Oblique Convergence as a Driving Mechanism for Protracted Exhumation, Basin Development, and Sedimentation during Island Arc Collision: A Case Study from Southern Alaska*

Brian A. Hampton[1]

Search and Discovery Article #30100 (2009)
Posted September 8, 2009

*Adapted from oral presentation at AAPG Annual Convention, Denver, Colorado, June 7-10, 2009

[1]Geological Sciences, Michigan State University, East Lansing, MI (bhampton@msu.edu)

Abstract

Late Cenozoic examples of island arc collision (e.g., Taiwan, Trinidad, Venezuela) have aided in our understanding of exhumation, basin development, and sediment dispersal in moderately- to highly-oblique convergent margin settings. However, in older mountain belts, often the timing, location, and duration of collision can only be inferred from stratigraphic and provenance trends from sedimentary basin that developed during suturing events. In the case of the North American Cordillera, Mesozoic island arc collision is recorded in a discontinuous belt (>2000-km-long) of clastic strata that are exposed inboard (cratonward) of the allochthonous Wrangellia composite terrane (composite island arc) from southern Alaska to Washington State. In southern Alaska, synorogenic strata of the Upper Jurassic-Cretaceous Kahiltna assemblage are located in the suture zone between the Wrangellia composite terrane and pericratonic Intermontane belt. Stratigraphic constraint and provenance trends from the Kahiltna assemblage, including U-Pb detrital zircon geochronology, reveal distinct temporal and spatial trends in regional exhumation and basin development during Jurassic-Cretaceous arc collision. U-Pb detrital zircon geochronology from base-to-top of the Kahiltna assemblage reveal an age distribution of primarily Mesozoic-age grains (Mz-74%) with less abundant Paleozoic (Pz-11%), and Precambrian (Pc-15%) age grains. A comparison of detrital zircon ages from older to younger stratigraphic intervals within the Kahiltna assemblage reveals three distinct stages of exhumation and basin development that are interpreted to represent: (1) An initial Late Jurassic-Early Cretaceous stage during which detritus was derived almost solely from Middle-Late Jurassic igneous sources of the Wrangellia composite terrane (Mz-100%-Pz-0%-Pc-0%) and deposited in a retroarc foreland basin, (2) An Early Cretaceous stage that reflects a transition to sedimentation in a remnant ocean basin setting and the first introduction of Paleozoic and Precambrian age detritus from pericratonic source areas (Mz-84%-Pz-11%-Pc-5%; Mz-59%-Pz-12%-Pc-29%), and finally, (3) An Early to Late Cretaceous stage that reflects a transition to a collisional foreland basin that was characterized by continued detrital contributions from inboard and outboard source areas and a relative decrease in Mesozoic arc source areas and increase in Precambrian and Paleozoic pericratonic sources (Mz-46%-Pz-16%-Pc-38%).

Copyright © AAPG. Serial rights given by author. For all other rights contact author directly.

Oblique Convergence as a Driving Mechanism for Protracted Exhumation, Basin Development, and Sedimentation During Island Arc Collision: A Case Study from Southern Alaska

Brian A. Hampton

MICHIGAN STATE UNIVERSITY

bhampton@msu.edu

Talk Overview

1) Introduction – Tectonic configuration of the North American Cordillera

-Current models for Mesozoic island arc accretion

2) Modern Example – Oblique arc collision in the Pacific (Luzon arc, Taiwan)

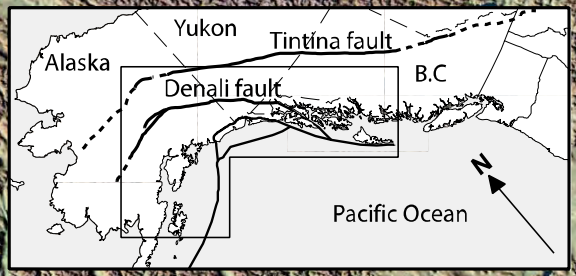
- Ocean basin closing and along-strike (axial) sediment transport
- Models for three-part stratigraphy (pre-, syn-, and post-collision)

3) Geologic Case Study – Alaska Range suture zone, southern Alaska

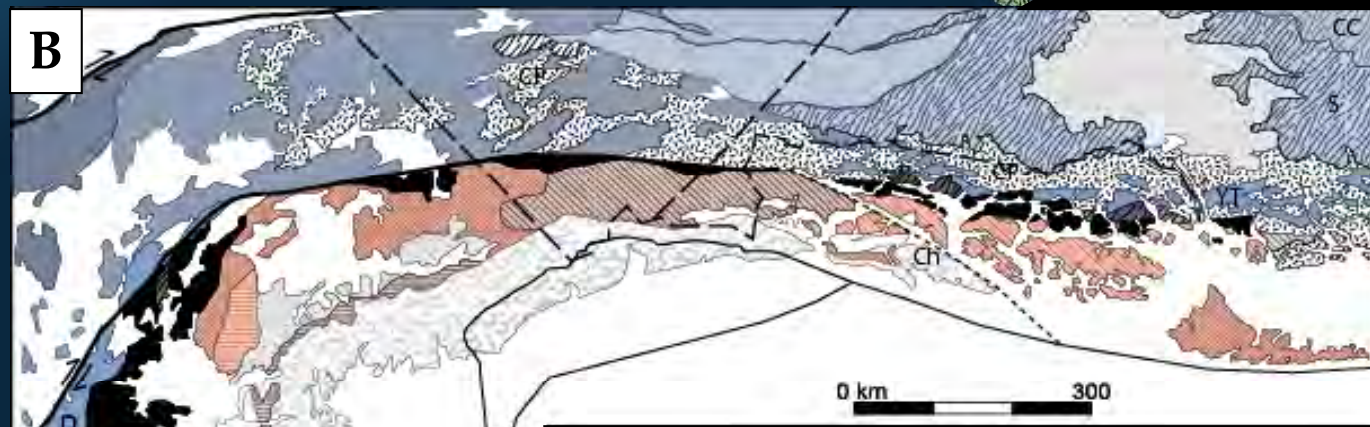
- Stratigraphy and provenance of the Jurassic–Cretaceous Kahiltna assemblage
- Provenance comparison from base-to-top of strata to get at the timing of exhumation and basin development

A

Tectonic configuration of the N.A. Cordillera



B



Continental margin – Pz-Mz

Kahiltna assemblage – Mz

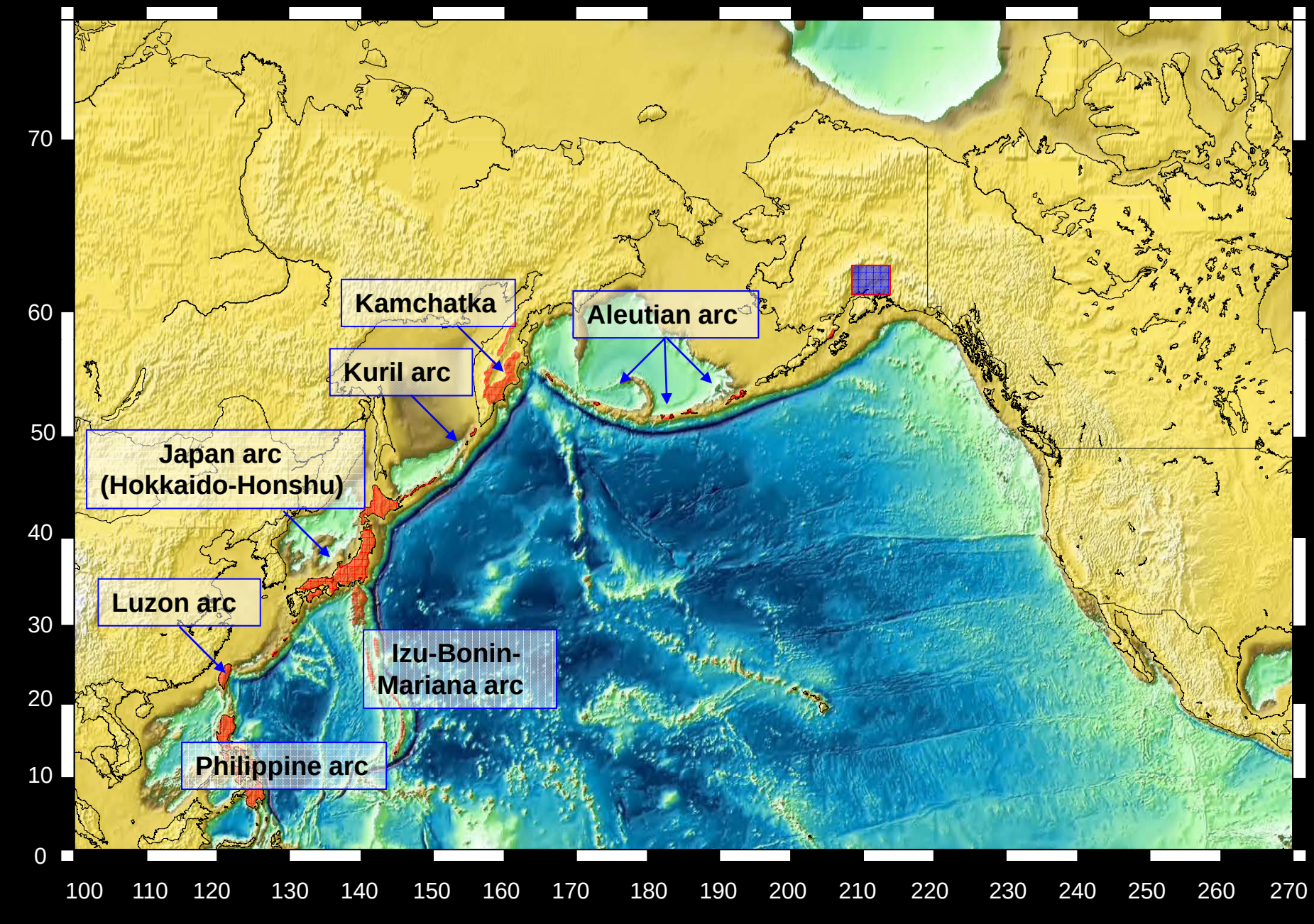
Island arc – Pz-Mz

Collisional model for Mesozoic accretion of the Wrangellia Island Arc

- Late Jurassic–Early Cretaceous island-arc accretion
- Late Cretaceous suturing of arc to margin and subsequent strike-slip faulting (~95 Ma)
- Syntectonic strata preserved in a linear trend along N. American margin

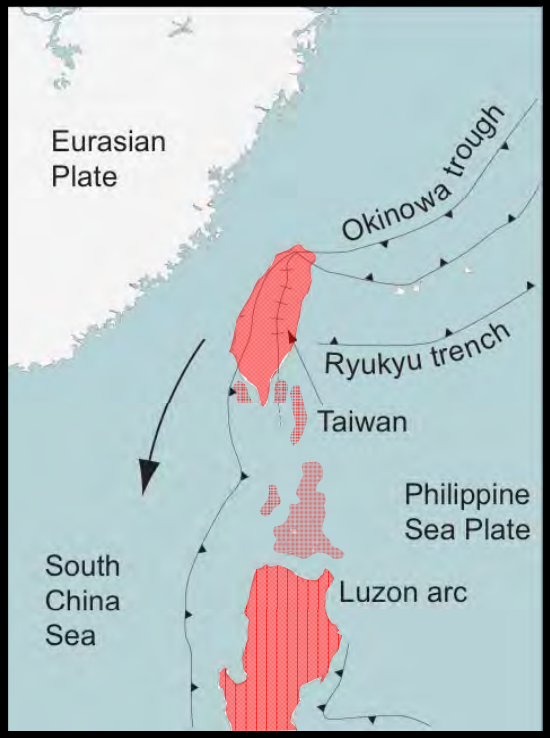
Reconstructions
by R. Blakey

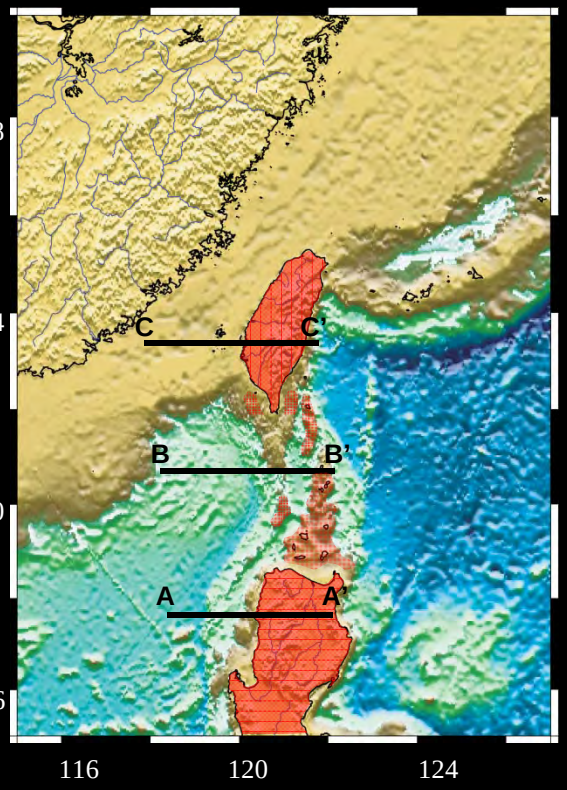
Modern Examples of Island Arc Generation/Accretion

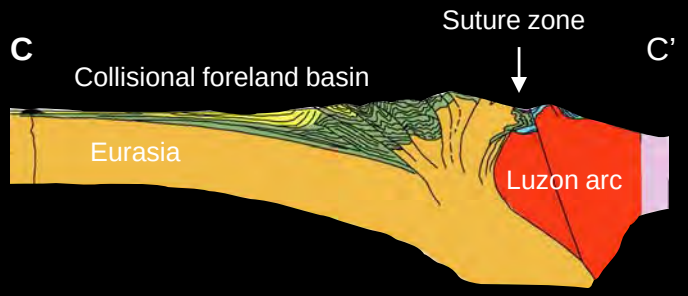


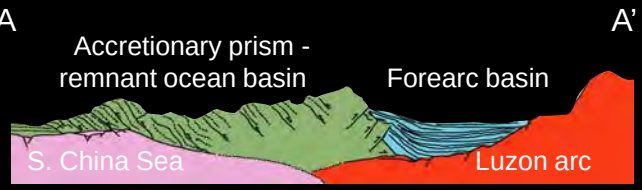
Example: Oblique Island Arc Accretion

Luzon arc (Taiwan)









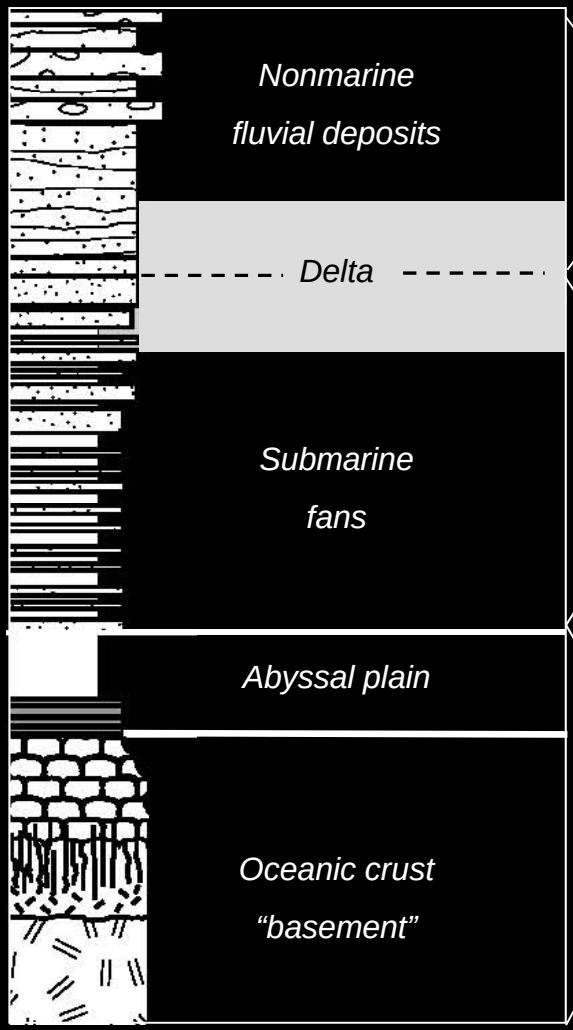
Modified from Stephan et al. (1986)

Diagnostic characteristics:

-Rapid uplift/exhumation; extreme sedimentation rates

-Along-strike (axial) sediment transport parallel to plate margin

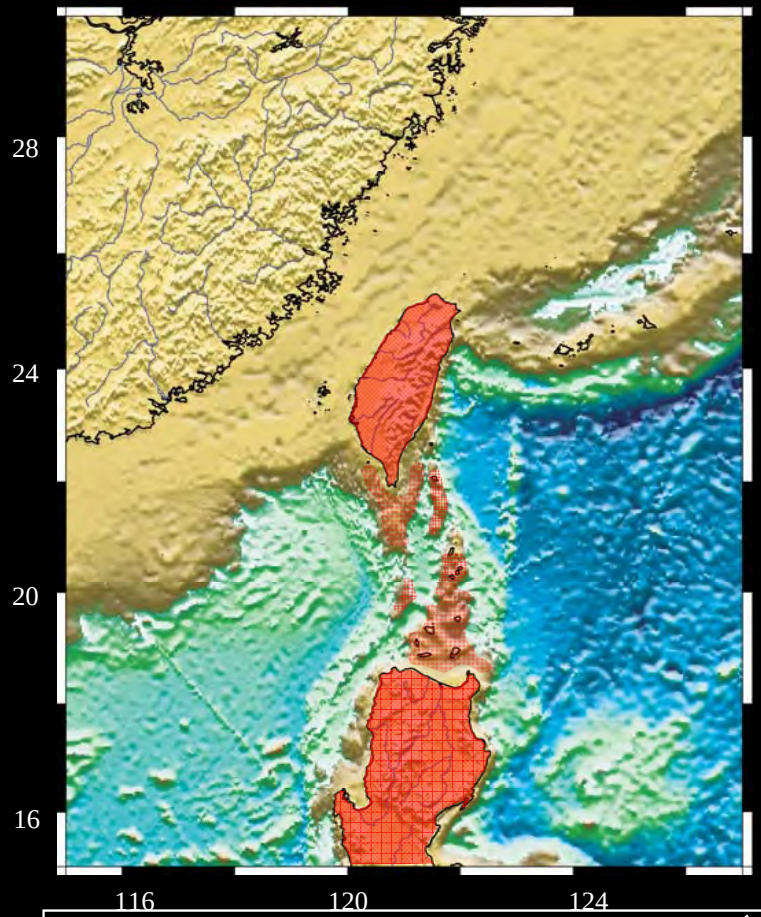
Spatial and temporal stratigraphic trends during oblique convergence

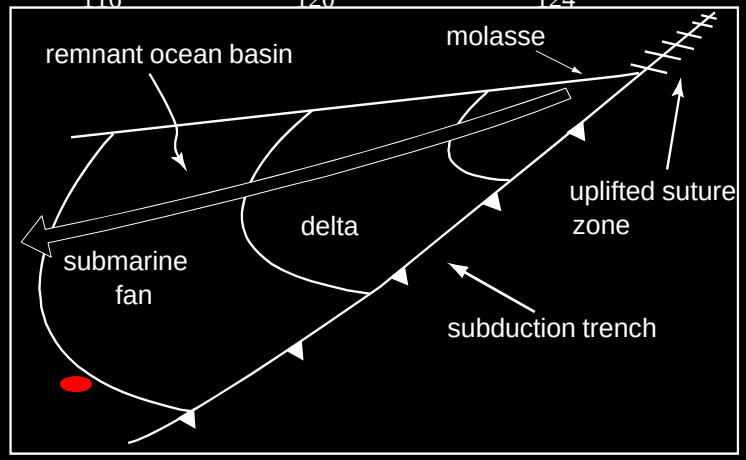


Phase 3: *Sedimentation and deformation*

Phase 2: *Rapid sedimentation*

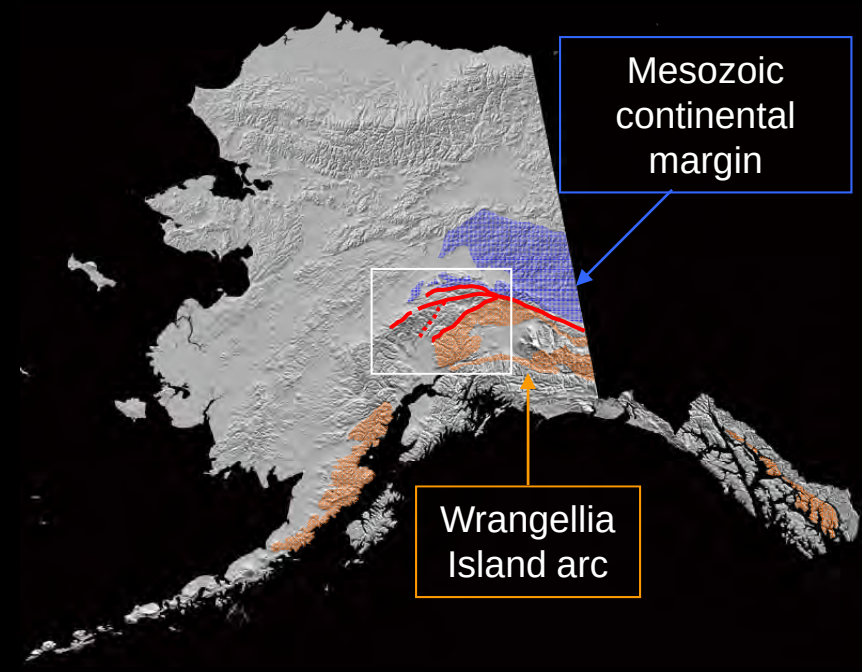
Phase 1: *Sediment starved*

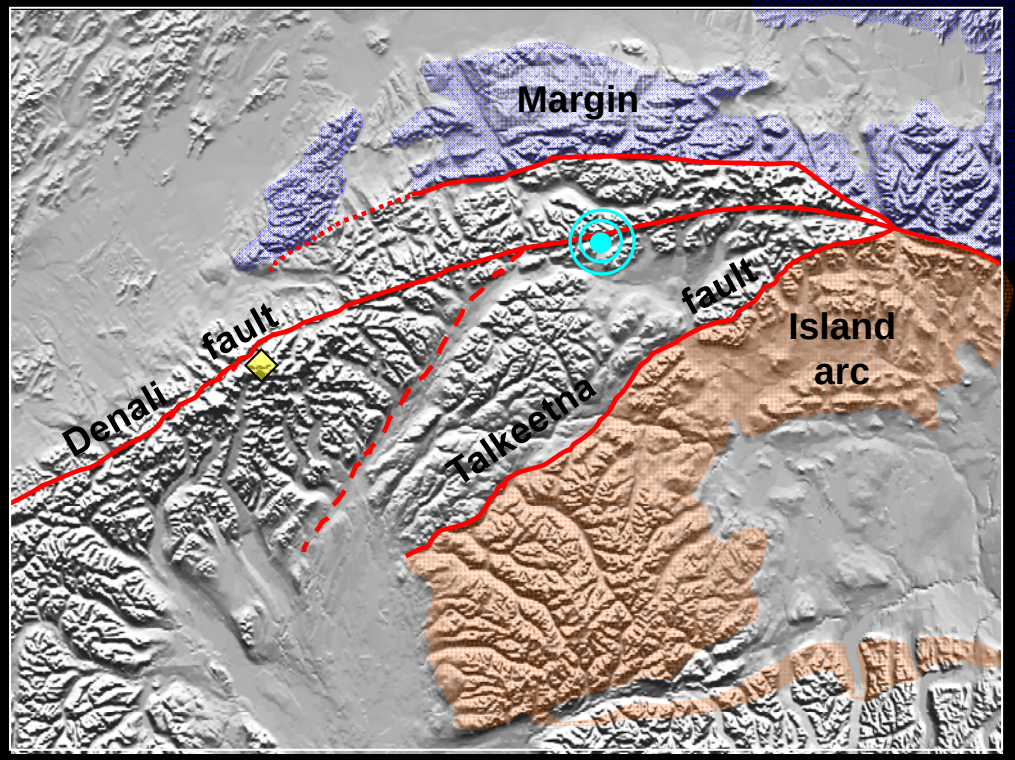




From Graham et al. (1975)

Case Study: Mesozoic Arc Accretion – Southern Alaska

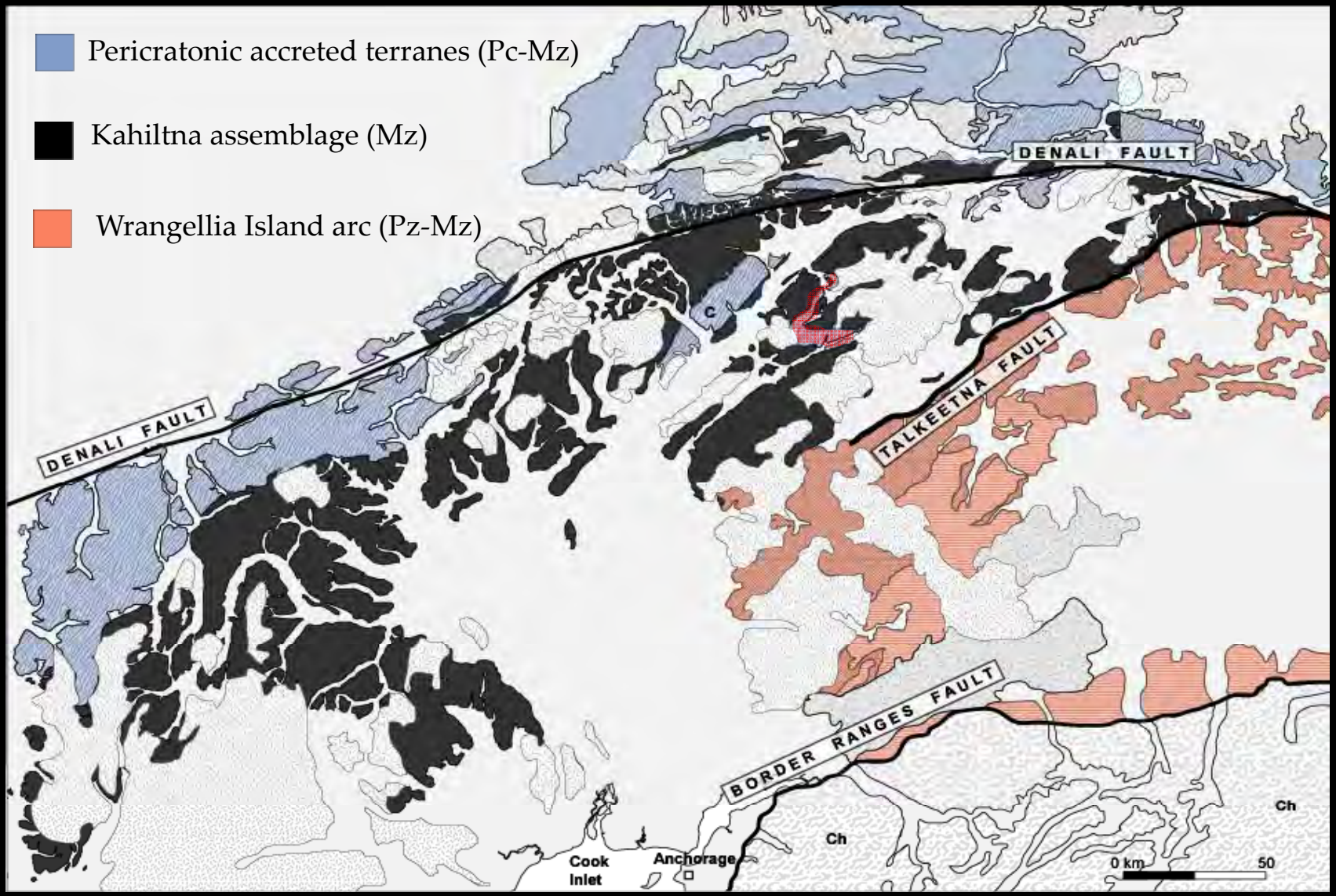




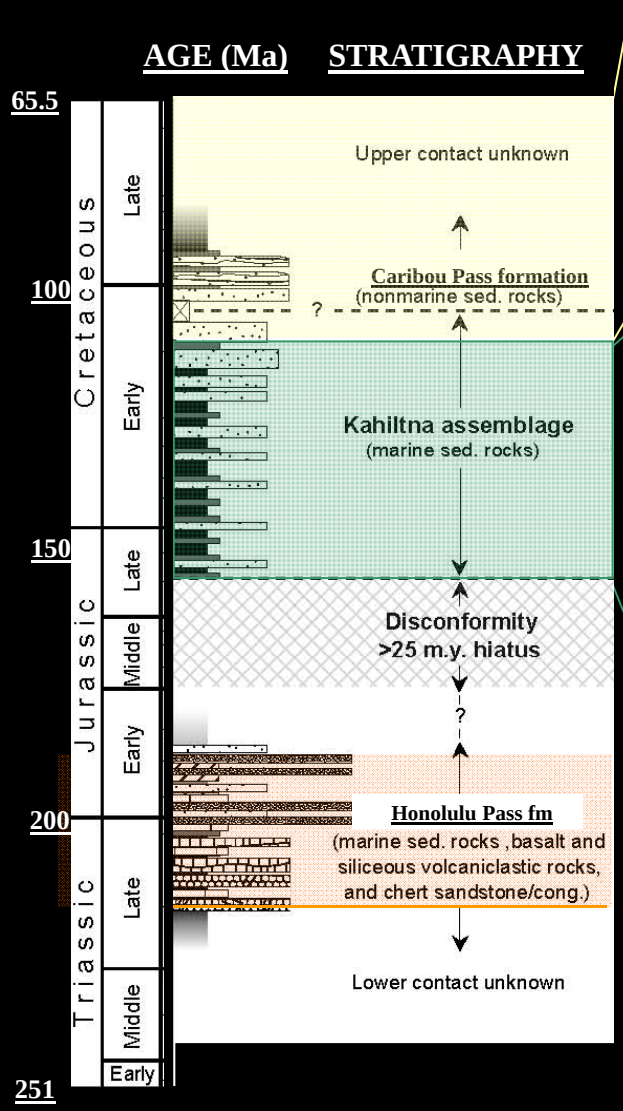
Diagnostic characteristics:

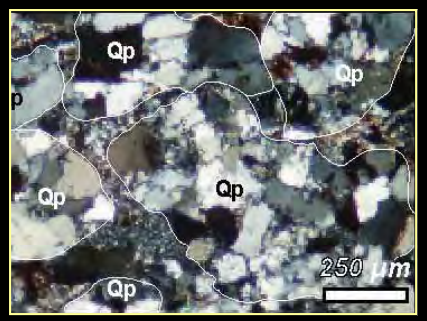
- Highest topography in North America
- Jr–K Kahiltna assemblage is part of a discontinuous belt (>2000 km long) exposed along the western margin of North America

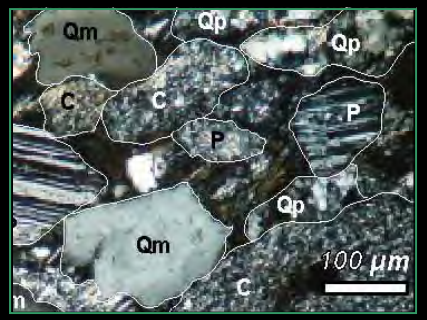
Alaska Range Suture Zone – Generalized Geology

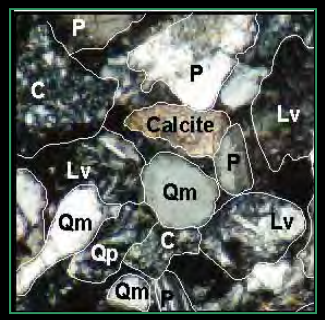


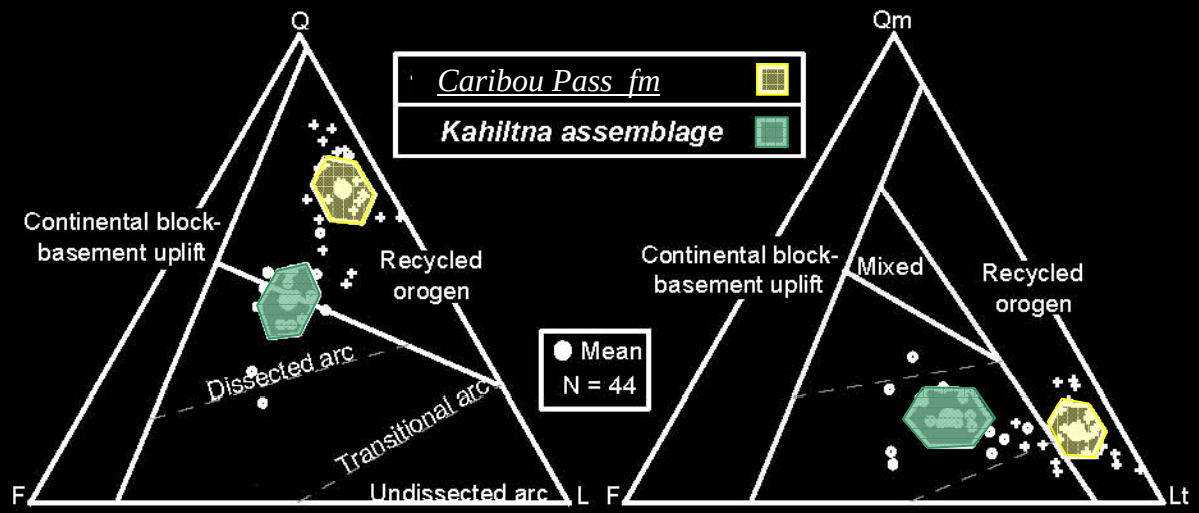
Alaska Range Suture Zone – Stratigraphic and Provenance Overview





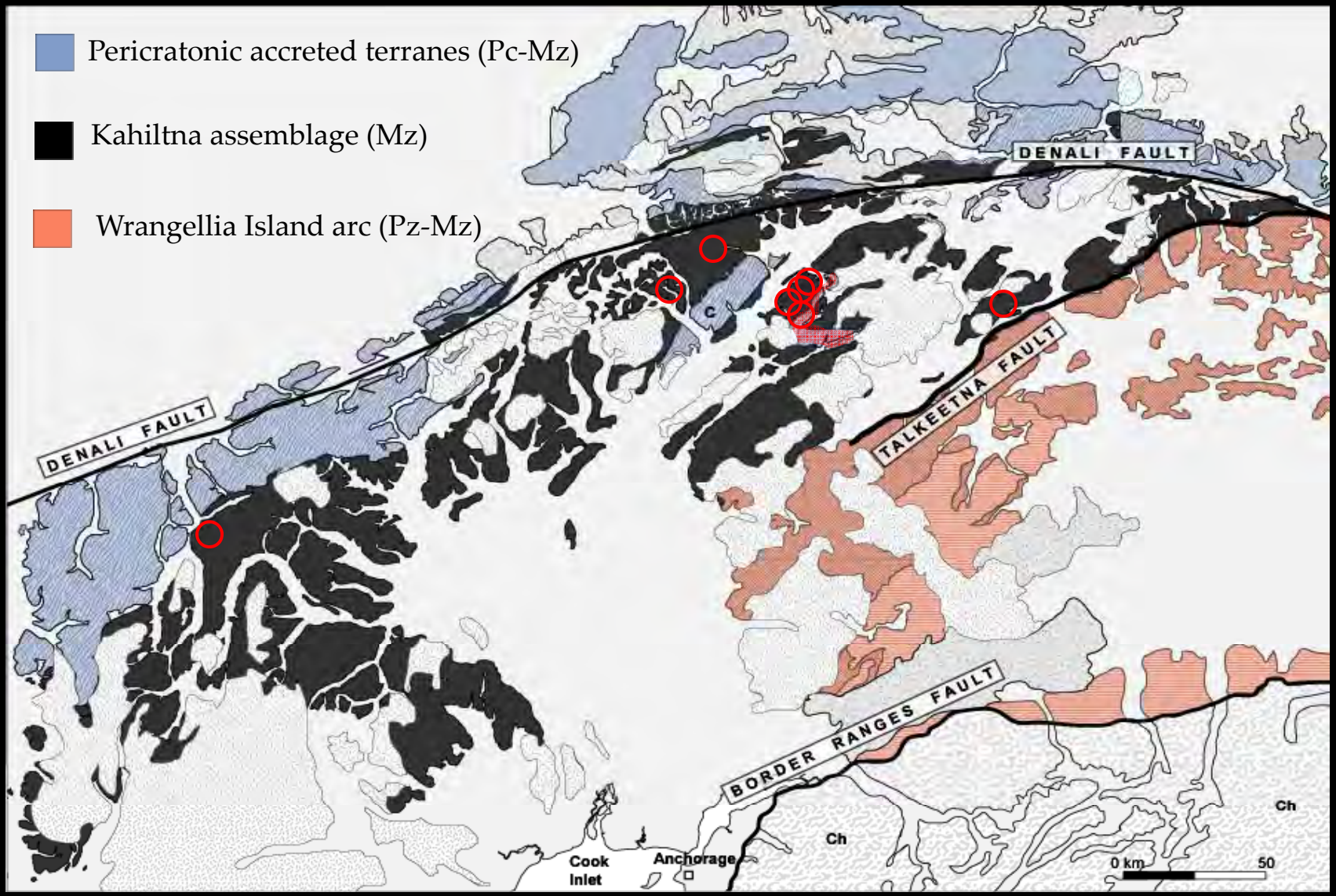






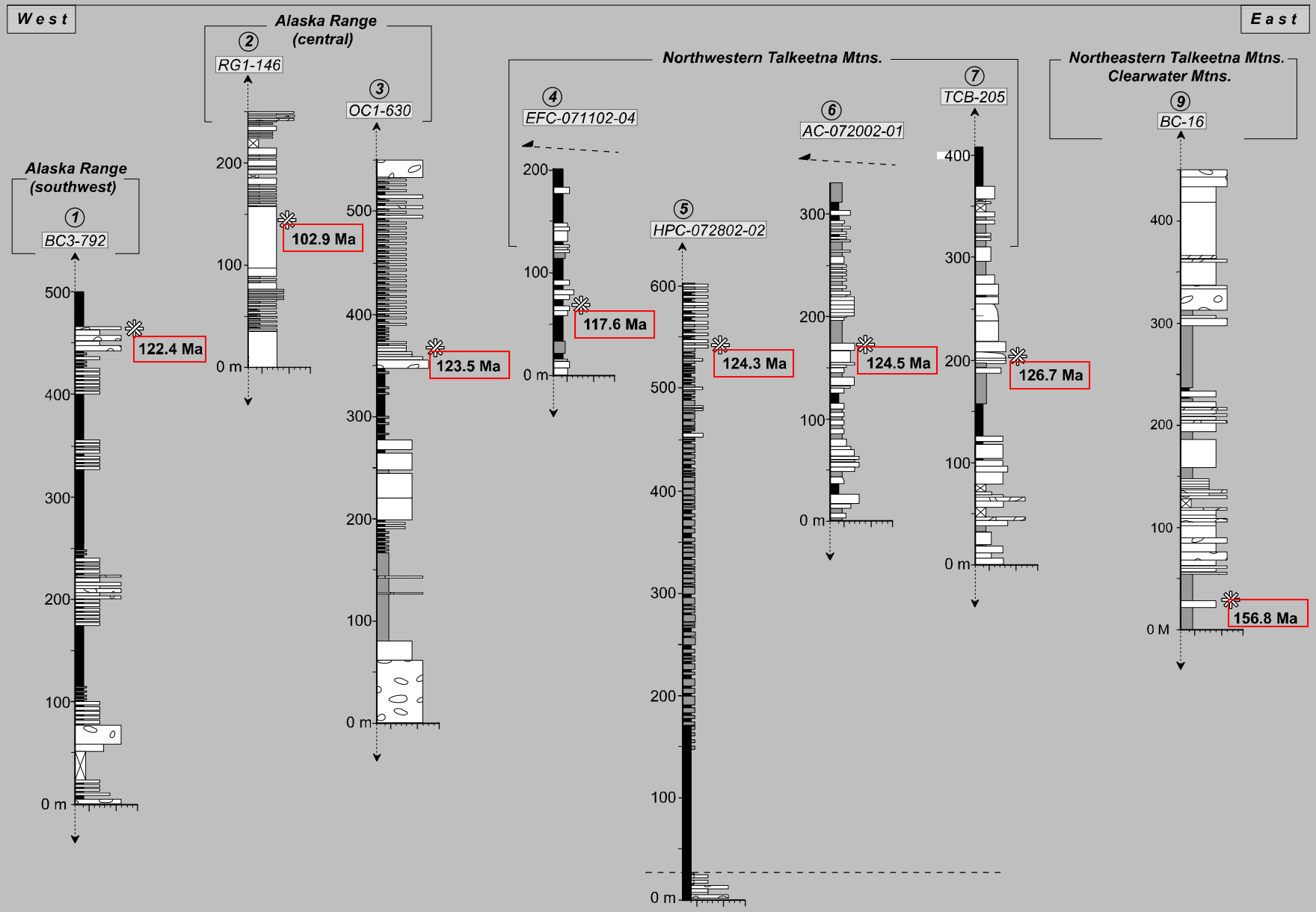
From Hampton et al. (2007)

Alaska Range Suture Zone – Kahiltna Assemblage



Alaska Range Suture Zone – Kahiltna Assemblage

Alaska Range Suture Zone – Kahiltna assemblage



Provenance: U-Pb Detrital Age Dating

Sink - Sample - Age

Collection

Separation

LA-ICP-MS

$^{206}Pb/^{238}U$

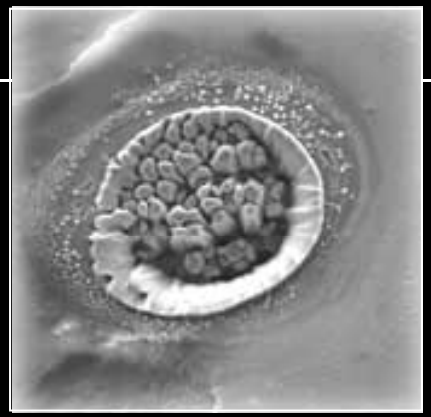
$^{207}Pb/^{235}U$

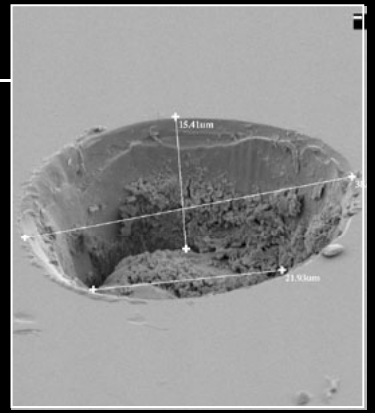




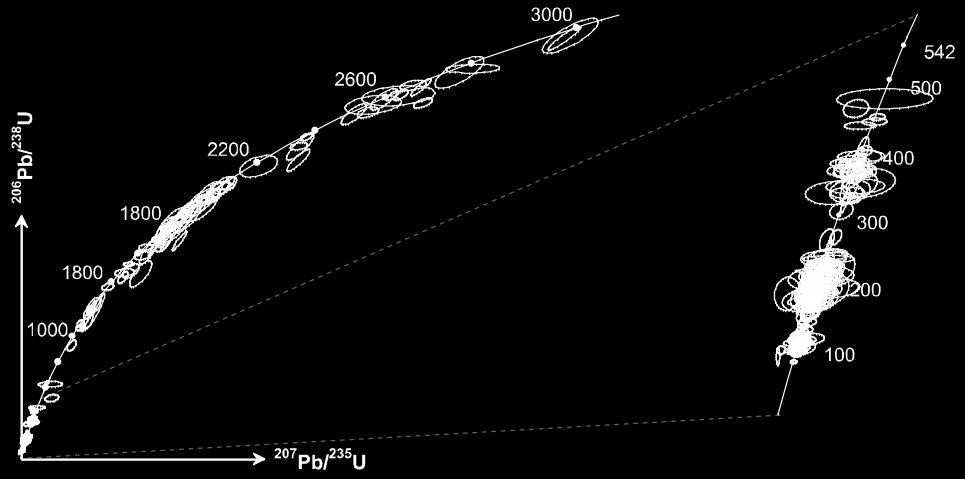


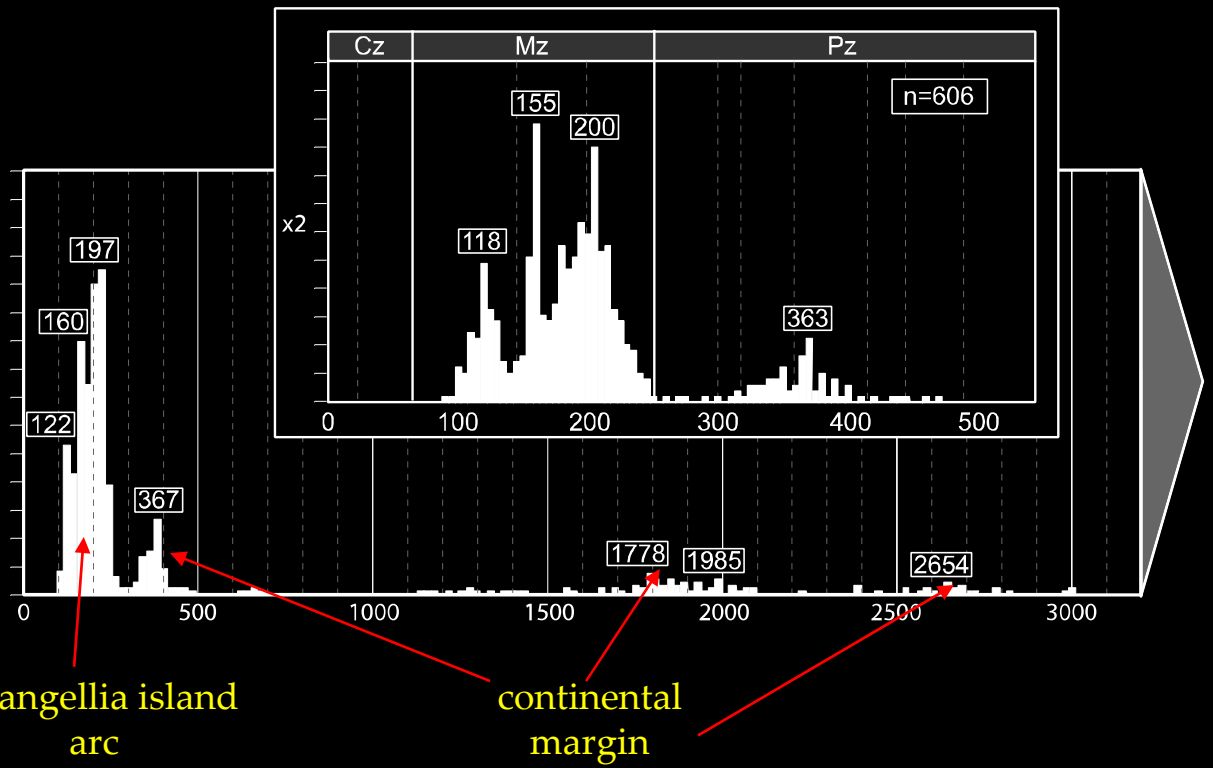




Bulk U-Pb Age Distribution – Kahiltna Assemblage





Total grains - n=714

74% Mesozoic
11% Paleozoic
15% Precambrian

AGE (Ma)

Wrangellia composite terrane (Composite island arc)

Peninsular | Wrangellia | Alexander

Intermontane Belt (Mesozoic continental margin)

Yukon-Tanana composite | Quesnellia Slide Mtn. | Stikinia | Cache Creek

Kahiltna assemblage

Summary of Pz-Mz

magmatic sources inboard and outboard of the Kahiltna basin

Talkeetna arc

Chisana arc

Chitina arc

Bonanza arc

Skolai arc

Permian-Triassic arc

Ordovician-Silurian plutons

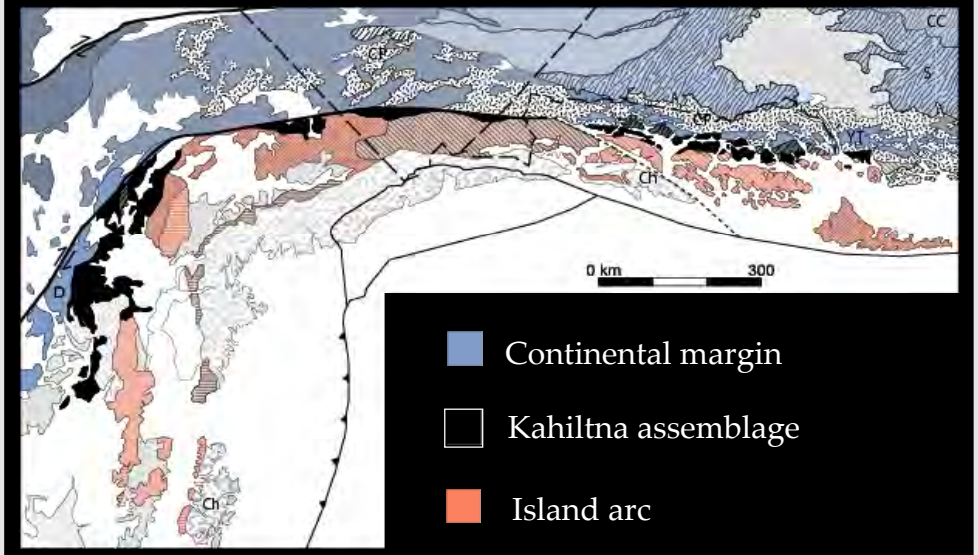
Cambrian and older plutons

Cretaceous arc

Triassic-Jurassic arc

Devonian-Miss. arc

Permian arc

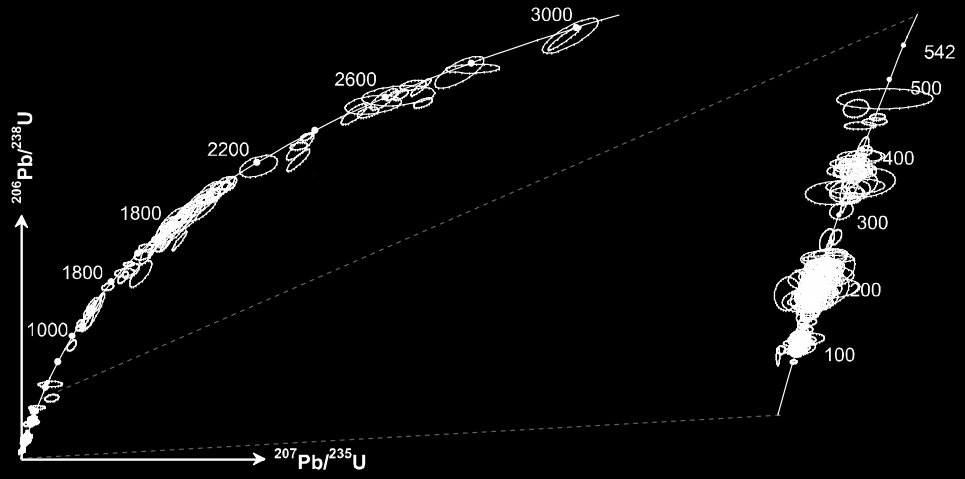


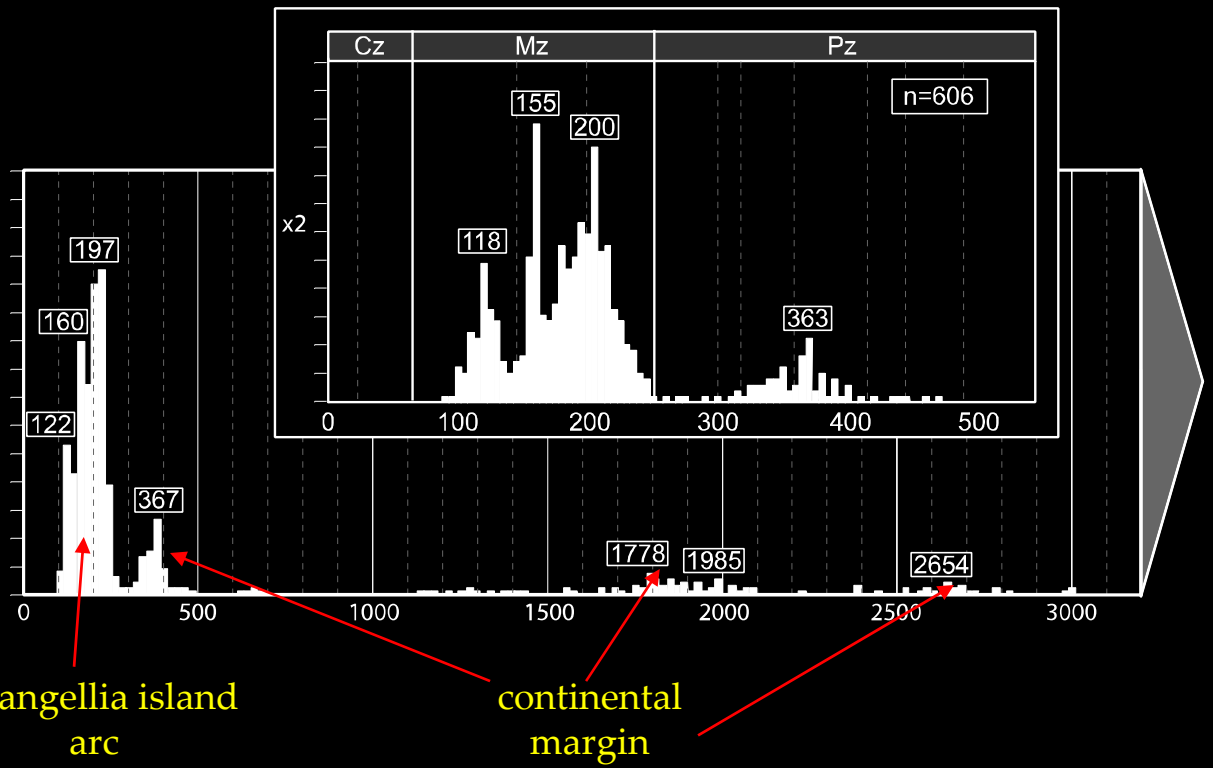
Continental margin

Kahiltna assemblage

Island arc

Bulk U-Pb Age Distribution – Kahiltna Assemblage

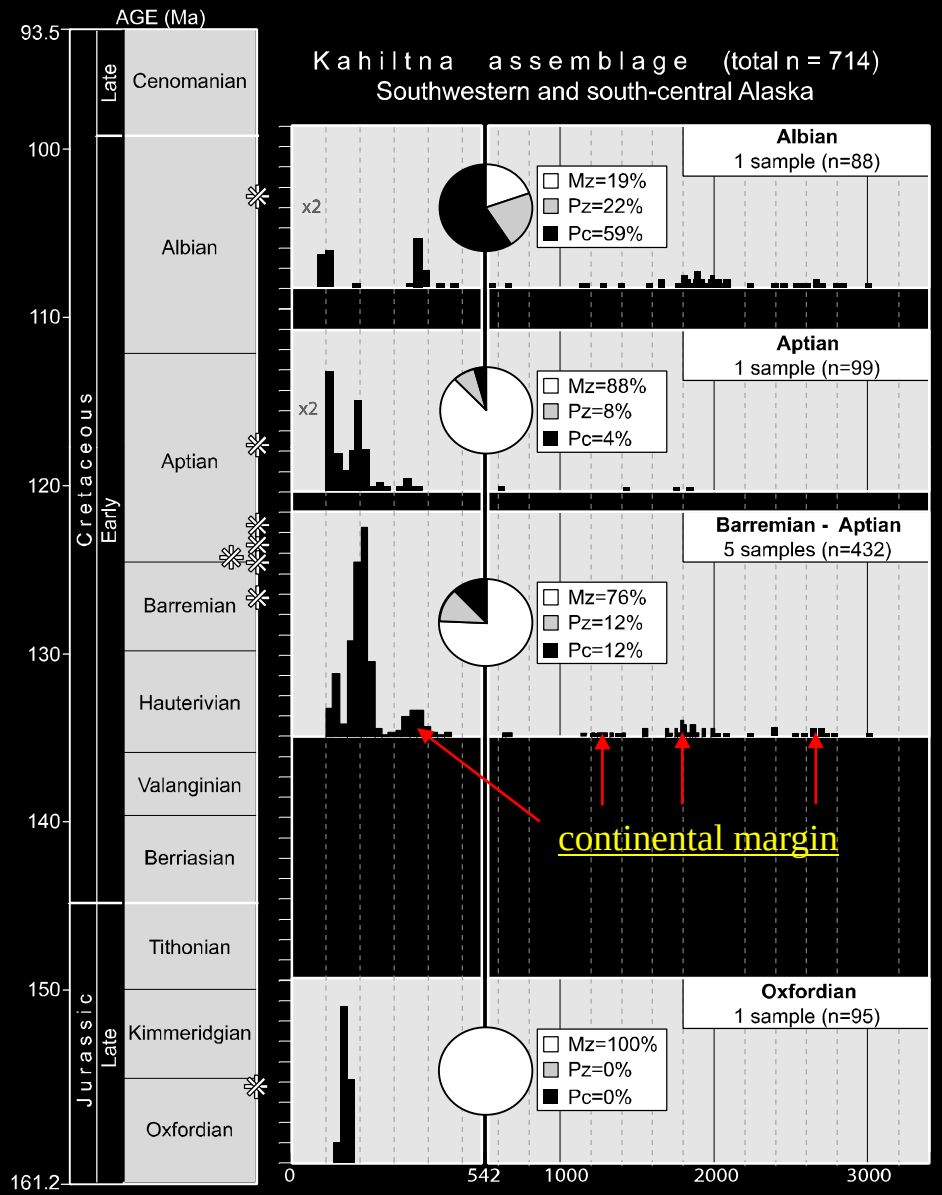




Total grains - n=714

74% Mesozoic
11% Paleozoic
15% Precambrian

Upsection Trends in Age Populations – A proxy for exhumation



Majority of detrital contributions from the inboard margin; decreased arc contibutions

First detrital contribution from the inboard margin; still primarily from the Wrangellia composite terrane

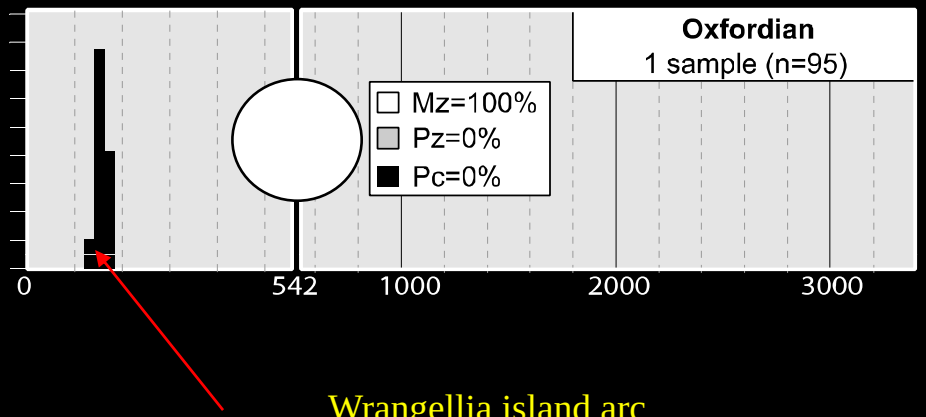
Detrital contributions almost entirely from the exhuming Wrangellia composite terrane

Conclusions: Stage 1 – Exhumation of Wrangellia Island Arc

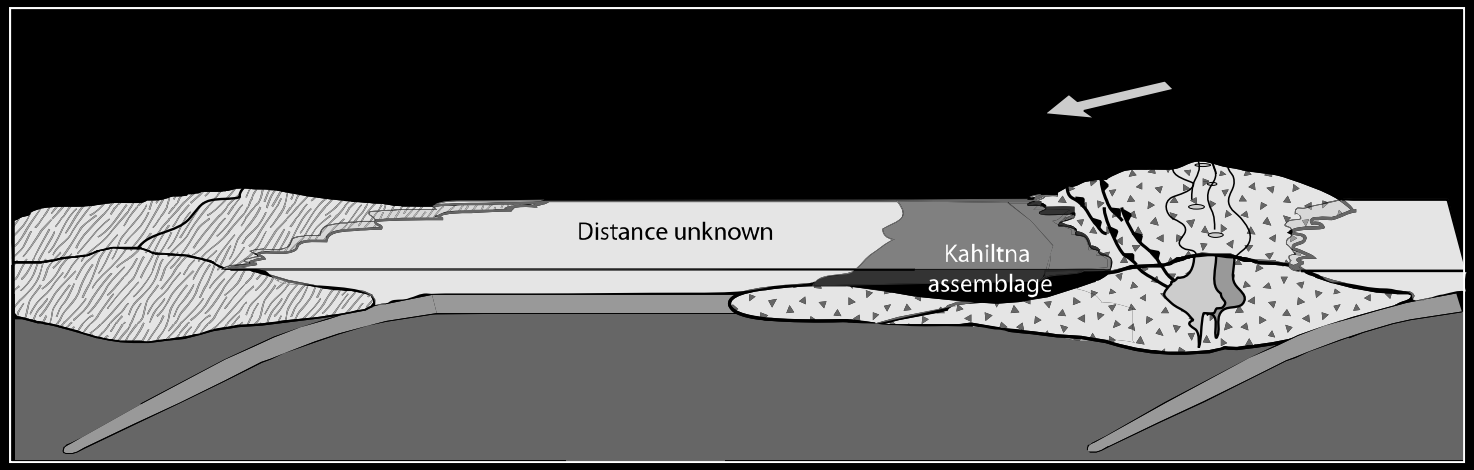
***STAGE 1*: Late Jurassic**

(Oxfordian–Tithonian)

161.2–145.5 Ma



Wrangellia island arc

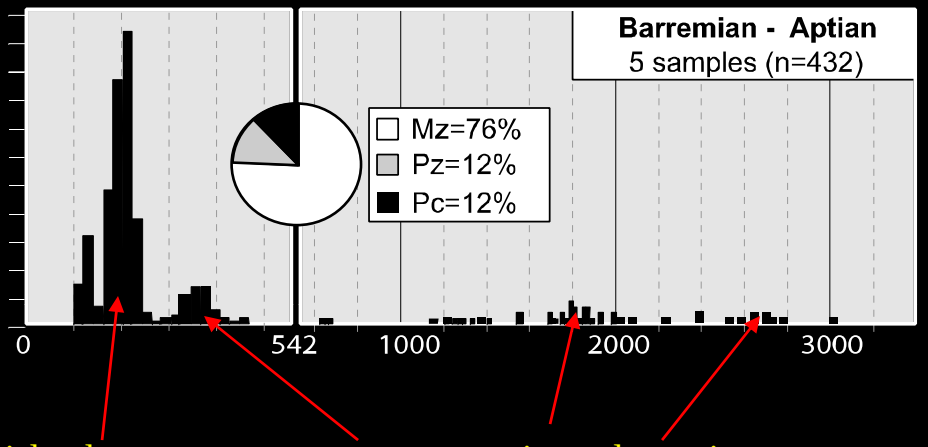


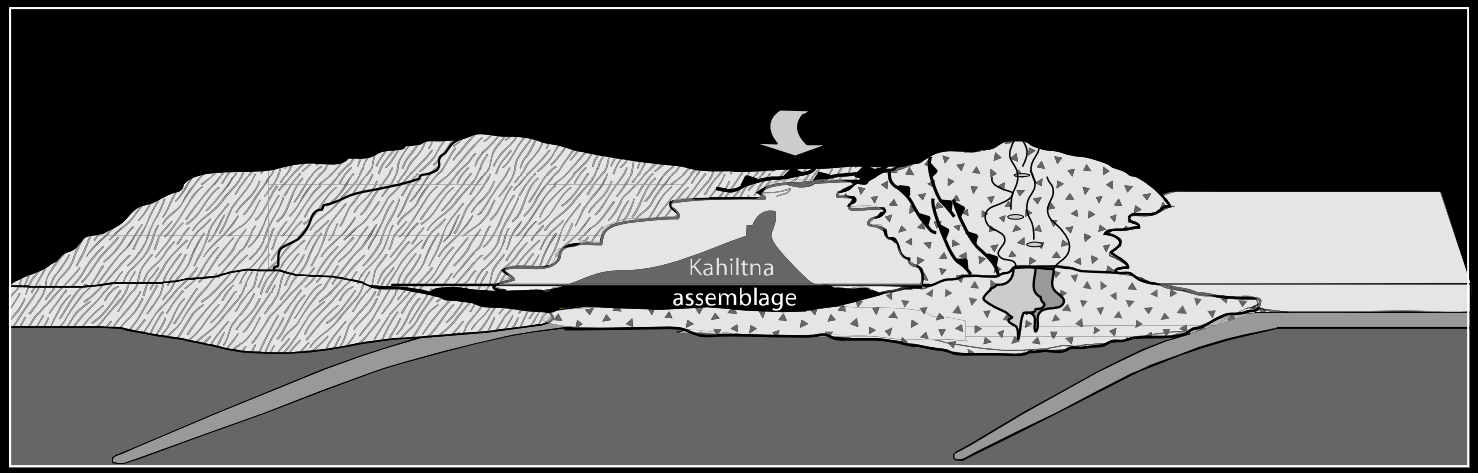
Conclusions: Stage 2 – Exhumation of Arc (primary) and Inboard Margin

***STAGE 2*: Early Cretaceous**

(Barremian–Aptian)

130–112 Ma



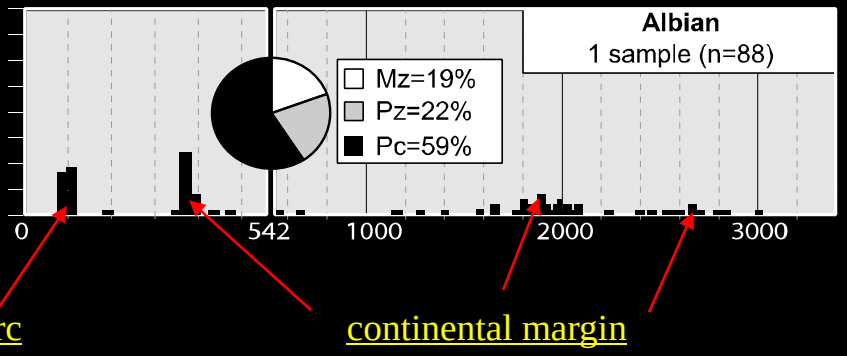


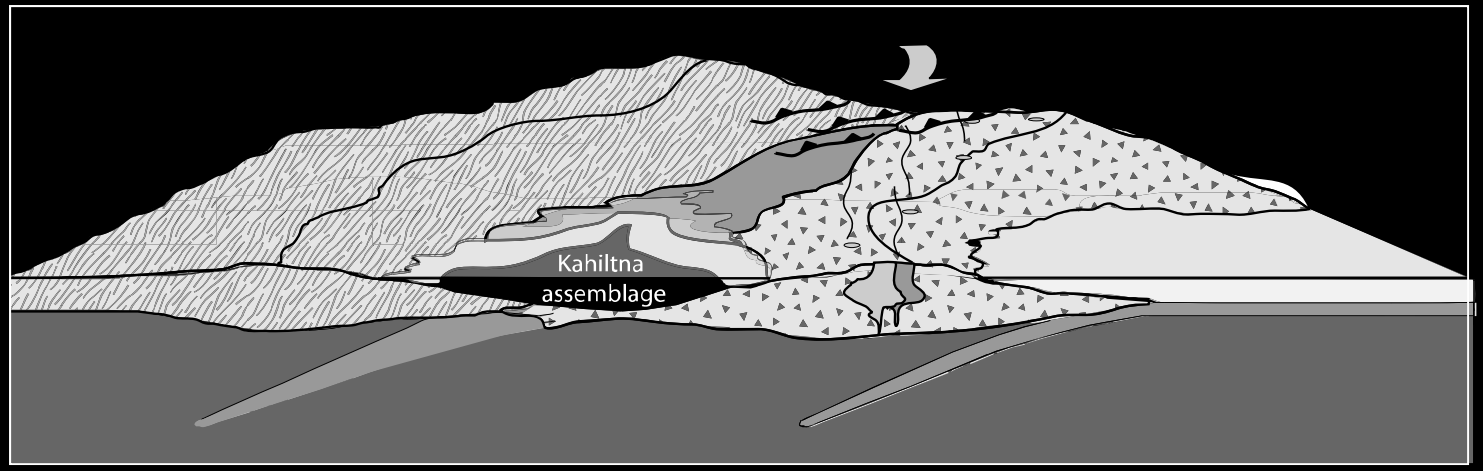
Conclusions: Stage 3 – Exhumation of Inboard Margin (primary) and arc

***STAGE 3*: Early Cretaceous**

(Albian)

112–199.6 Ma





Acknowledgments

Dwight Bradley (*USGS*)

George Gehrels (*U. of Arizona*)

Ken Ridgway (*Purdue U.*)

Jeanine Schmidt (*USGS*)

Basin Research Lab (at MSU):

- Michael Ackerson (*MSU*)

- Jenifer Deloge (*MSU*)

- Matthew Malkowski (*MSU*)

National Science Foundation

U.S. Geological Survey

Michigan State University

References

Blakey, R., 2007, Paleogeography and geologic evolution of North America: Web accessed 14 August 2009 http://jan.ucc.nau.edu/~rcb7/nam.html

Graham, S., W.R. Dickinson, and R.W. Ingersoll, 1975, Himalayan-Bengal model for flysch dispersal in the Appalachian-Ouachita system: GSA America Bulletin, v. 86, p. 273-286.

Hampton, B.A., K.D. Ridgway, J.M. O'Neill, G.E. Gehrels, J.M. Schmidt, and R.B. Blodgett, 2007, Pre-syn-, and post-collisional stratigraphic framework and provenance of Upper Triassic–Upper Cretaceous strata in the northwestern Talkeetna Mountains, Alaska, *in* Ridgway, K.D., Trop, J.M., J. Glen, and J.M. O'Neill, eds., Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska: GSA Special Paper 431, p. 401–438,

Stephan, J.F., R. Blancet, C. Rangin, B. Pelletier, J. Letouzey, and C. Muller, 1986, Geodynamic evolution of the Taiwan-Luzon-Mindoro belt since the late Eocene: Tectonophysics, v. 125, p. 245-268.