

The Alaska convergent margin: 200  
million years of subduction/strike-slip  
tectonics

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With Extensive Contributions From:

STEEP research group, Talkeetna Arc Group,  
and Chugach mafia: Jeff Amato, and Peter Clift

Support over years: NSF, USGS

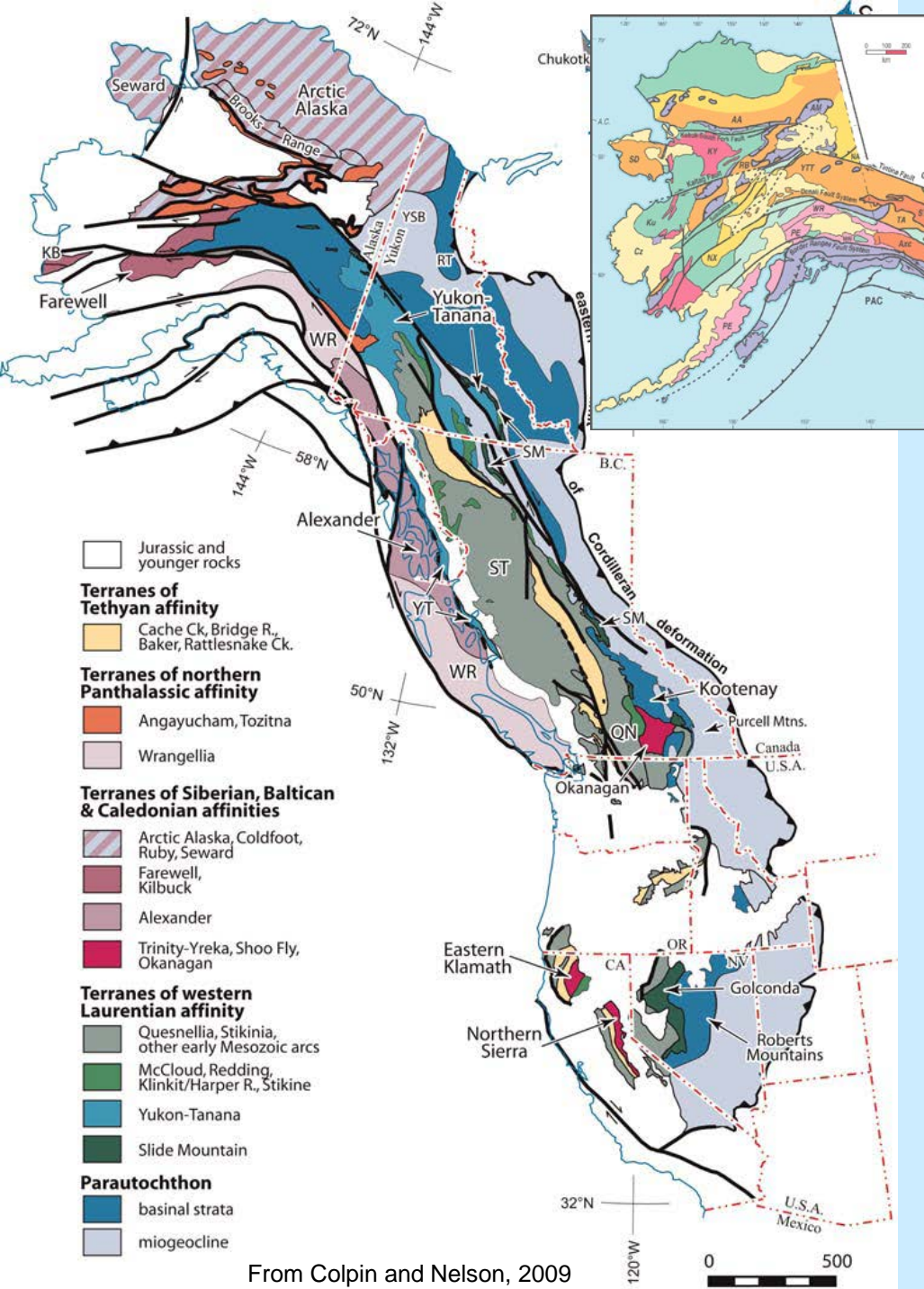
Alaska—Big place!

Purpose of this talk:

- 1) Summary of southern Alaskan tectonics with some caveats
- 2) Plug for geoprisms to go beyond active tectonics—rich opportunities for integrating ancient and modern records

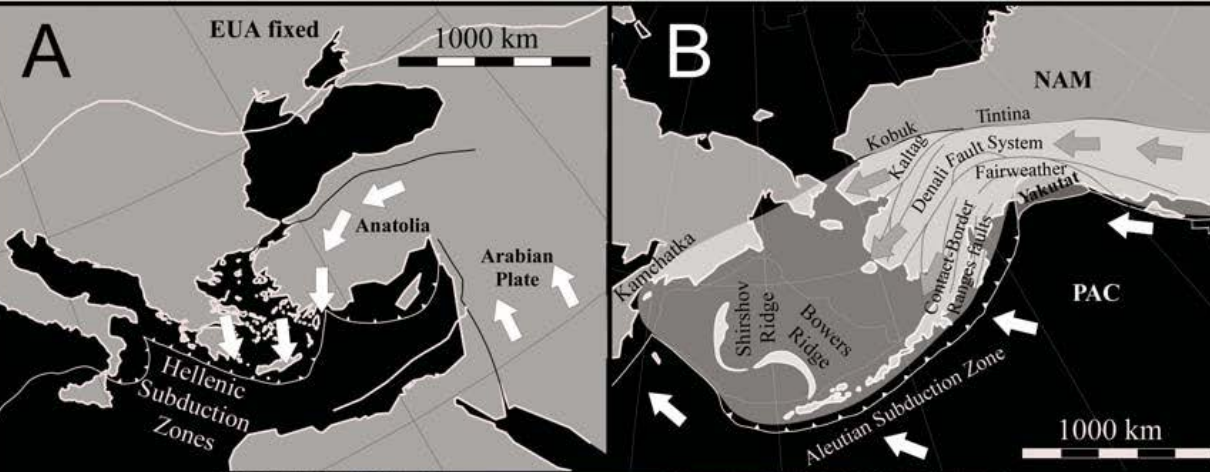






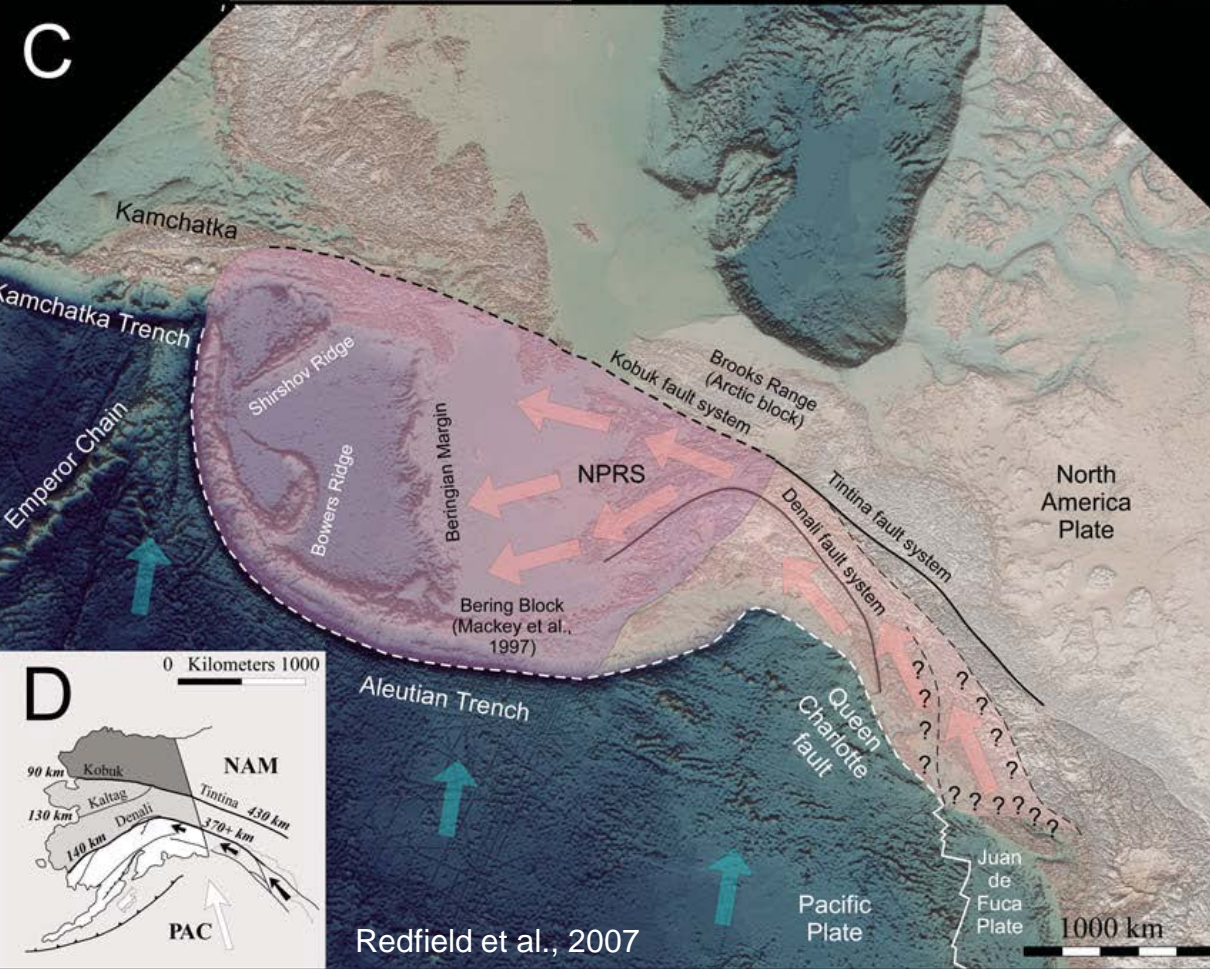
## Geologic history Alaska— northern Cordilleran history:

- I. Recall; Alaska is where terrane analysis was invented (with all its good and bad points...)
- II. Crudely—four lithotectonic belts
  - a) Miogeoclinal thrust belt (NA Neoproterozoic rifted margin except in Alaska)
  - b) Older accreted terranes (mid cordilleran assemblage, terrane I to old Canadian lit.)
  - c) The exotics (Wrangellia Composite assemblage)
  - d) Forearc Accretionary complex
- III. For Geoprisms—main focus here will be on the last two (the exotic elements that form the backstop to the accretionary complex, and the accretionary complex itself)



Caveat to always remember in northern Cordillern geology: Cenozoic strike-slip

Documented cumulate displacement ~1000km; almost certainly much more



- Importance:
- 1) Present geography is a poor guide to where things formed
  - 2) Important part of this system (Bering Sea & Aleutians) formed during this strike-slip event

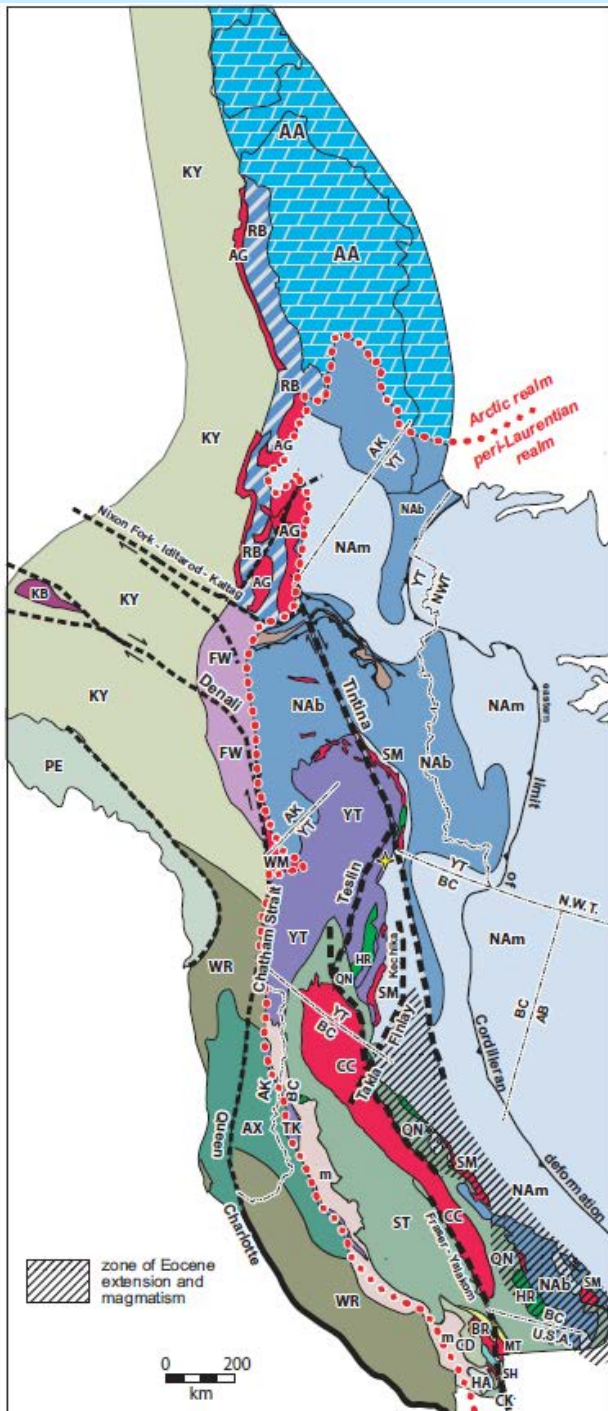


Example: Even a conservative restoration of Paleogene faults (as Nelson and Colpron do here) puts southern Alaska in the forearc of the Coast Orogen of Canada in the late Mesozoic

And

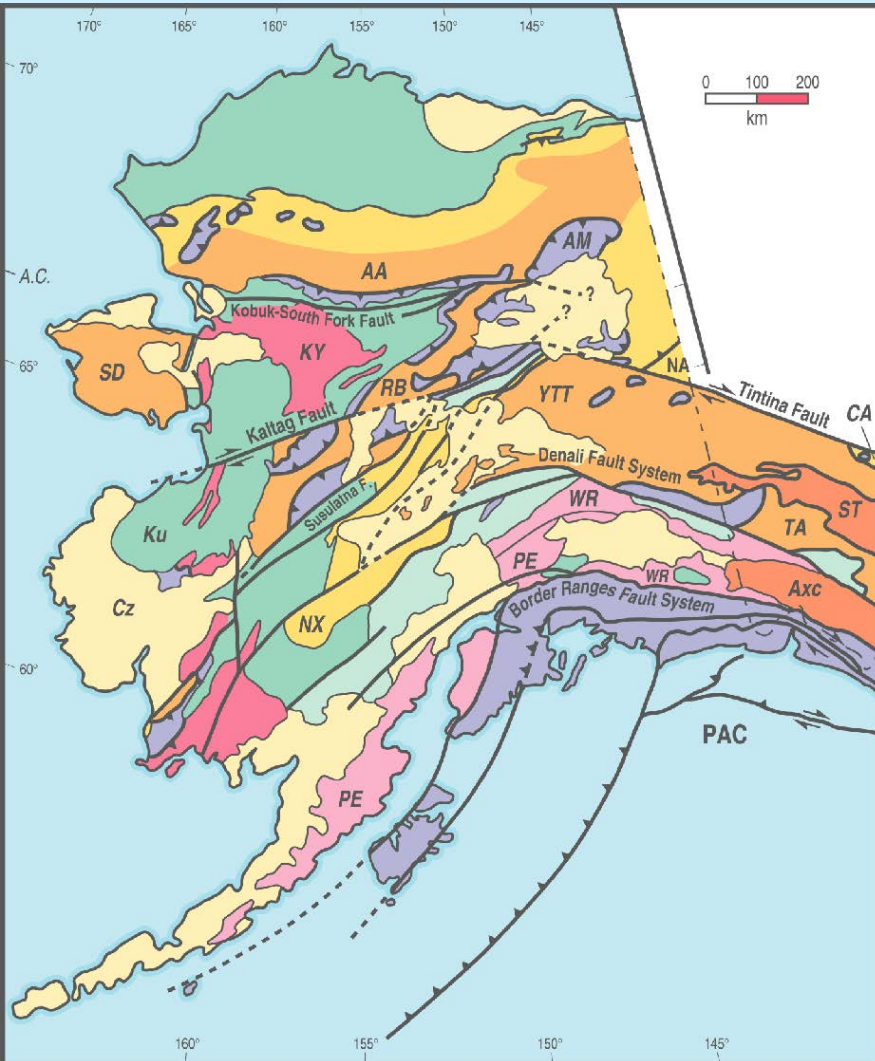
Middle Mesozoic—much of this stuff was out in the ocean somewhere.

IMPORTANT ISSUES FOR GEOLOGIC HISTORY--YOU CAN'T BE A 2D THINKER IN ALASKAN TECTONICS



From Nelson and Colpron, 2007

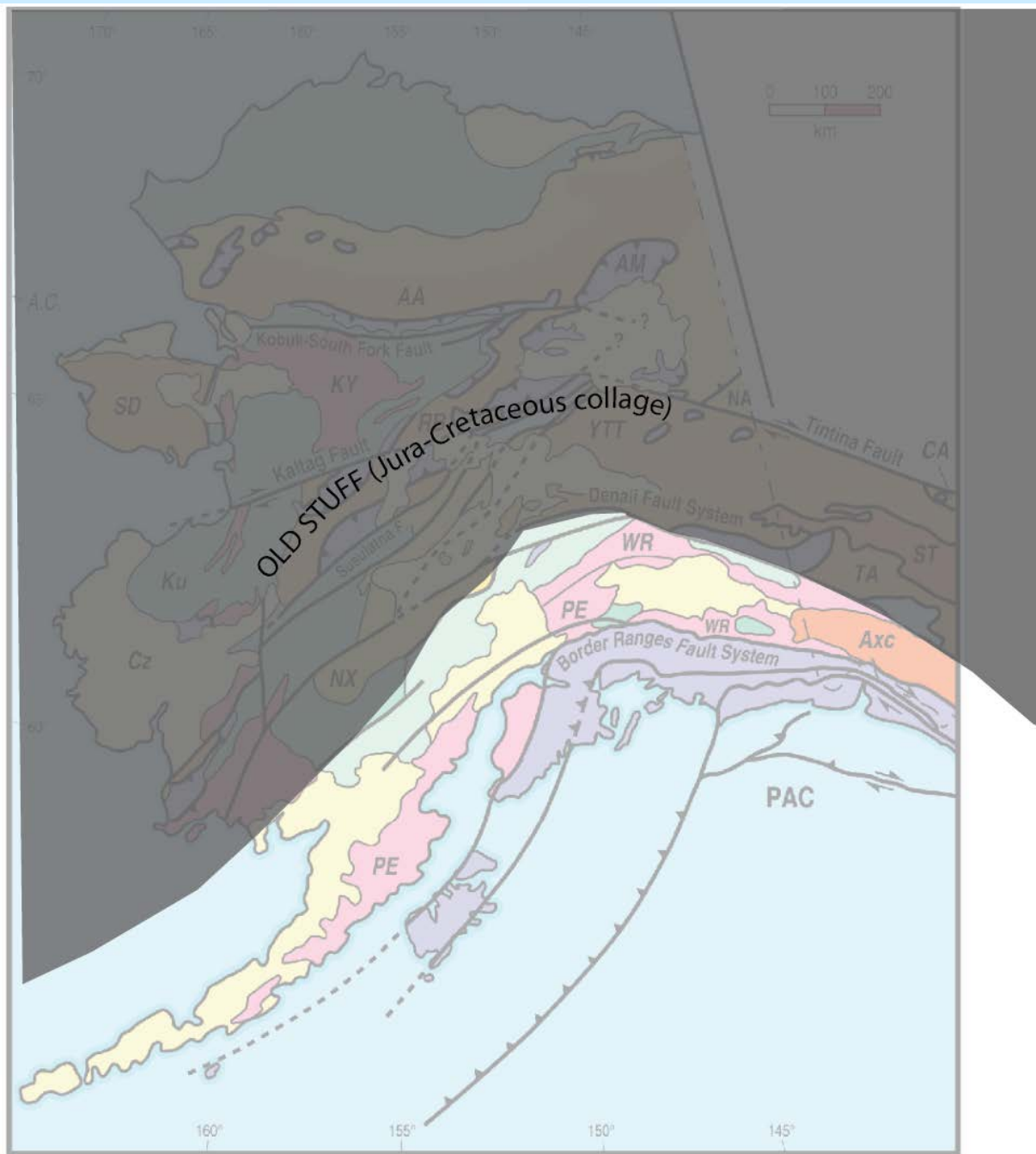
# GENERALIZED TECTONIC HISTORY OF THE ALASKA MARGIN



Terrane map—usually makes geophysicist's eye's glaze over

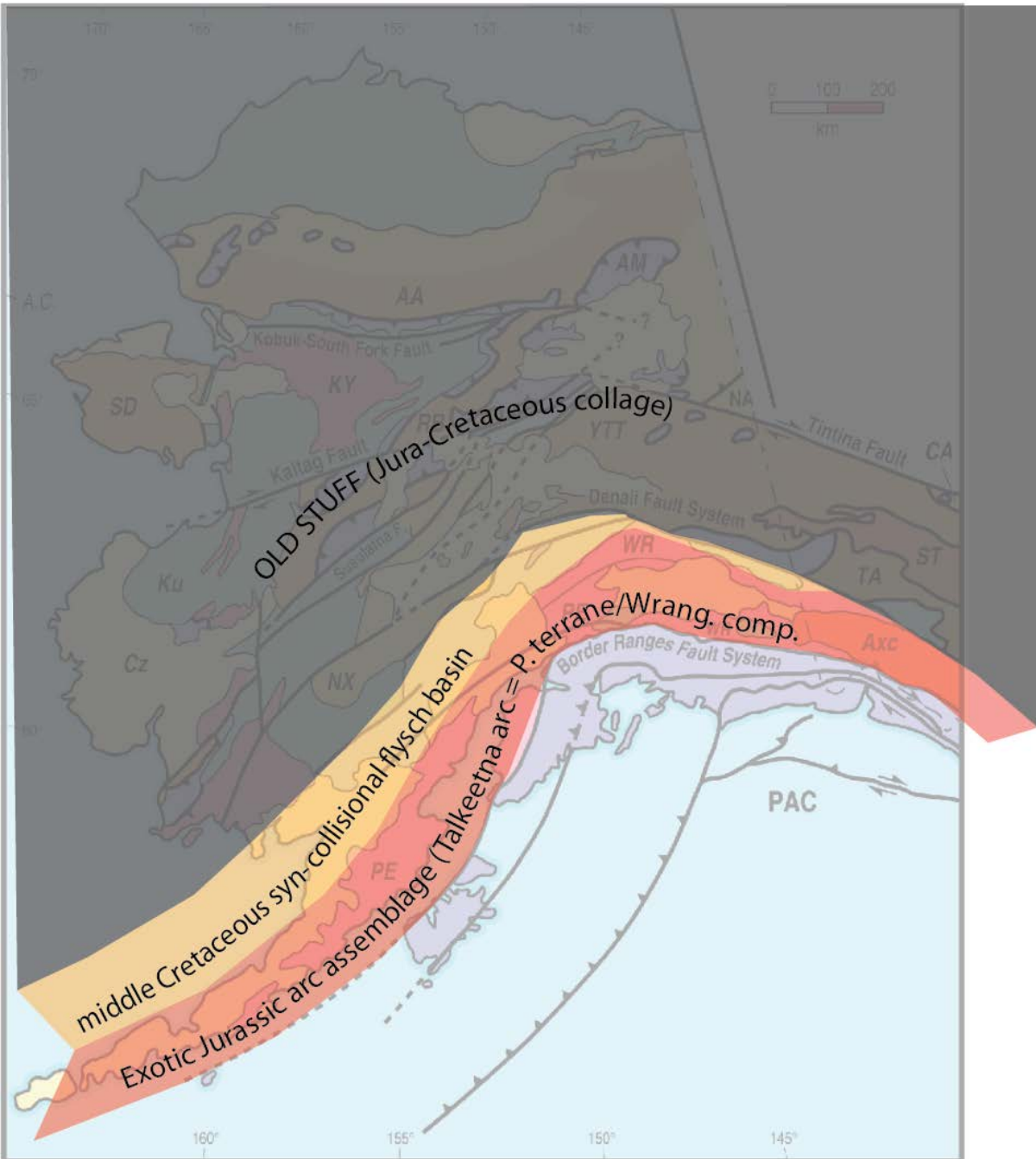
So let's simplify for this workshop.

Figure compliments of Sarah Roeske



First—we'll ignore most of the “backstop” to the subduction system

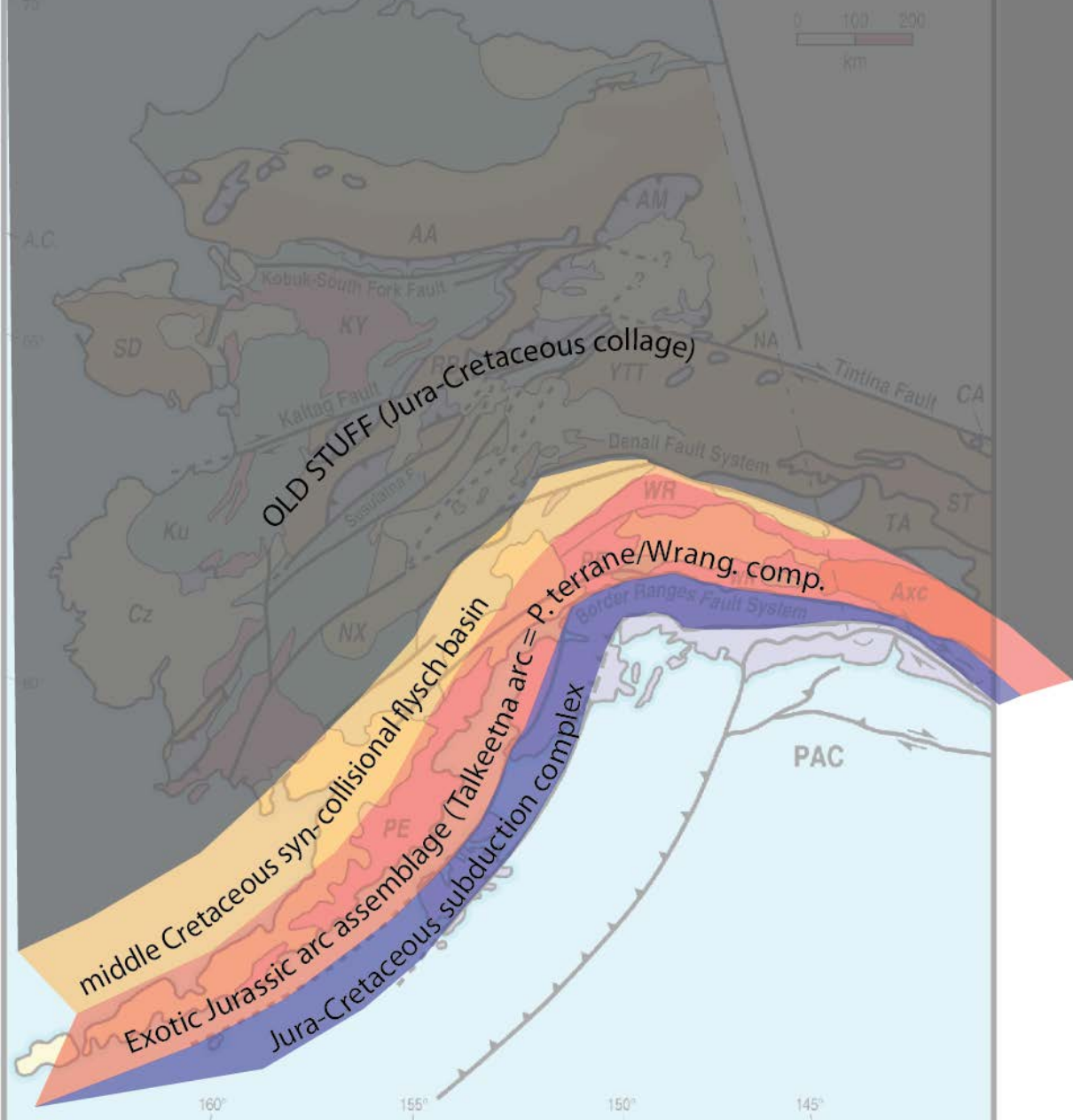
Mesozoic mess of older rocks, accreted in Jurassic to earliest K...



In late Mesozoic:  
 Exotic arc assemblage was accreted to North America (Wrangellia and it's lesser known cousin, the Peninsular terrane, a Jurassic oceanic arc; aka Talkeetna arc)

Suture—syn-collision flysch basin was closed by ~100Ma  
 (debate on backarc closure vs exotic collider not really relevant here; effectively it was part of NA by ~100.)

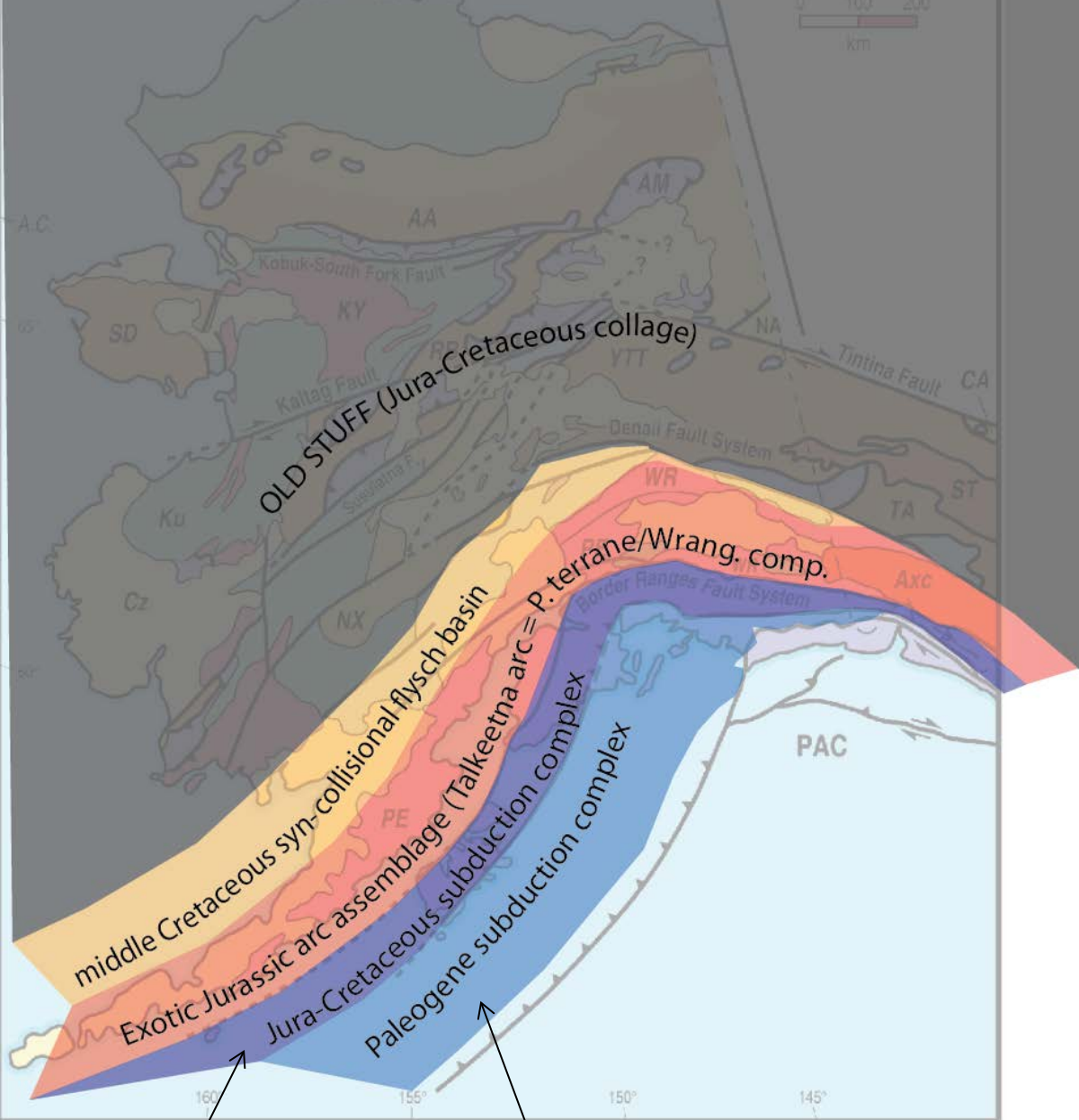




Ocean arc—carried with it a forearc accretionary complex; aka Chugach terrane.

Accretionary complex: records both a pre-collisional record (Jurassic-Early Cretaceous) and a syn-to post-collisional record

(paired assemblage oceanic arc and its forearc is an important ancient analog for geoprisms; more later)

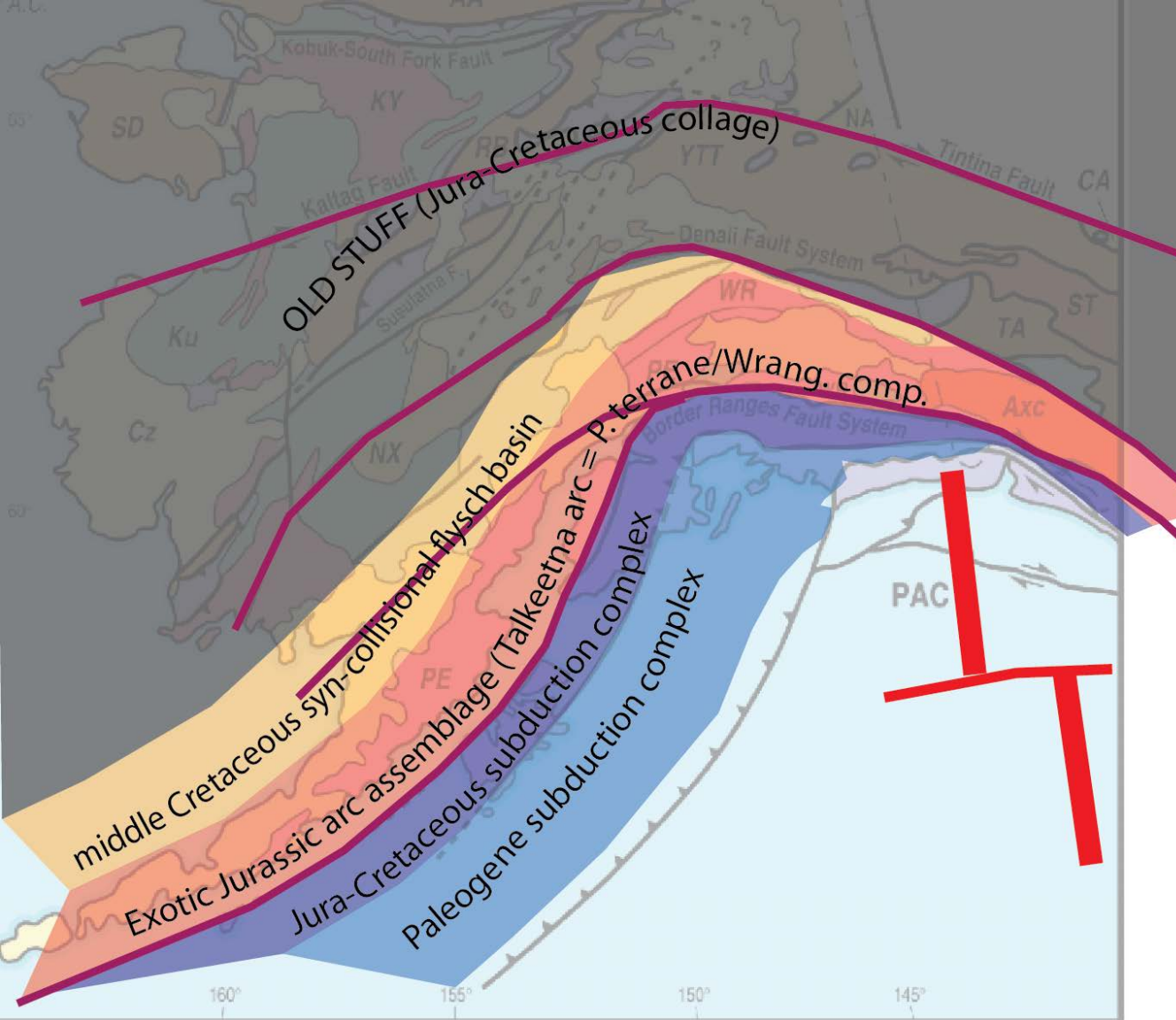


Most of the present accretionary complex was constructed by the end of the Eocene—indeed, Chugach and Prince William terranes are really virtually indistinguishable other than abundant Tertiary volcanics in the Prince William Terrane

Chugach Terrane

Prince William Terrane



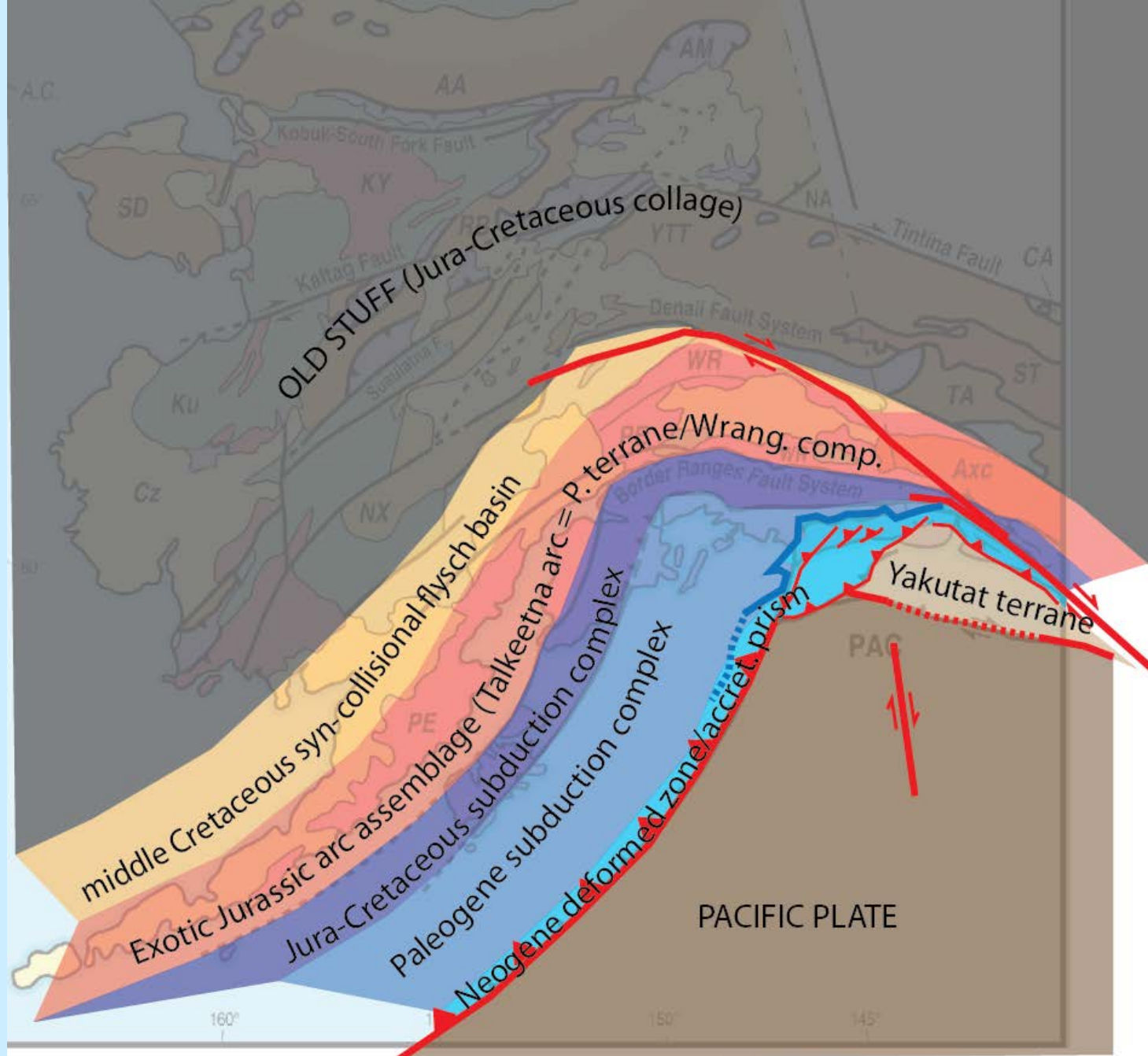


Following (and probably during) accretion—the accretionary complex was influenced by two events:

- 1) Large magnitude strike slip
- 2) Forearc plutonism, high-grade metamorphism in the forearc, and emplacement of forearc ophiolites

General consensus:

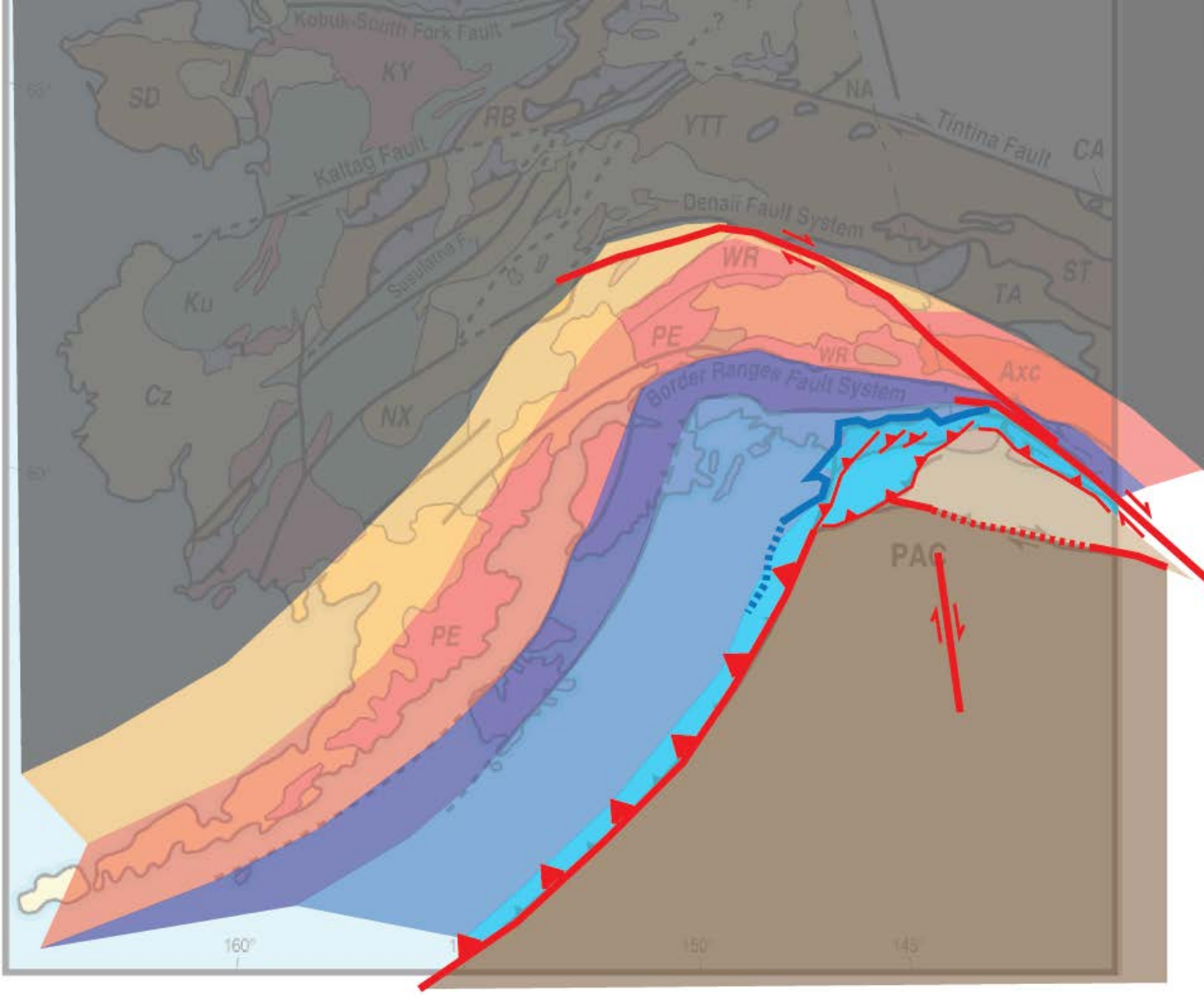
- Second, product of ridge subduction (although what ridge is in debate)
- Both events are related and are also related to formation of the Aleutian arc (Dave's talk)



Of course, final phase of history, most interest to most of this audience

- 1) Present subduction system
- 2) Collision of the Yakutat terrane

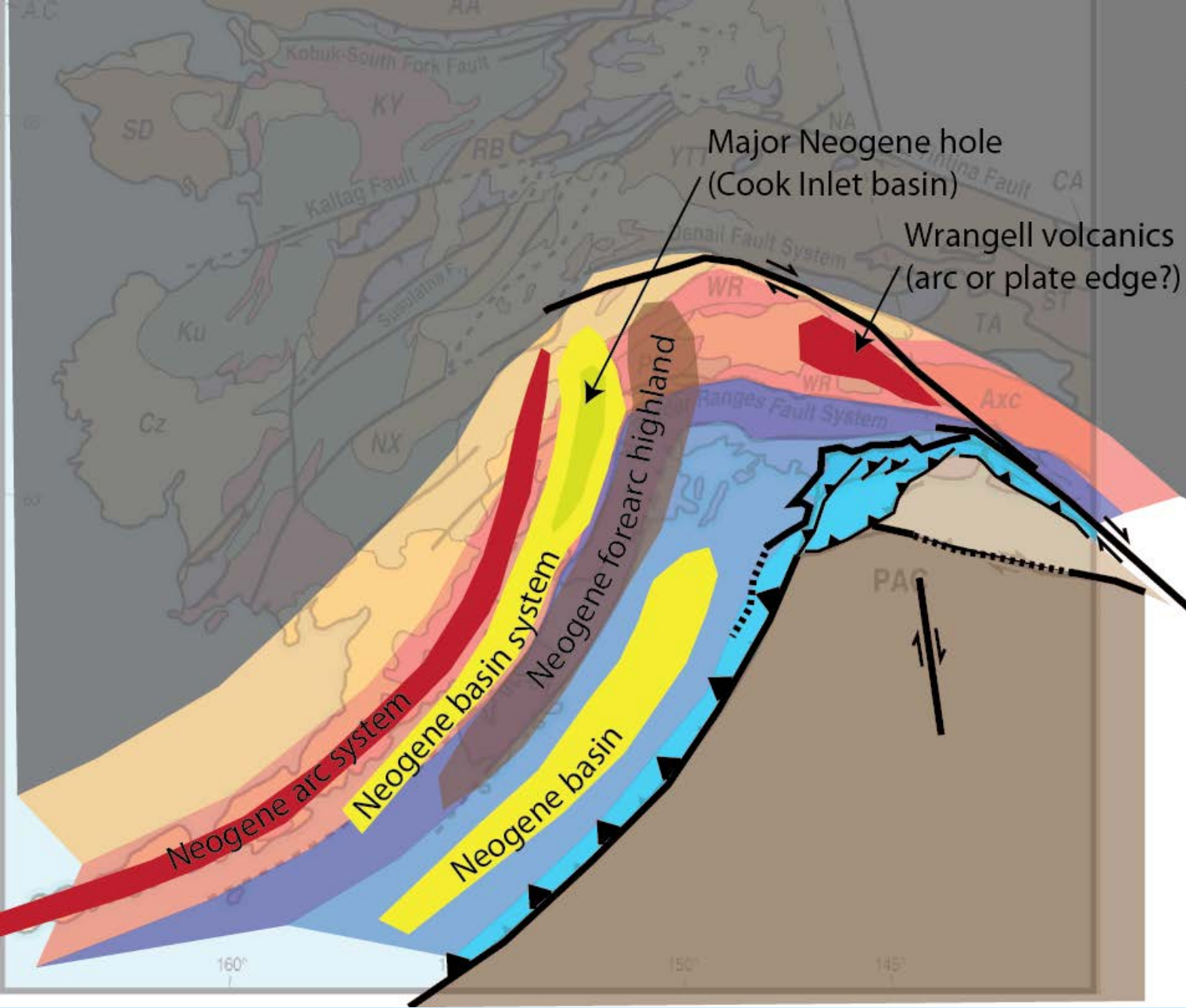




**OPINION:**

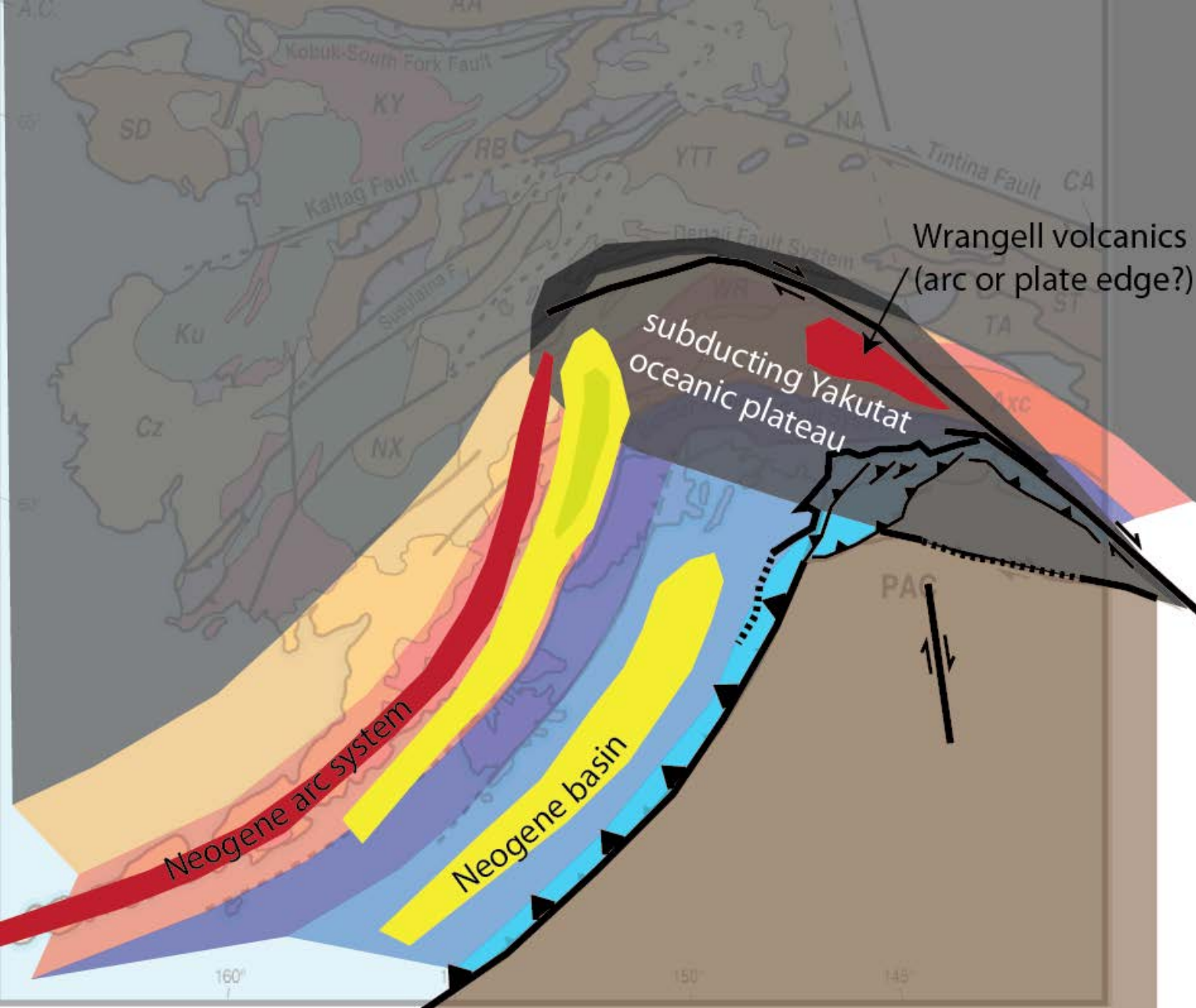
An important thing to remember in Neogene tectonics of Alaska—two different processes influence this margin

Depending on which you focus on, influence your thinking

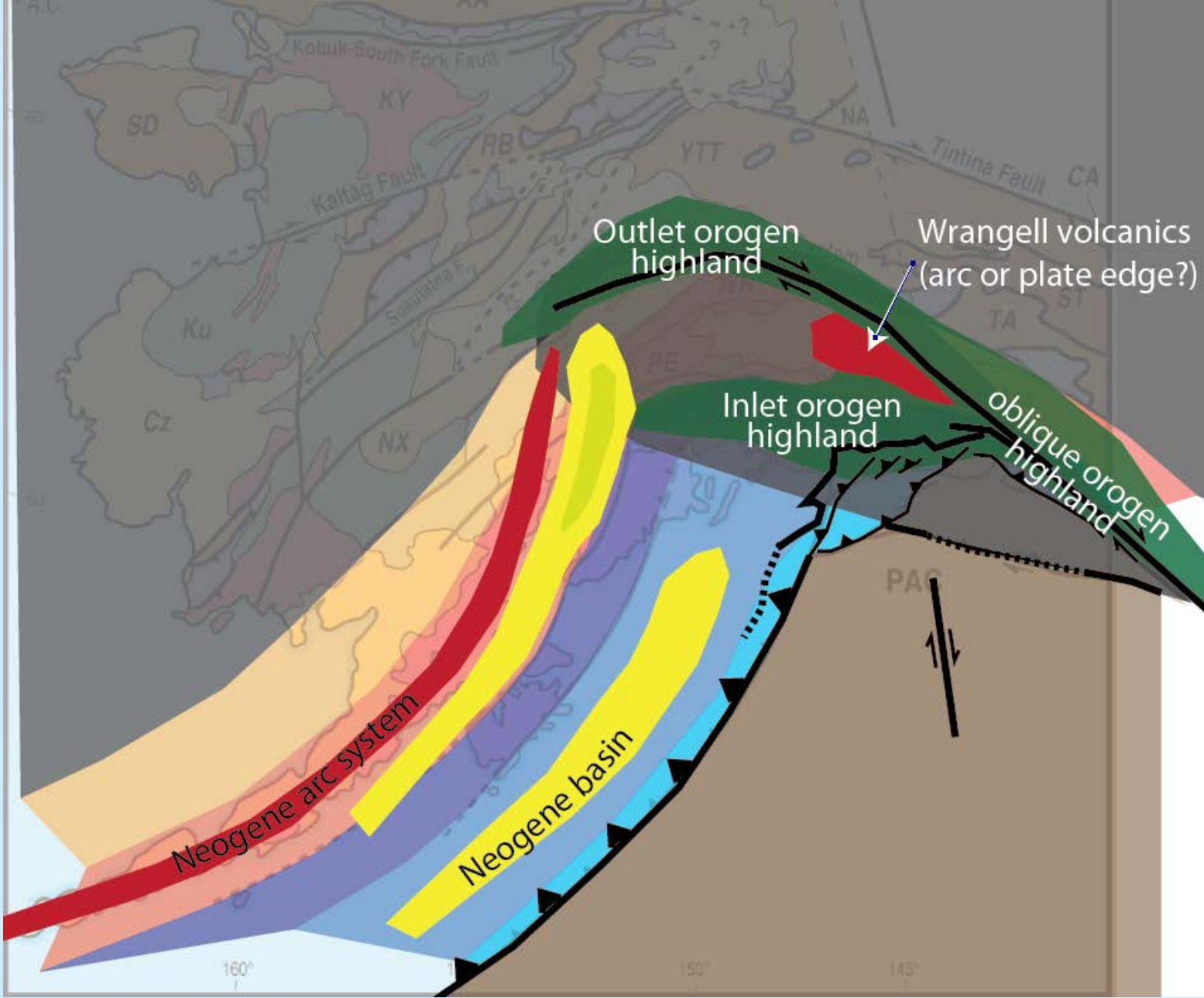


Subduction Centric viewpoint





Collision centric Viewpoint—flat slab, yakutat plateau



Note overlap in core of the “Alaskan orocline”

Terminology of Koons et al., 2010

Collision centric view of modern Topography

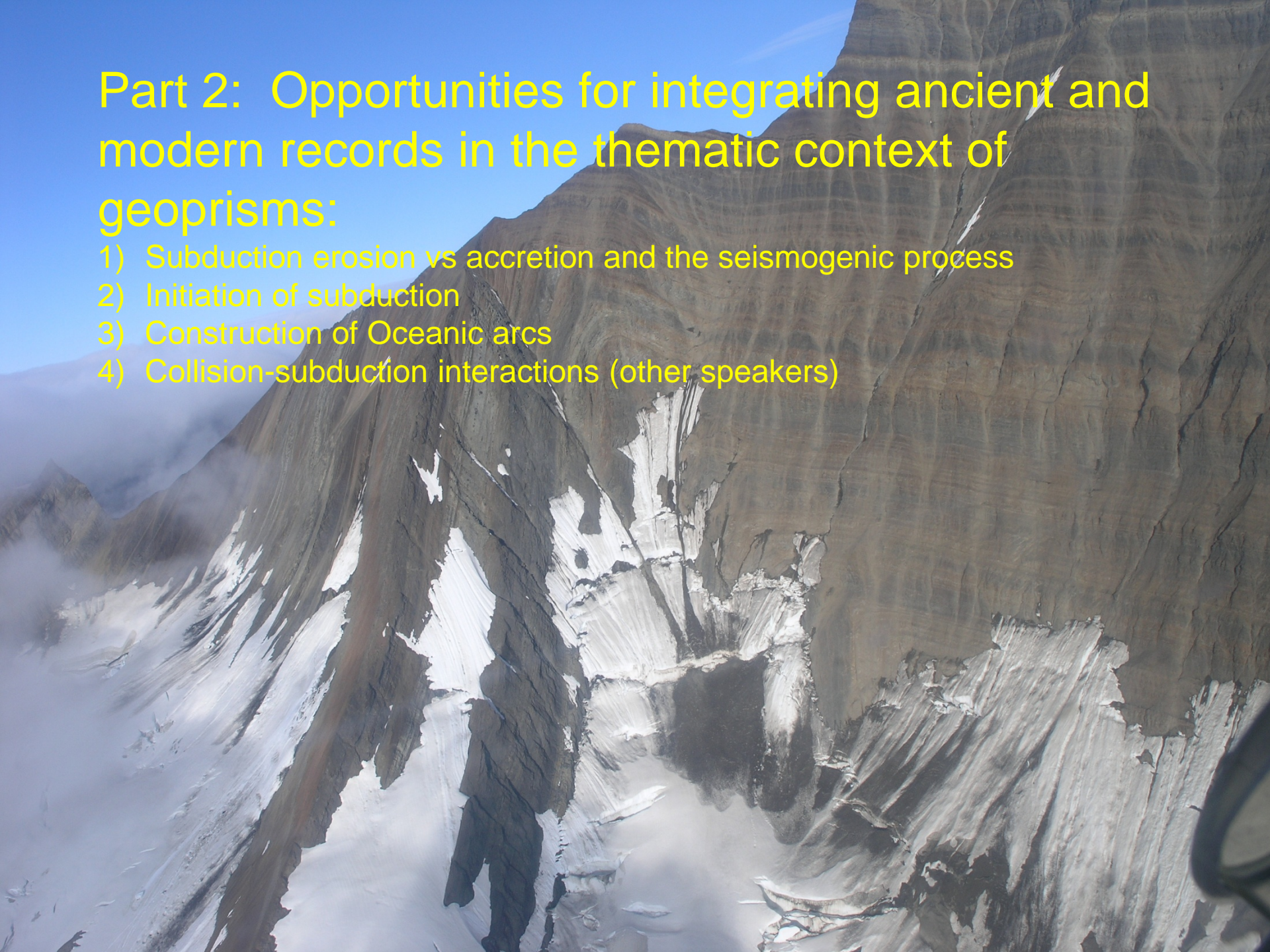
# Geoprisms will need to come to grips with this issue

- Single corridor can't address both systems
- Multifaceted approach is probably ideal (e.g. earthquakes don't seem to care about this—why?)



## Part 2: Opportunities for integrating ancient and modern records in the thematic context of geoprisms:

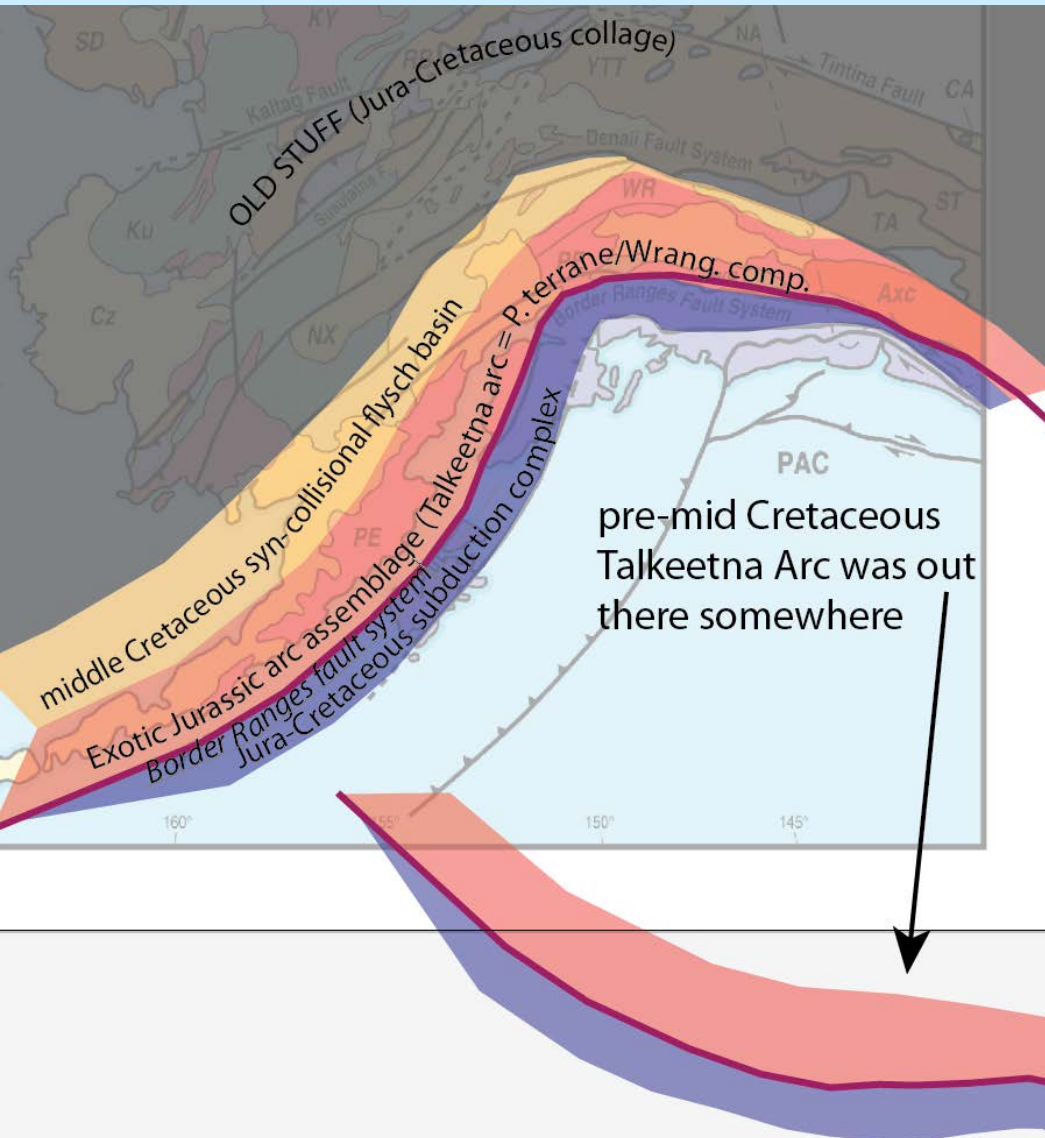
- 1) Subduction erosion vs accretion and the seismogenic process
- 2) Initiation of subduction
- 3) Construction of Oceanic arcs
- 4) Collision-subduction interactions (other speakers)





# Mesozoic rocks on this margin carry a record of:

- 1) Subduction/accretion/erosion—  
Geology of the Chugach terrane
- 2) Initiation of subduction—buried  
in the history of BRF (very  
deeply, unfortunately)
- 3) Oceanic arc processes—  
recorded in rocks uplifted along  
BRF

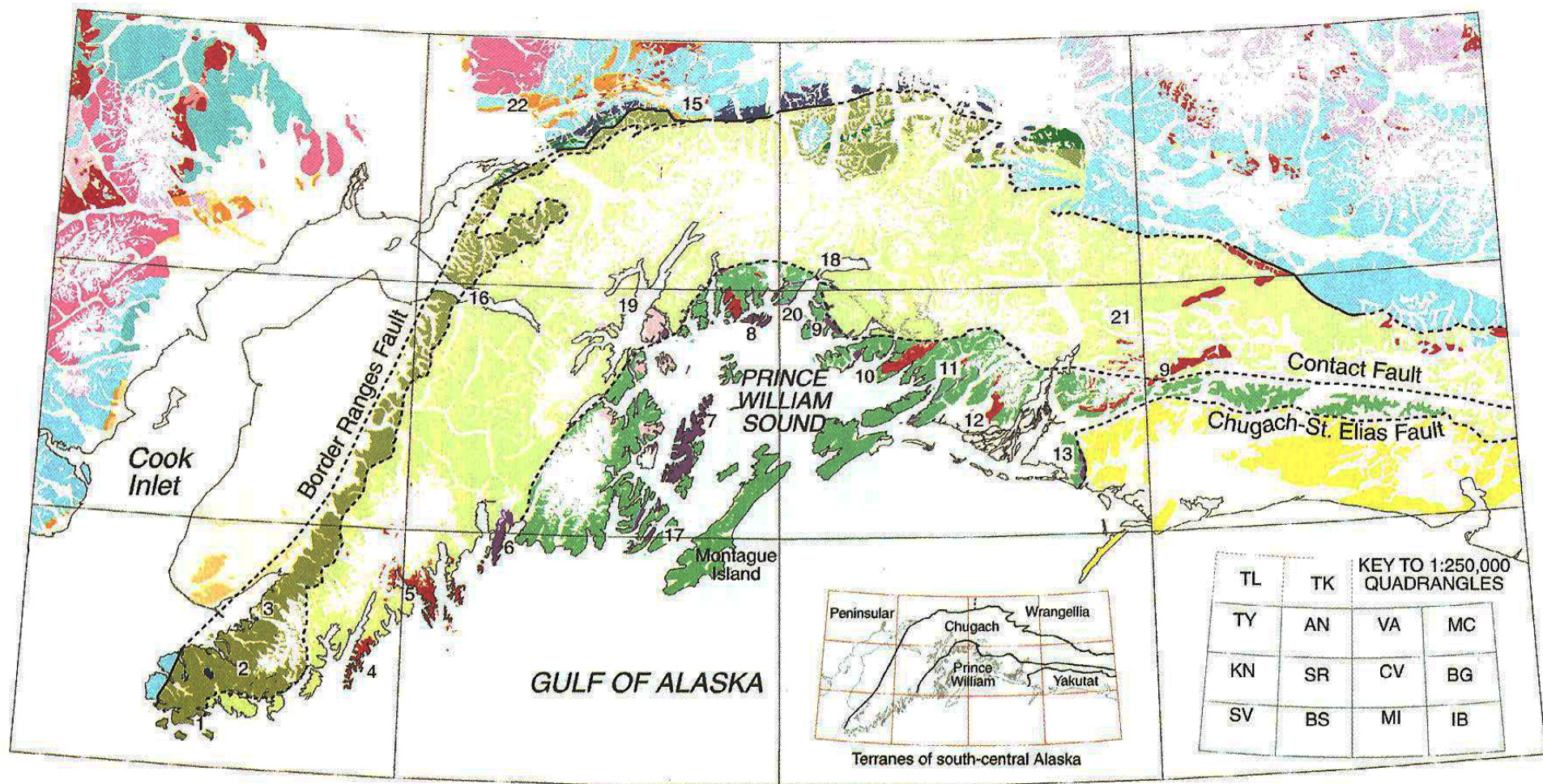


BUT—remember, this stuff was way out in an ocean in Mz; so depending on the time window, we have a different record

So—let's talk about rocks along BRF (Border Ranges fault) and Chugach terrane

# Chugach Terrane: Divided into two distinct assemblages

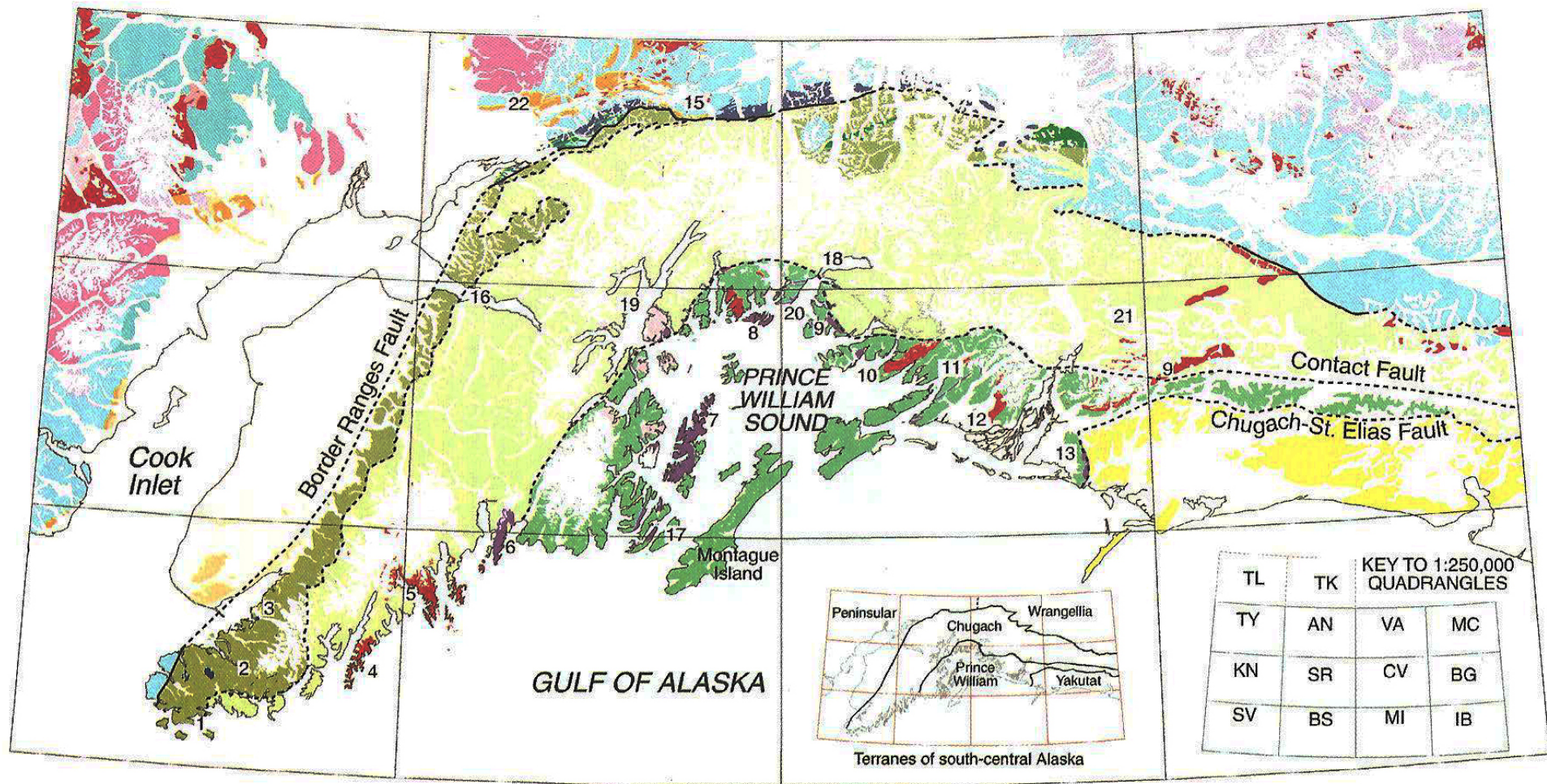
- Melange assemblage (dark green—McHugh complex and other names)
- Younger, coherent (flysch) assemblage (light green—Valdez Group, Kodiak Fm., etc.)





# Known for decades:

- melange is at least in part pre-mid Cretaceous
- coherent assemblage (flysch subterranean) latest Cretaceous
- BUT—until recently we knew little about the details of the melange







Reason—all we had to go on were:  
**fossil ages from Radiolarian chert blocks**

Regional chert ages—all over the place (Paleozoic to mid Cretaceous)

no surprise—subduction could carry these 1000's km before accretion; nearly useless age



All that has changed with detrital zircon dating

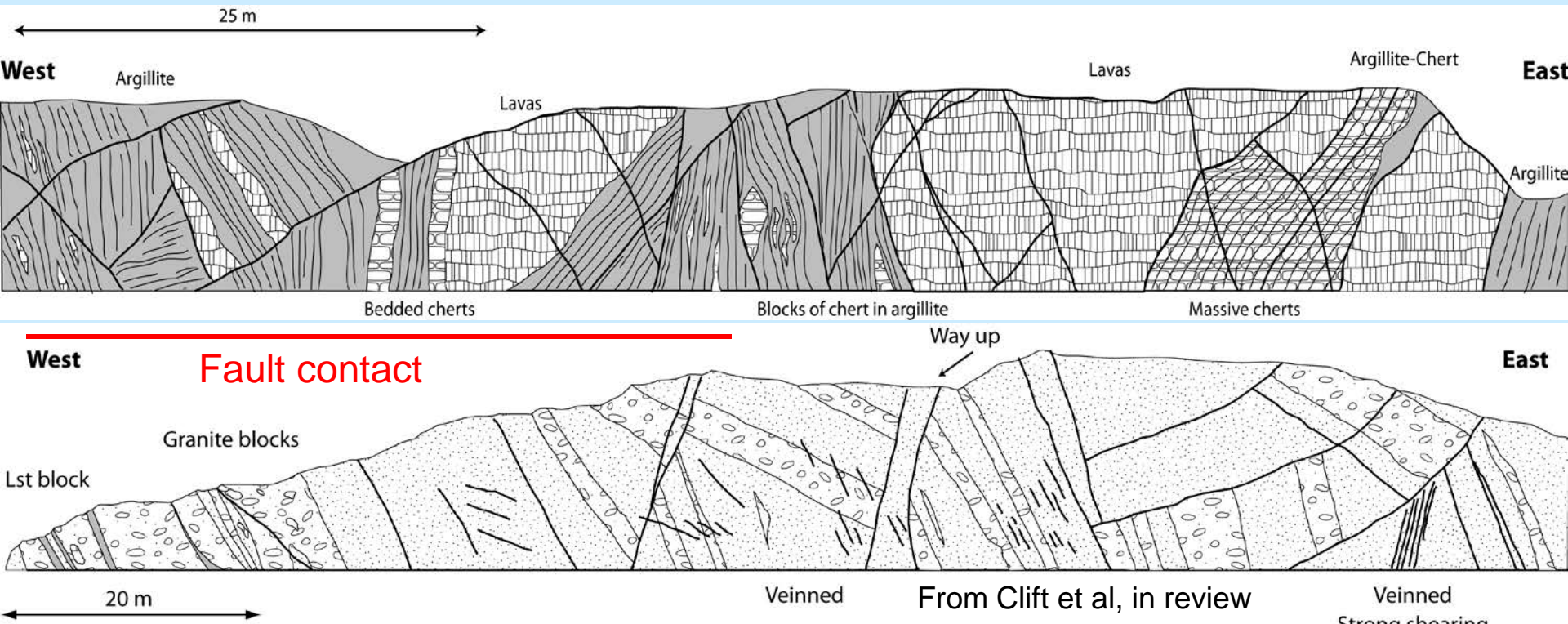
- 1) Key: allows dating of trench fill turbidites carried into the accretionary complex (depositional age versus the accretion age)
- 2) AND unlike crappy California outcrops—melange is fantastically well exposed



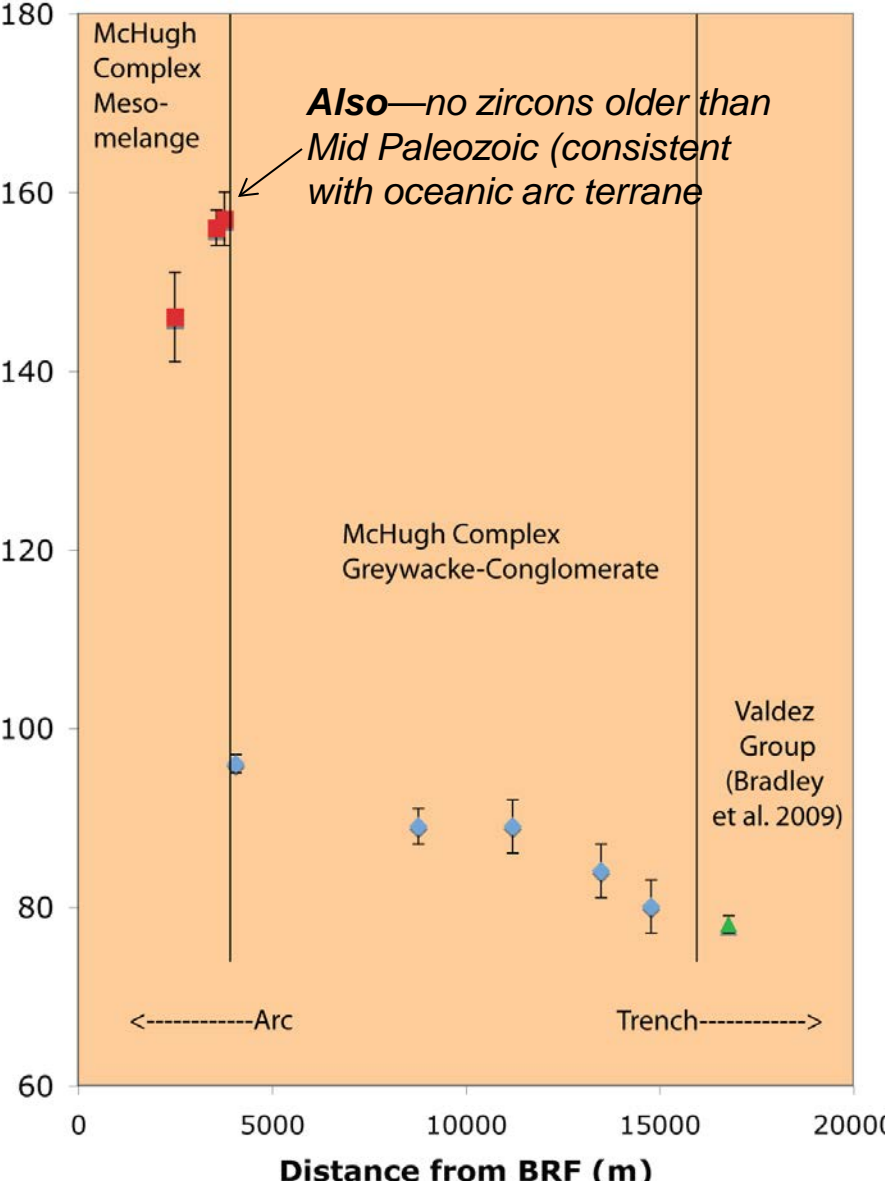
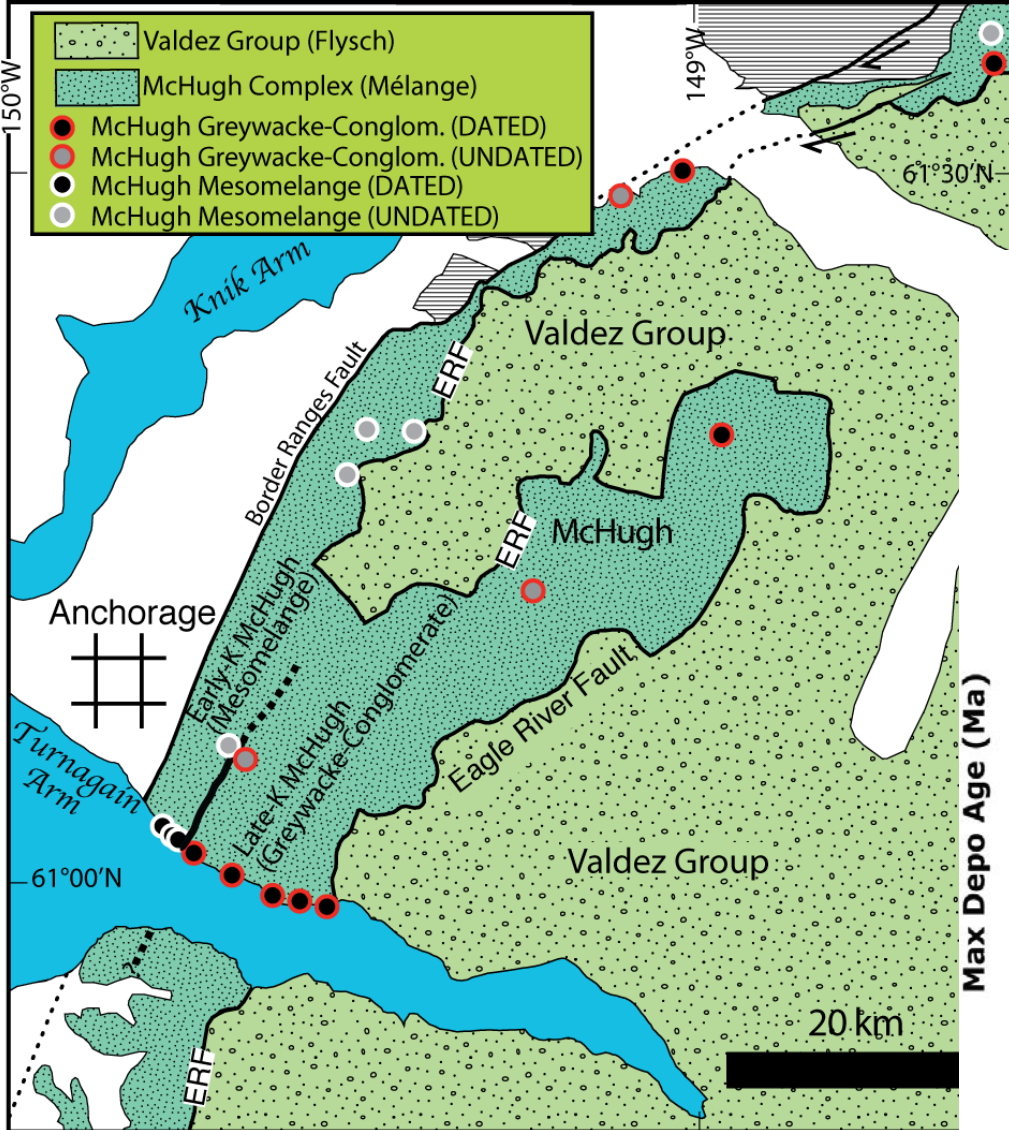


# Initial Results tell a Tale of Two (or more) McHughs

- In Anchorage area—two distinct lithologic assemblages separated by fault
- Carry very different detrital zircon ages



More data now—  
pattern was clear early  
in study



After Amato and Pavlis, 2010

# Why is this significant?

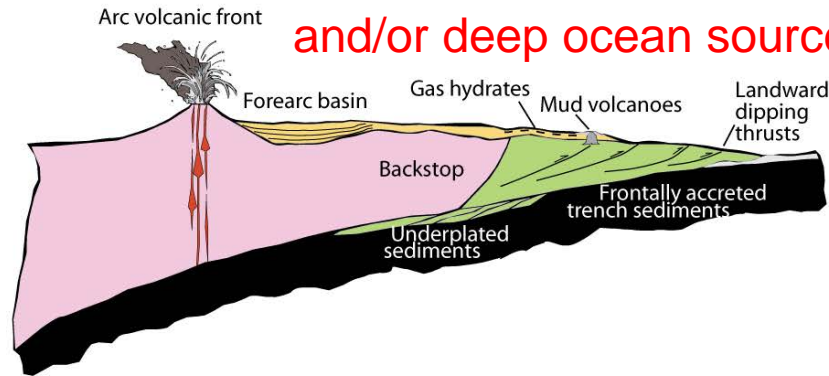
- **Answer:** DZ's can be used as a monitor for subduction accretion vs erosion



# We now know sediment subduction and tectonic erosion are important processes

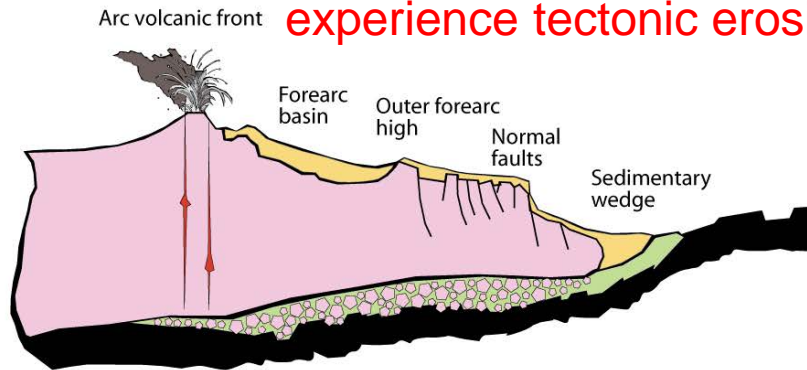
## SUBDUCTION ACCRETION

Accreted sediment can have arc and/or deep ocean sources



## SUBDUCTION EROSION

Half of modern subduction zones experience tectonic erosion



Clift and Vannucchi, 2004

AND—although Dave Scholl and R. von Huene were lone wolves howling about this for a long time

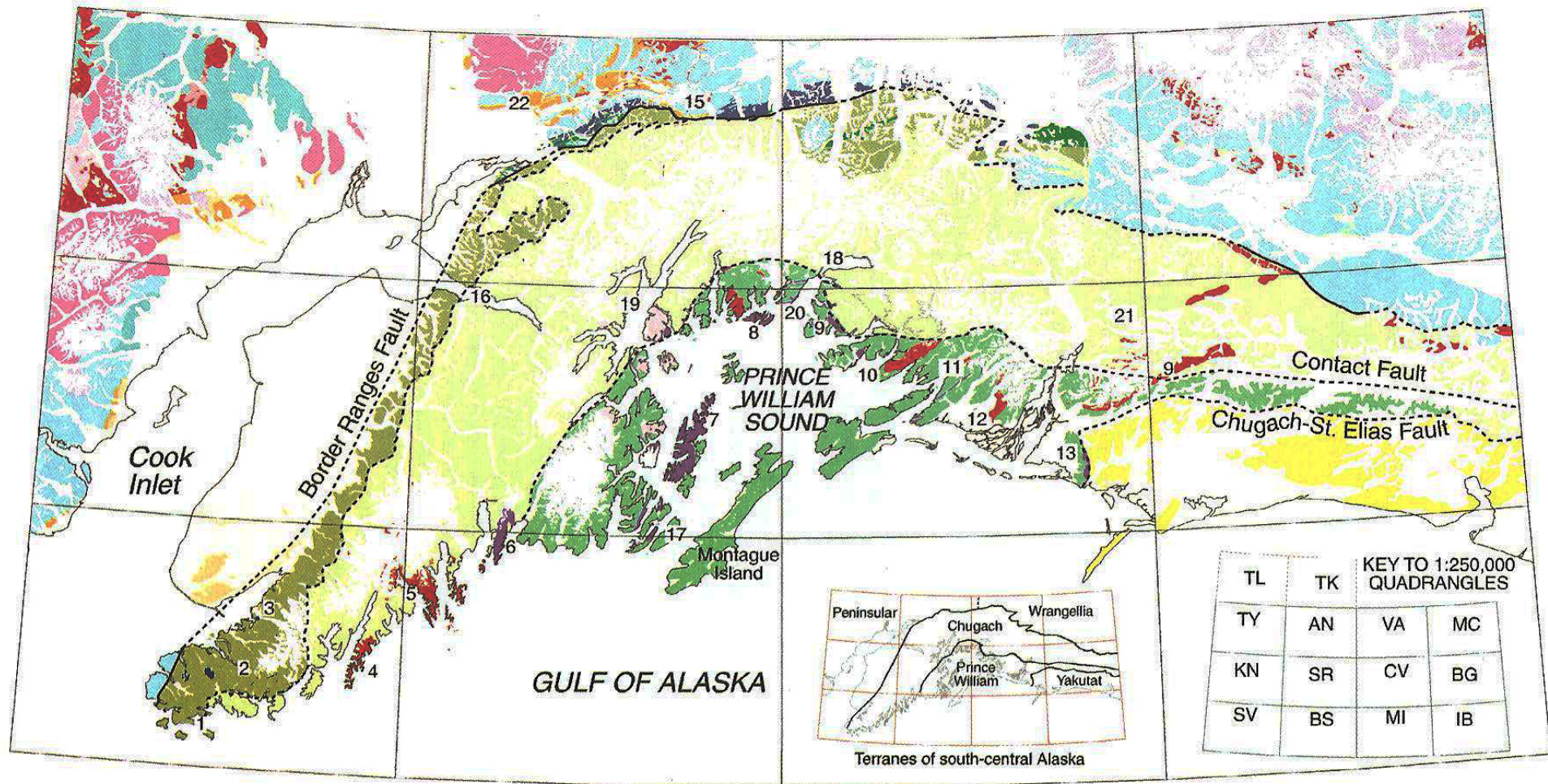
Ability to resolve accretion ages with dz's gives us unprecedented abilities to pick apart melanges like the McHugh!

# Challenge to Geoprisms community

- Intensive study of the modern subduction interface could be coordinated with a new look at the chugach melange
- Integration of the two results—could produce important new insights
- Not a new idea—talk to Casey Moore—but with new methods and data, we may get new insights

Other information for geoprism in the Mesozoic:

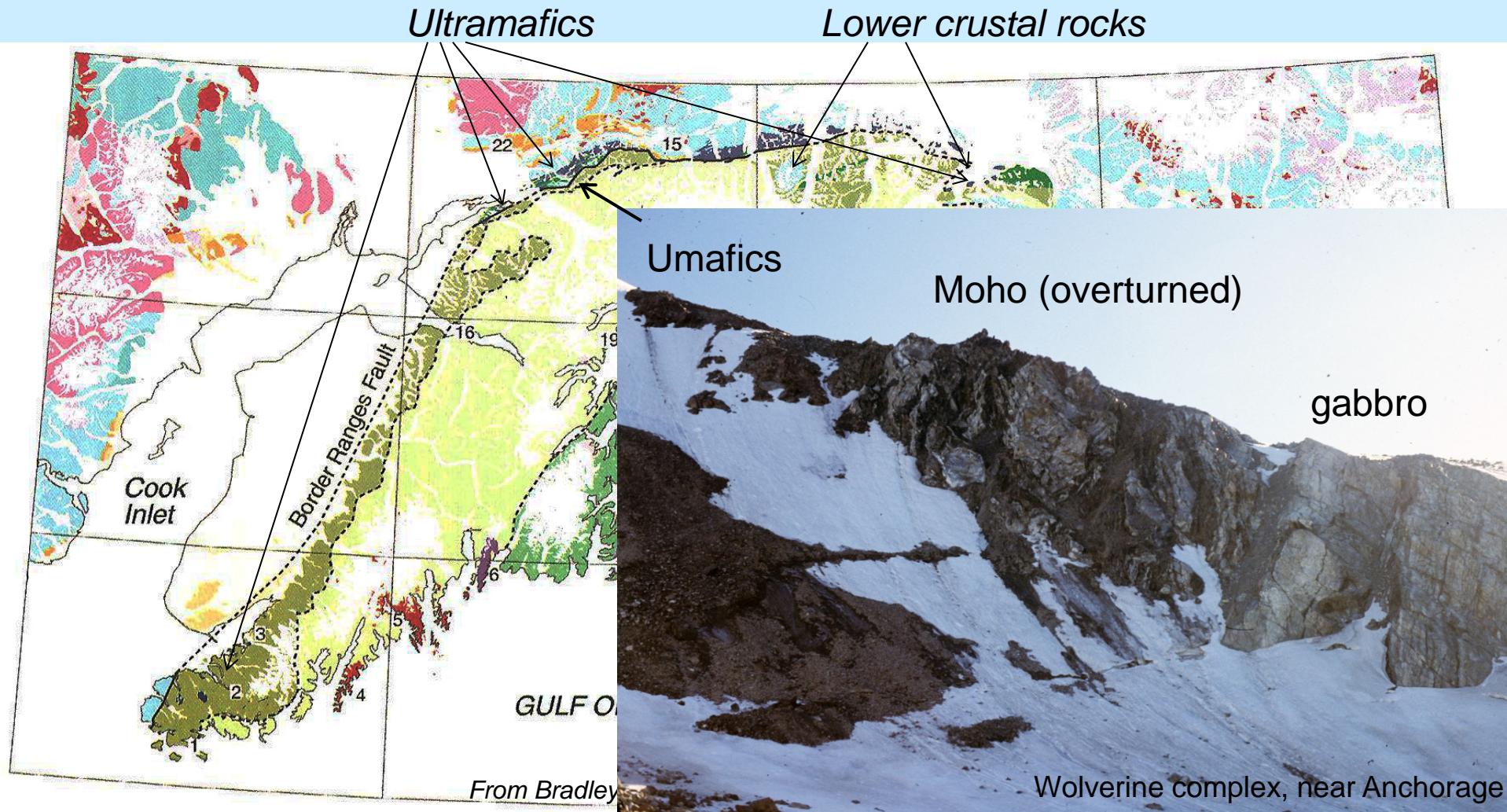
- 1) Border Ranges fault—in an ideal world carries a record of subduction initiation
- 2) Unfortunately—nasty overprints obscure the problem  
(long complex history, too much to cover here—see Pavlis and Roeske, 2007)





**MORE IMPORTANTLY**—Uplift along BRF has exposed basement of a Jurassic oceanic arc in its hanging wall—including lower crust and upper mantle rocks with local exposures of the arc Moho!

- Not many places to see this kind of crustal section
- Exceptional opportunities to compare to a modern system right near by in Aleutians (see papers by Talkeetna Arc Group for details—Ask P. Kelemen)





# SUMMARY: Some Opportunities for Geoprisms beyond the usual suspects

- Exceptional onland exposures of forearc accretionary complexes record a record of subduction accretion to erosion cycles—excellent opportunity for integrated studies
- Subduction initiation records in Mesozoic (albeit messed up) and the Paleogene (Aleutian arc)
- Excellent opportunities for studies comparing an ancient oceanic arc (Talkeetna arc) and the modern Aleutian arc



On to below sea level  
From the greatest rise from sea level on earth  
(south face of Mt. St. Elias)

