Crustal Deformation, Basin Subsidence, and Paleo-River Response to Eocene Accretion of Siletzia, SW Oregon

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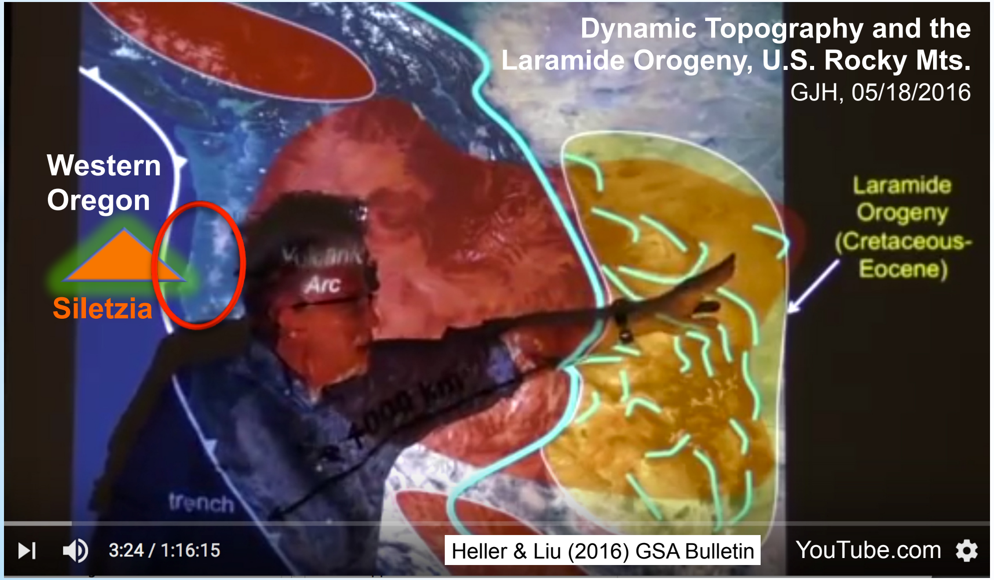
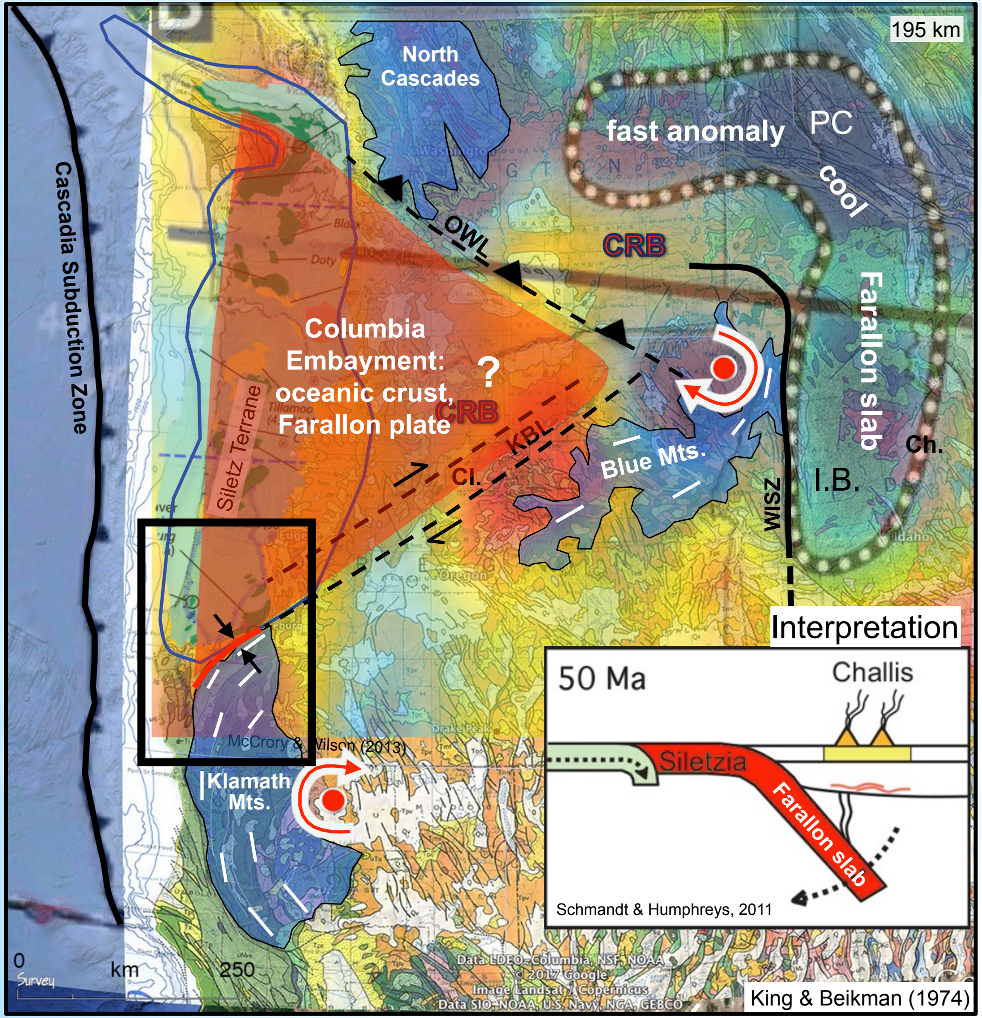
With thanks to Paul Heller,
a great scientist, friend and mentor



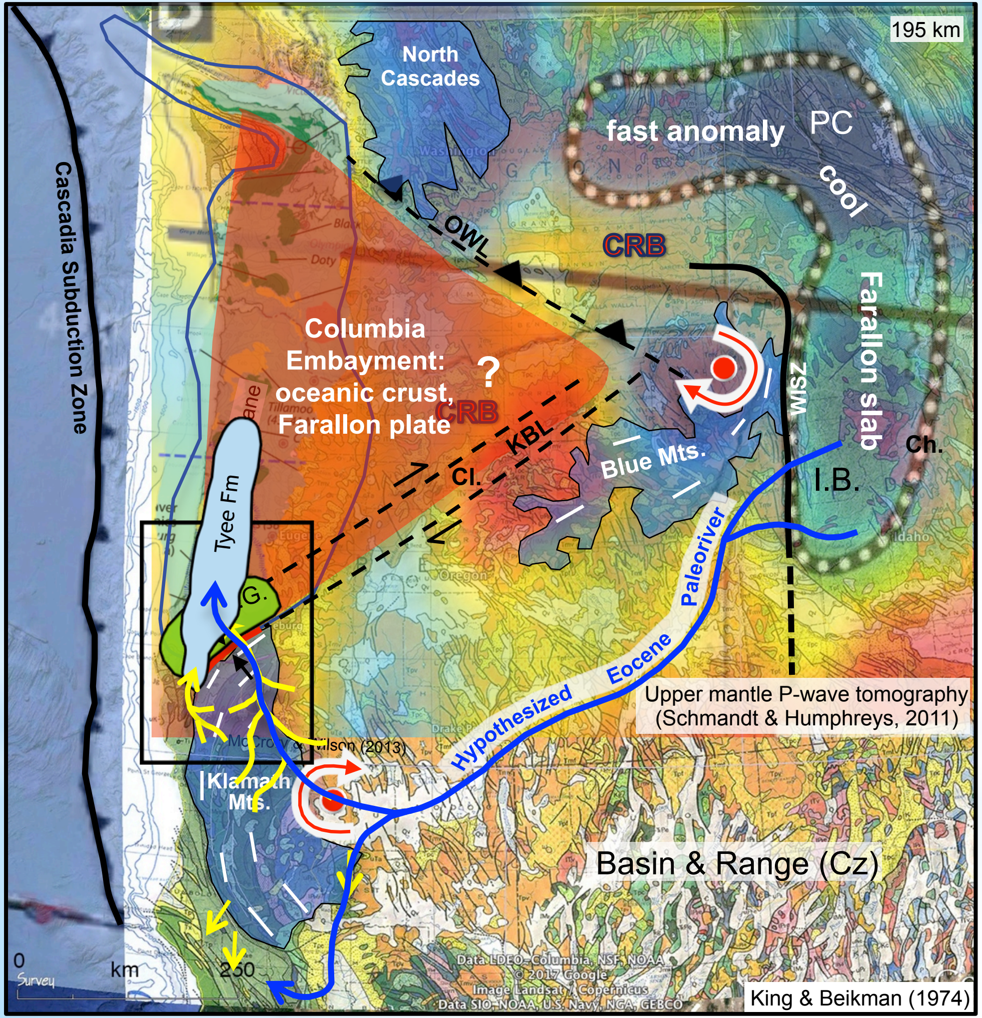
- **Goal:** Understand *what happened* when Siletz Terrane (large oceanic plateau) collided with North America, Early Eocene (~54 Ma) – SW Oregon.
- **Integrate**: lithospheric dynamics, crustal deformation, surface processes …
- **Synthesize Data:** geology, stratigraphy, geochronology, petrology, paleomag …



Tectonics of the PNW Region

Some Highlights:

- Pz-Mz terranes, Cz volcanic cover; accretion completed by ~ 145 Ma.
- Craton boundary and suture WISZ.
- Siletz Terrane: tholeiitic basalts, 20-30 km thick oceanic plateau (56-50 Ma), accreted in E. Eocene.
- P-wave tomography: vertical slab of stalled oceanic lithoshere.
- Two poles of CW oroclinal rotation: complex history …
- **SW Oregon**: Eocene suture between Siletz terrane and N. Klamath Mts.



Tectonics of the PNW Region

SW Oregon – Summary:

(1) Excellent record of <u>Siletz collision</u>, completed by ~ 49 Ma.

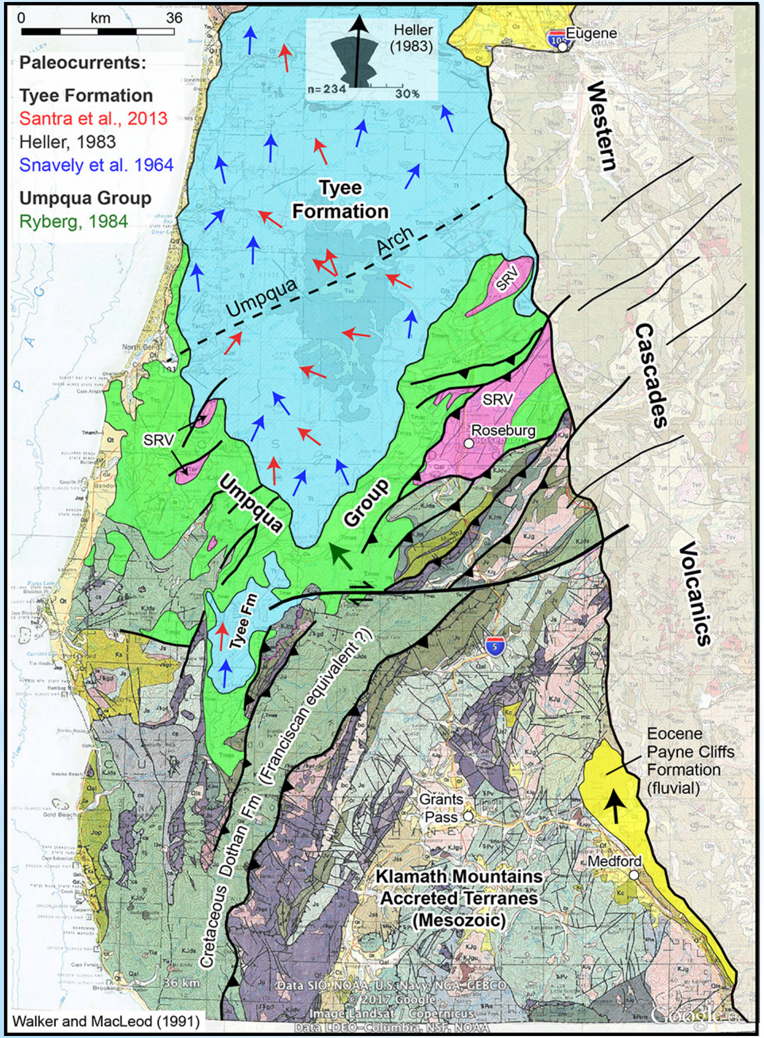
(2) <u>UMPQUA GROUP</u> ~ 54 – 49 Ma
Syn-collisional foredeep basin,
Sediment source in Klamath Mts.

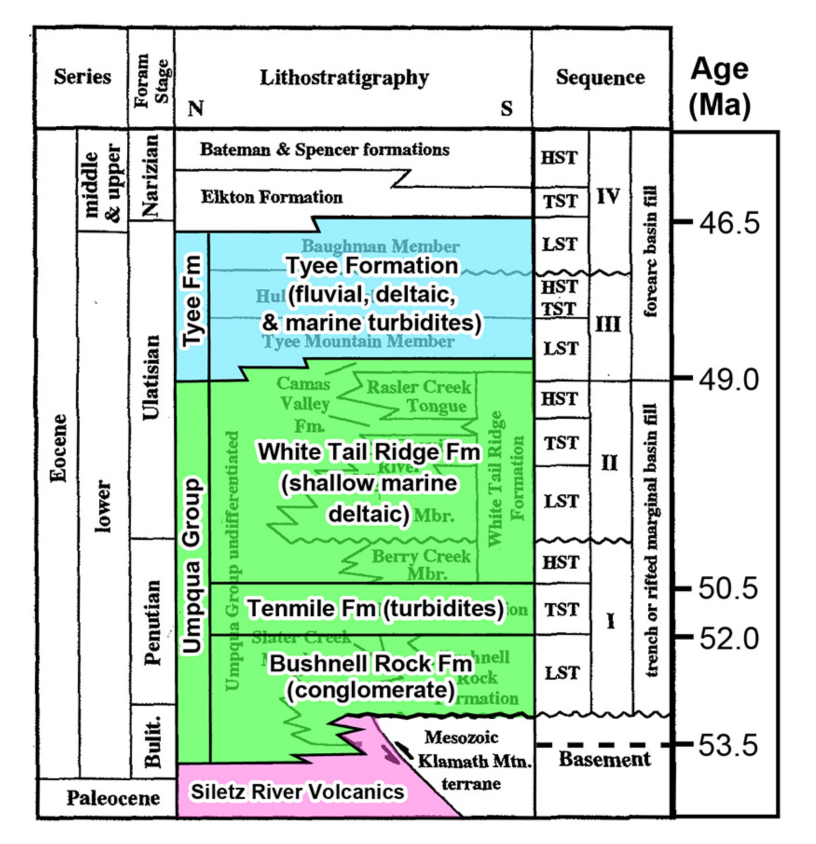
(3) <u>TYEE FORMATION</u> 49 – 46 Ma
Post-collisional, overlaps thrusts.

(4) <u>Idaho Source for Tyee Paleoriver</u> poses interesting problems …

(5) <u>Multiple Datasets</u>: Suggest **Tyee Fm from Klamath Mts?**

Tectonic Stratigraphy of SW Oregon



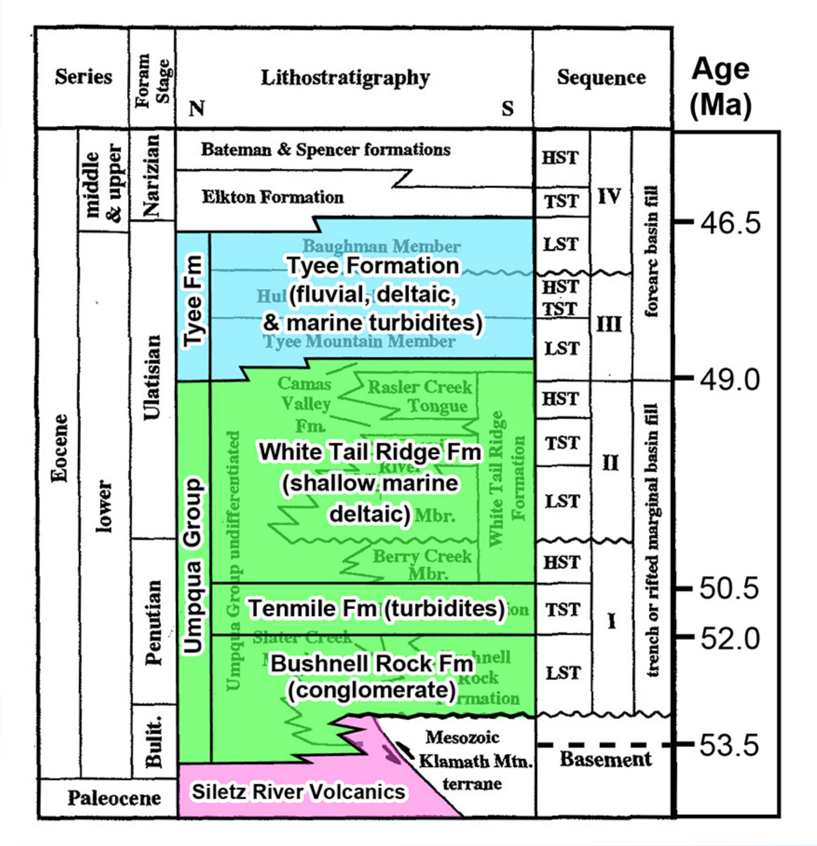


Ryu & Niem 1999 (ages from Wells et al., 2014)

Tectonic Stratigraphy of SW Oregon

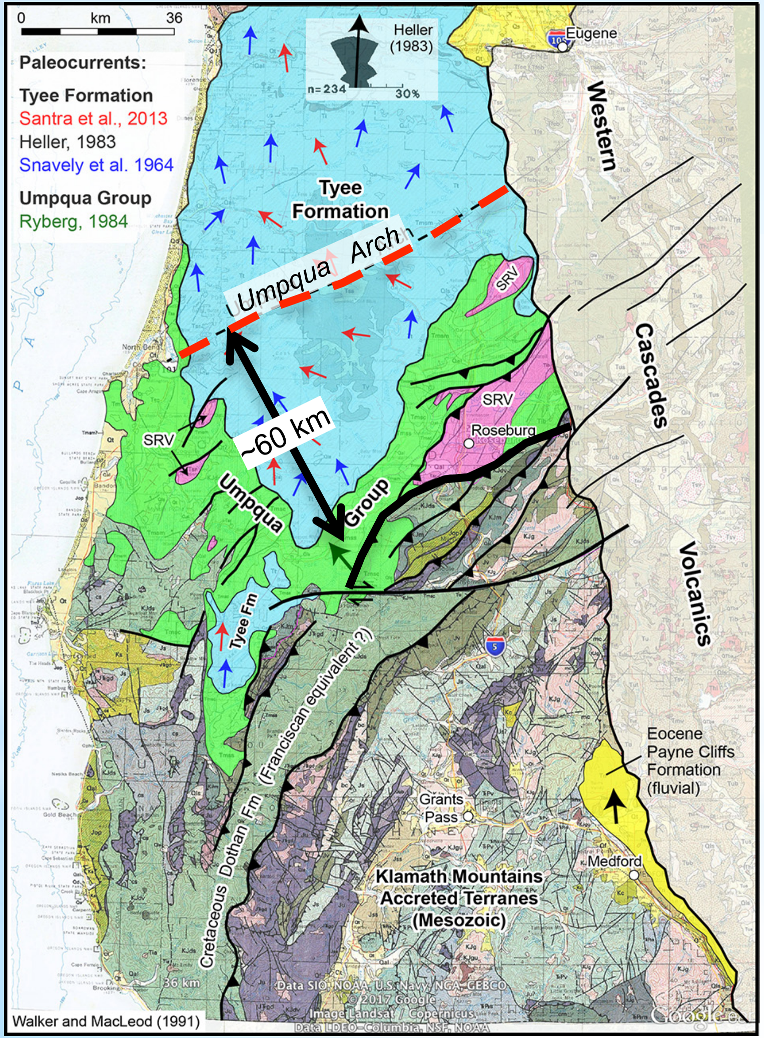

Tyee Formation: turbidites
(Idaho Batholith source ??)

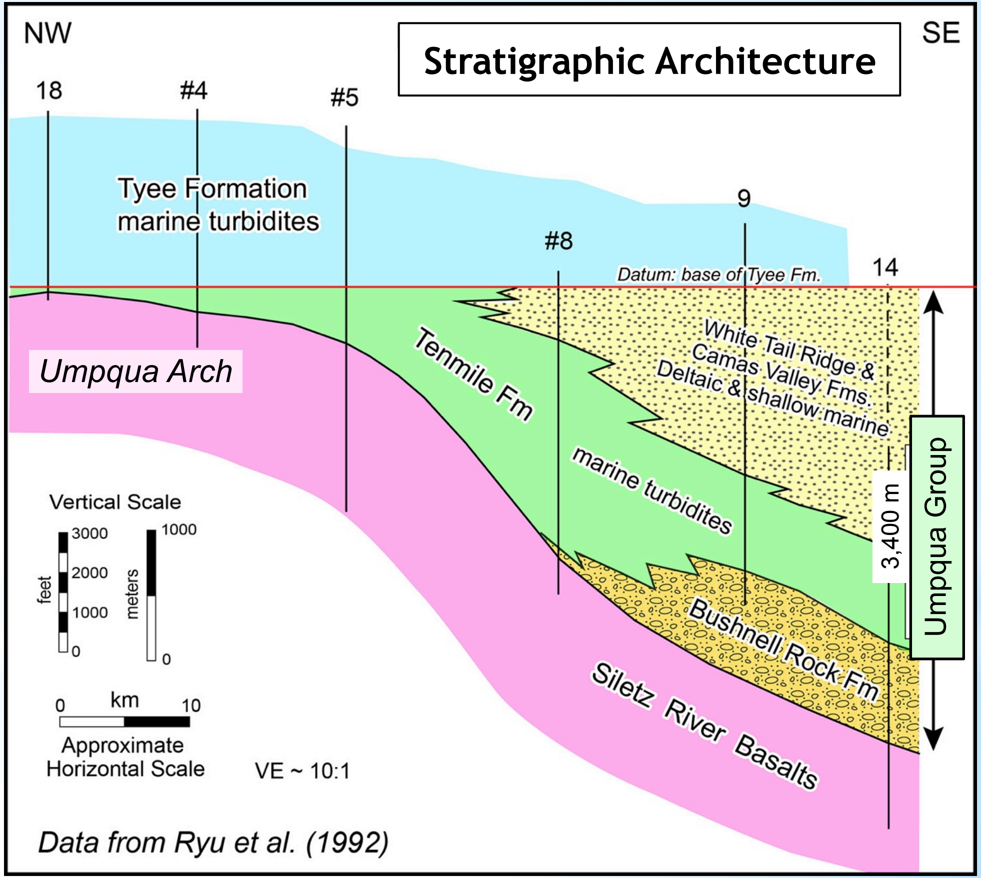

Siletz River Basalts:
56-53 Ma, Roseburg area



Ryu & Niem 1999 (ages from Wells et al., 2014)

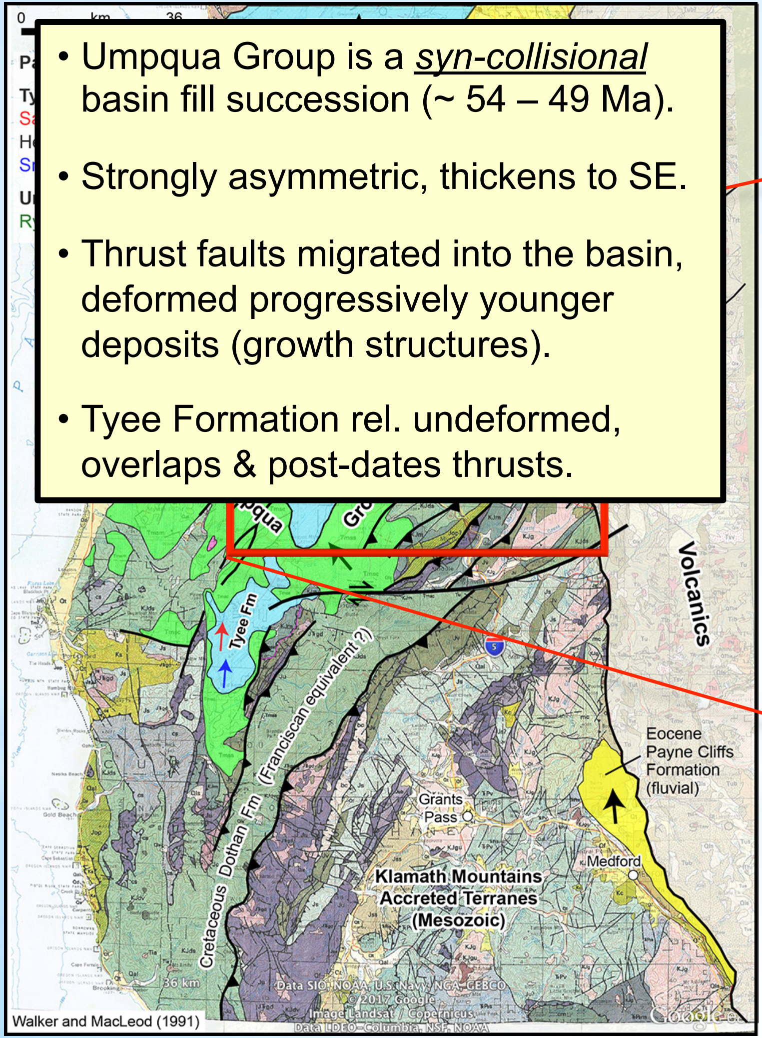
Umpqua Basin – Stratigraphy



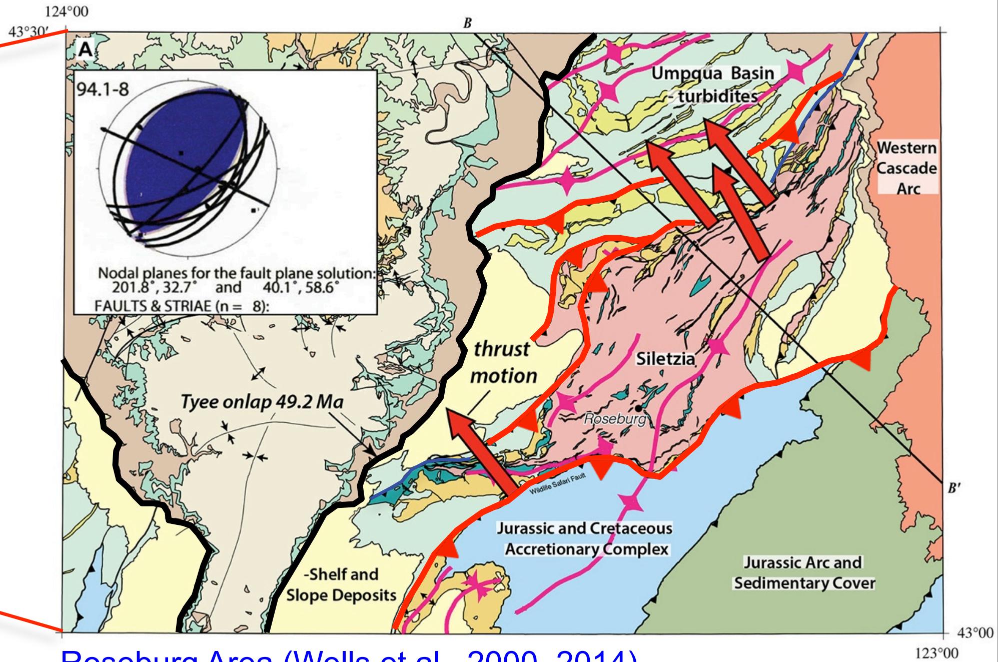


Umpqua Basin – Structure

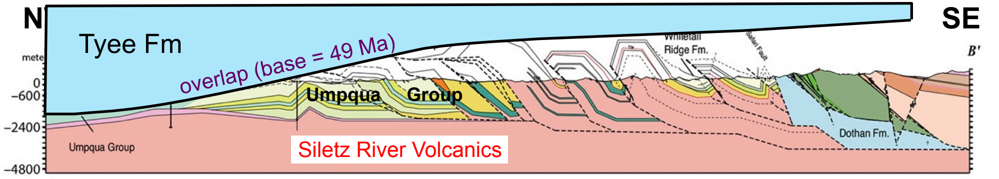
- Umpqua Group is a *syn-collisional* basin fill succession (~ 54 – 49 Ma).
- Strongly asymmetric, thickens to SE.
- Thrust faults migrated into the basin, deformed progressively younger deposits (growth structures).
- Tyee Formation rel. undeformed, overlaps & post-dates thrusts.



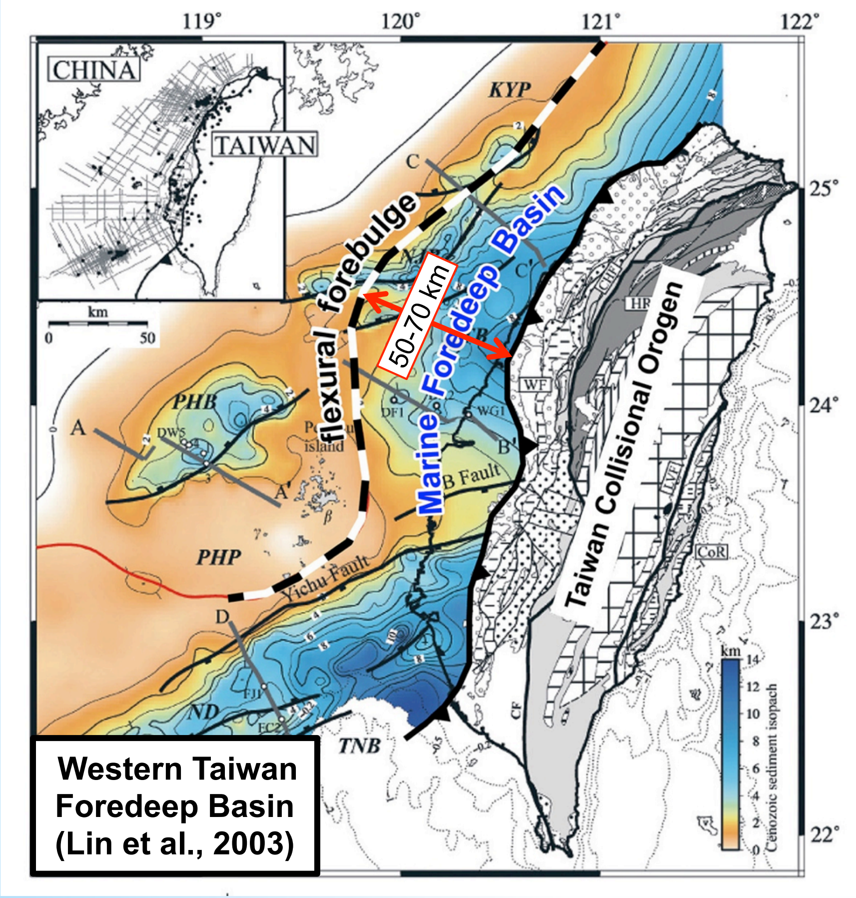
Walker and MacLeod (1991)

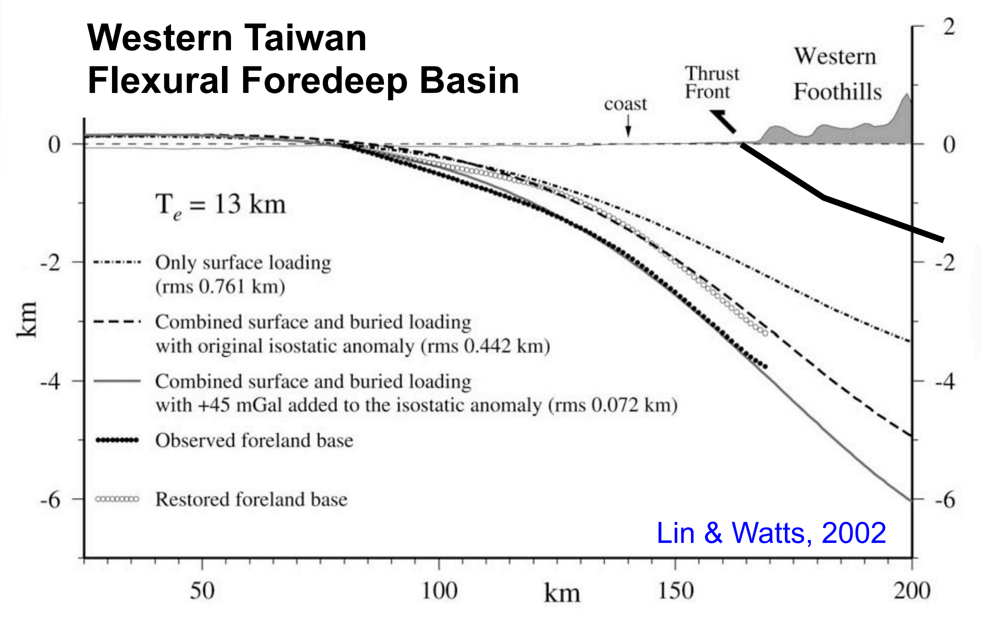


Roseburg Area (Wells et al., 2000, 2014)



Western Taiwan Foredeep: Modern Analog for Umpqua Basin

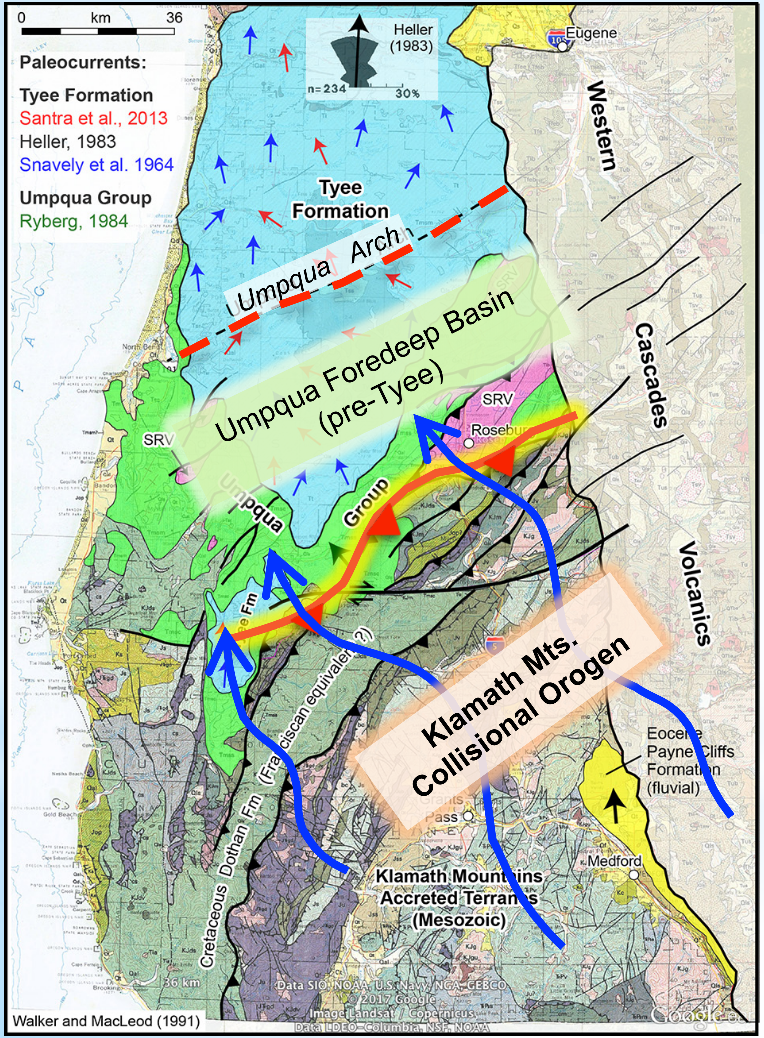


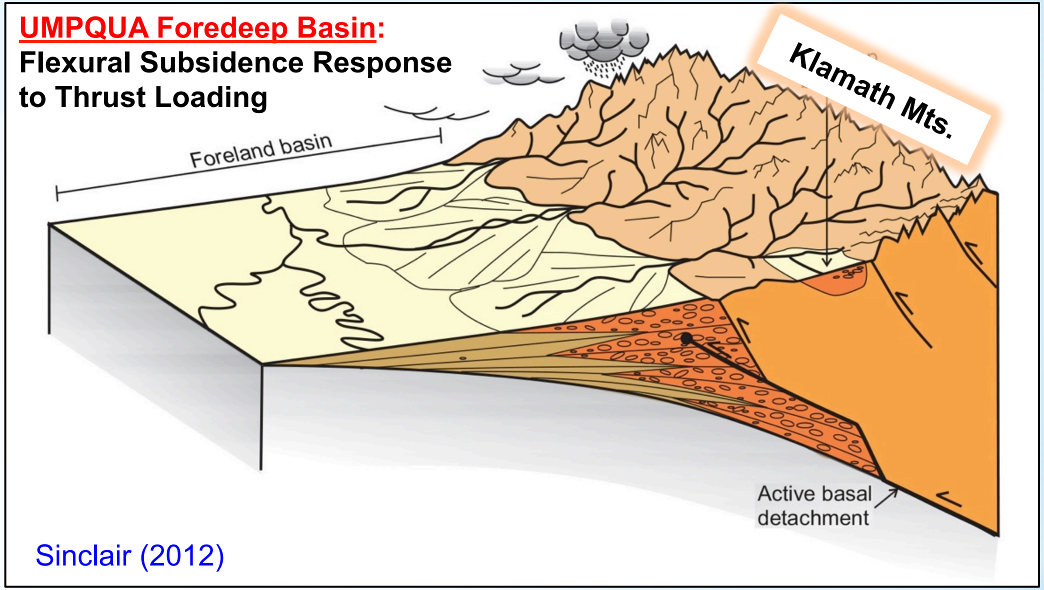


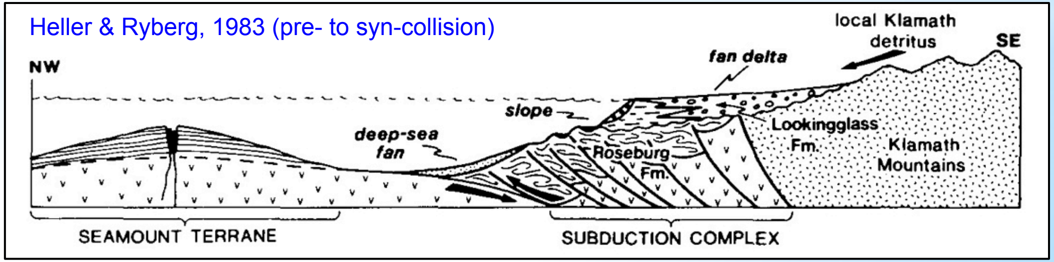
Taiwan Foredeep & Umpqua Basin have similar

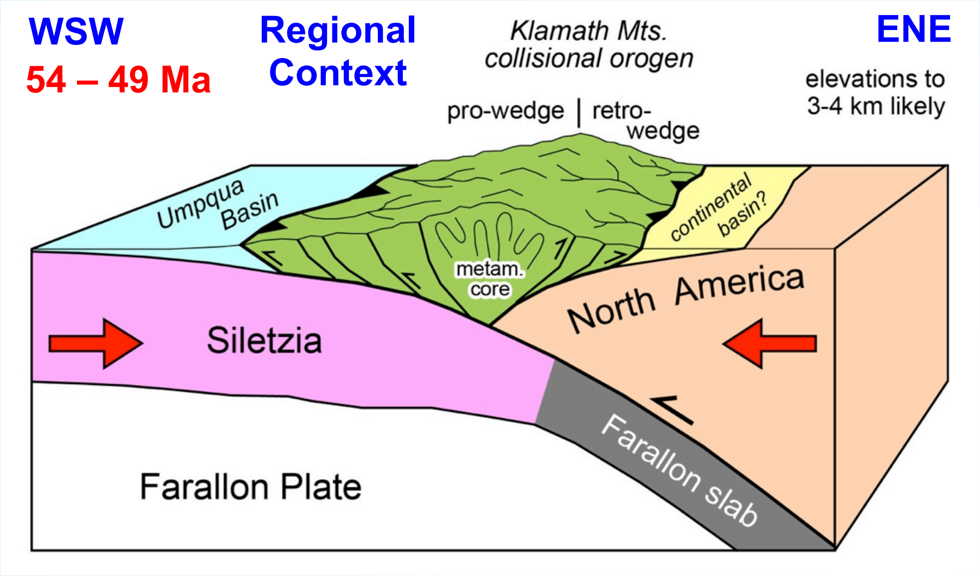
- Scale (width, depth)
- Rate and duration (~ 5 Myrs)
- Genetic relation to thrust belt (flexural load)
- Basin migration, progressive thrusting

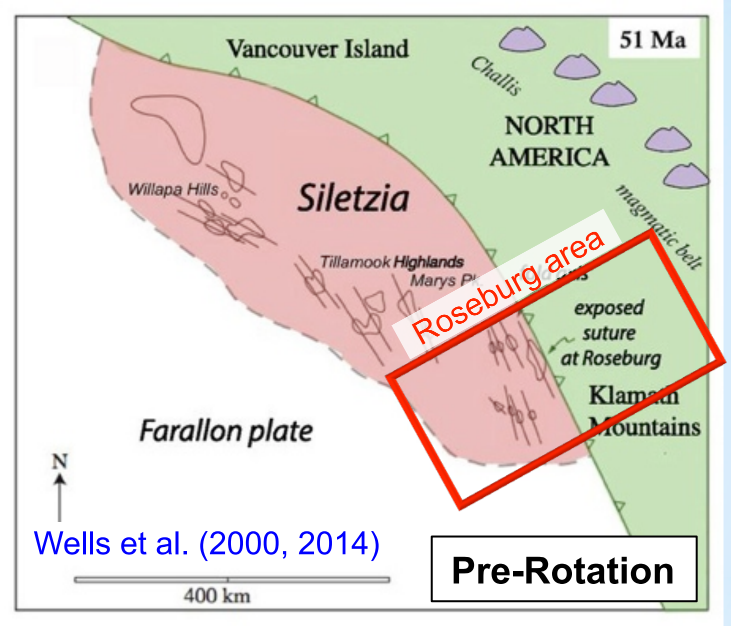
Collisional Orogen & Foredeep Basin











Paleomagnetic Data

Unit	Age (Ma)	Clockwise Rotation	Syn-Collision (mid-value)	Syn-Collision (max.)
W. Cascades	post-40	~ 30°		
Tyee Fm.	49-46	**67° ± 14.5°**		
Umpqua Gp.	**54-49**	**(intermed.)**	**~ 12°**	**~ 39°**
Siletz R. Volcanics	56-53	**79° ± 12.5°**		

Wells et al. (2000, 2014)

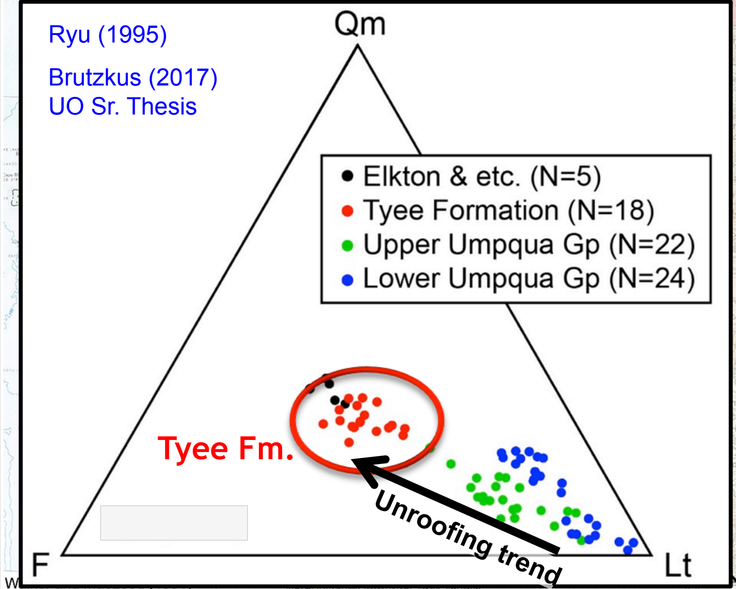
- Northern Klamaths rotated at least 67° ± 14.5°, *post-53 Ma*.
- Up to ~ 50% of total rotation may be ***syn-collisional***.
- Restored margin NNW strike (pre-Columbia embayment?)

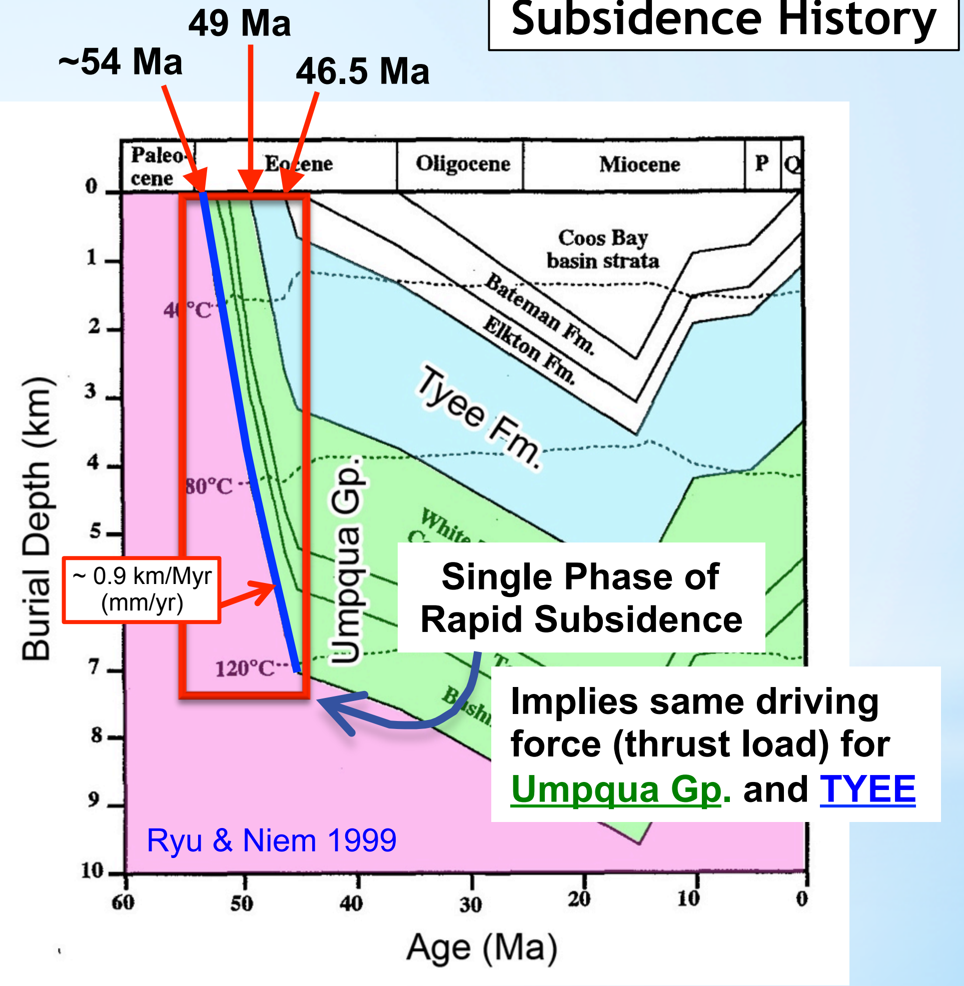
Subsidence History

Umpqua Group and Tyee Formation display **indistinguishable:**

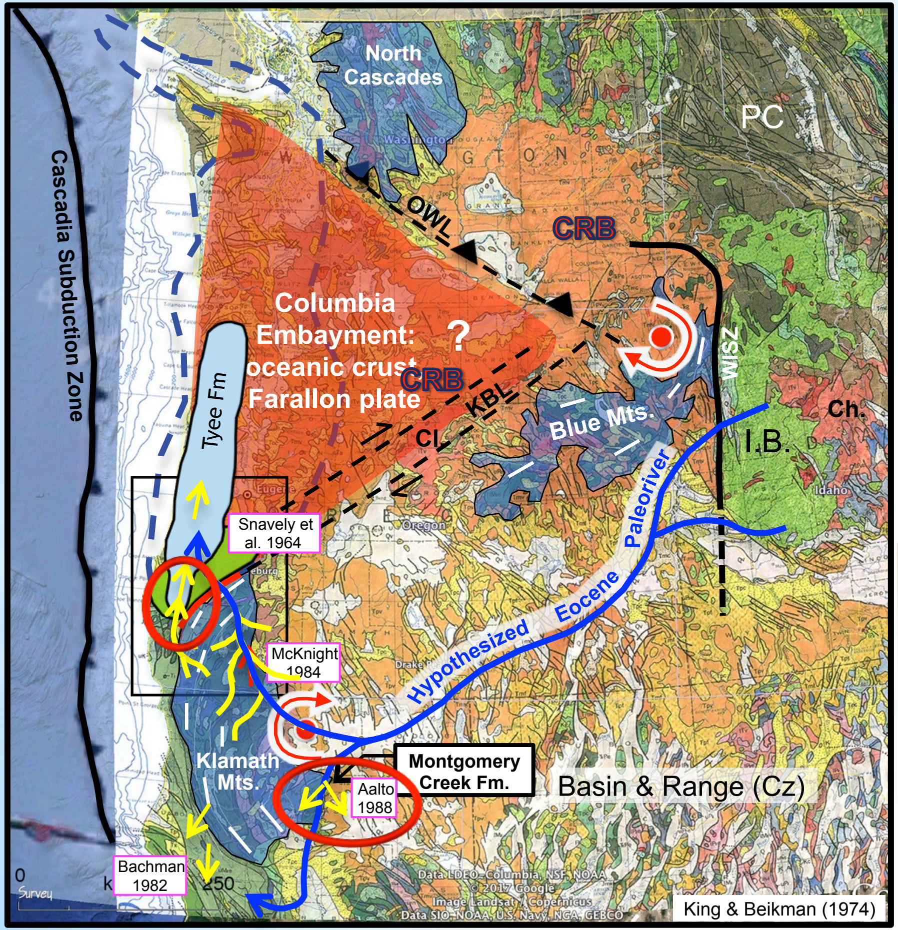
- Subsidence rate/history
- Implied driver of subsidence
- Sediment dispersal pattern

And: Progressive change in sandstone composition (unroofing trend)





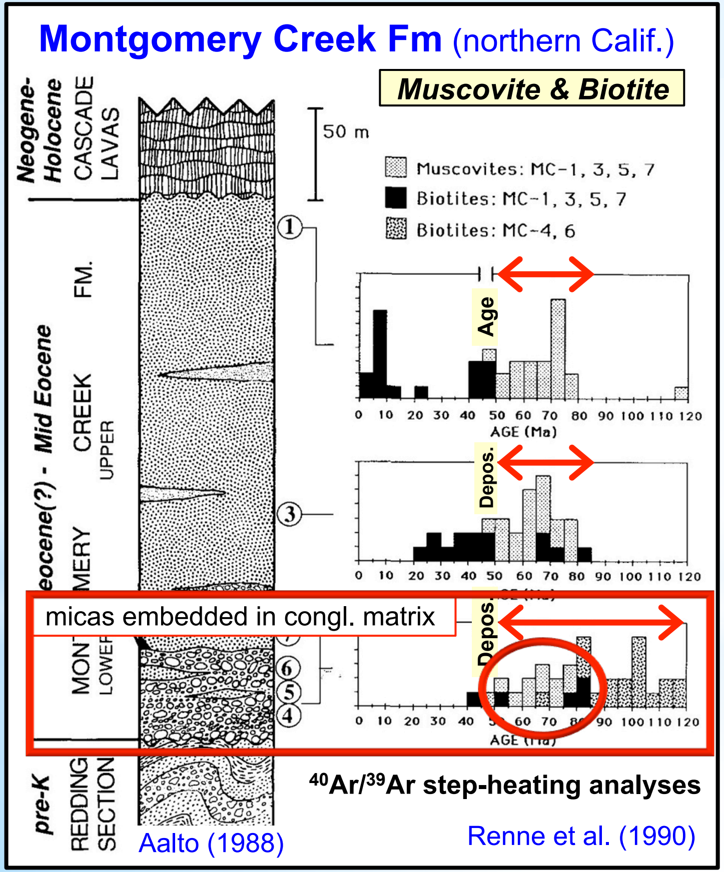
Source of the TYEE FORMATION: Klamath Mts. or Idaho Batholith ?



Provenance Hypothesis	Main Data Types	References
Klamath Mts. (original)	Sst petrography Clast compositions Paleocurrent data	Snavely et al., 1964; Bachman, 1982; McKnight, 1984; Aalto, 1988
Idaho Batholith	Sst petrography Isotope geochemistry Detrital mica ages Detrital zircon ages	Heller & Ryberg, 1983; Heller et al., 1985, 1992; Renne et al. 1990; Dumitru et al., 2013
Klamath Mts. (reconsidered)	Sst petrography Paleocurrents & Facies Subsidence analysis Sedim. mass balance	Ryu et al, 1992; Ryu 1995; Ryu and Niem, 1999; Santra et al. 2013; This Study

detrital micas

Detrital Mica Ages



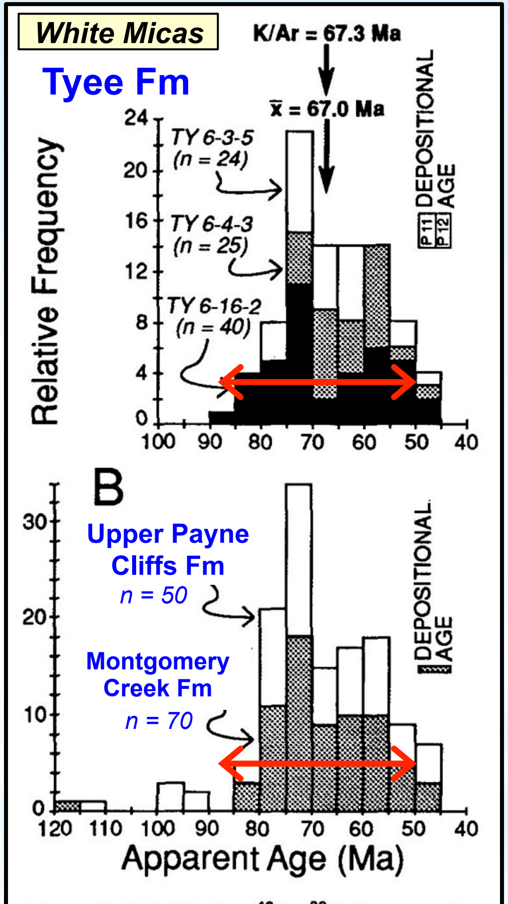


Figure 3. Total-fusion $^{40}Ar/^{39}Ar$ laser probe data from (A) Tyee Formation (TY) and (B) Montgomery Creek and upper Payne Cliffs Formations.

Many ages **50–90 Ma**

Rocks of this age not known in Klamath Mts., well documented in western Idaho (plutonic and metamorphic rocks).

Support western Idaho source of Tyee Fm and other Eocene deposits …

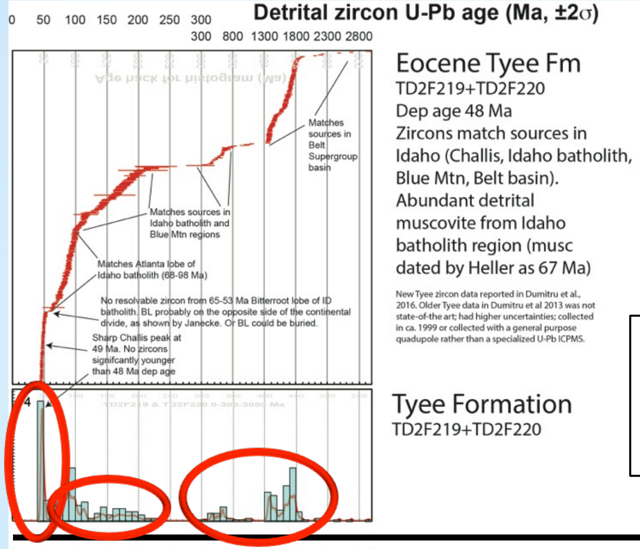
However,

- Klamaths source for lower Montgomery Ck. Fm (Aalto, 1988), incl. ***50–90 Ma micas***.
- No published mica ages for Umpqua Group.

Detrital Zircon Ages

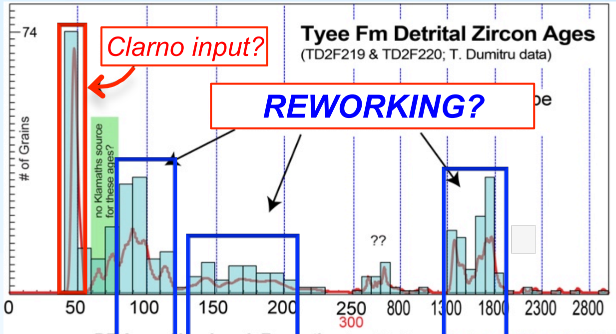
(T. Dumitru, unpubl.)

Tyee Formation

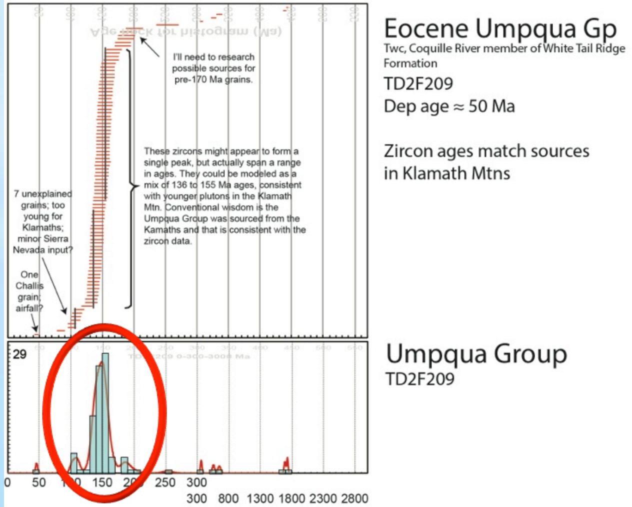


Except ….

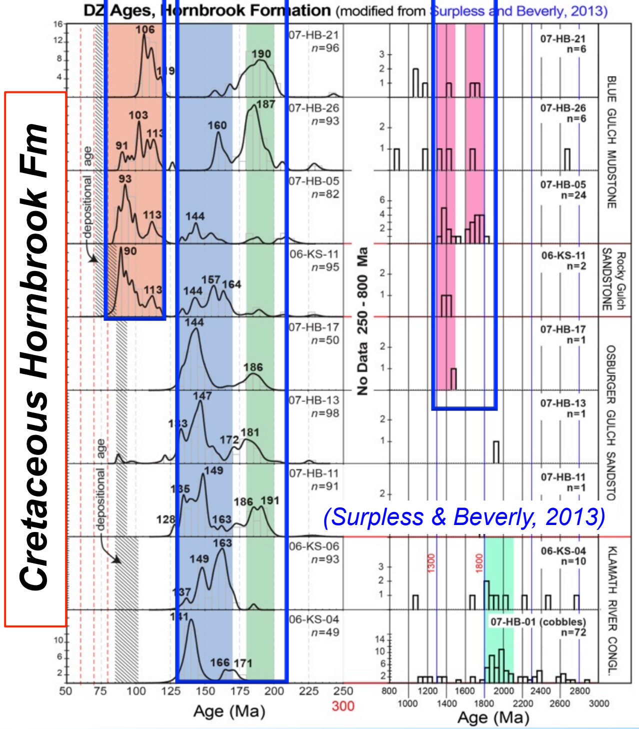
- Multi-modal distribution
- Peaks at 49, 70-200, Pz, PC
- Consistent with Idaho Batholith, Challis, Belt S.G. sources



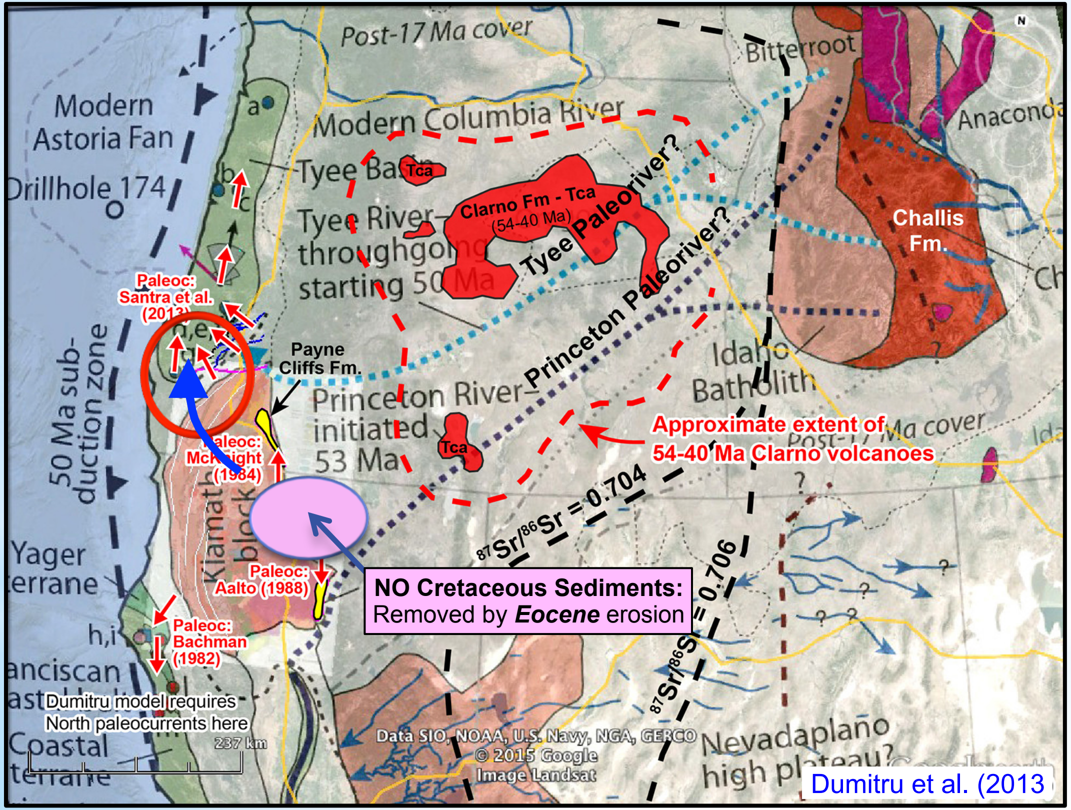
Umpqua Group



- Dom. Mesozoic ages
- Peak at ~ 150 Ma
- Consistent with source in Klamath Mts.



Eocene Paleoriver Problem

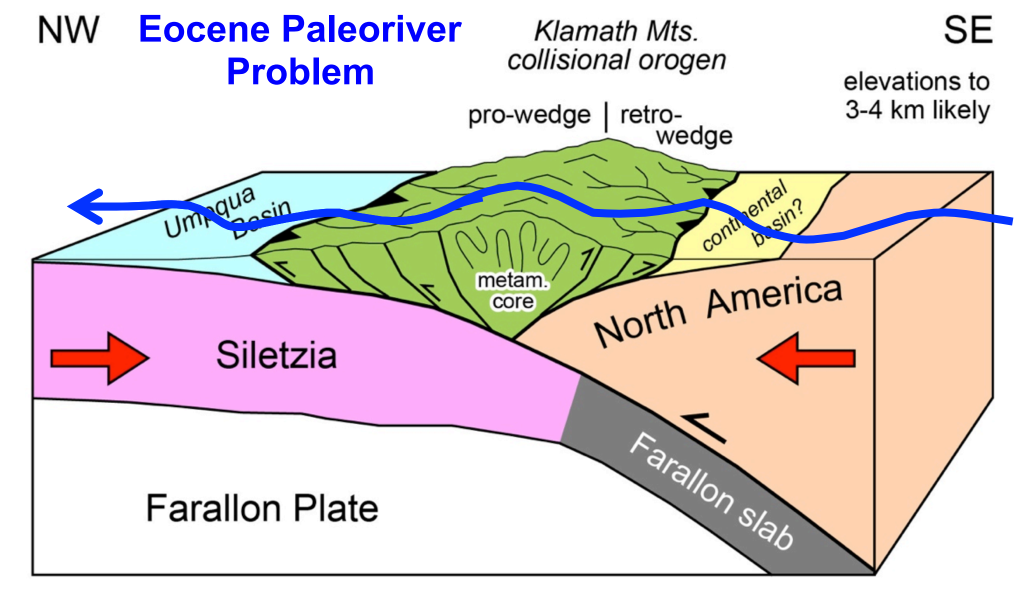


Tyee Fm Source – Hypotheses
and supporting datasets

(1) Western Idaho (Id. Batholith, Challis):
- Isotope geochemistry
- Detrital mica ages (with caveats)
- Detrital zircon ages (with caveats)

(2) East-Central Klamath Mountains:
- Sandstone petrography
- Paleocurrent data & facies distribution
- Gravel clast compositions
- Cretaceous deposits (eroded from Klamaths)
- Rb-Sr model ages NOT consistent with Idaho Batholith source (Heller et al., 1985)

A key difference between proposed sources is location relative to the Sr 0.704/0.706 line: Idaho is on the N.A. craton, Klamaths are in accreted terranes. However, some rocks in the Klamath Mts have high $^{87}Sr/^{86}Sr$ ratios (0.706-0.710; Frost et al., 2006).



- Tyee Formation could be eroded from Klamath Mts. at average erosion rates **< 1.0 mm/yr …**
- Typical rate for active collisional orogens.
- Tyee source in Klamath Mts. is physically plausible, chemistry & petrology debated.

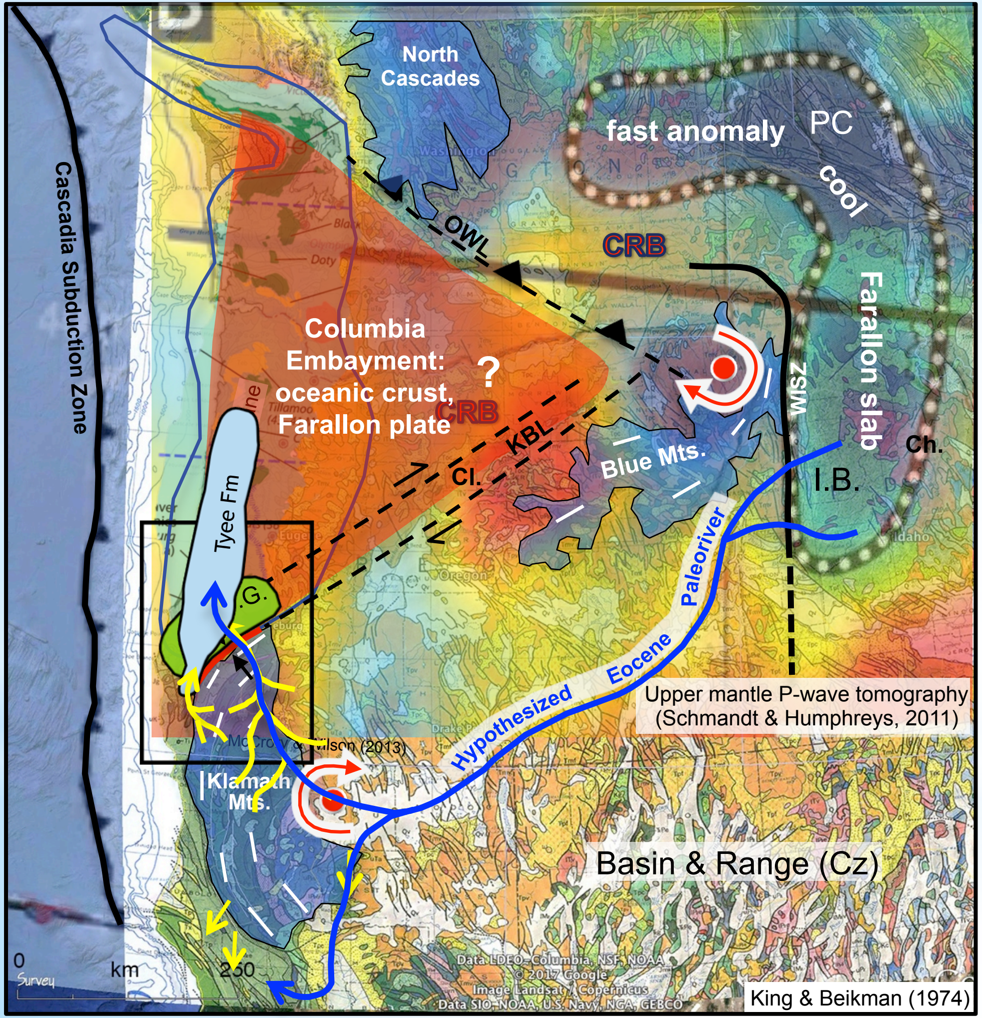
***Know:* Tyee Paleoriver traversed the Klamath Mountains:** *required by* paleo-current data and facies distribution.
This permits <u>several scenarios</u>:

(1) Paleoriver originated in Idaho, and crossed Klamath Mts across either:
(a) low-lying topography (inactive), or
(b) gorge cut through mountains.

<u>**1a** is problematic</u>: Klamath Mts formed an active orogen for 5 Myr immediately prior to Tyee deposition – no time to reduce topography by erosion before Tyee Fm.

<u>**1b** is problematic</u>: orogen-crossing gorge requires antecedant drainage *(not)*, or headward erosion from retro side *(not likely in an actively deforming/uplifting orogen)*.

(2) Paleoriver originated in Klamath Mts.



CONCLUSIONS (progress report)

(1) Excellent record of Siletz collision in SW Oregon – Roseburg area.

(2) UMPQUA GROUP ~ 54 – 49 Ma
Syn-collisional foredeep basin,
Sediment source in Klamath Mts.

(3) TYEE FORMATION 49 – 46 Ma
Post-collisional, overlaps thrusts.

(4) Idaho-Sourced Tyee Paleoriver poses some problems …

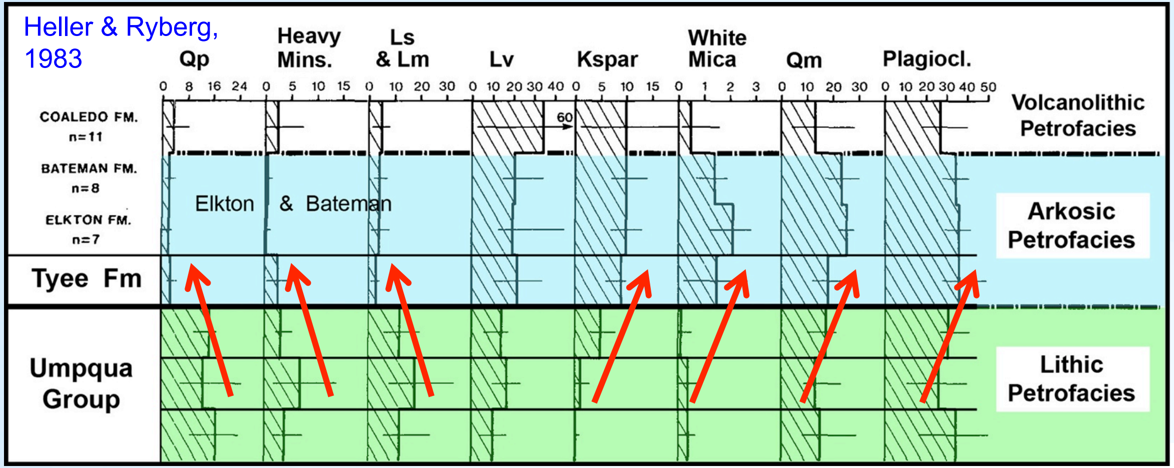
(5) Multiple Datasets: Suggest
Tyee Fm from Klamath Mts.?
Unresolved problem.

Unit	Volume (km^3)	Duration (Myr)	Flux (km^3/Myr)	Likely Catchmt. Area (km^2)	Estimated Erosion Rate (mm/yr)
Tyee Fm	~ 21,600	~ 2.5	8,640	10-20,000	**0.4 – 0.8**
Umpq. Gp	~ 10,500	~ 5.0	2,100	5-10,000	**0.2 – 0.4**
TOTAL	**32,100**	~ 7.5	4,280		**< 1.0**

"The source area for Tyee sediments is believed to be a metamorphic, igneous, and sedimentary terrane in the area of the ancestral Klamath Mountains that lay south of the geosyncline. Active andesitic volcanism immediately east of the geosyncline also contributed pyroclastic and epiclastic debris to the streams." (**Snavely et al., 1964,** *Kansas Geological Survey Bulletin* **169**, 461-480).

"The provenance of these sandstones included S-type (two-mica) granites that formed in Late Jurassic time from sources that included an old crustal component. Rocks in the Klamath Mountains and northern Sierra Nevada do not possess these features … The sandstones most likely were derived from the Idaho batholith." (**Heller et al., 1985,** *GSA Bulletin* **96**, p. 770-780).

Sandstone Petrography



Idaho Batholith Source

Klamath Mts. Source