Fining-upward(?) (Jcp_{2A}) and coarsening-upward(?) (Jcp_{2B}) successions of tabular-bedded siltstone and sandstone
- Gradational, planar base

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

Triangle Peak Reference Exposure

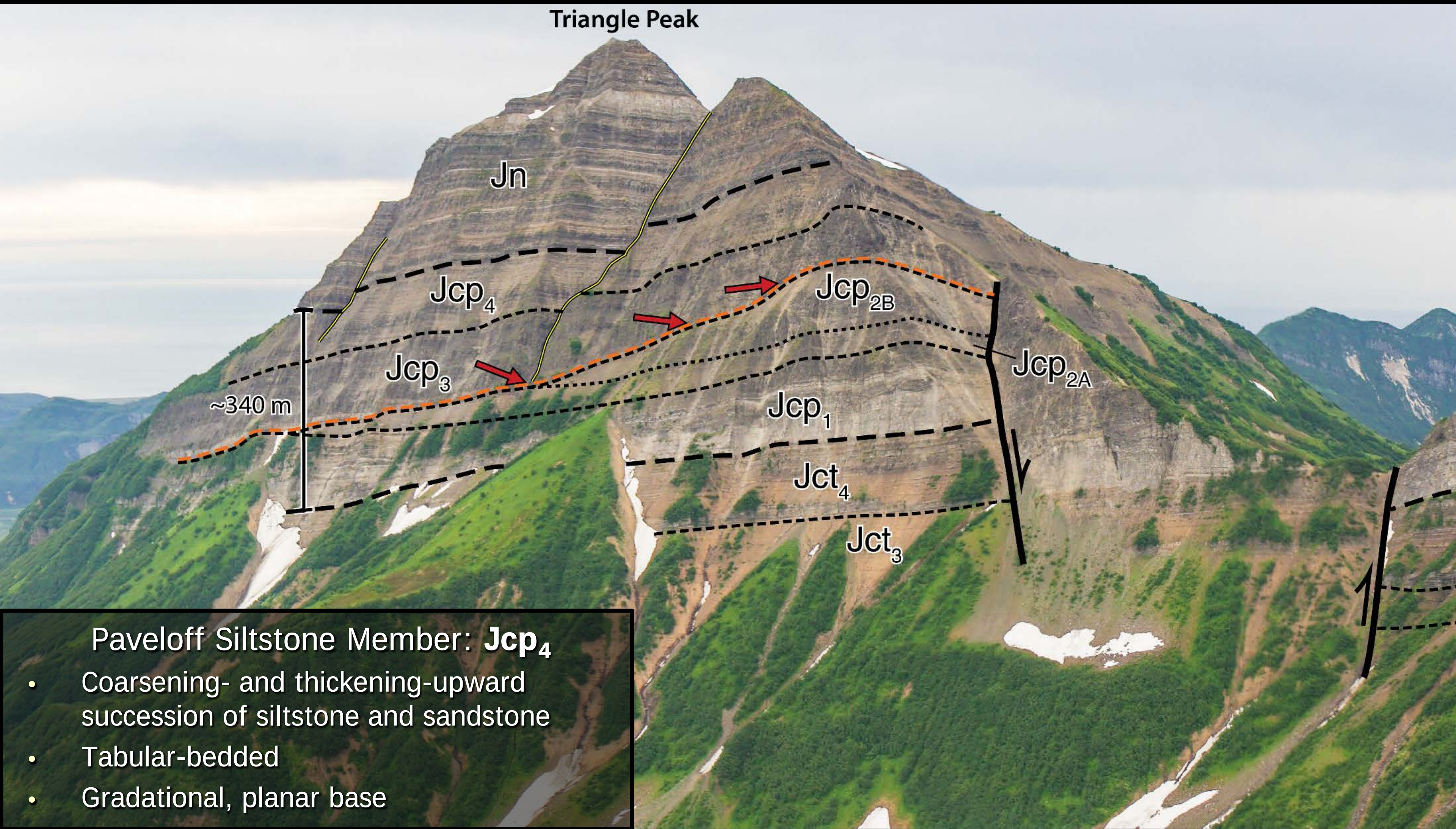


Paveloff Siltstone Member: **Jcp₃**

- Slumped, channelized, and tabular-bedded siltstone and sandstone
- Succession onlaps and fills 100+ m erosional relief at base that cuts into and locally through Jcp_2

Stratigraphic Architecture of the Chinitna Formation—Paveloff Architectural Units

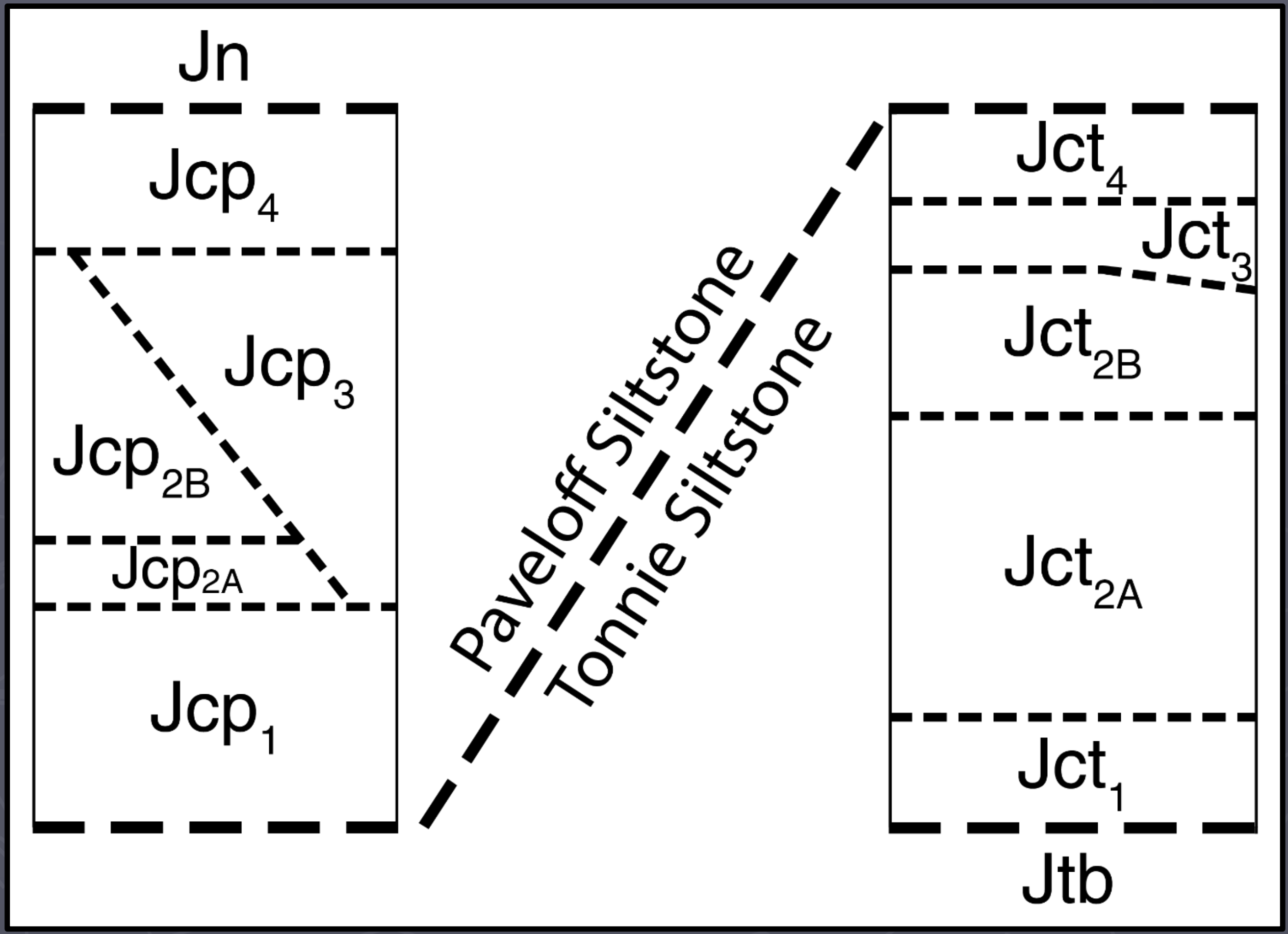
Triangle Peak Reference Exposure



Paveloff Siltstone Member: **Jcp₄**

- Coarsening- and thickening-upward succession of siltstone and sandstone
- Tabular-bedded
- Gradational, planar base

Stratigraphic Architecture of the Chinitna Formation—Architectural Units Summary



Presentation Outline

- Geologic Setting—Cook Inlet Forearc Basin
- Chinitna Formation—Stratigraphic Overview
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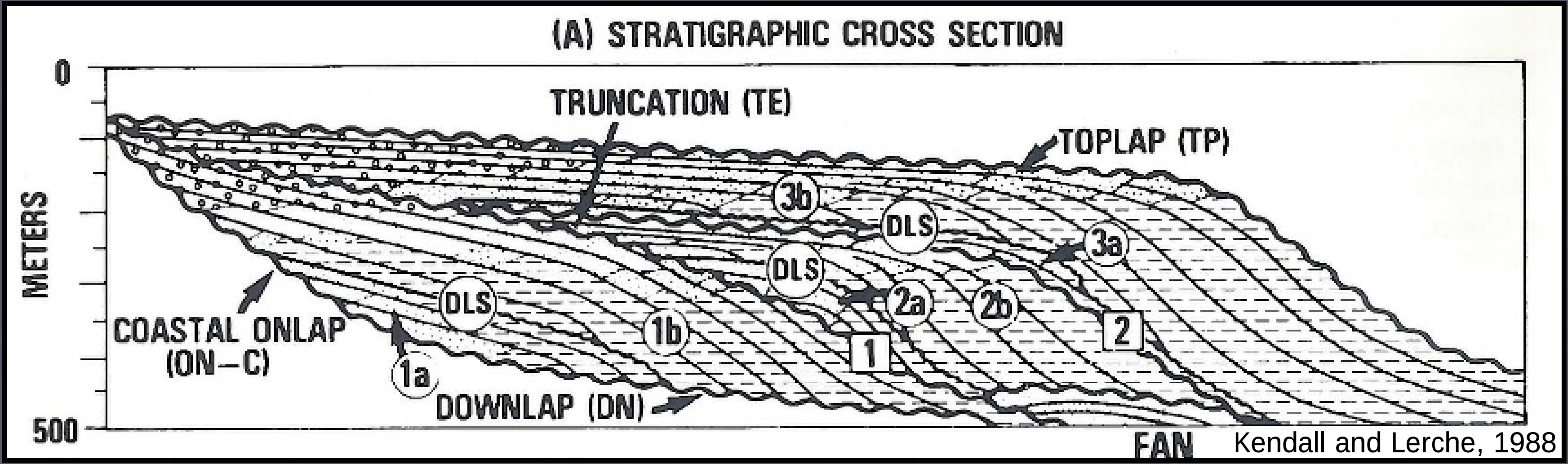
  - Observations and photogeologic mapping
  - Depositional environment interpretations, again
- Stratigraphic Architecture of the Chinitna
- Sequence-Stratigraphic Framework of the Chinitna
  - Surfaces, systems tracts, and sequences
  - Depositional environments, once again
- Petroleum Systems Context, Oil-stained Outcrops, and Reservoir Quality Considerations
- Summary and Conclusions

Sequence Stratigraphy

- What is sequence stratigraphy? The study of stratal stacking patterns in a multi-dimensional framework, with emphases on depositional systems trends, stratigraphic cyclicity, and the interplay between accommodation (A) and sediment supply (S)

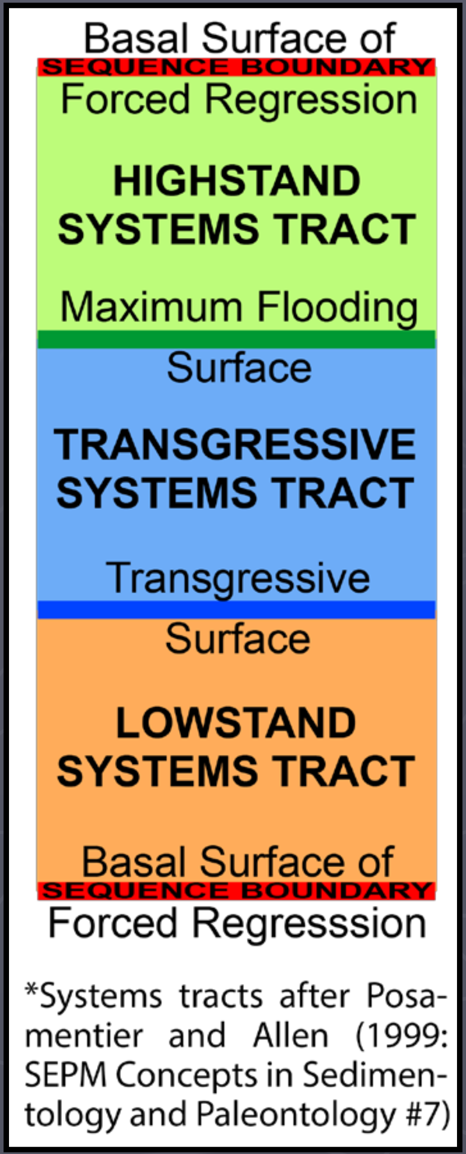


Kendall and Lerche, 1988

- Sequence stratigraphy provides a framework to organize observations, generate reasonable and ideally testable hypotheses, and leverage observations and interpretations from one's own "window into the world" to depositional reaches beyond a studied area
  - See reviews by Catuneanu et al. (2009, 2011)
    - Also Catuneanu (2002, 2006, 2017)

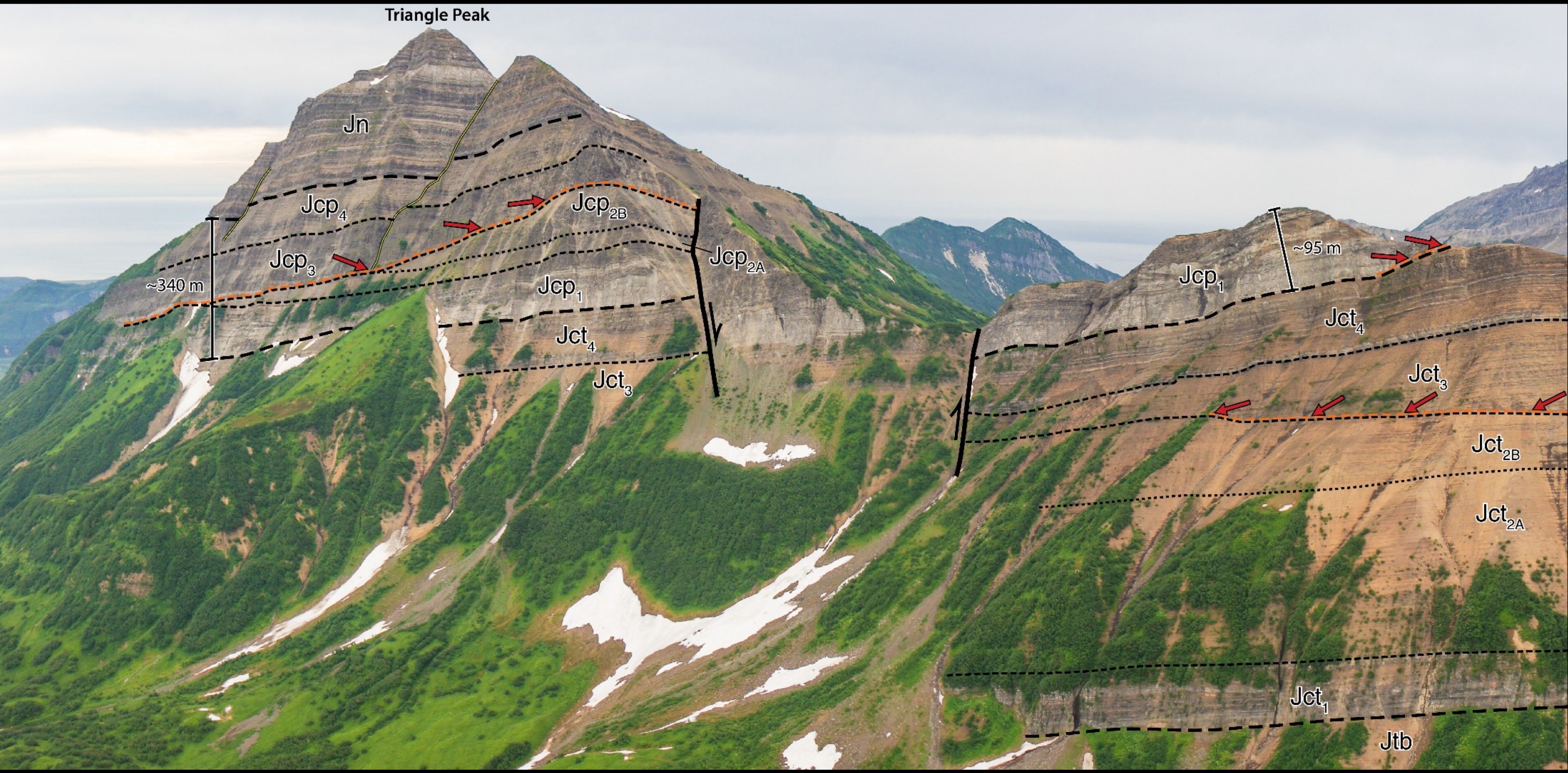
Sequence-Stratigraphic Framework of the Chinitna Formation—Methods

- Outcrop-based study of depositional environment trends, stratigraphic architecture, and stratal terminations:
  - Sequence stratigraphic surfaces
  - Systems tracts
  - Stratigraphic sequences
- Three surfaces:
  - BSFR, TS, MFS
    - BSFR (Hunt and Tucker, 1992) as sequence boundary (Posamentier and Allen, 1999)
- Three systems tracts (Posamentier and Allen, 1999):
  - LST (FR+LNR), TST, and HST (HNR)



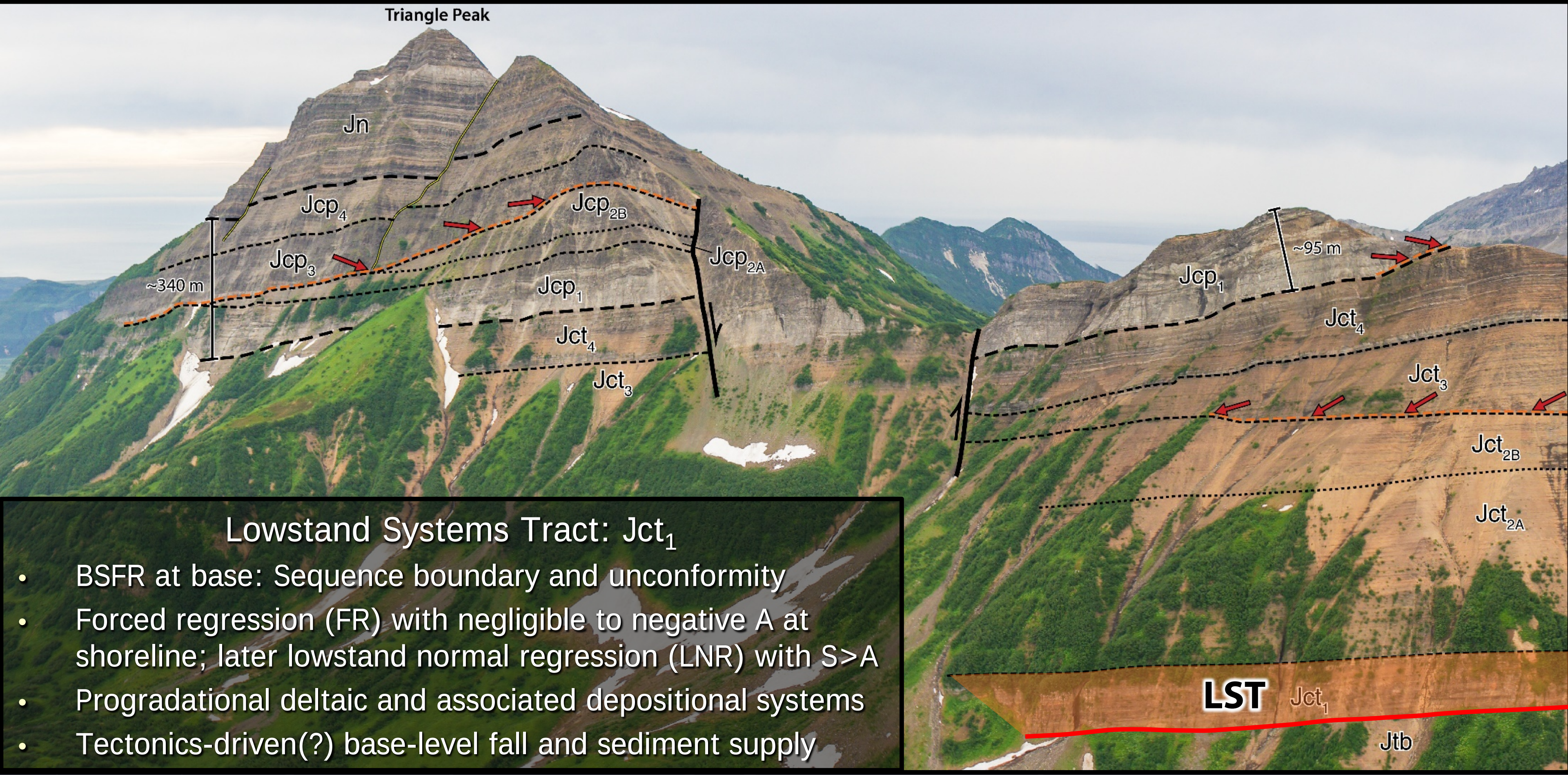
Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure



Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure

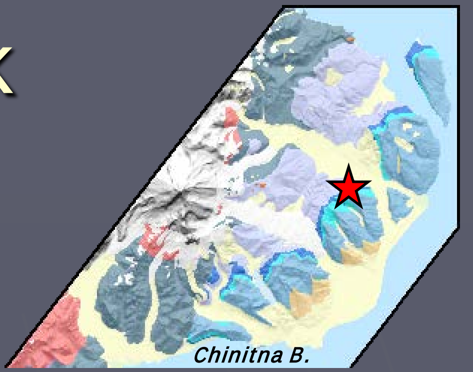


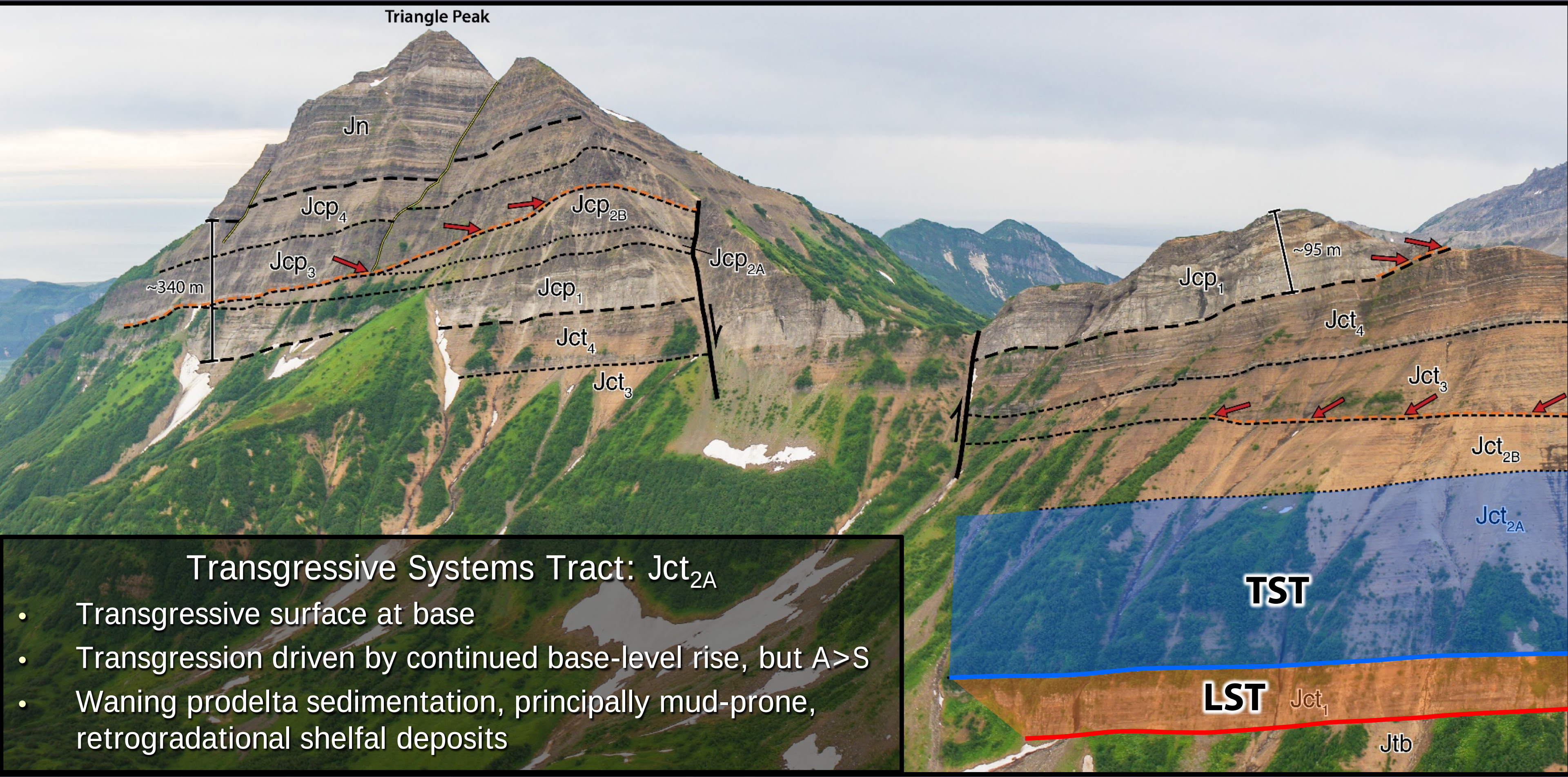
Lowstand Systems Tract: Jct_1

- BSFR at base: Sequence boundary and unconformity
- Forced regression (FR) with negligible to negative A at shoreline; later lowstand normal regression (LNR) with S>A
- Progradational deltaic and associated depositional systems
- Tectonics-driven(?) base-level fall and sediment supply

Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure



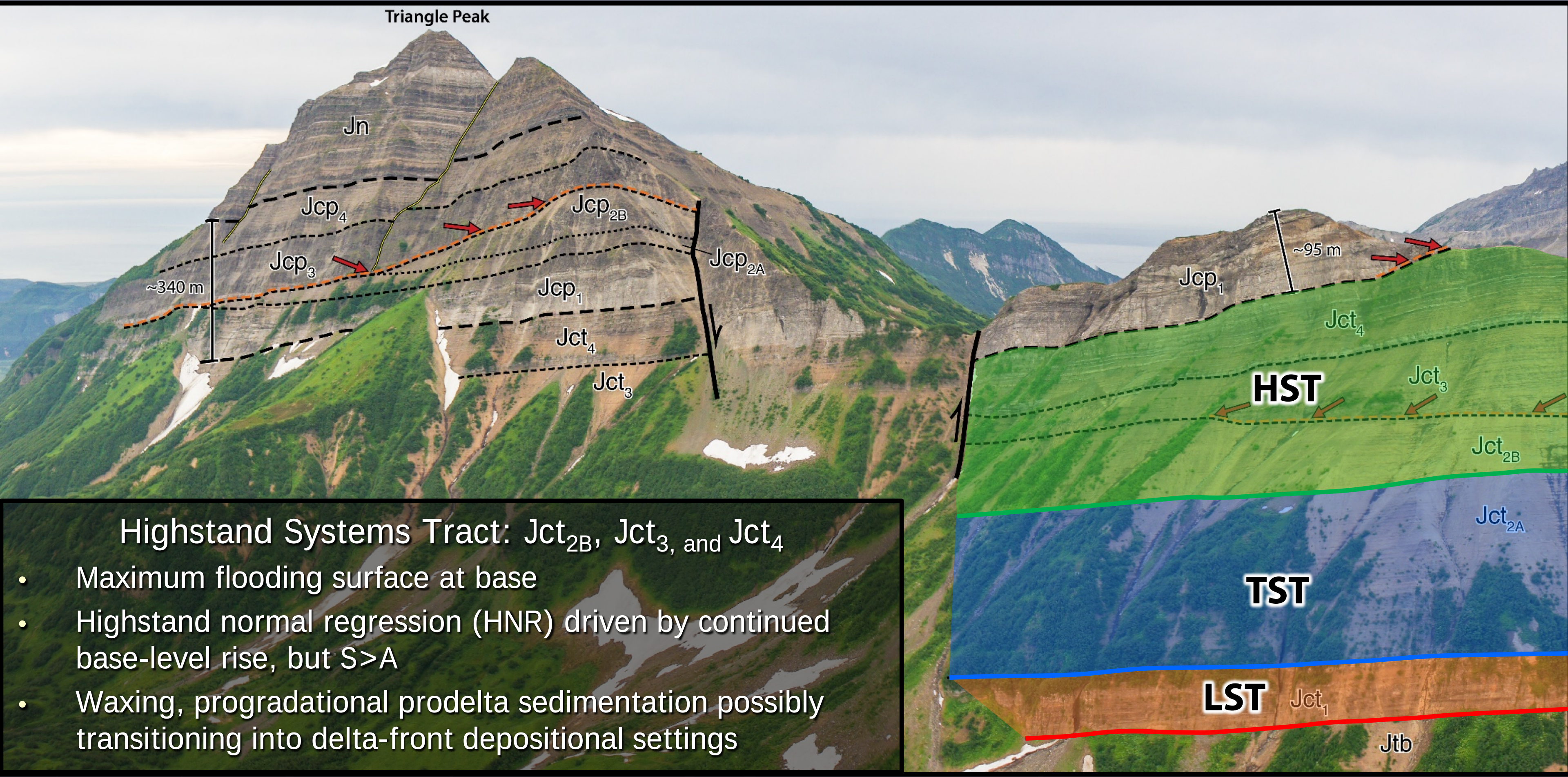


Transgressive Systems Tract: Jct_{2A}

- Transgressive surface at base
- Transgression driven by continued base-level rise, but A>S
- Waning prodelta sedimentation, principally mud-prone, retrogradational shelfal deposits

Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure

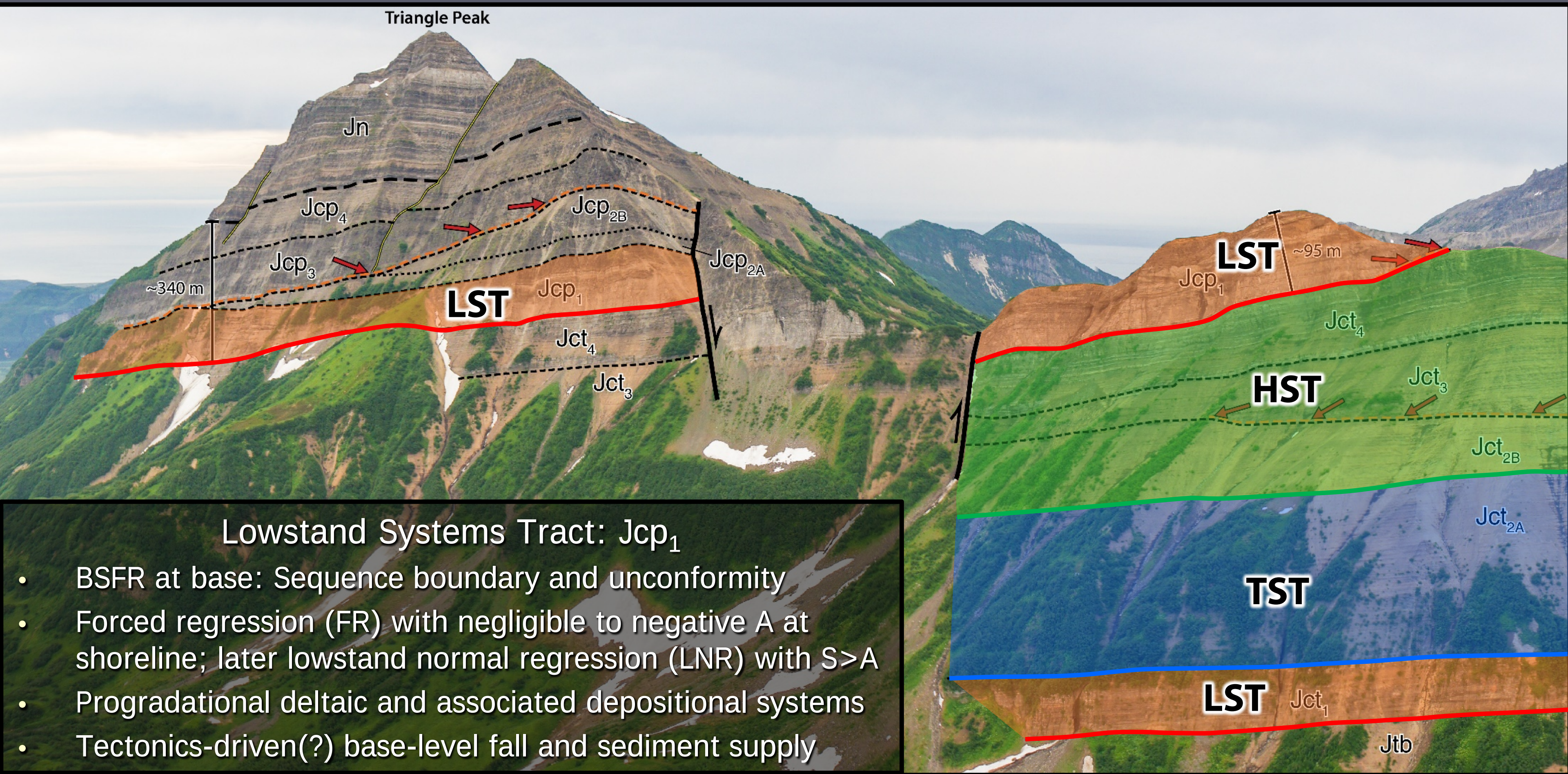


Highstand Systems Tract: Jct_{2B}, $Jct_{3,\ \text{and}}$ Jct_4

- Maximum flooding surface at base
- Highstand normal regression (HNR) driven by continued base-level rise, but S>A
- Waxing, progradational prodelta sedimentation possibly transitioning into delta-front depositional settings

Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure



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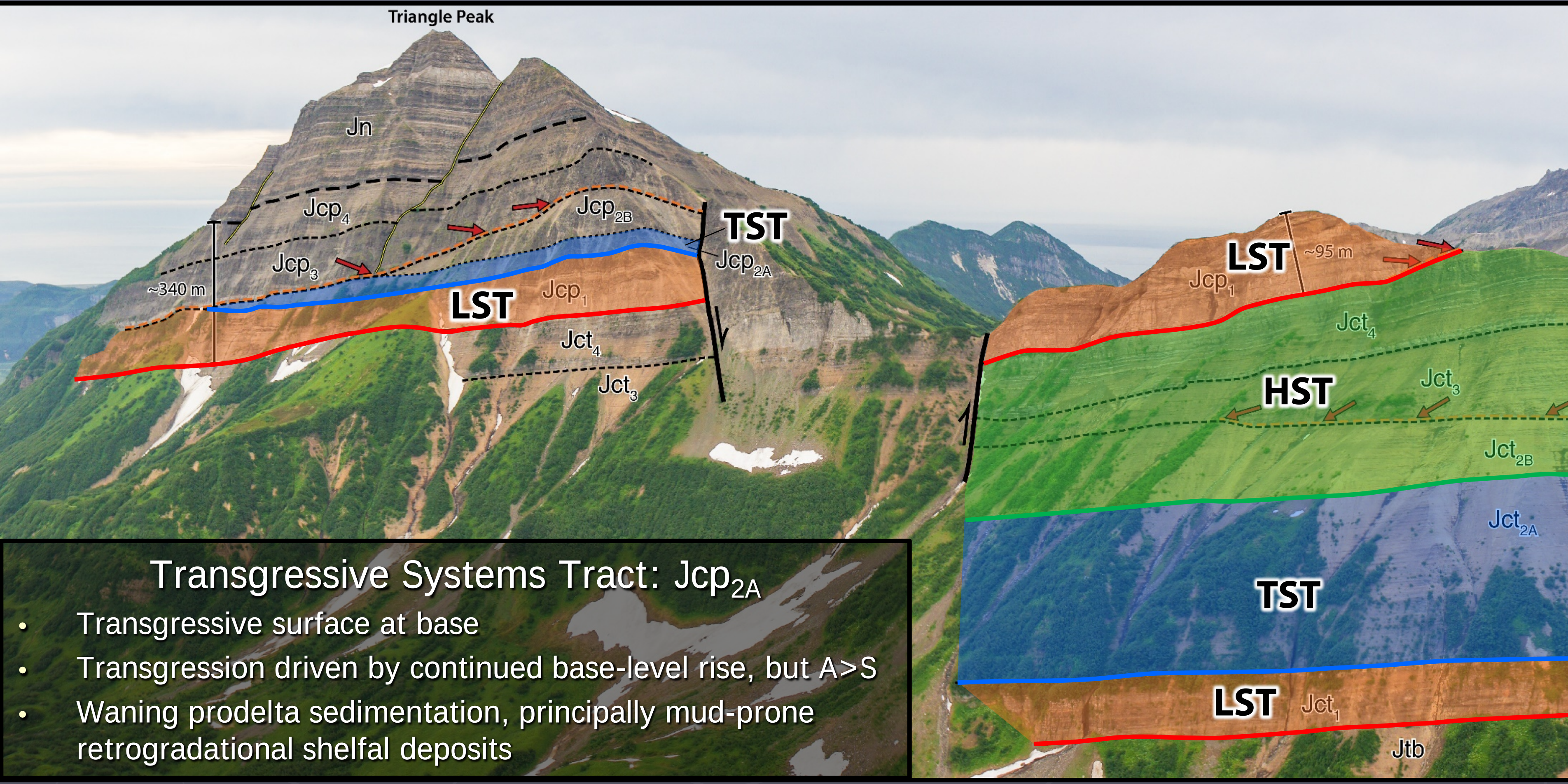
- Tectonics-driven(?) base-level fall and sediment supply

Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure



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Sequence-Stratigraphic Framework of the Chinitna Formation

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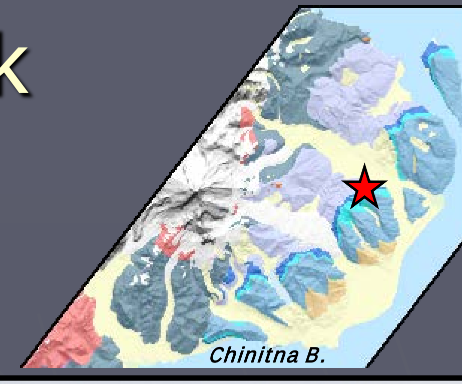
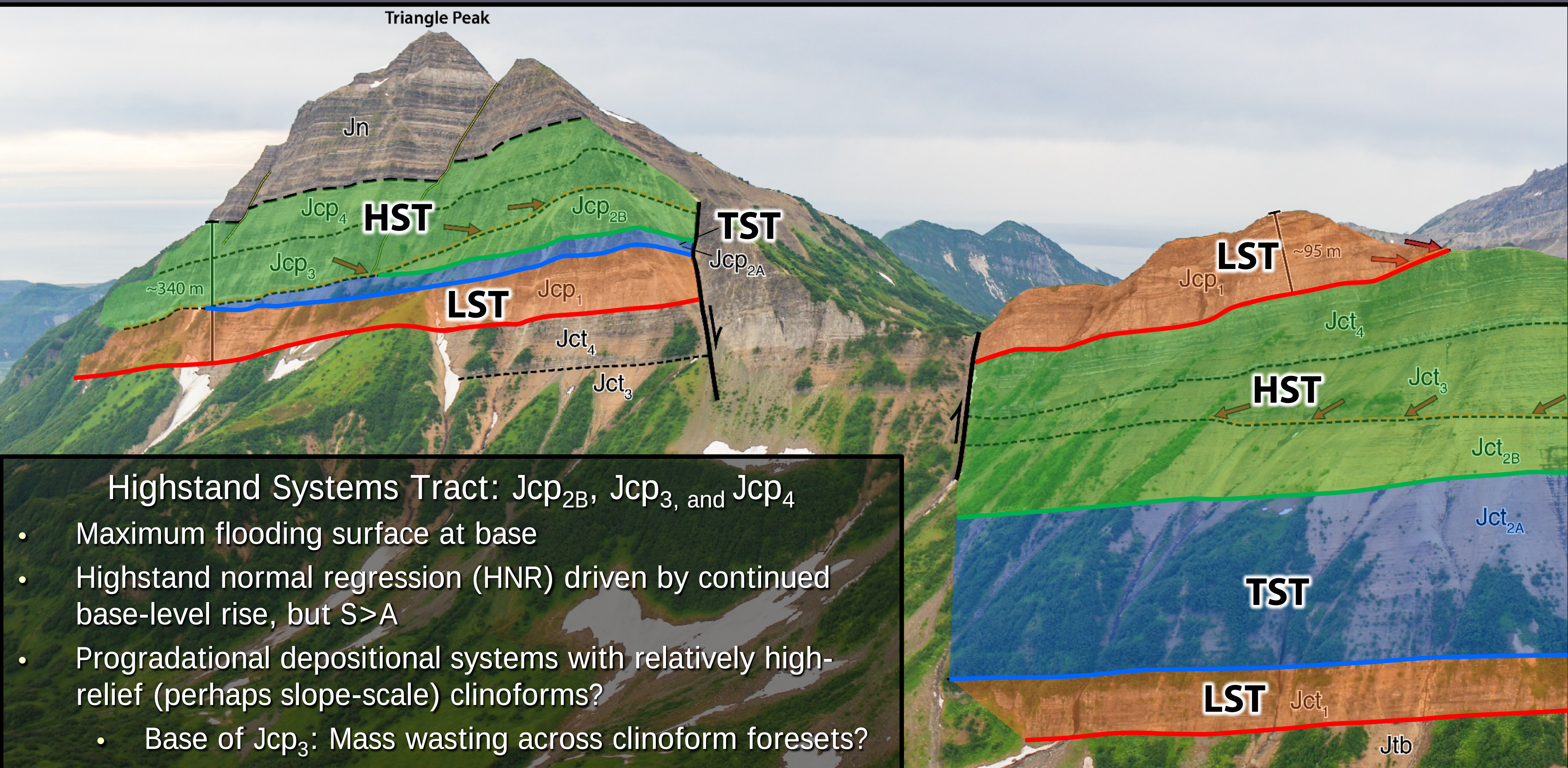


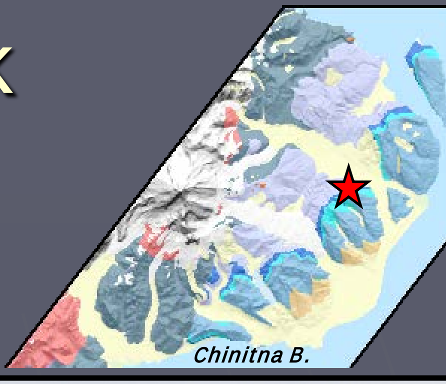


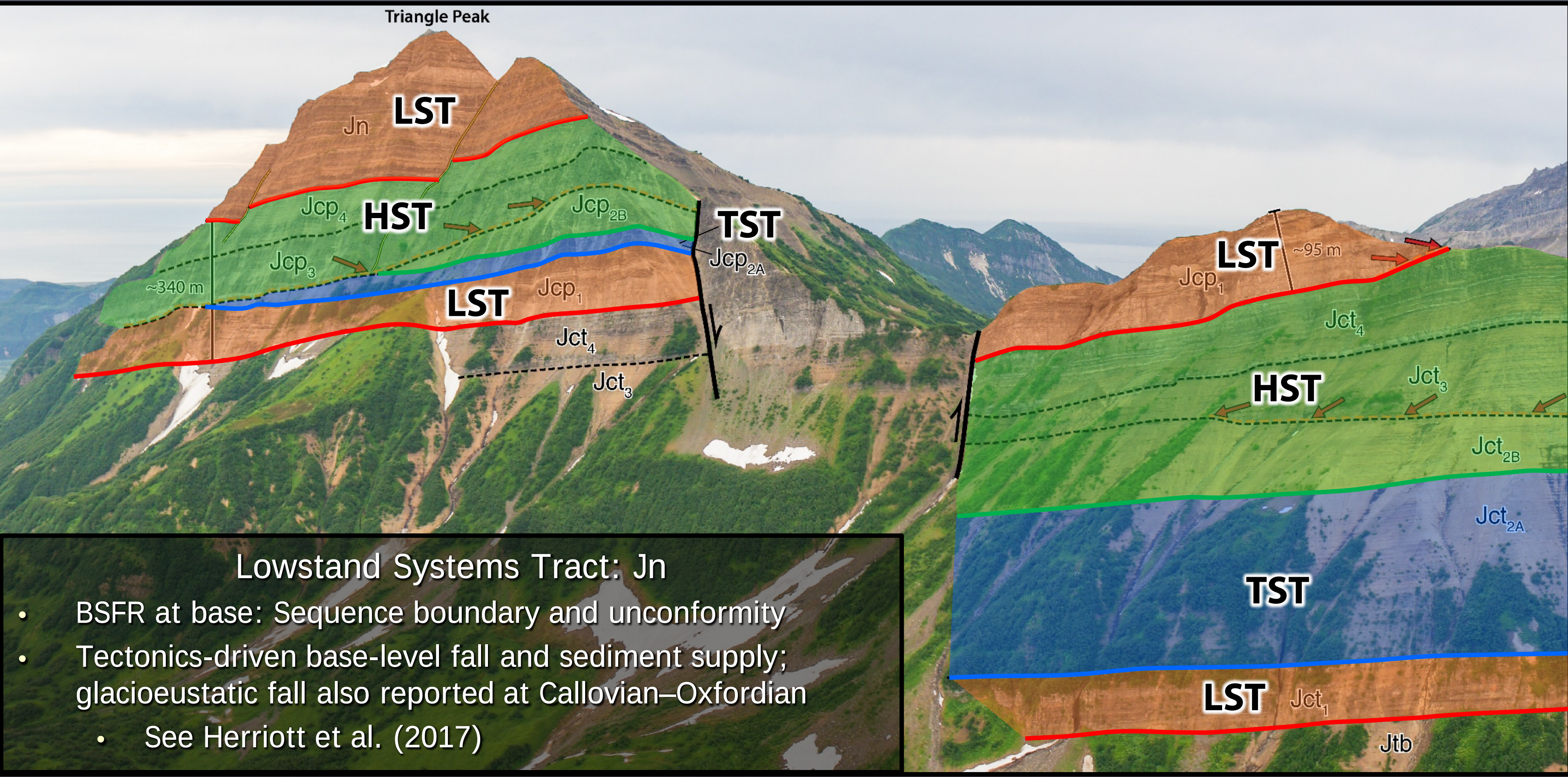
Highstand Systems Tract: Jcp_{2B}, Jcp_{3}, and Jcp_4

- Maximum flooding surface at base
- Highstand normal regression (HNR) driven by continued base-level rise, but S>A
- Progradational depositional systems with relatively high-relief (perhaps slope-scale) clinoforms?
  - Base of Jcp_3: Mass wasting across clinoform foresets?

Sequence-Stratigraphic Framework of the Chinitna Formation

Triangle Peak Reference Exposure

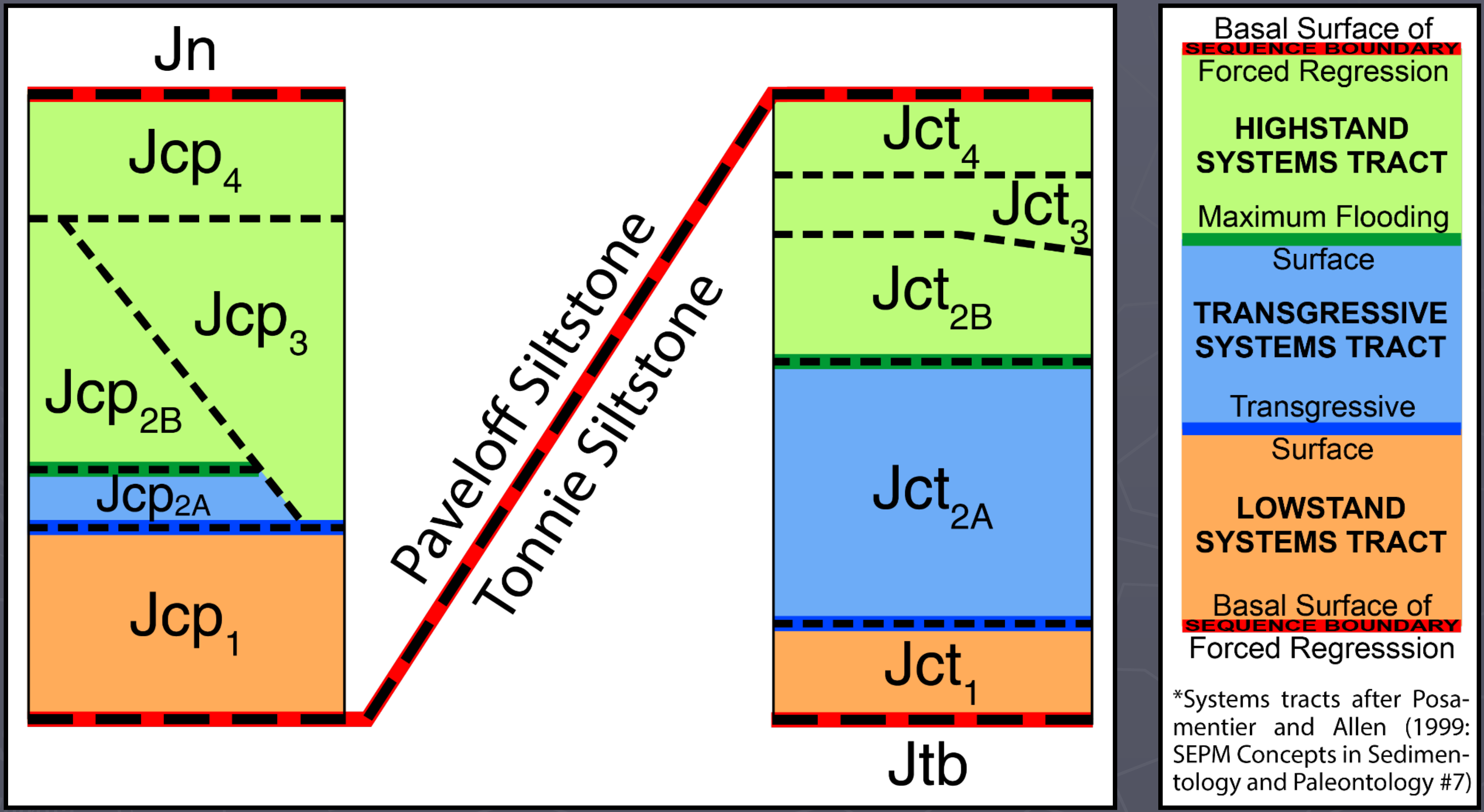




Lowstand Systems Tract: Jn

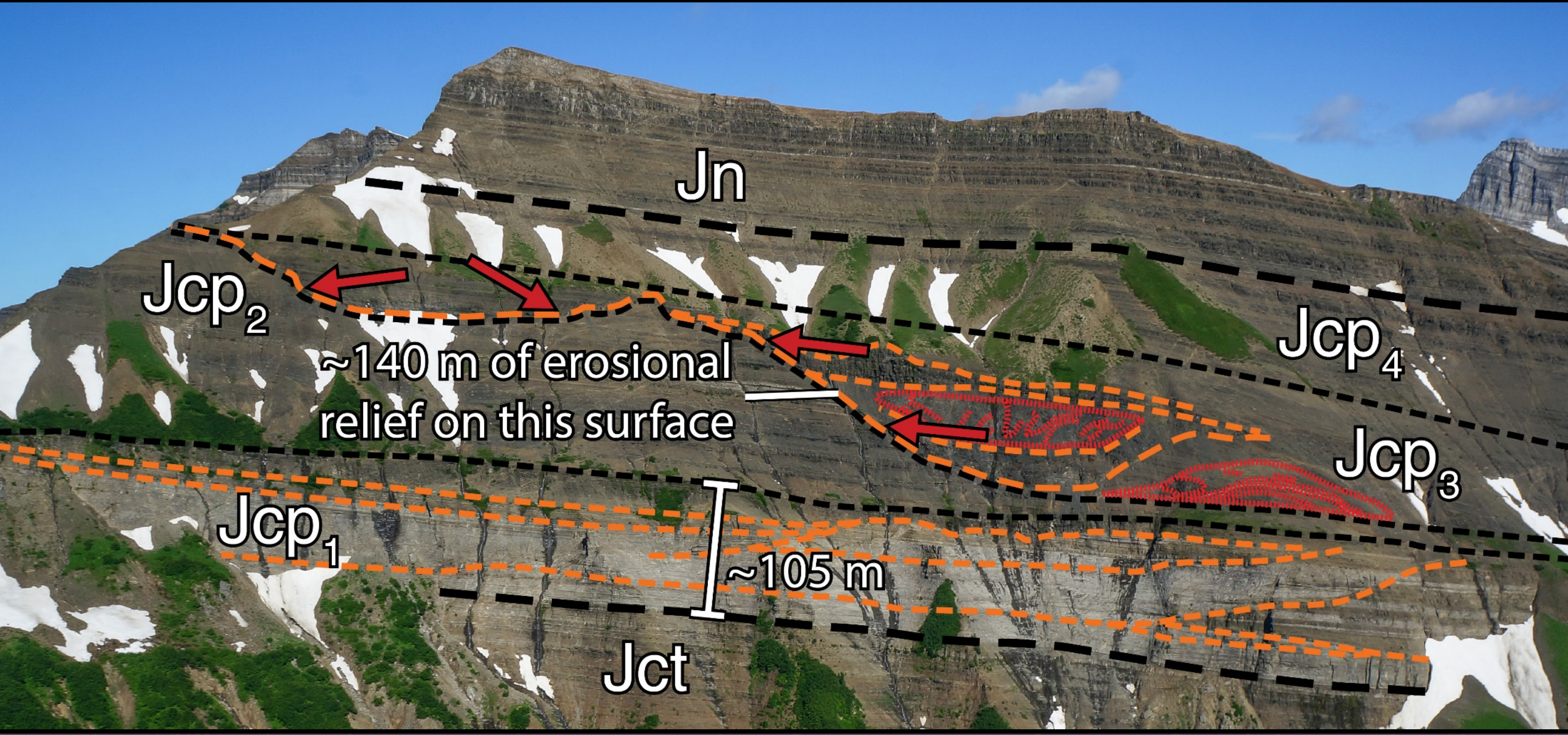
- BSFR at base: Sequence boundary and unconformity
- Tectonics-driven base-level fall and sediment supply; glacioeustatic fall also reported at Callovian–Oxfordian
  - See Herriott et al. (2017)

Sequence-Stratigraphic Framework of the Chinitna Formation—A Summary



Sequence-Stratigraphic Framework of the Chinitna Formation

Further discussion of base-of-Jcp_3 surface: Autogenic (e.g., HST mass wasting) or allogenic (i.e., regional base level-fall) origin?



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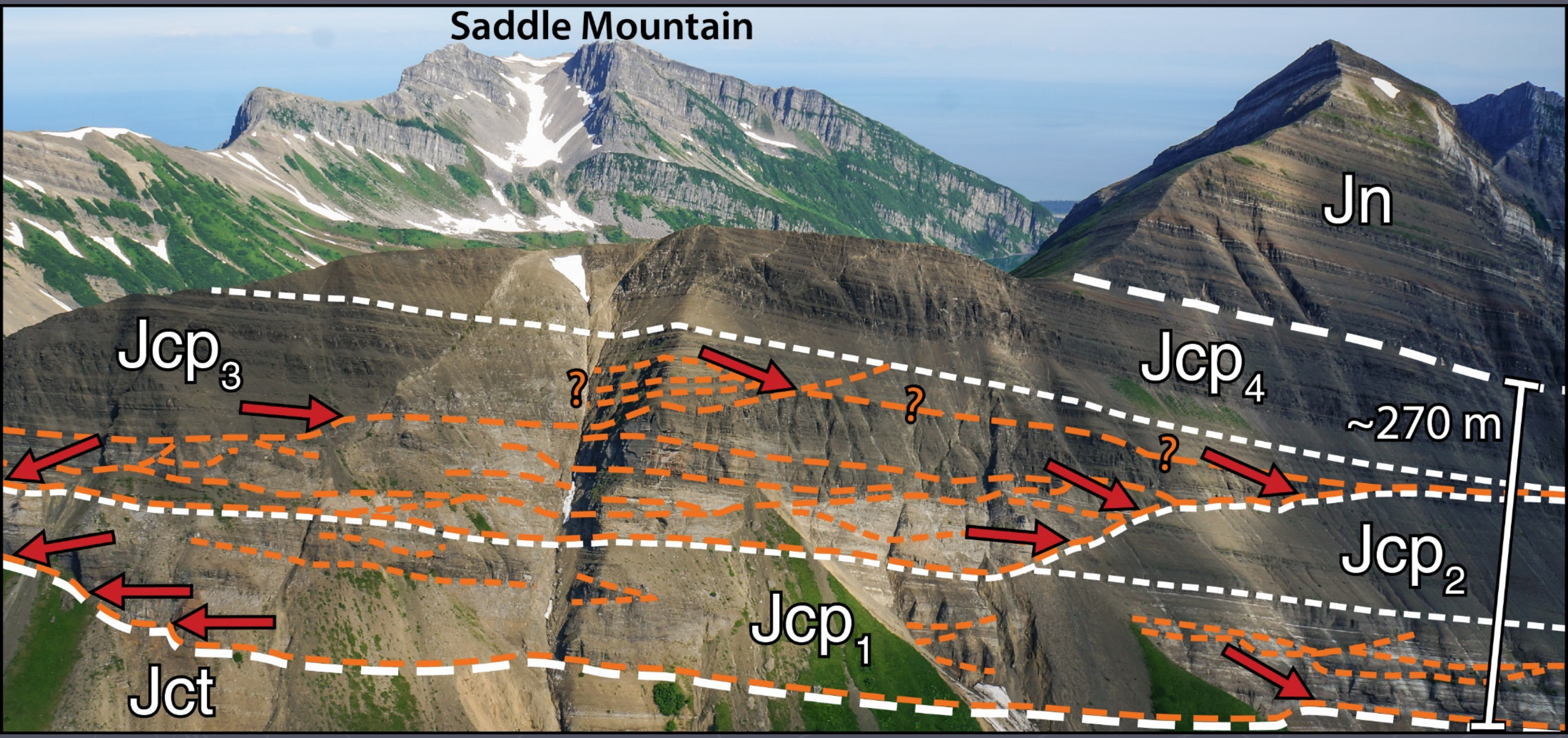
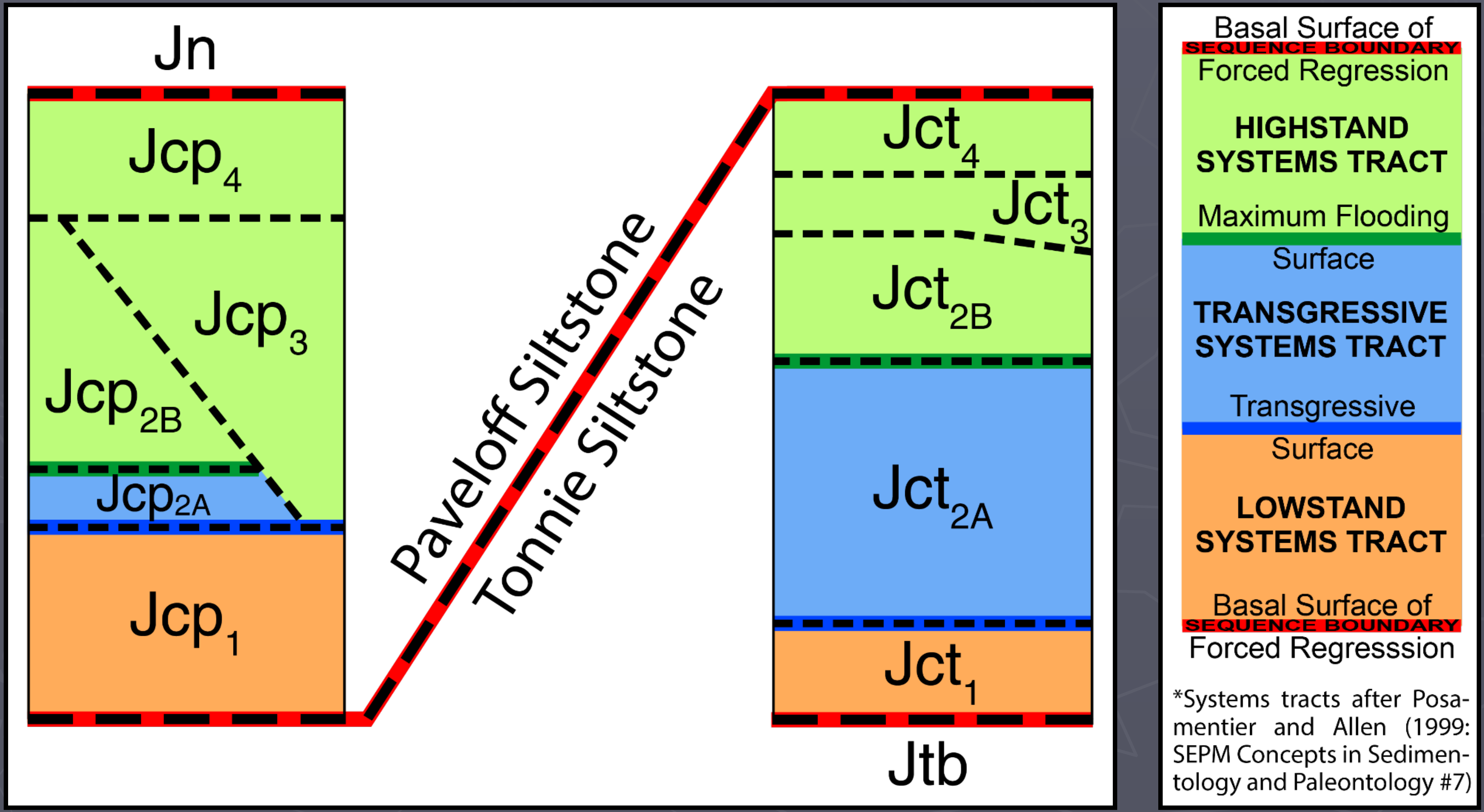


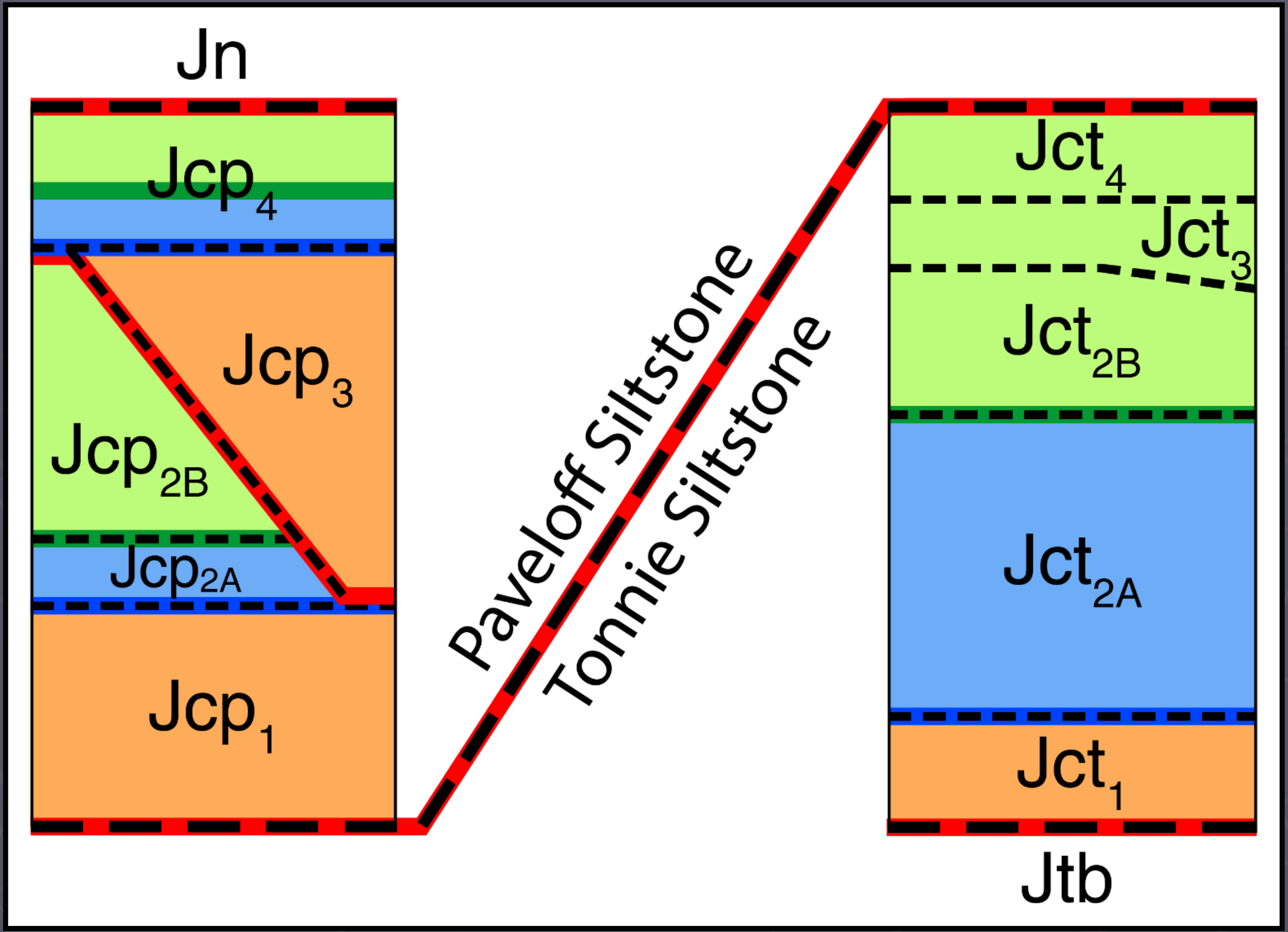
Sequence-Stratigraphic Framework of the Chinitna Formation—A Summary

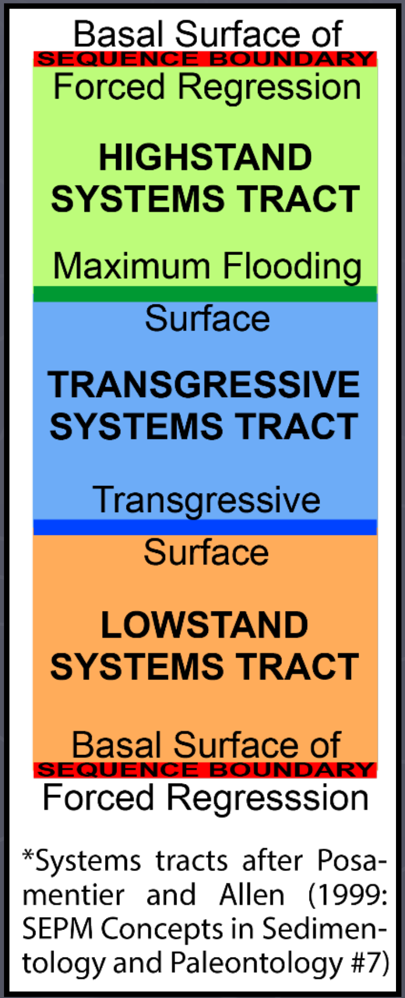
Base-of-Jcp_3 surface: Autogenic or allogenic origin?



Sequence-Stratigraphic Framework of the Chinitna Formation—A Summary

Base-of-Jcp_3 surface: Autogenic or allogenic origin?
Preliminarily, either seems permissible, but if incision is allogenically driven, then an alternative interpretation may be considered:





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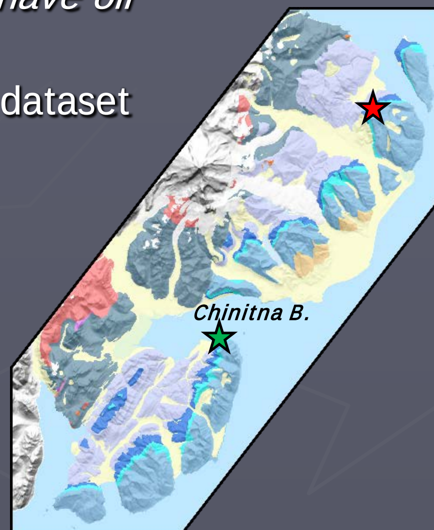
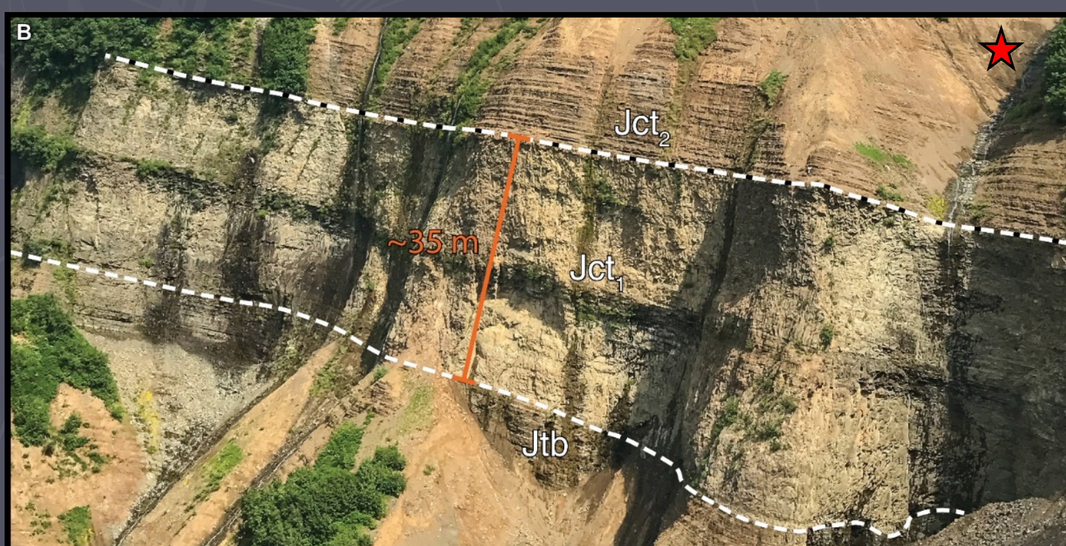
Petroleum Systems Context

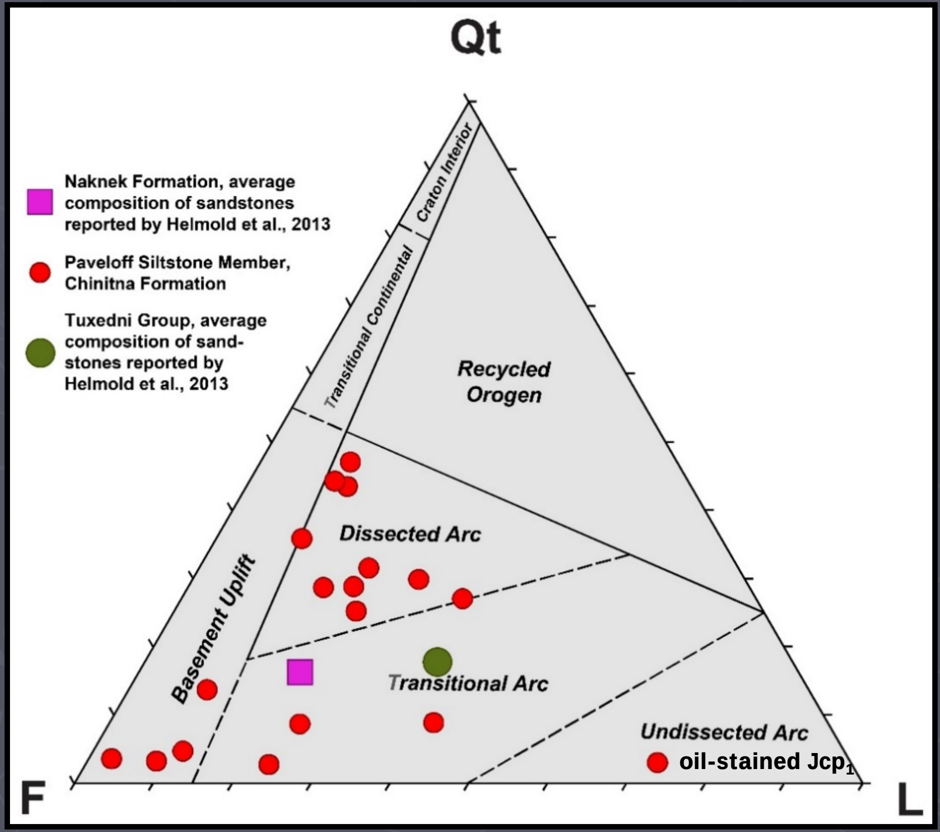
- Oil production in Cook Inlet is from Tertiary reservoirs
- Oil source rocks in the basin occur in the Middle Jurassic Tuxedni Group and/or Triassic strata
- *Does the Chinitna Formation have oil reservoir potential?*
- Paveloff sandstone petrology dataset
- Jct_1 and Jcp_1 are sand-prone, shallow-marine deposits
- Both LSTs are oil stained in outcrop
  - ★ (green) Jcp_1: Wartes and Herriott, 2015
  - ★ (red) Jct_1: Herriott and Wartes, 2017

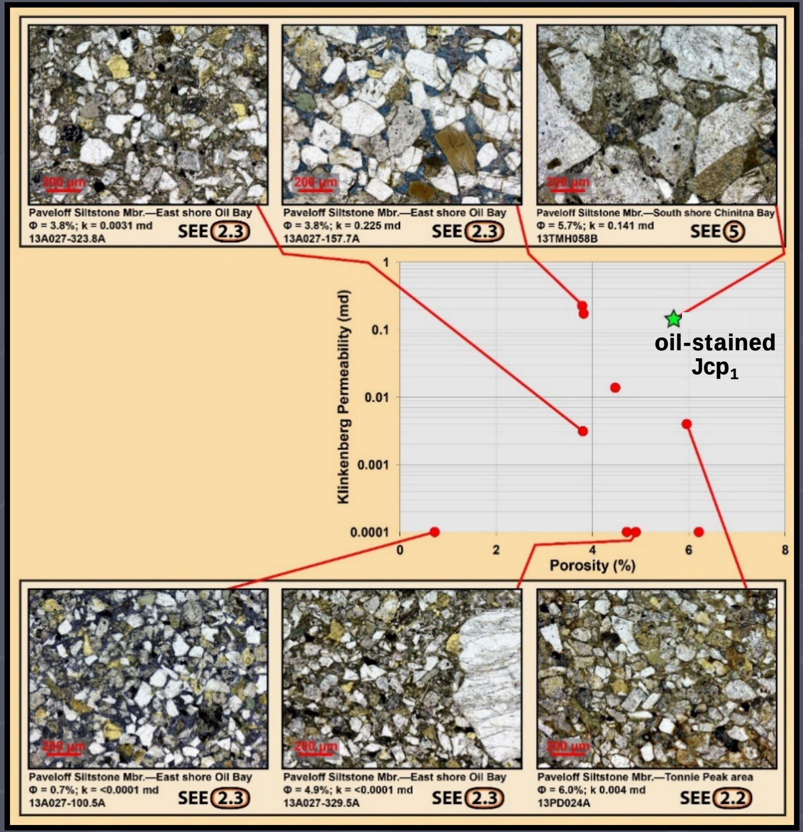




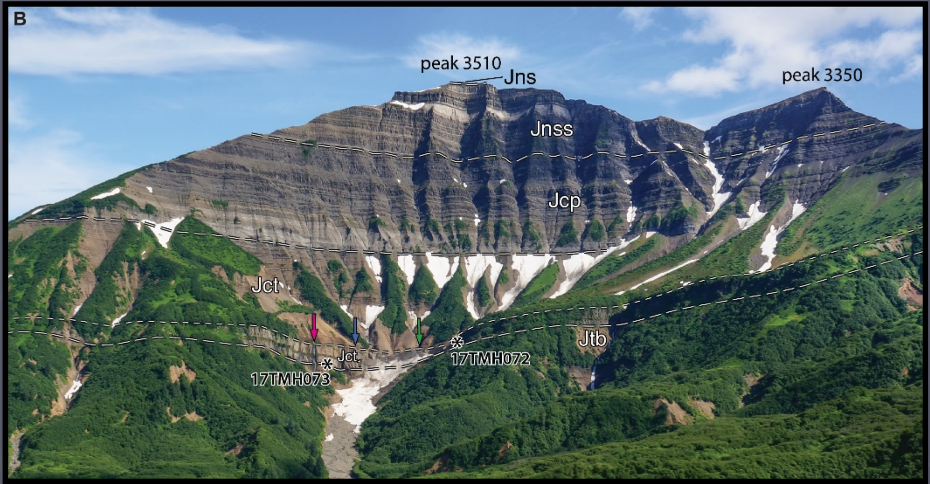
Paveloff Sandstone Compositional Data and Reservoir Quality Considerations

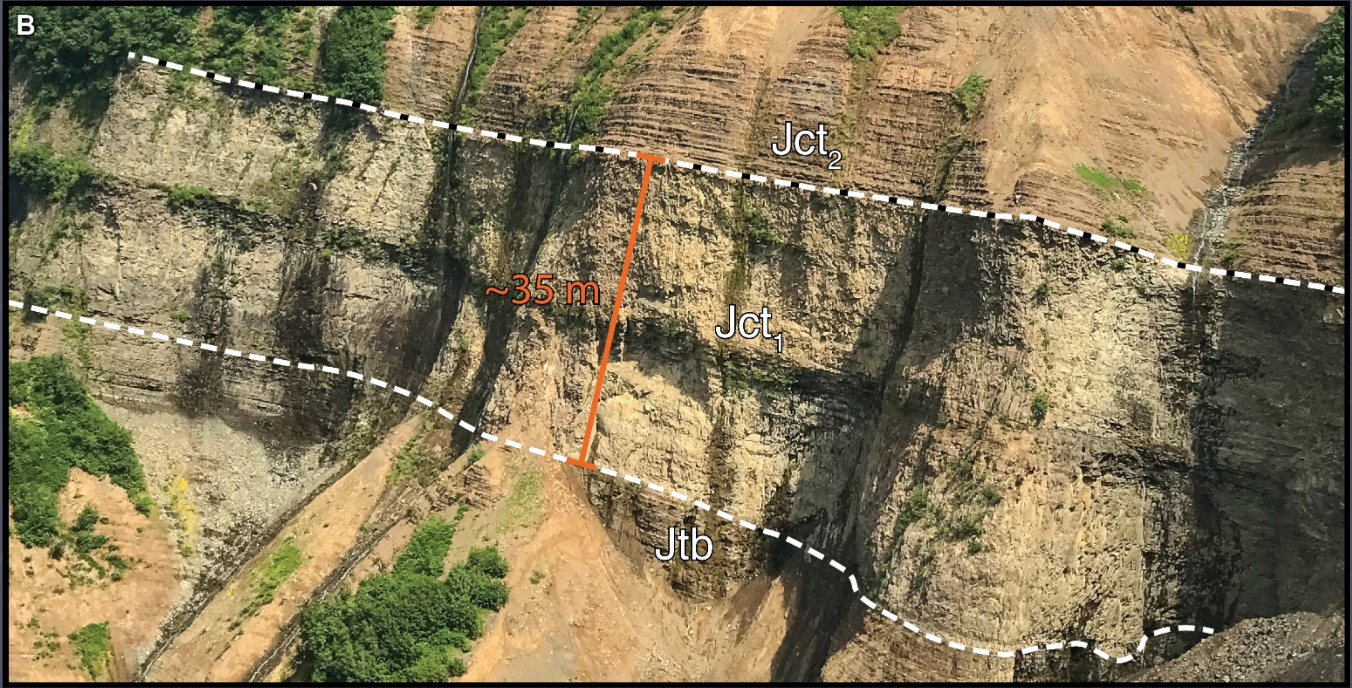
- Jurassic forearc stratigraphy is a first-cycle, arc-associated unroofing sequence: Tuxedni–Chinitna–Naknek (see LePain et al., 2013; Egbert 1982)
- Paveloff feldspathic sandstones:
  - Average ~50% feldspars and ~20% volcanic rock fragments
  - Authigenic chlorite and heulandite cements
  - Sandstones range up to ~6% porosities and ~0.2 millidarcies
- Reservoir quality: Zone of diagenetic control *sensu* Helmold et al. (2013)





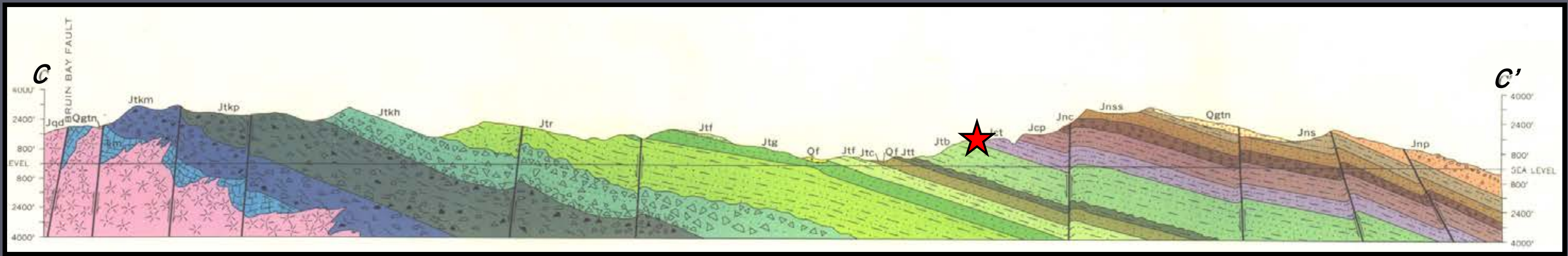
Oil-Stained Locality: Amphitheater—Jct_1 LST

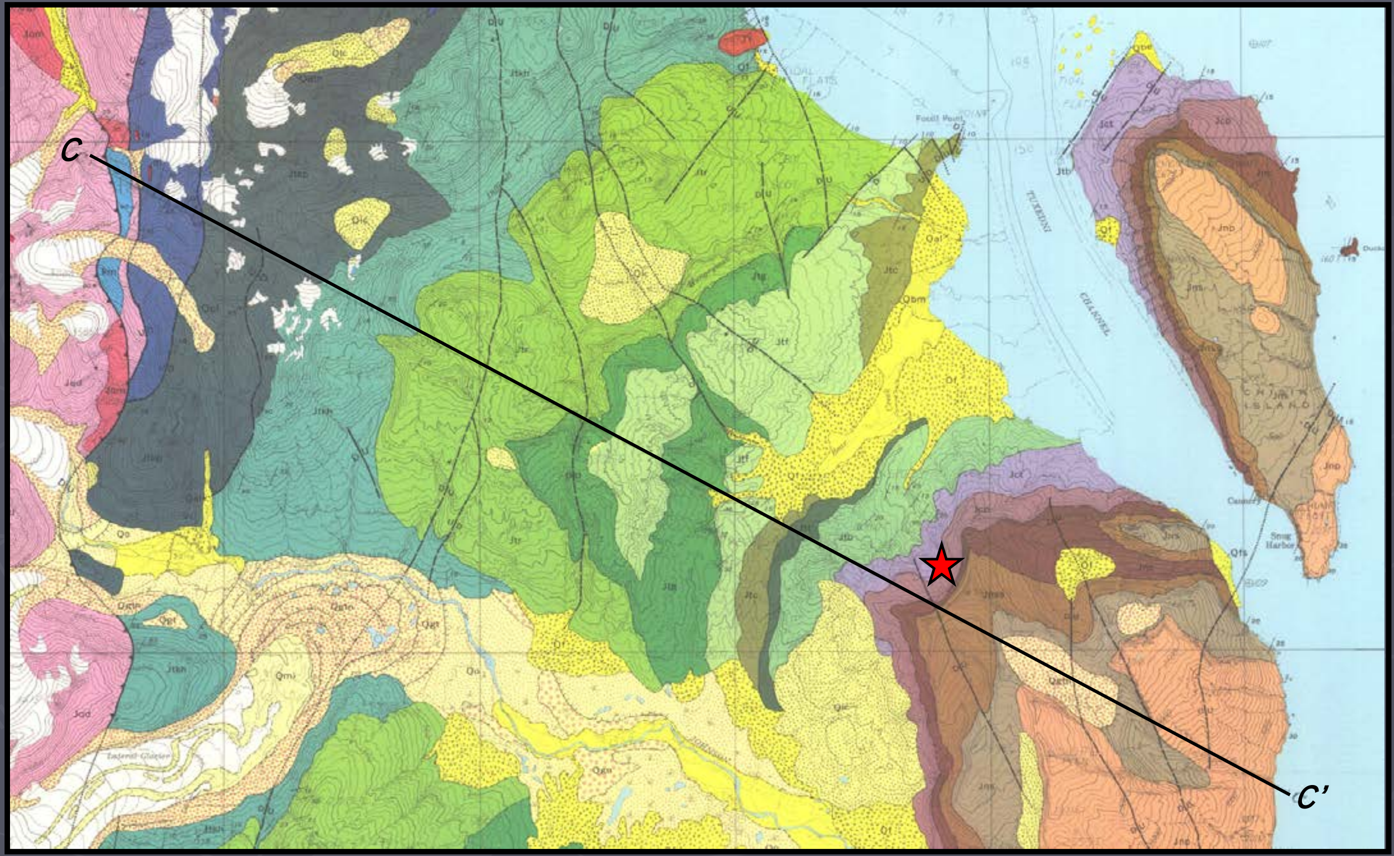




- Rubble and outcrop of the ~35-m-thick Jct_1 at this locality are ubiquitously oil stained across a >250-m-wide lateral extent
- Herriott and Wartes, 2017

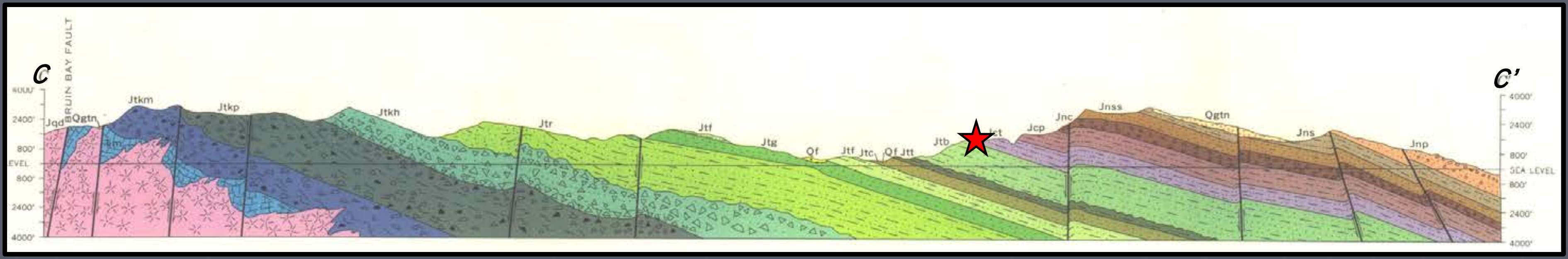
Oil-Stained Locality: Amphitheater—Jct_1 LST

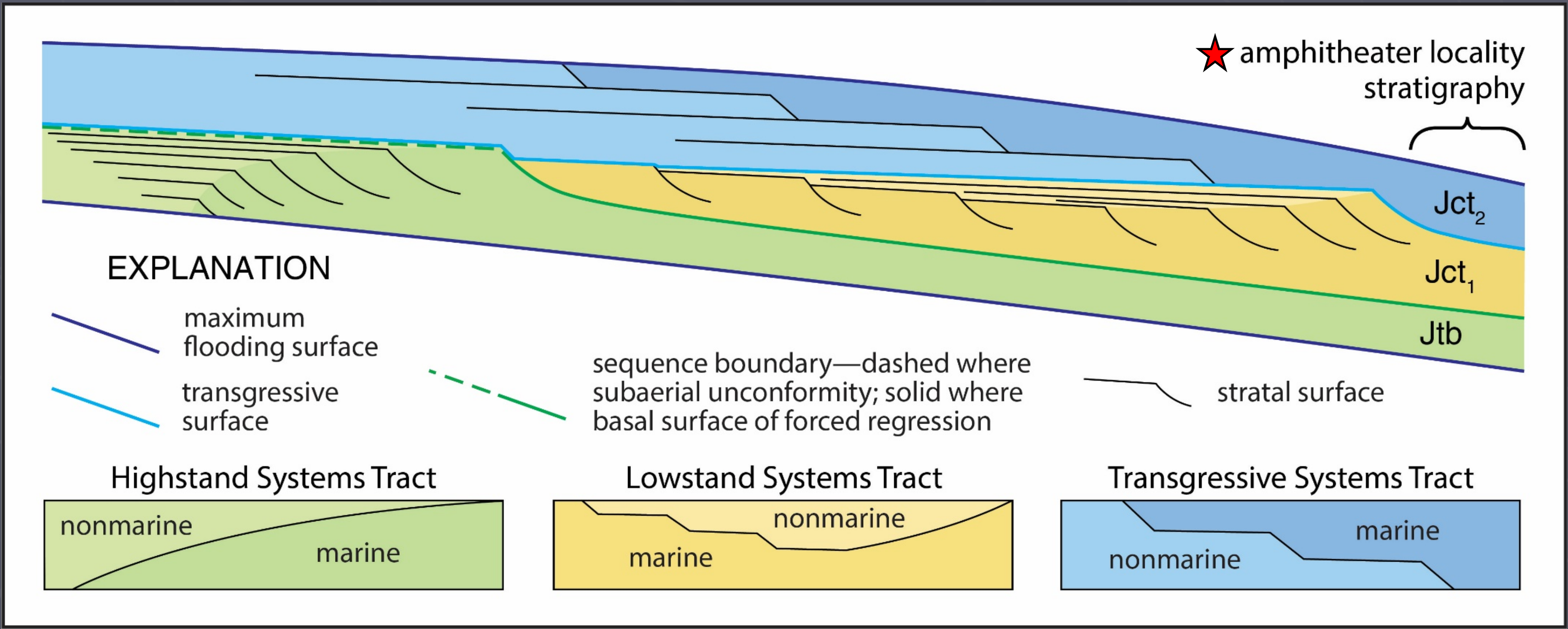




Detterman and Hartsock, 1966

Oil-Stained Locality: Amphitheater—Jct_1 LST

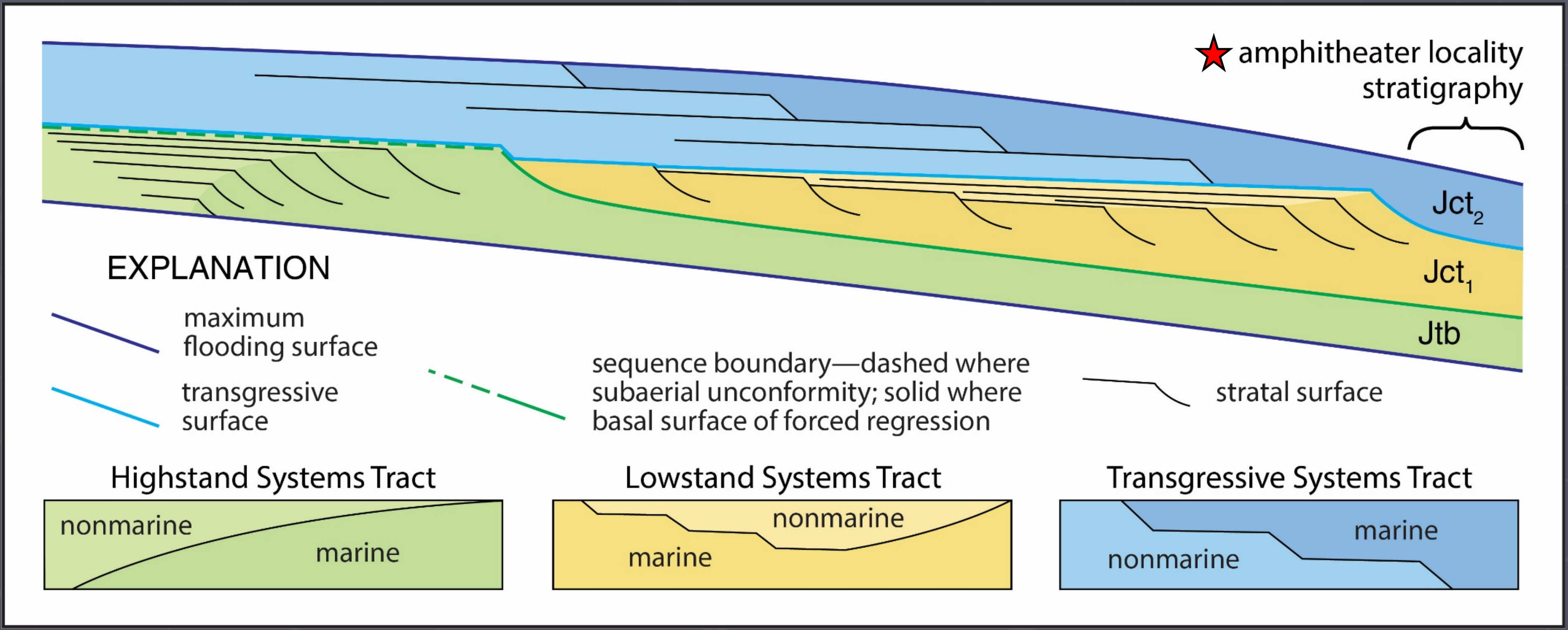




Herriott and Wartes, 2017

Oil-Stained Locality: Amphitheater—Jct_1 LST

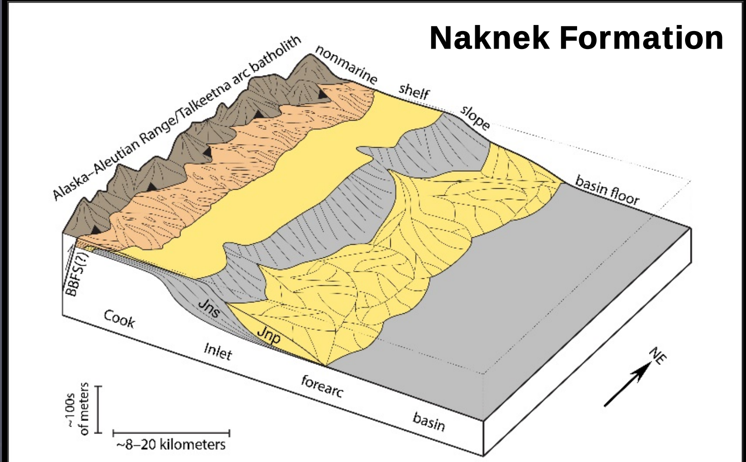
"…our reconnaissance of Jct_1 at the amphitheater locality indicates that this exposure is a candidate outcrop analogue for an oil-field-scale, sandstone-hosted, potentially stratigraphically trapped hydrocarbon accumulation in the Jurassic stratigraphy of Cook Inlet."



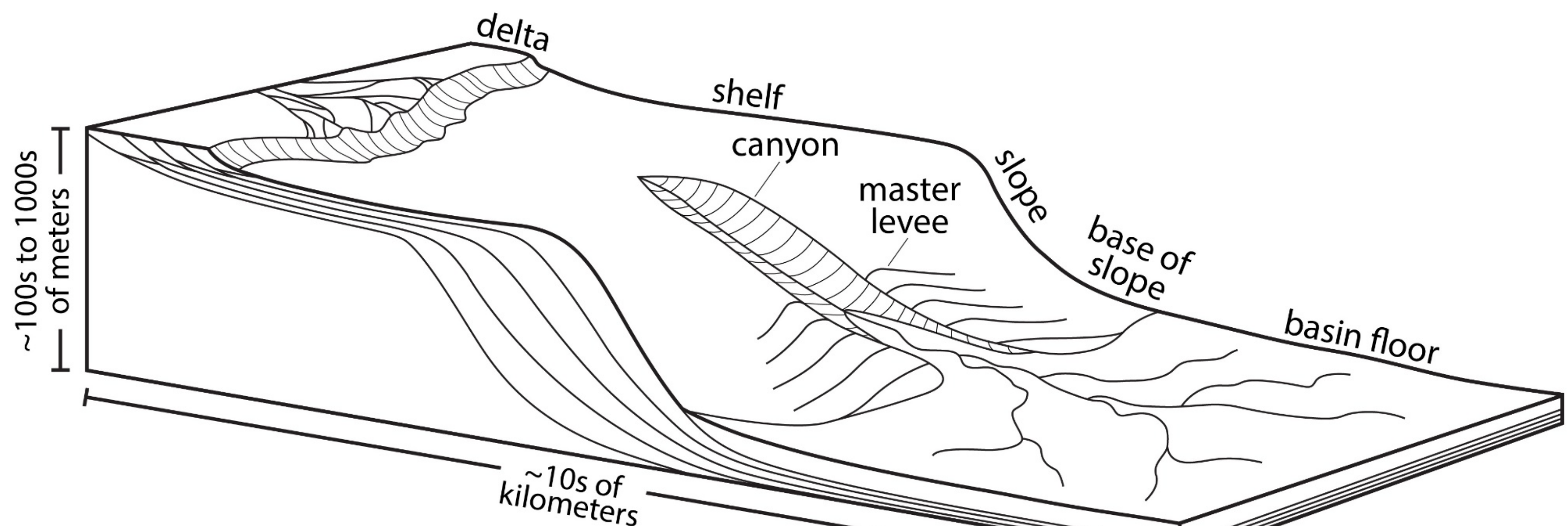
Herriott and Wartes, 2017

Hydrocarbon Reservoir Implications: LSTs in the Subsurface

- Chinitna Formation LSTs:
  - Shallow-marine settings in outcrop
  - Distal extents are not defined, but coarse sediment exported beyond the outcrop belt
    - Deep-water equivalents? Possibly
    - Naknek Formation analogues
- Jurassic reservoir presence/quality considerations:
  - Composition and burial history long recognized
  - Sequence-stratigraphic framework is new



Herriott et al., 2017



Herriott et al., 2017

Presentation Outline

- Geologic Setting—Cook Inlet Forearc Basin
- Chinitna Formation—Stratigraphic Overview
- Sedimentologic Character of Typical Chinitna
  - Observations and process–response studies
  - Depositional environment interpretations
- Stratigraphic Character of Basal Successions
  - Observations and photogeologic mapping
  - Depositional environment interpretations, again
- Stratigraphic Architecture of the Chinitna
- Sequence-Stratigraphic Framework of the Chinitna
  - Surfaces, systems tracts, and sequences
  - Depositional environments, once again
- Petroleum Systems Context, Oil-stained Outcrops, and Reservoir Quality Considerations
- Summary and Conclusions

Summary and Conclusions

- Chinitna Formation comprises ~700 m of principally fine-grained marine strata that are the latest Middle Jurassic forearc record of Talkeetna arc magmatic processes and exhumation

- Field observations, geologic mapping, and sedimentologic and stratigraphic-architecture studies delineate chiefly shallow-marine depositional systems and member-scale cyclicity

- This work is the basis for a sequence-stratigraphic interpretation of the Chinitna Formation
  - Coarse-grained basal successions in each member are lowstand systems tracts
    - Two notable sediment supply signals are marked by Chinitna LSTs, suggestive of tectonic activity within the Talkeetna arc, although BBFS may not be responsible
  - Finer-grained middle and upper parts of each member are transgressive and highstand systems tracts, although upper Paveloff may reflect an additional base-level cycle

- The depositional-systems and sequence-stratigraphic framework of this study—and oil-stained LST outcrops—demonstrate that viable scenarios exist for oil reservoirs in the Chinitna Formation
- We present a framework for predicting coarse-grained Chinitna sedimentation in time and space
  - Are there deep-water, coarse-grained equivalents in the Cook Inlet subsurface?
  - Stratigraphic trap potential of Chinitna and other Mesozoic units should also be examined

- Increased resolution of how late Middle Jurassic Cook Inlet forearc basin filled with sediment

http://dggs.alaska.gov/publications/ **Keyword:** Chinitna Formation **Range of Years:** 2014–2018

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Thank You. Questions?