CONSTRAINING STRATIGRAPHIC RELATIONSHIPS AND PROVENANCE OF EOCENE SYNOROGENIC STRATA IN THE SOUTHEASTERN SAN JUAN BASIN, NORTHWESTERN NEW MEXICO

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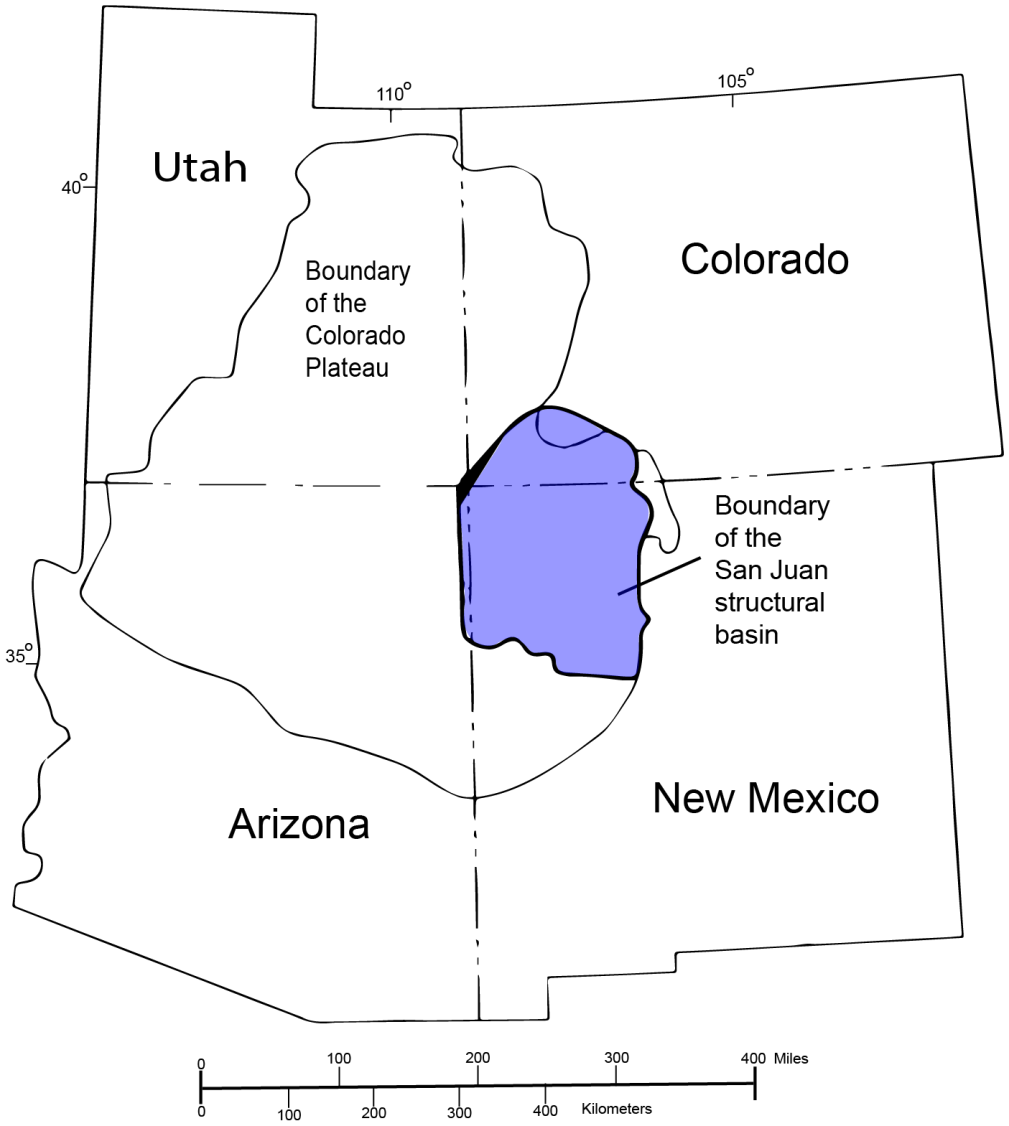
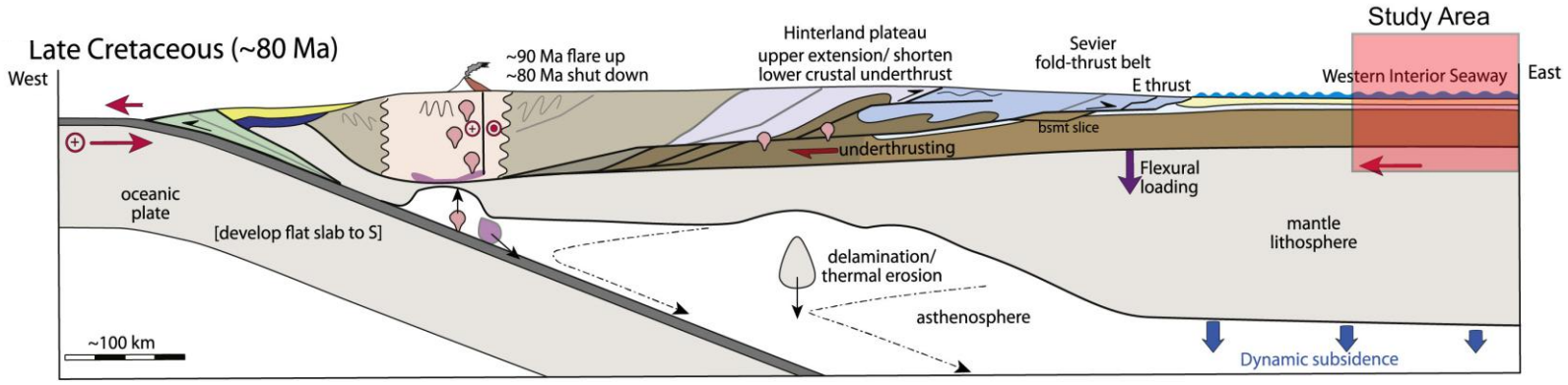
Geologic Background

San Juan Basin



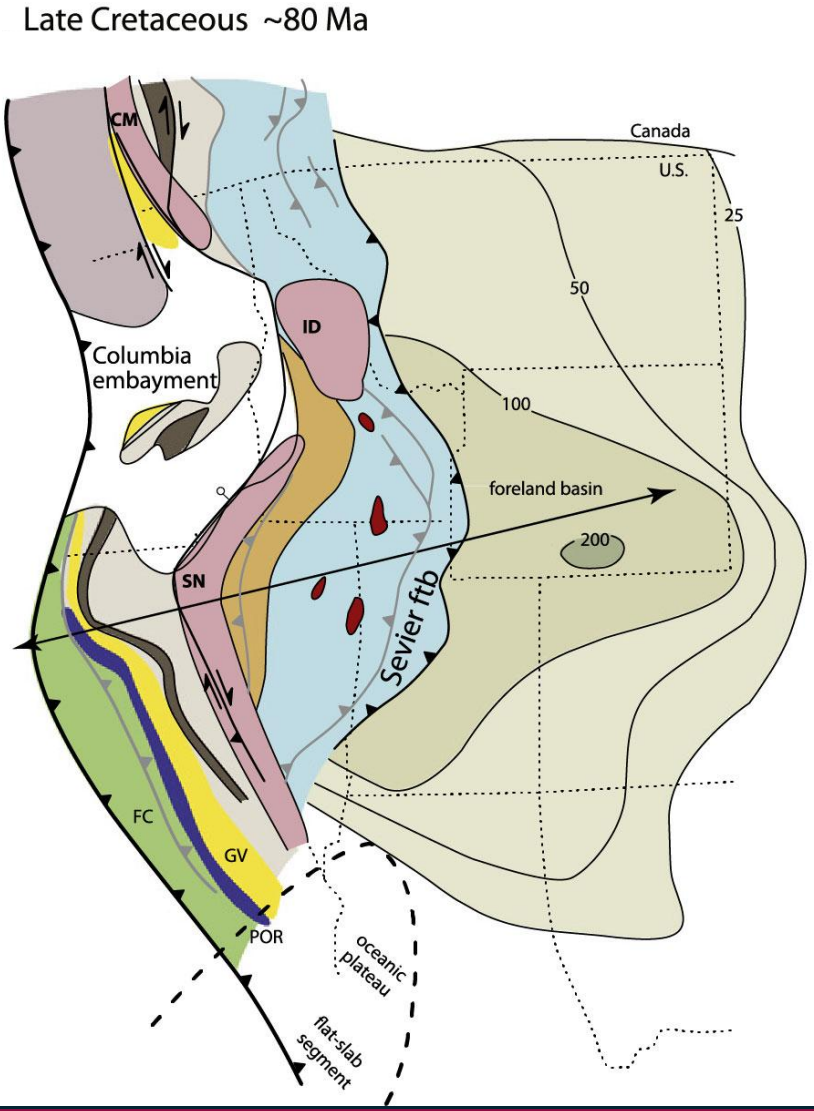
Adapted from Craig, 2001

(Pre) Laramide Orogeny

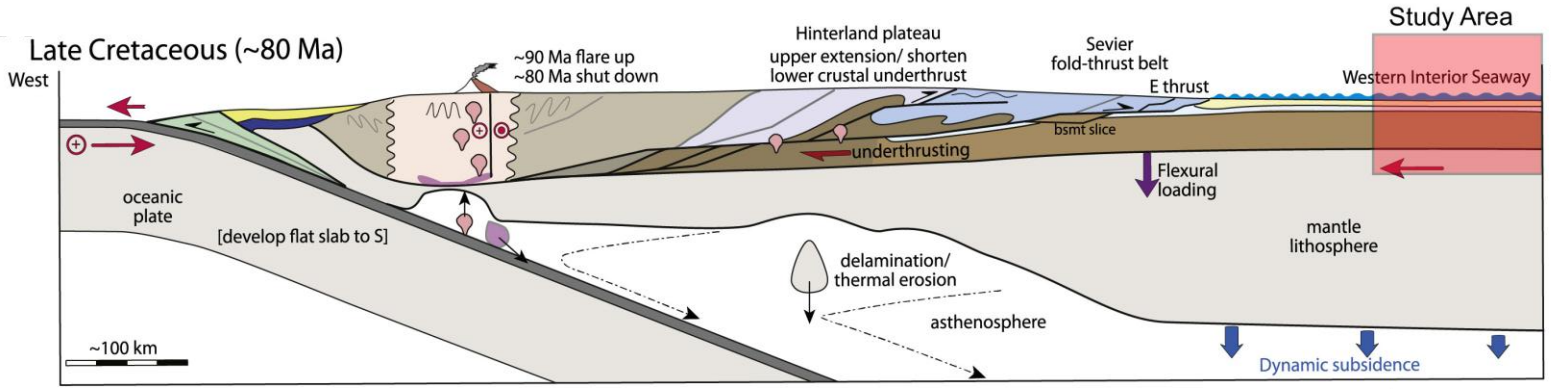


Yonkee and Weil, 2015

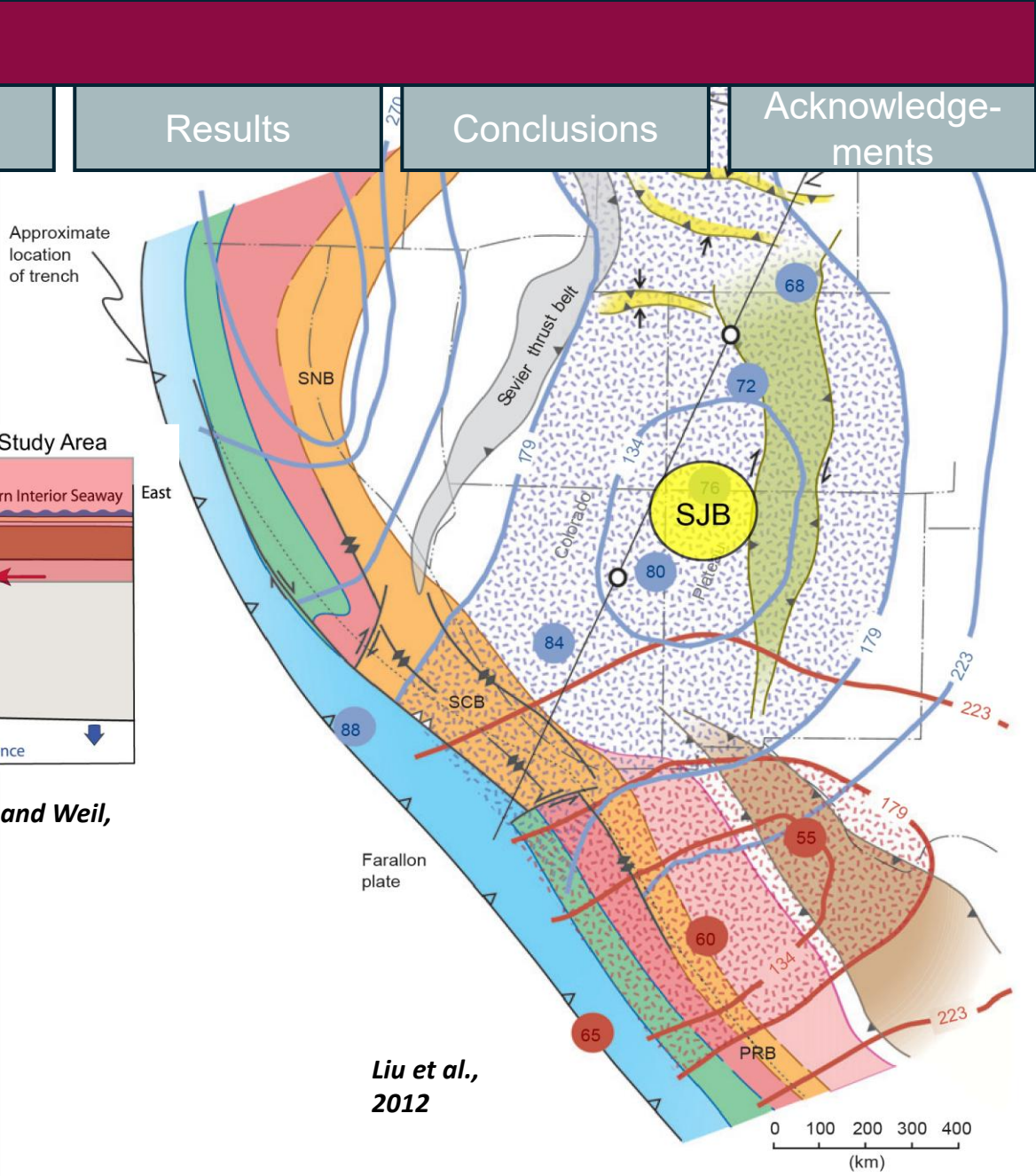
- Normal Subduction to the east
  - Cordilleran Arc
  - Sevier FTB and Foreland Basin
- Western Interior Seaway



Laramide Orogeny



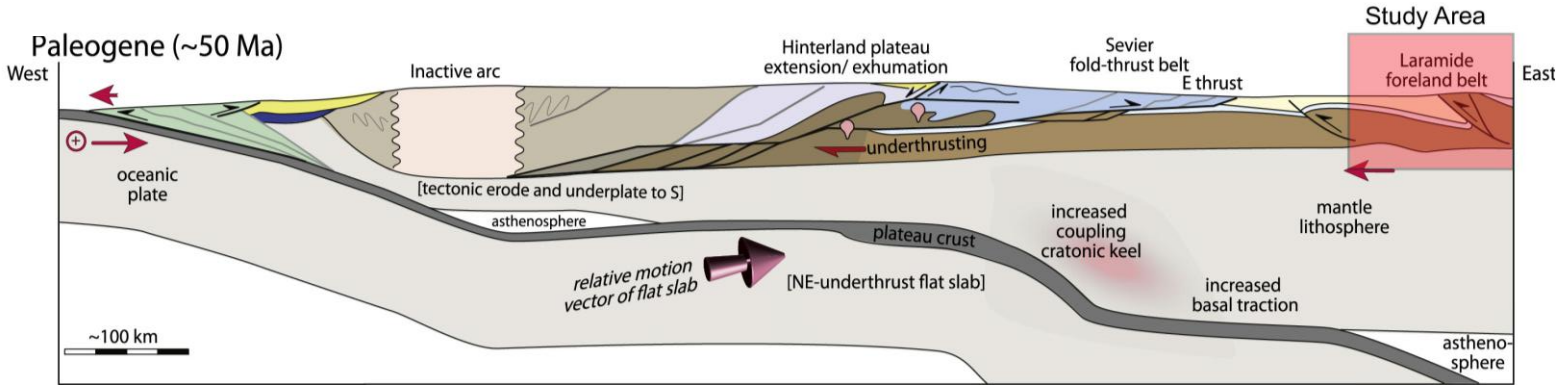
Yonkee and Weil, 2015



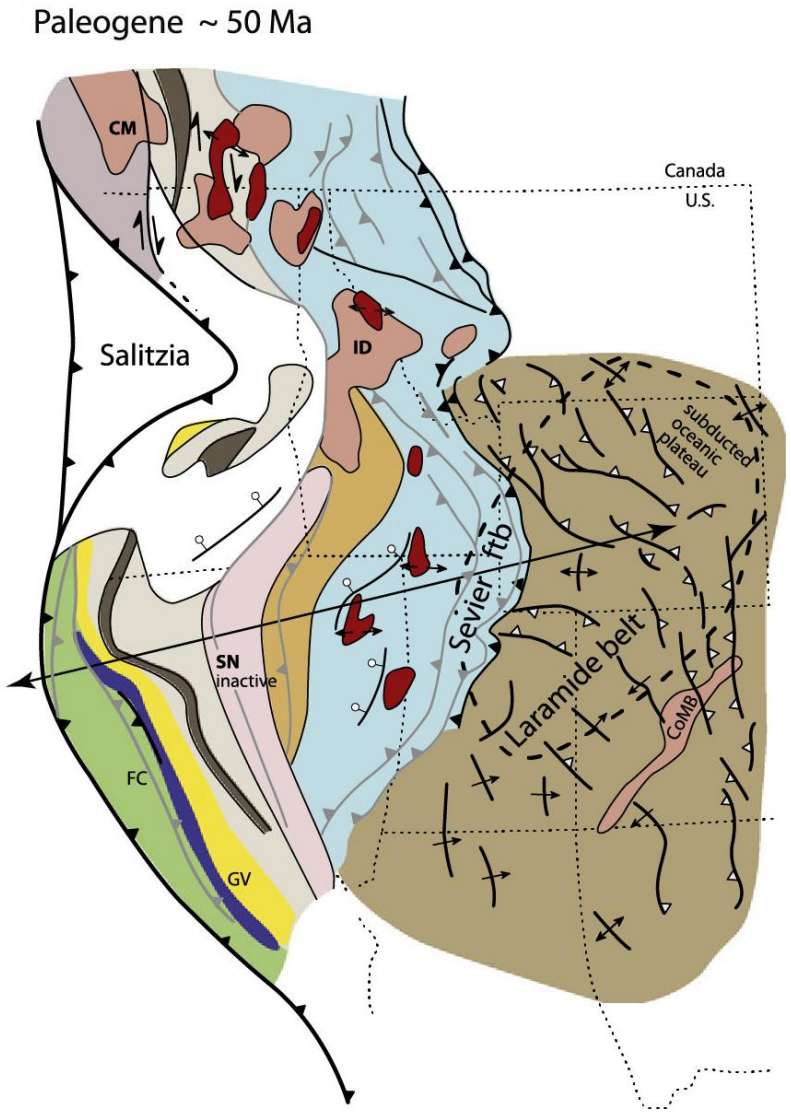
Liu et al., 2012

- Normal Subduction (?)
  - Shatsky Rise and Hess Conjugate

Laramide Orogeny



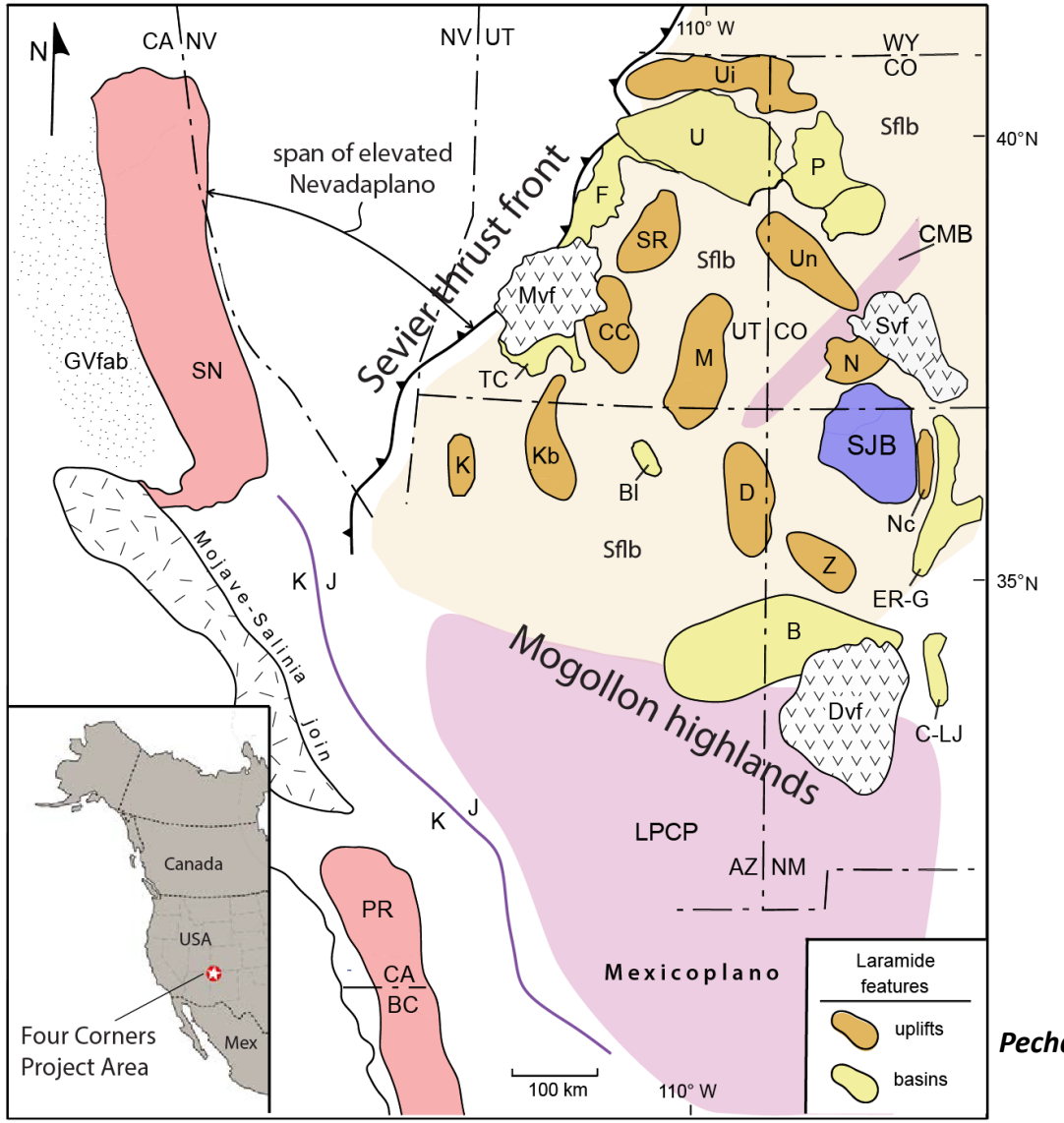
Yonkee and Weil, 2015



- Really Shallow Subduction!!
  - Basement cored deformation
  - Dynamic subsidence
- LARAMIDE OROGENESIS!!!

San Juan Basin

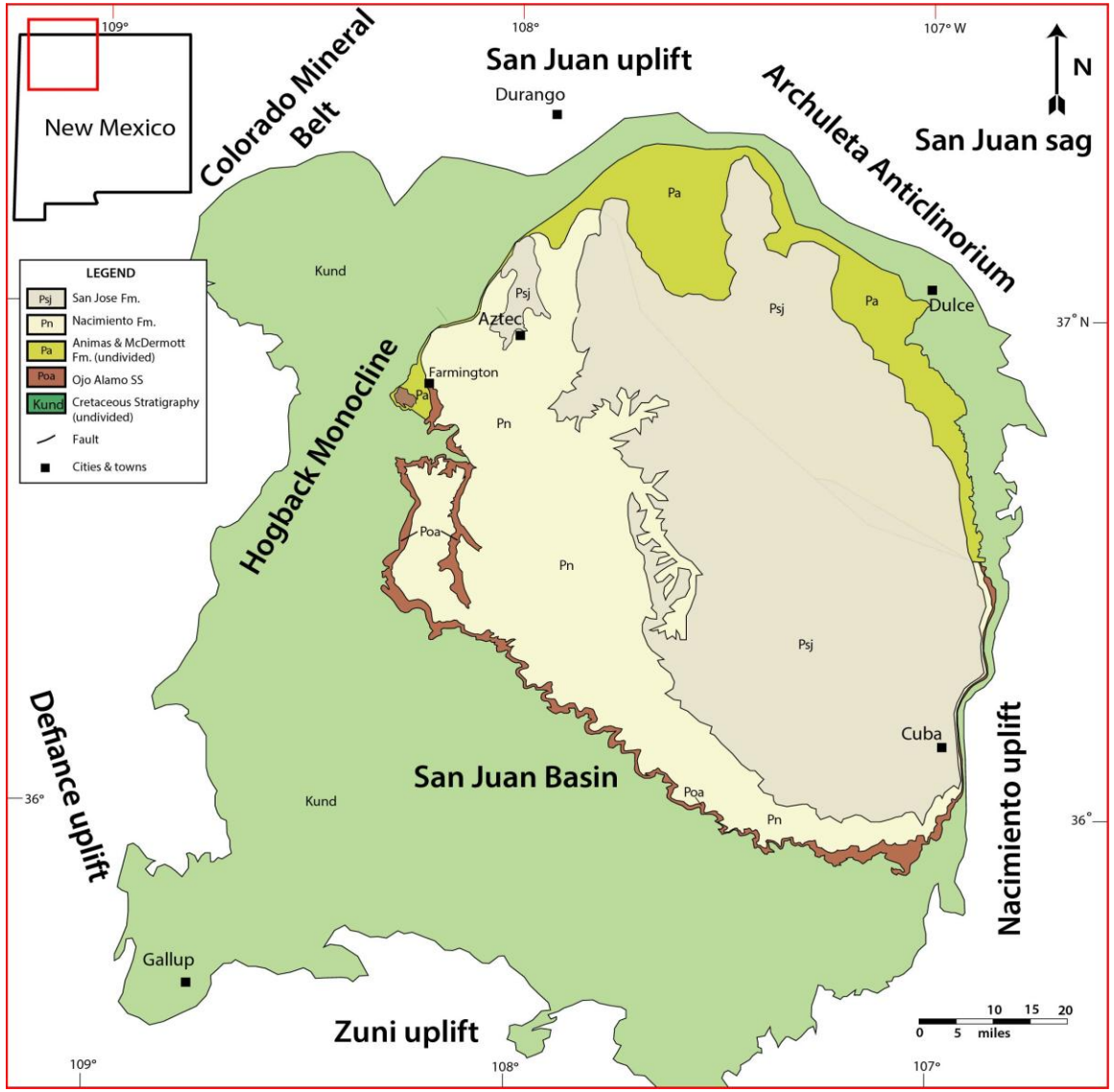
- Laramide Uplifts
  - Nacimiento, Zuni, Defiance, Needle Mountains, and Monument Mountains
- Laramide Basins
  - SJB, Baca, Galisteo, and La Joya



Pecha et al., 2018

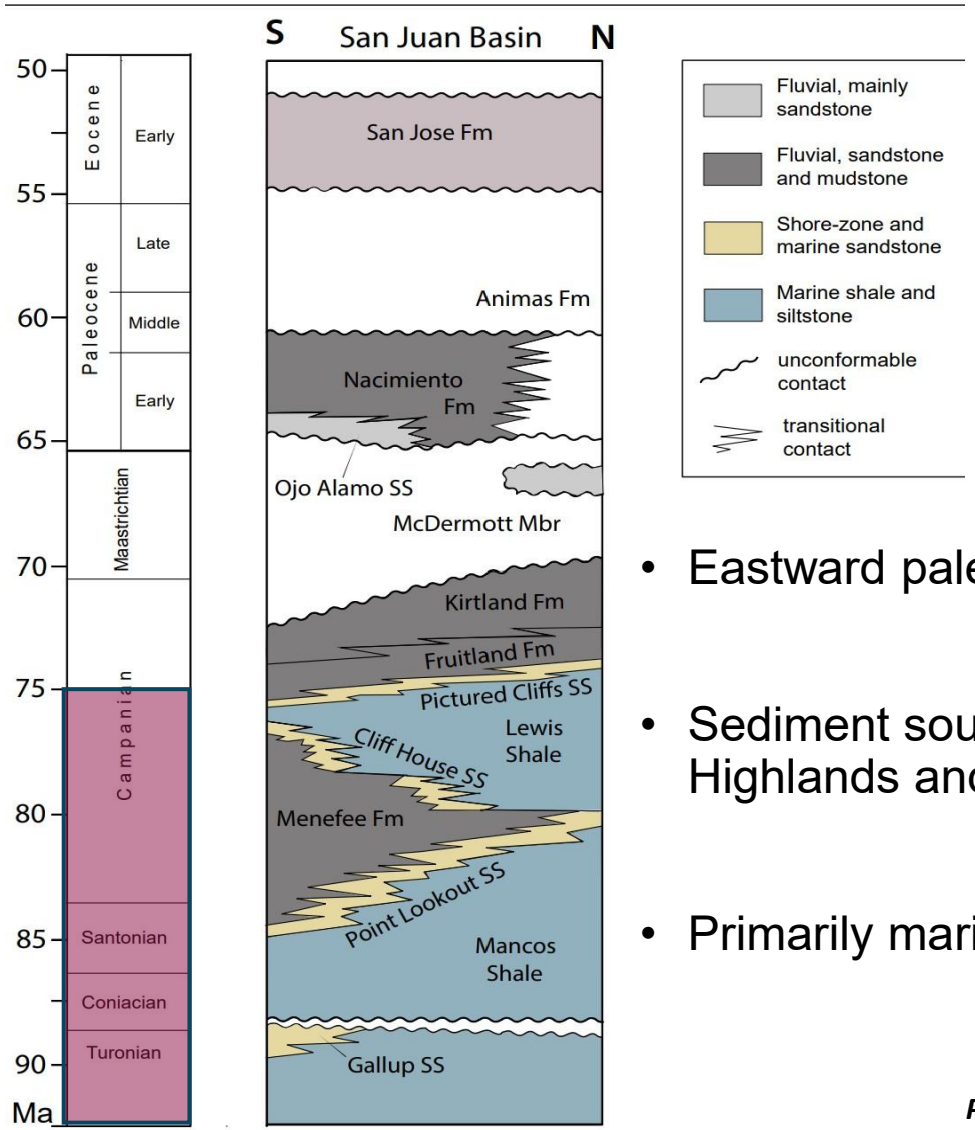
San Juan Basin

- Stratigraphy from Cretaceous through Eocene
- Near horizontal stratigraphy throughout the basin



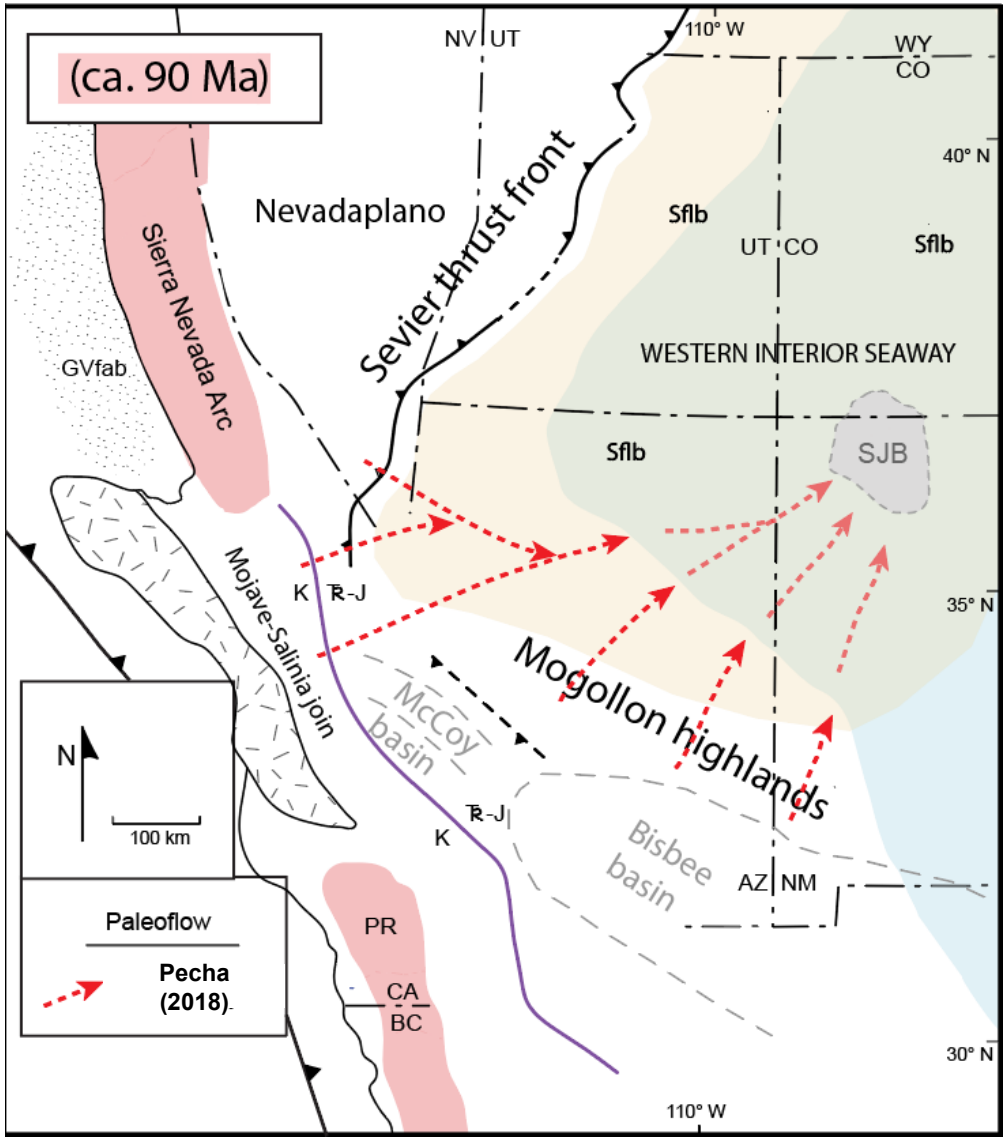
Pecha et al., 2018

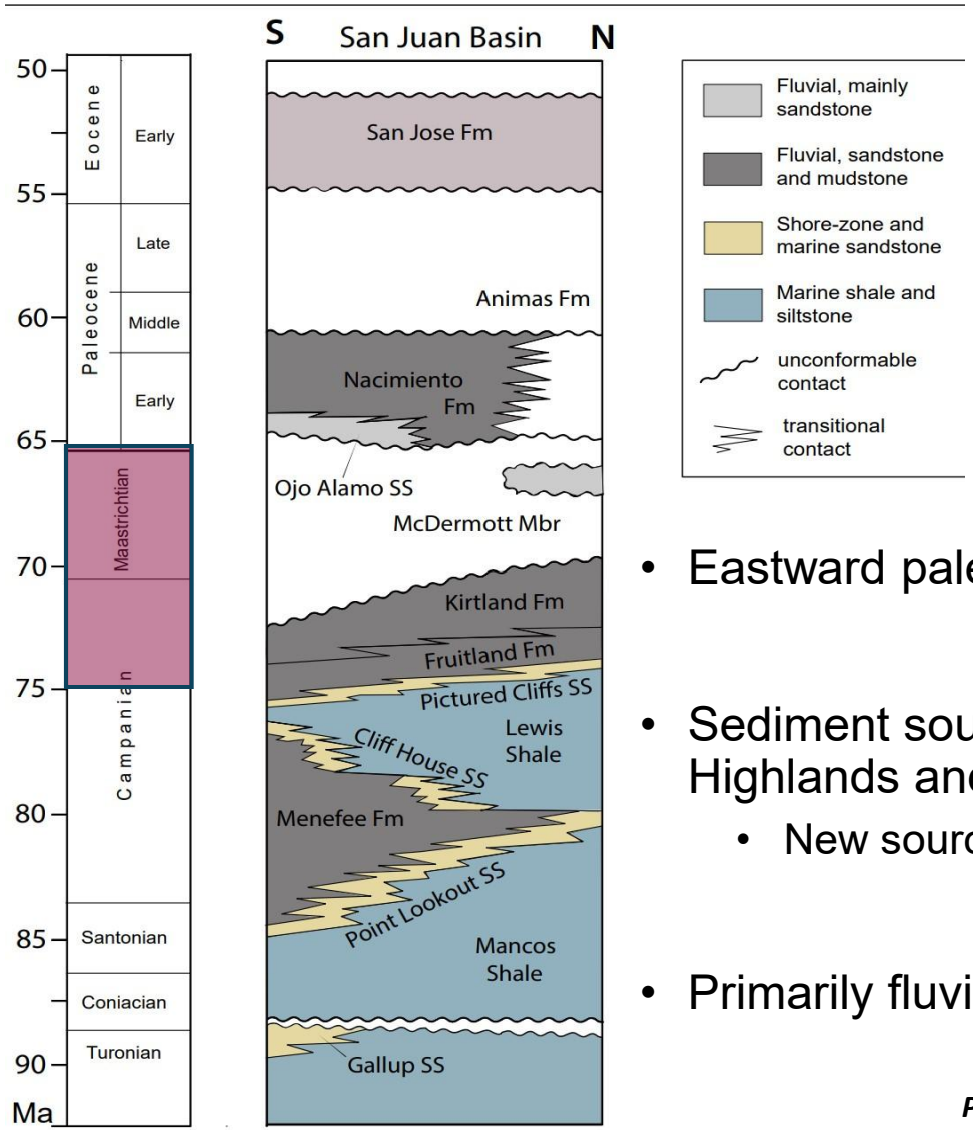
Stratigraphic Overview



- Eastward paleoflow
- Sediment sourced from Mogollon Highlands and Sevier FTB
- Primarily marine sedimentation

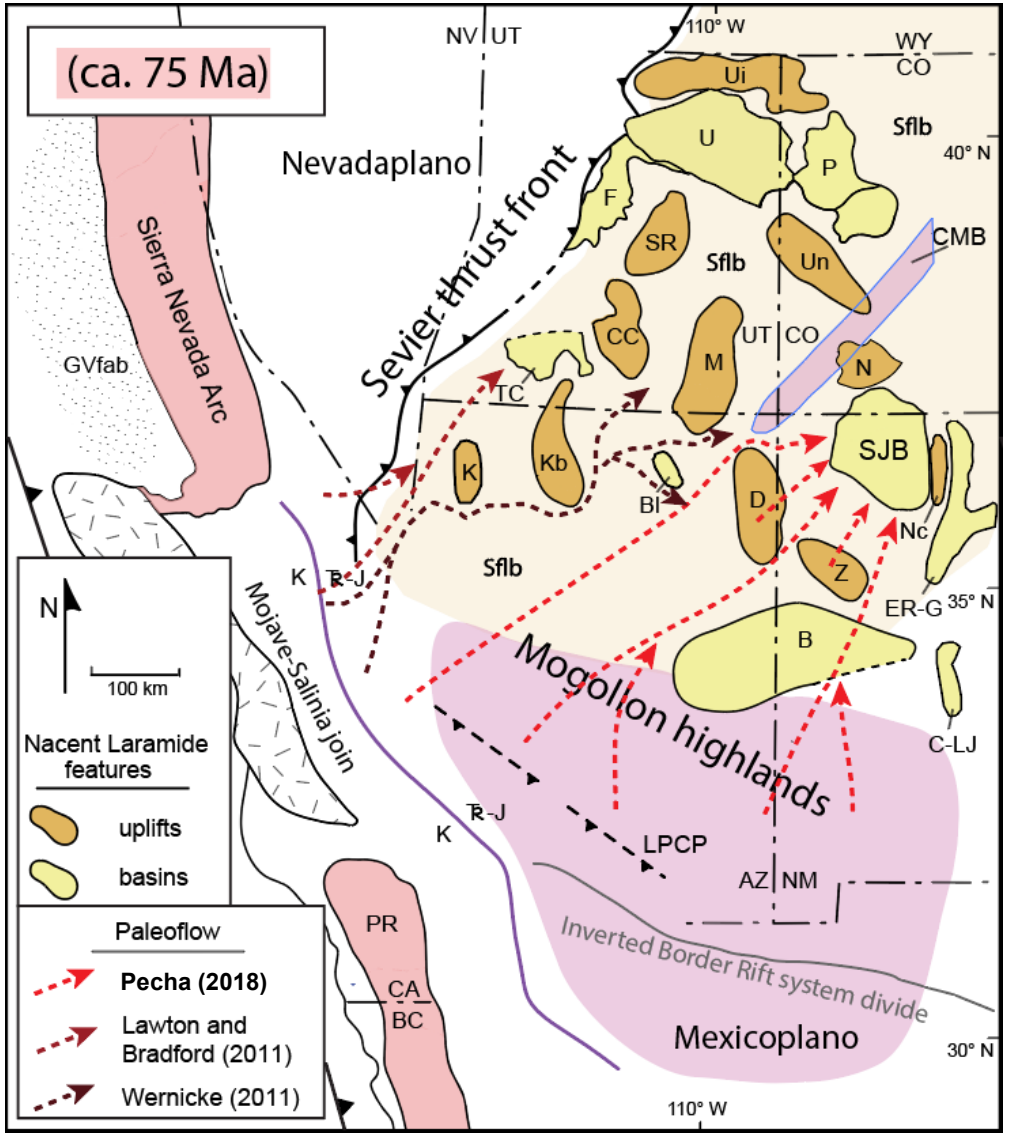
Pecha et al., 2018

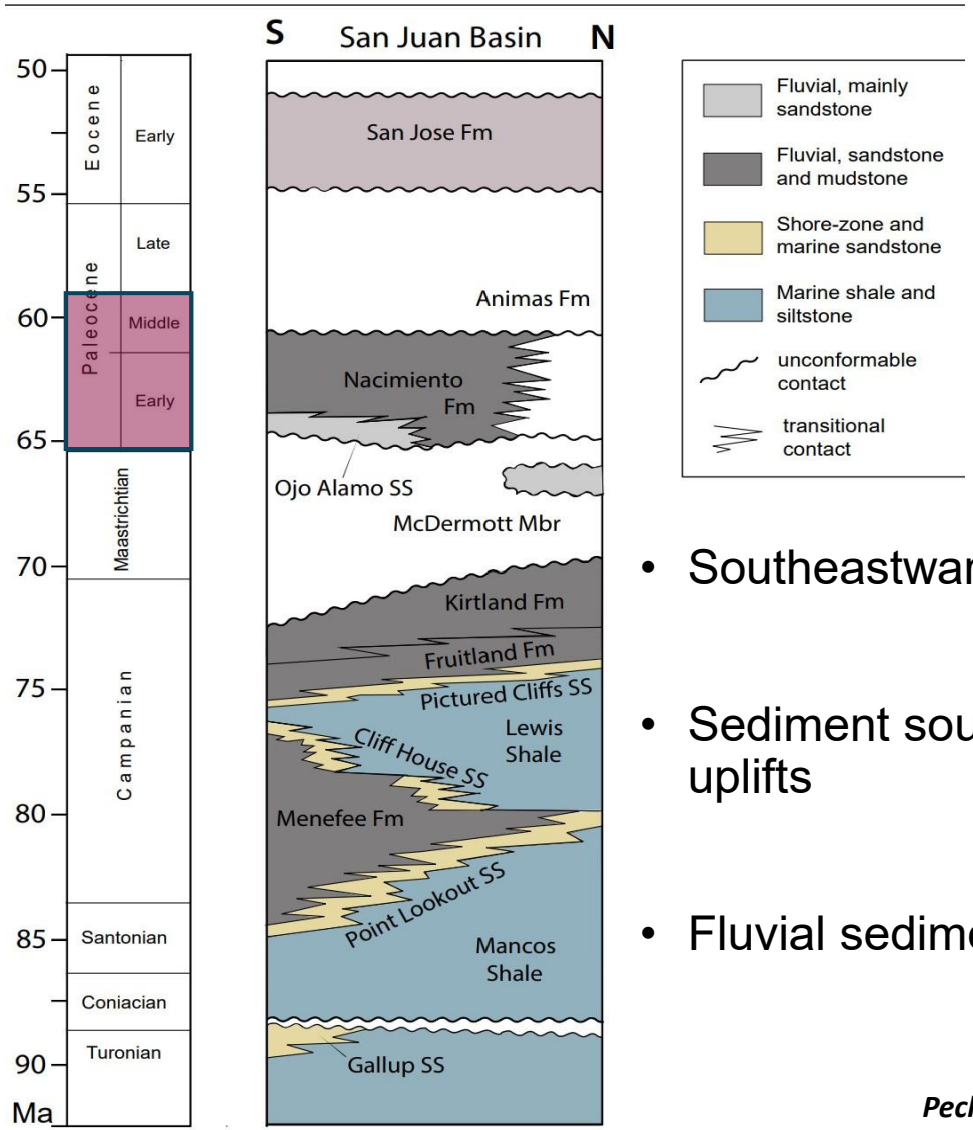




- Eastward paleoflow
- Sediment sourced from Mogollon Highlands and Sevier FTB
  - New sources from Laramide uplifts
- Primarily fluvial sedimentation

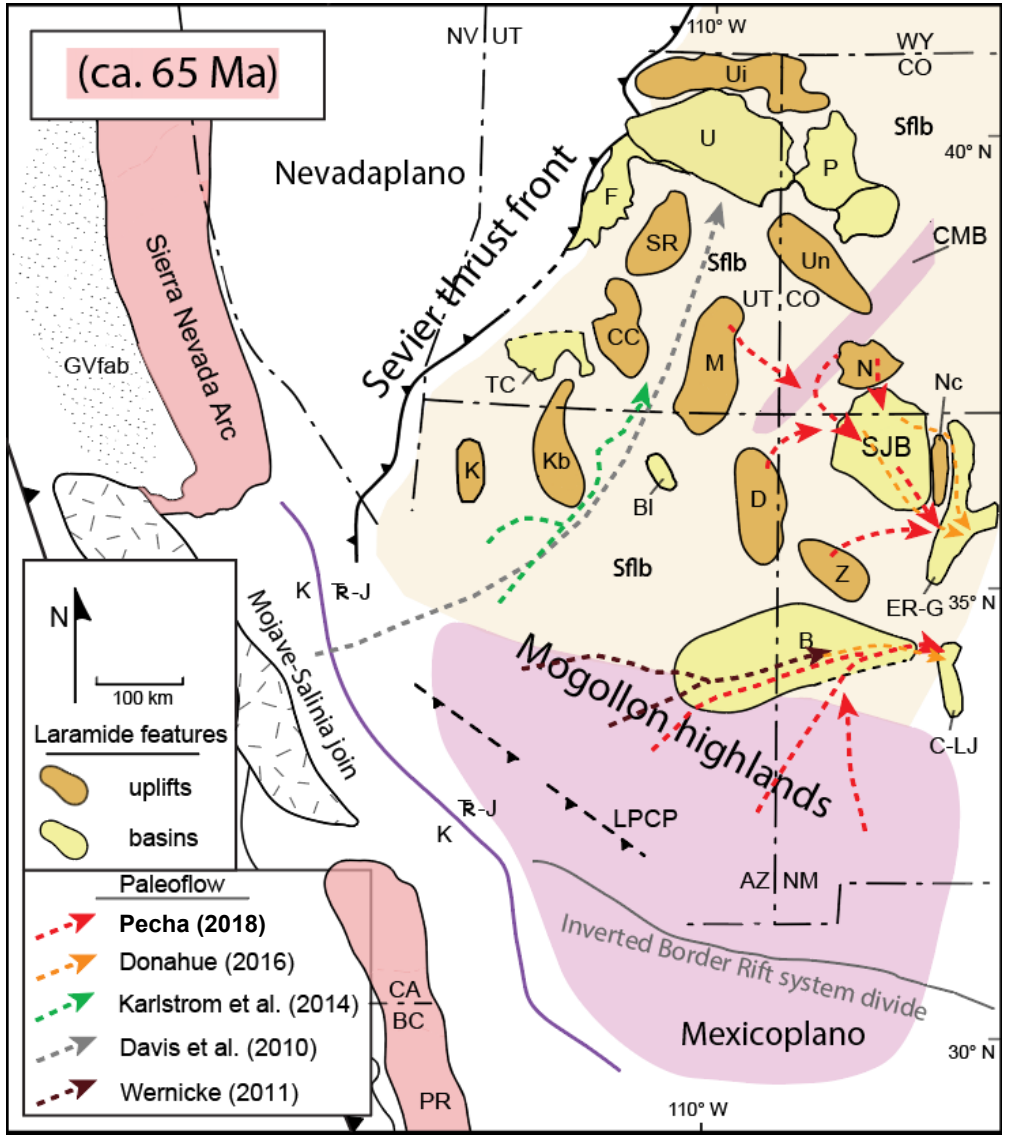
Pecha et al., 2018

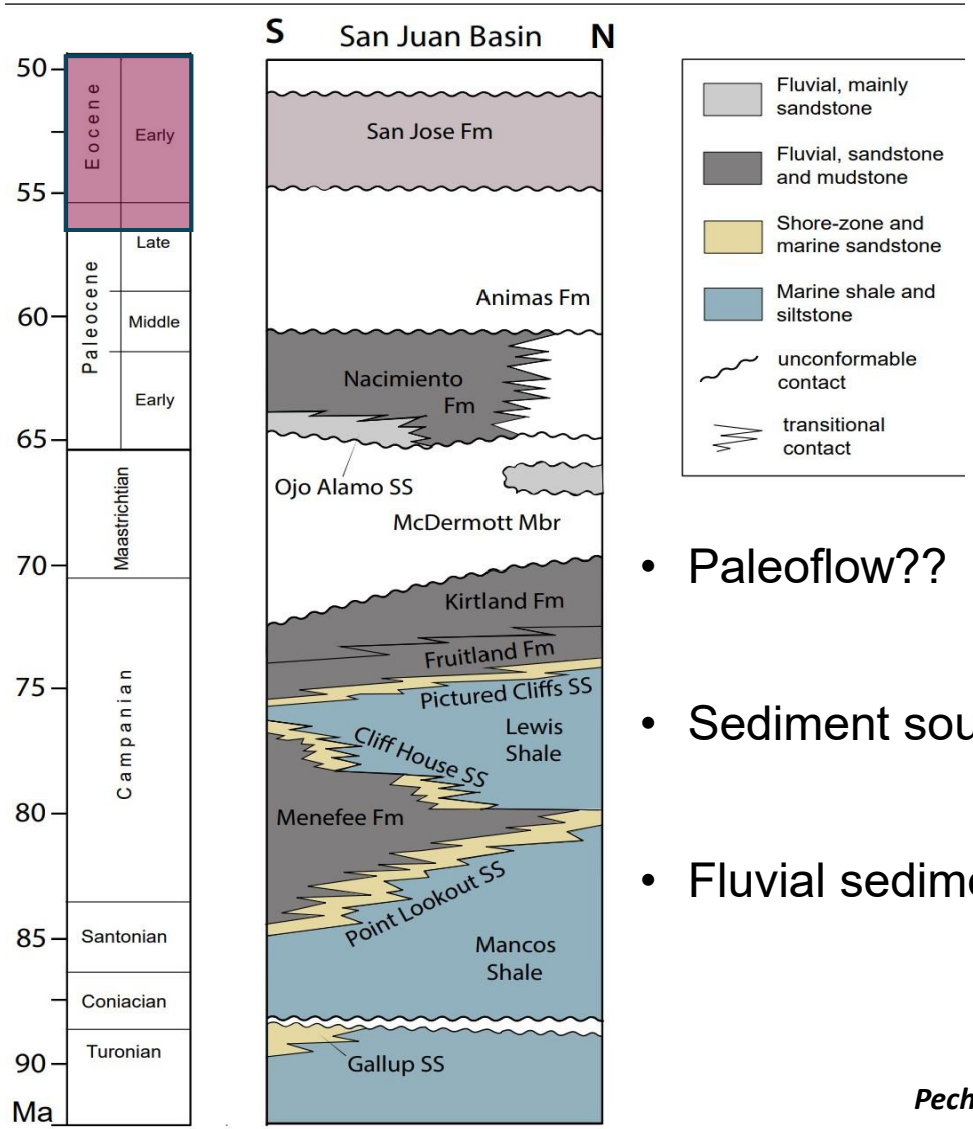




- Southeastward paleoflow
- Sediment sourced from Laramide uplifts
- Fluvial sedimentation

Pecha et al., 2018

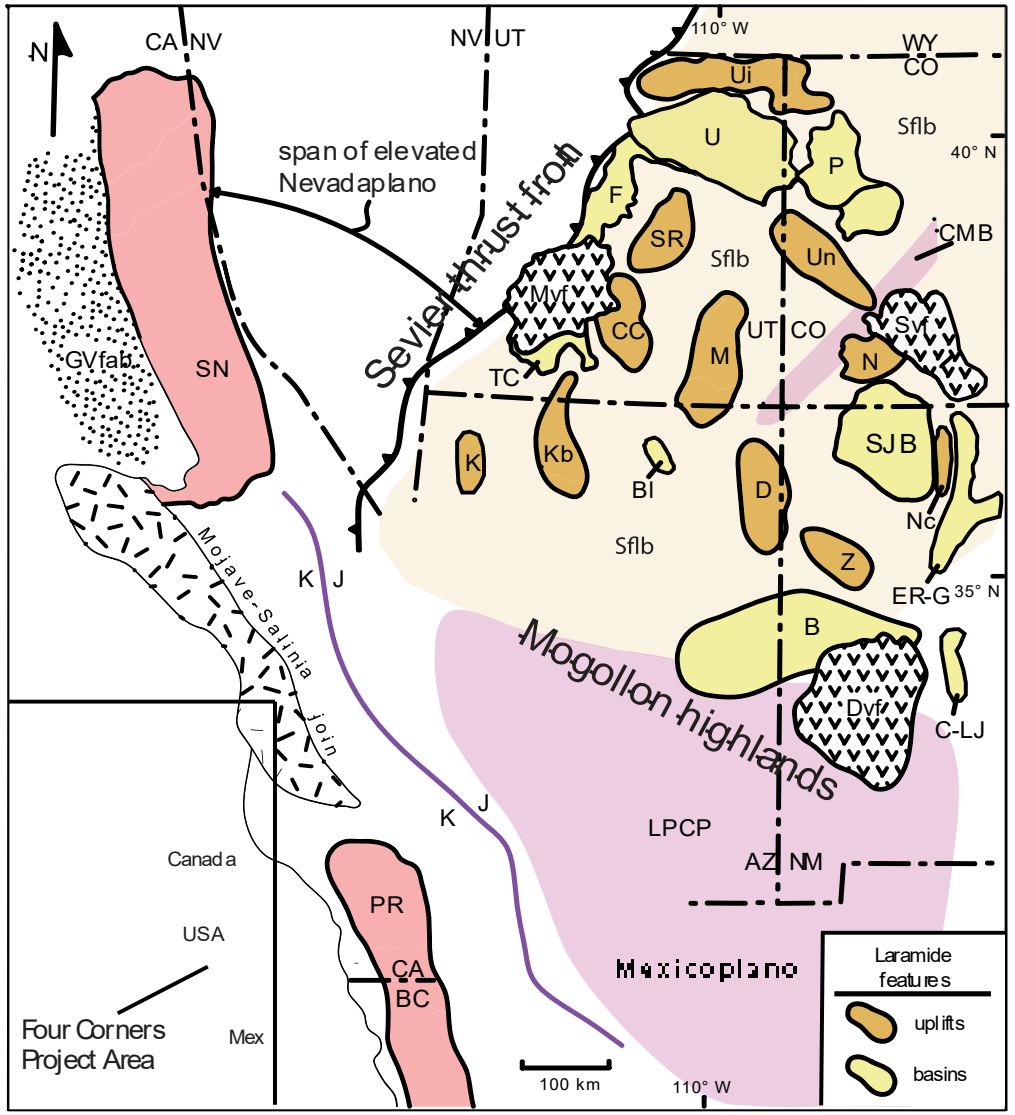


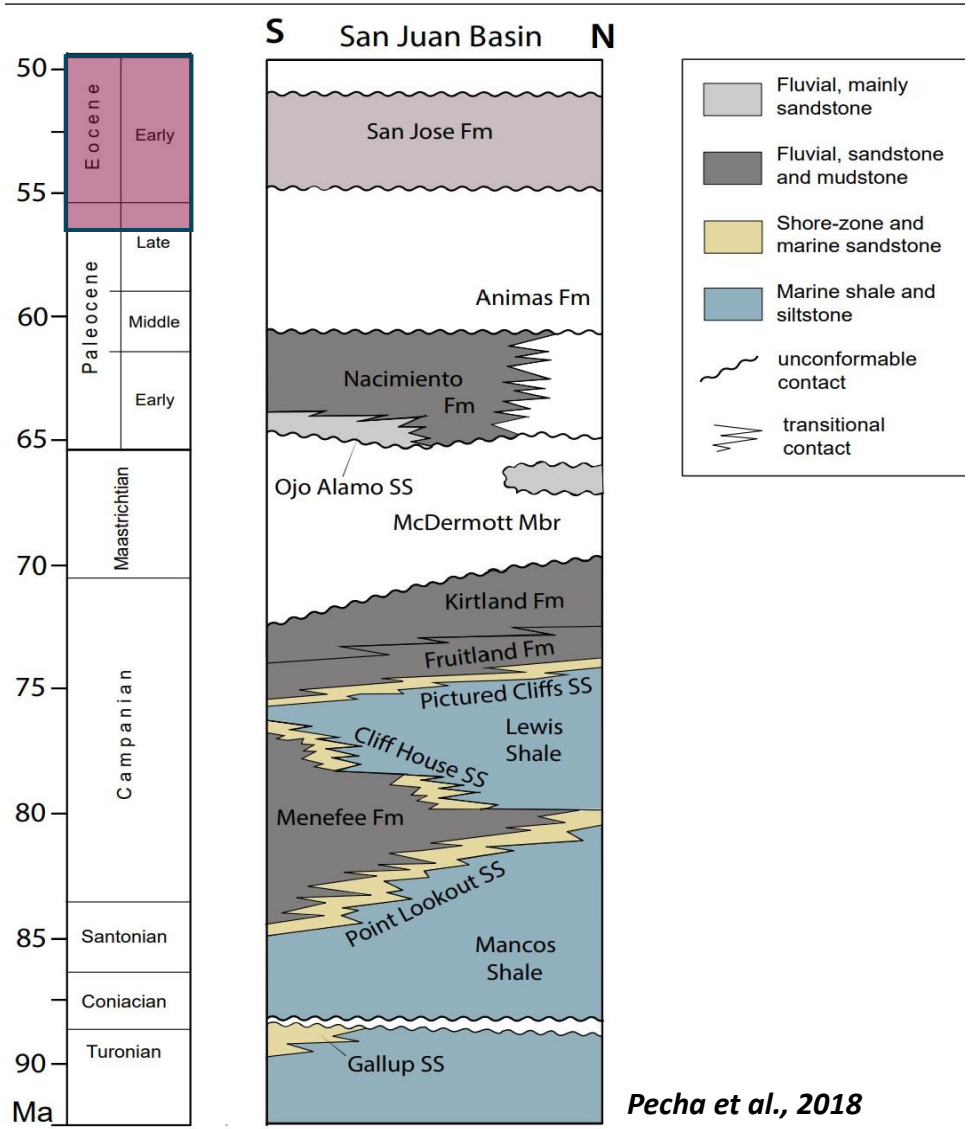


55-50 Ma?

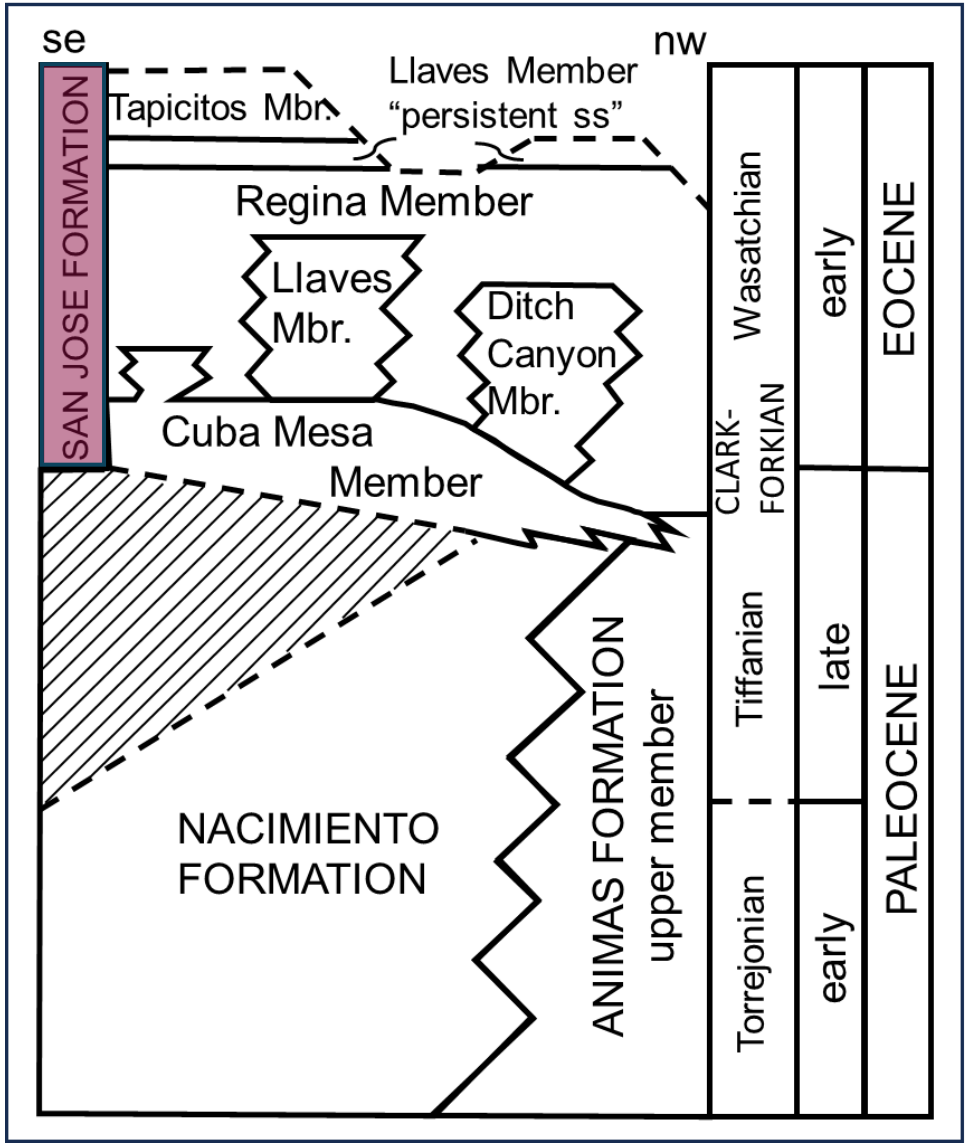
- Paleoflow??
- Sediment source??
- Fluvial sedimentation

Pecha et al., 2018





Pecha et al., 2018



Smith and Lucas, 1991

Cuba Mesa Member

- Thickly bedded very coarse-grained lenticular sandstones
- Locally conglomeratic
- 4-100m thick
- Unconformably (?) overlies Nacimiento Formation in the south
- Intertongues with the Regina Member in the north

Regina Member

- Overlies and intertongues with the Cuba Mesa Member
- Mudstone dominated
- Extensive bodies of multicolored clay and siltstones
- Minor shales and sandstones
- Southward coarsening of grains → pinchout of Cuba Mesa

Llaves Member

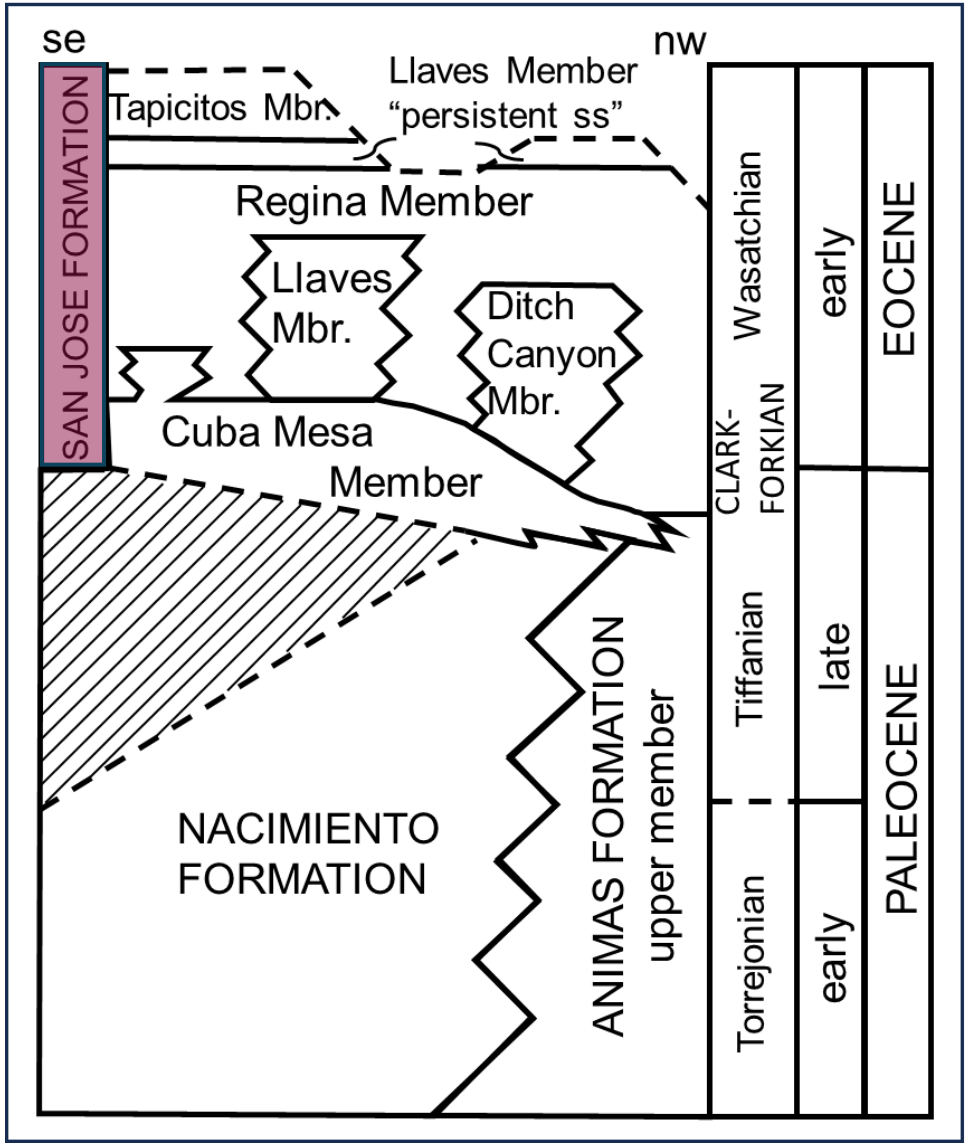
- Sheet sandstones
- Locally conglomeratic
- Multicolored → red, yellow, and grey
- Thickly bedded
- Intertongues with Regina Member in the east-central portion of basin

Tapacitos Member

- Slope forming unit
- Red sandy-mudstone and pink sandstone
- Cap the high topography of the east-northeastern portions of the basin

San Jose Formation

- Last preserved sedimentation during the Laramide
- High energy, low-sinuosity streams, extensive muddy floodplains
- Most extensively preserved/ exposed Eocene strata in New Mexico
- Most diverse fossil vertebrate faunas of early Eocene age in North America
- Defined by 4 key stratigraphic members

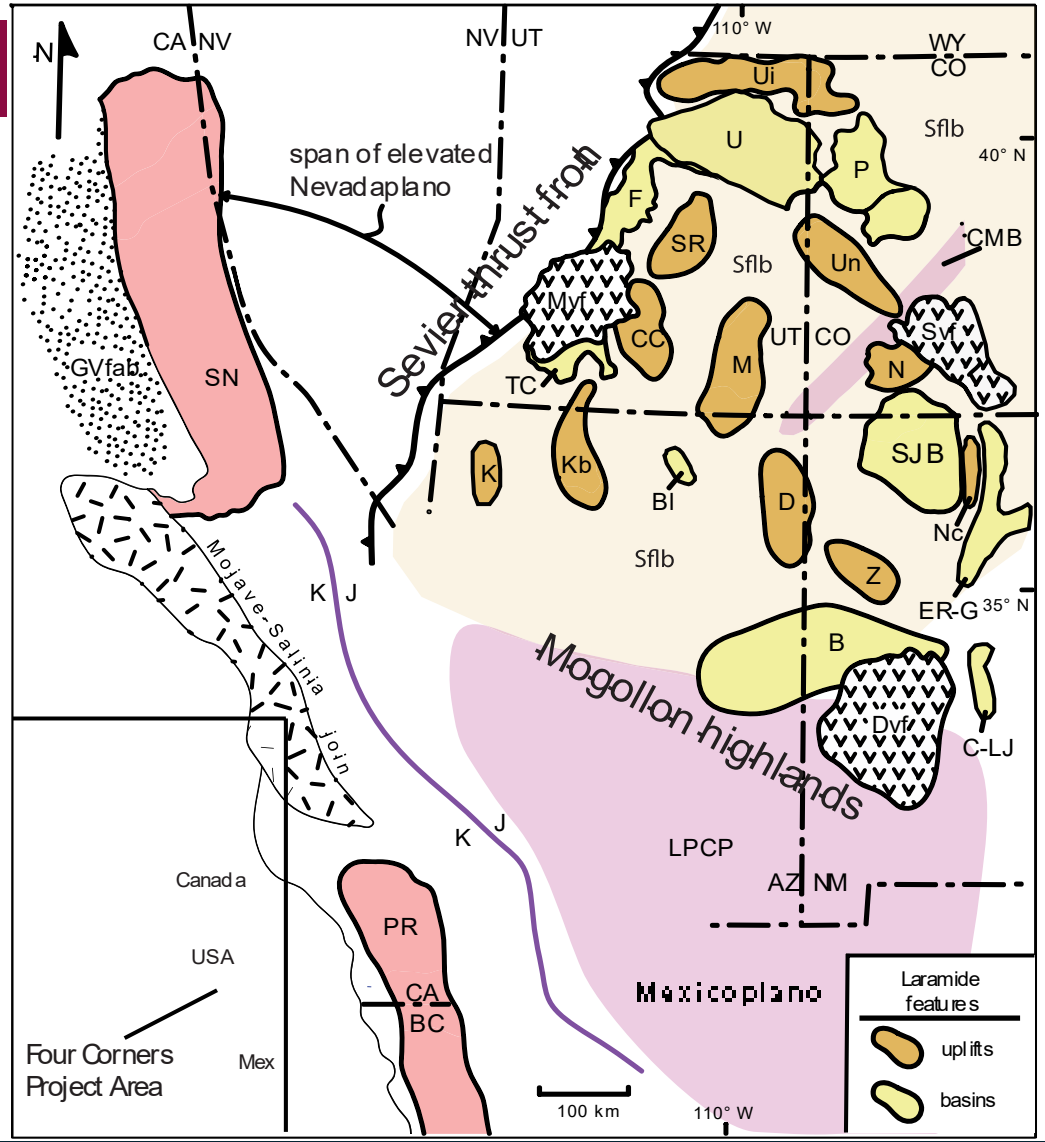


Smith and Lucas, 1991

Key Questions

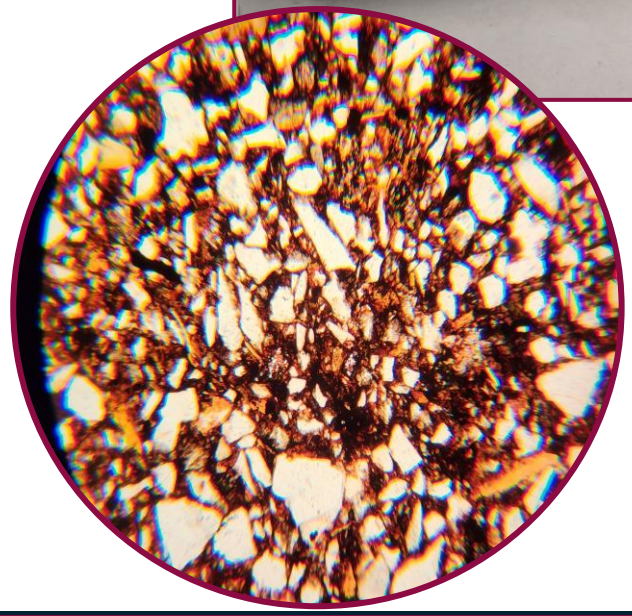
55-50 Ma?

- Geochronology?
- Provenance?
- Sed/Strat relations?
- Active late-stage Laramide structures?
- Tectonic drivers→ subsidence in the San Juan?

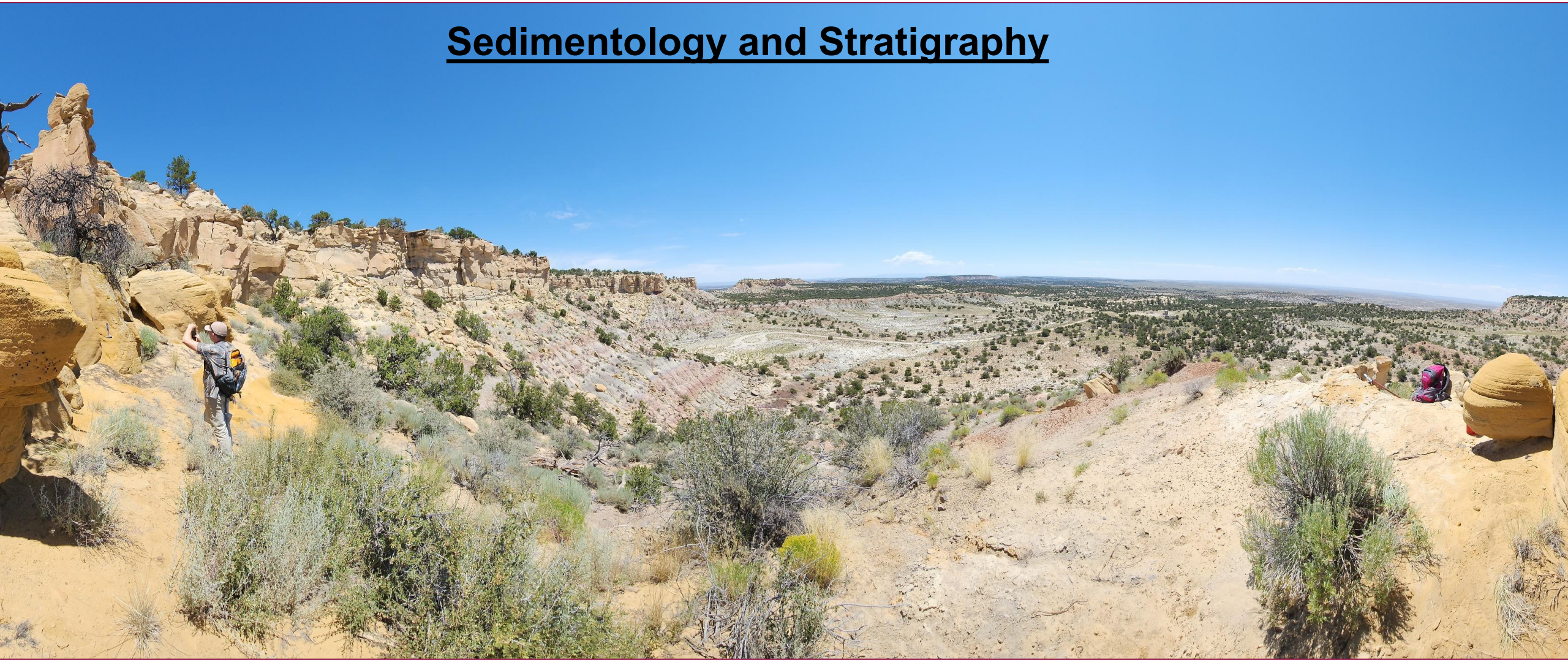


Pecha et al., 2018

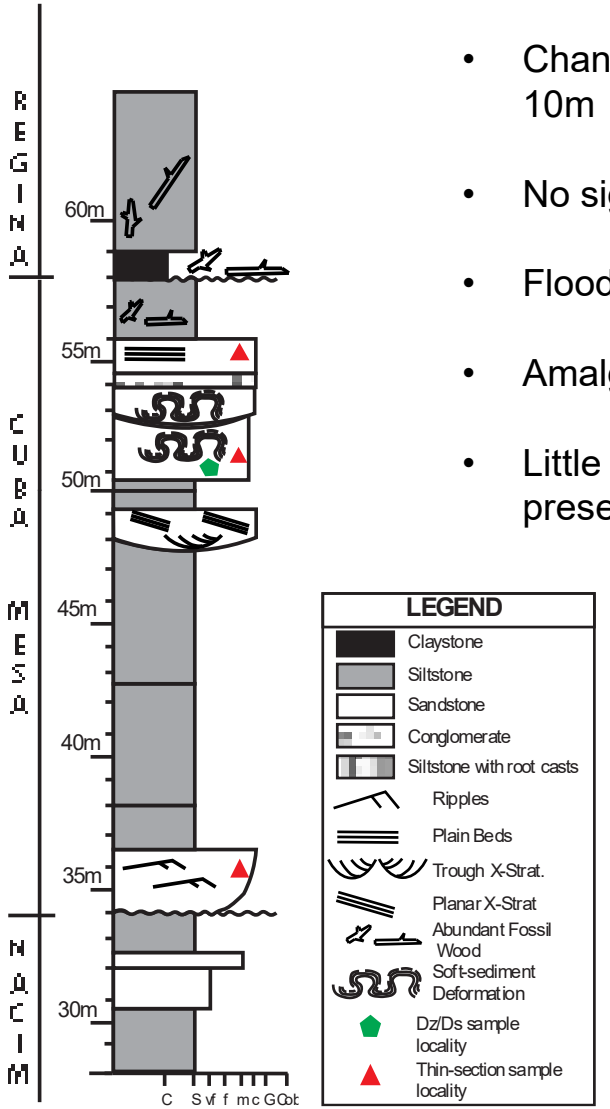
- **Measured Sections**
  - Changes in lithofacies
  - Changes in textural maturity
  - Paleoflow
  - Fluvial system evolution?
- **U-Pb Geochronology**
  - Provenance
  - Maximum Depositional Ages (MDA)
- **Point counting**
  - Modal compositions
    - → Provenance
    - →Sediment dispersal patterns



Sedimentology and Stratigraphy

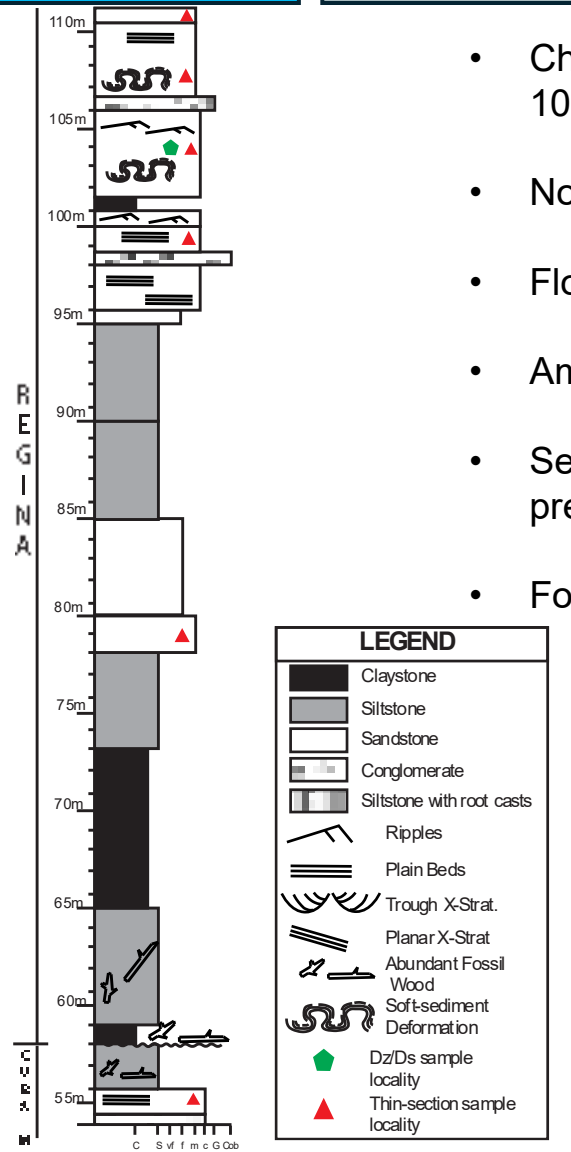


Cuba Mesa Member



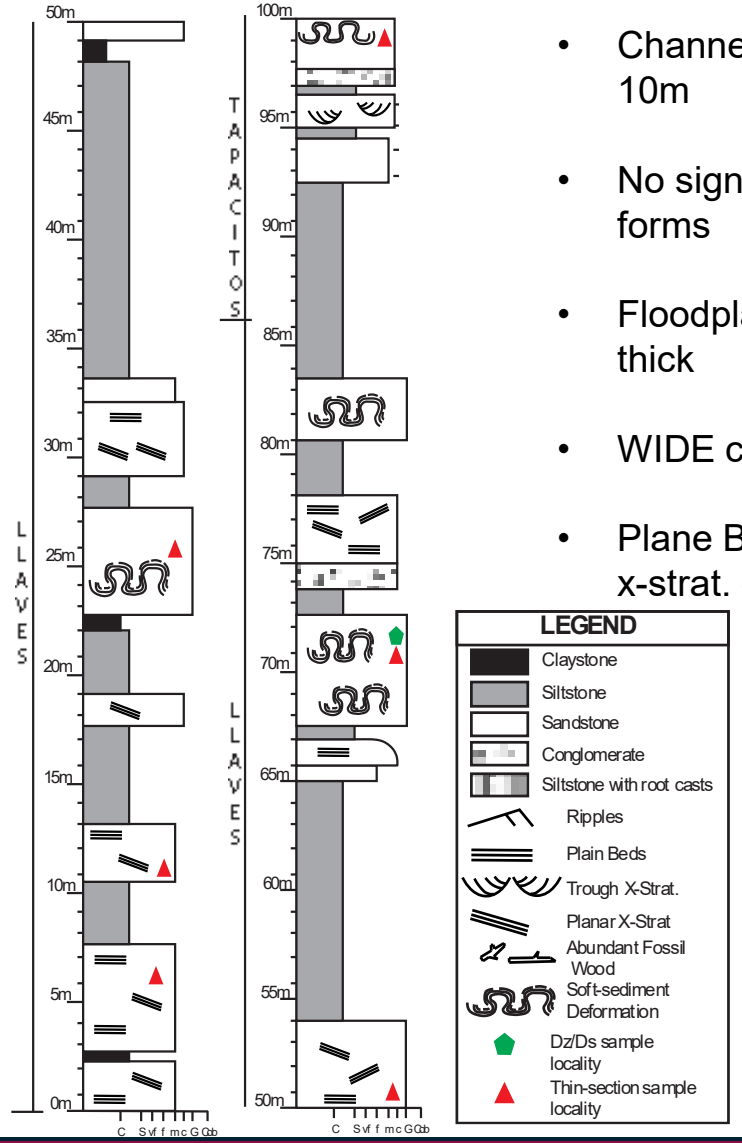
- Channel bodies: max-10m
- No significant bar forms
- Floodplain: 2-10m thick
- Amalgamated channels
- Little sed. structures preserved

Regina Member



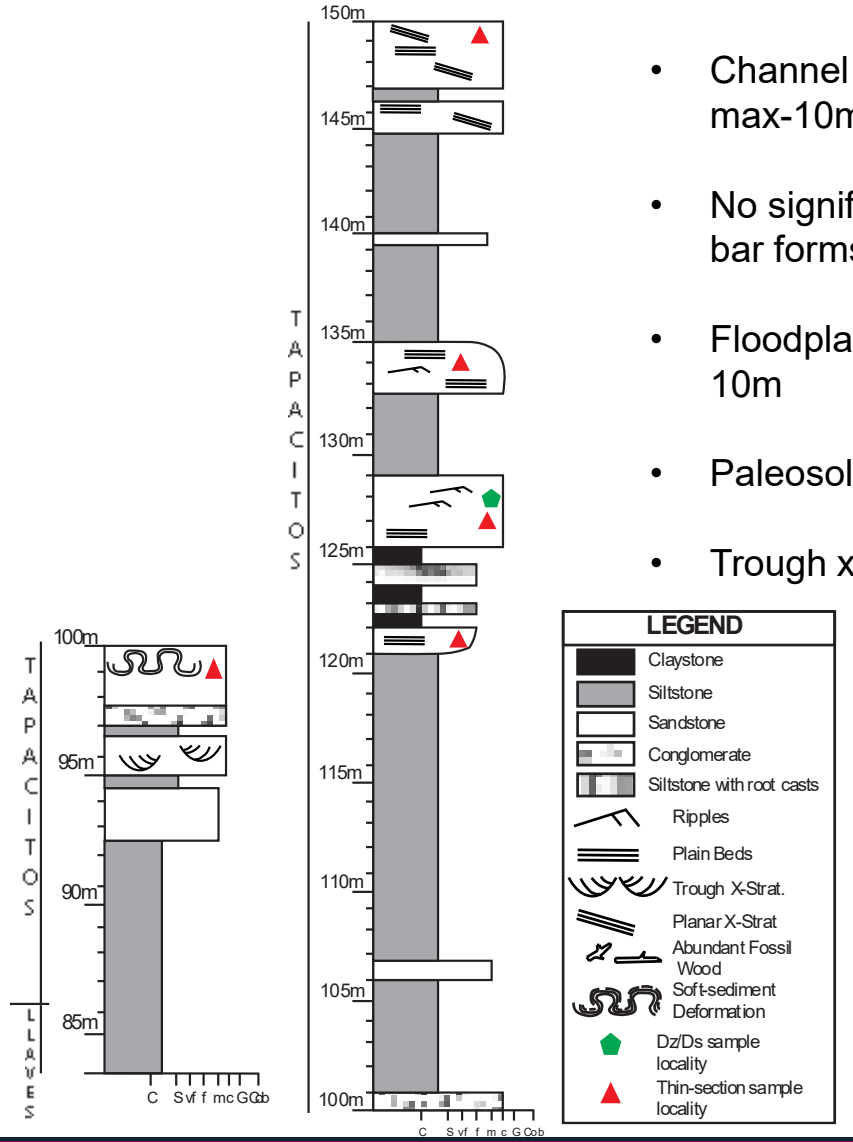
- Channel bodies: max-10m
- No significant bar forms
- Floodplain: 2-10m thick
- Amalgamated channels
- Sed. structures preserved
- Fossil trees!

Llaves Member



- Channel bodies: max-10m
- No significant bar forms
- Floodplain: 2-15m thick
- WIDE channels
- Plane Beds and planar x-strat. dominate

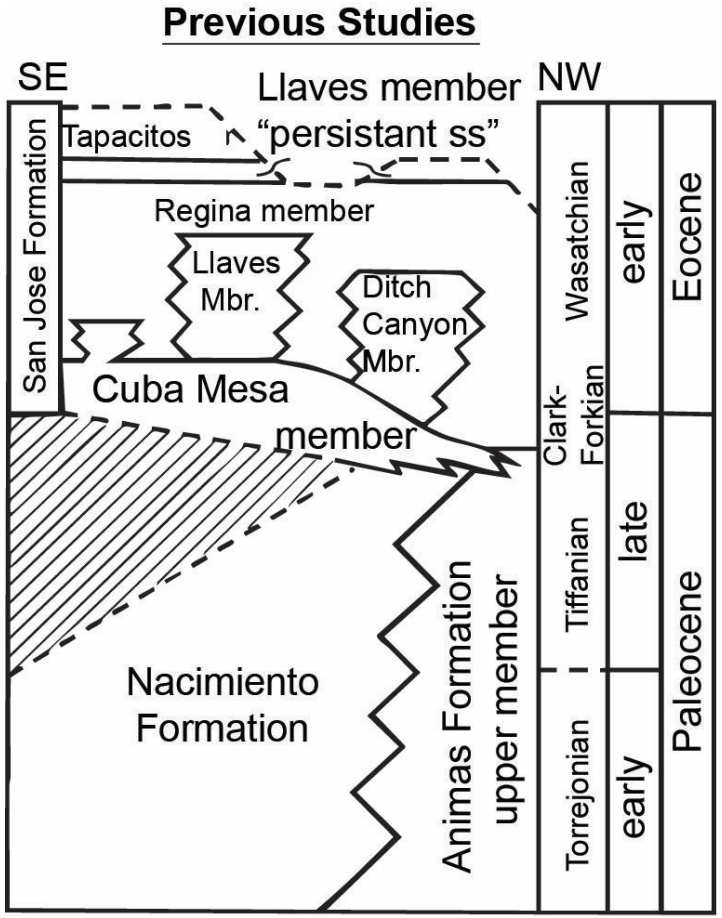
Tapacitos Member

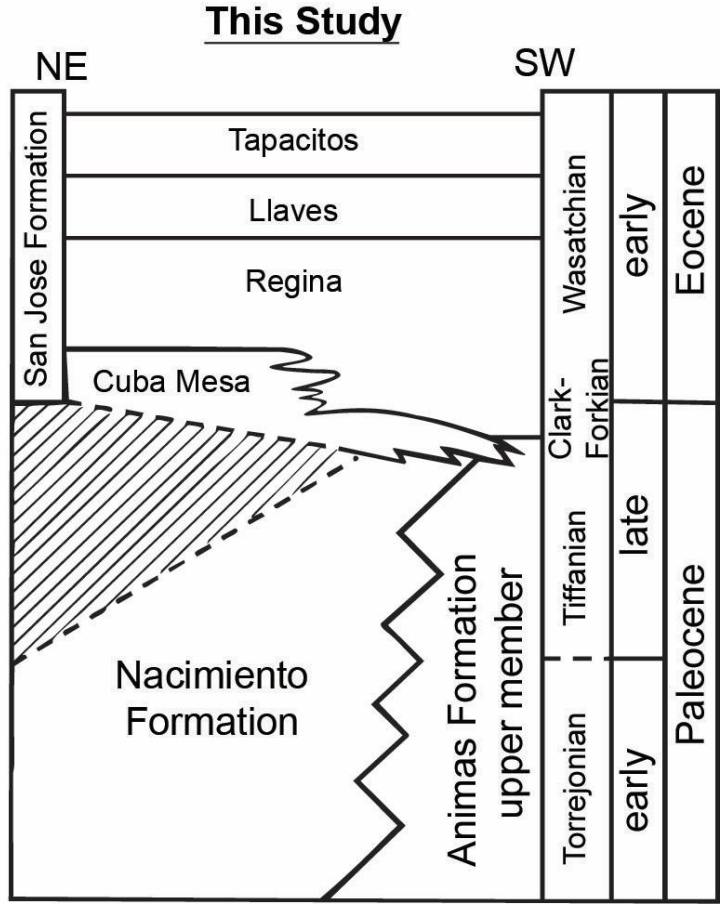


- Channel bodies: max-10m
- No significant bar forms
- Floodplain: 2-10m
- Paleosols
- Trough x-strat.

Key Take Aways

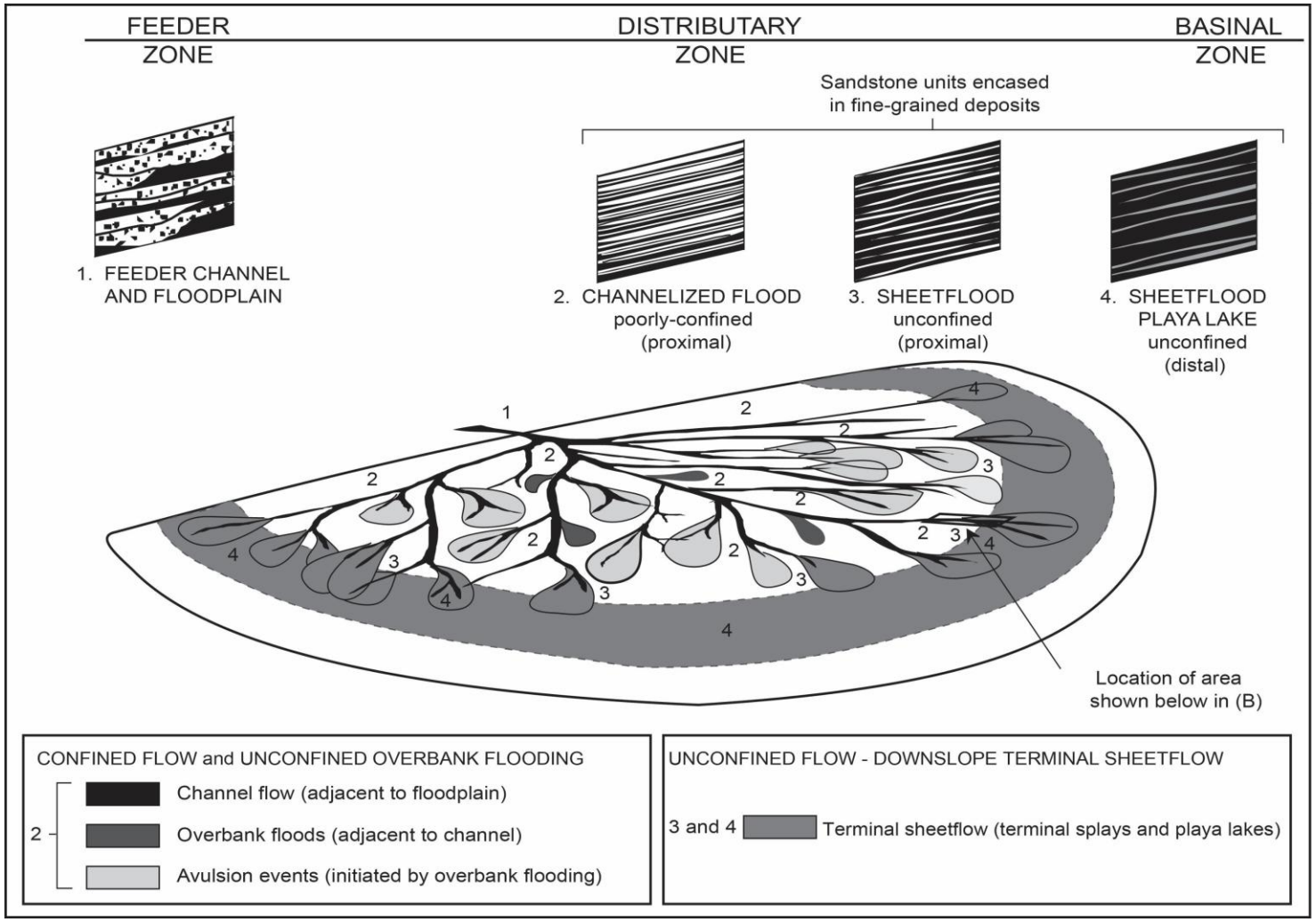
- **SS Bodies >0.5 m**
  - Lenticular and tabular geometries
  - Poorly confined fluvial channels
  - Unconfined sheetflood
- **Dominant Lithofacies:**
  - Horizontal stratification
  - Ripple cross-strat.
- **Detritus sourced regionally…?**
- **Soft Sediment Deformation??**
  - Dewatering→ rapid sedimentation
  - Liquefaction→ seismic events
- **Cuba Mesa/Regina**
  - Near identical lithologic traits





Key Take Aways

- **San Jose Formation Depositional Style:**
  - Laterally extensive channels
    - Aggraded in place
    - Did not migrate across floodplain
    - Channel avulsion
  - Floodplain Surfaces
    - Relatively stable
      - Promoted vegetation to mature



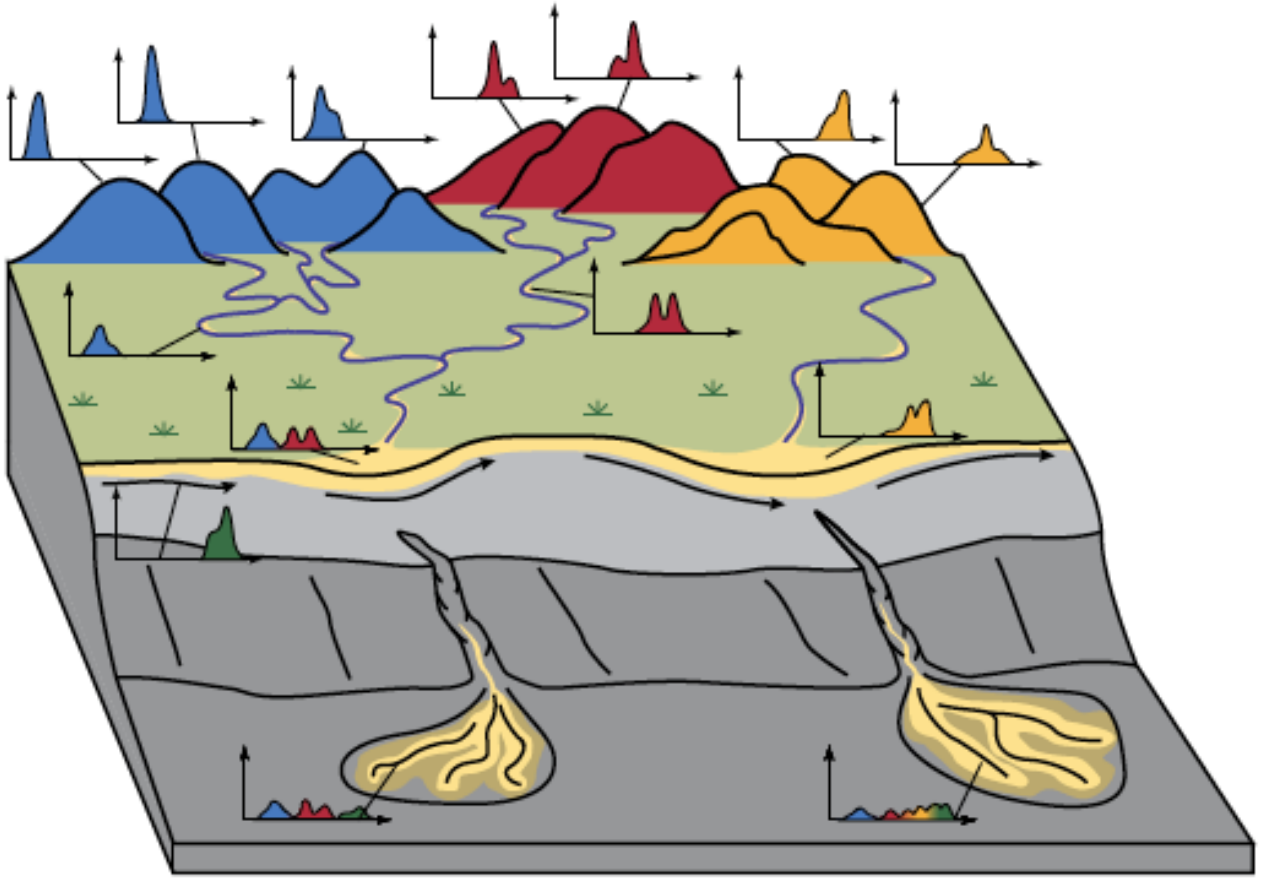
Hampton and Horton, 2007

We're done with the Sed/Strat!!

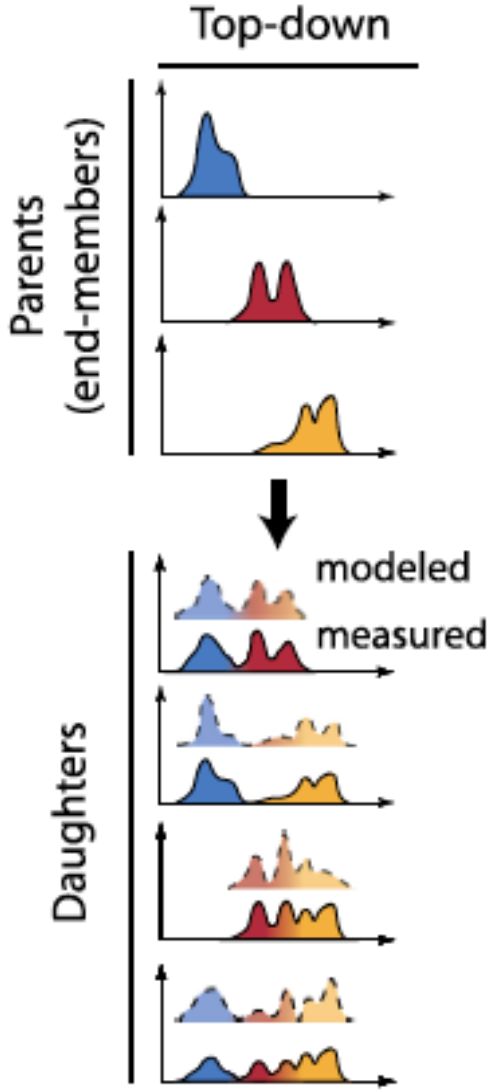
Leo Kuyl, at the Arizona LaserChron Center

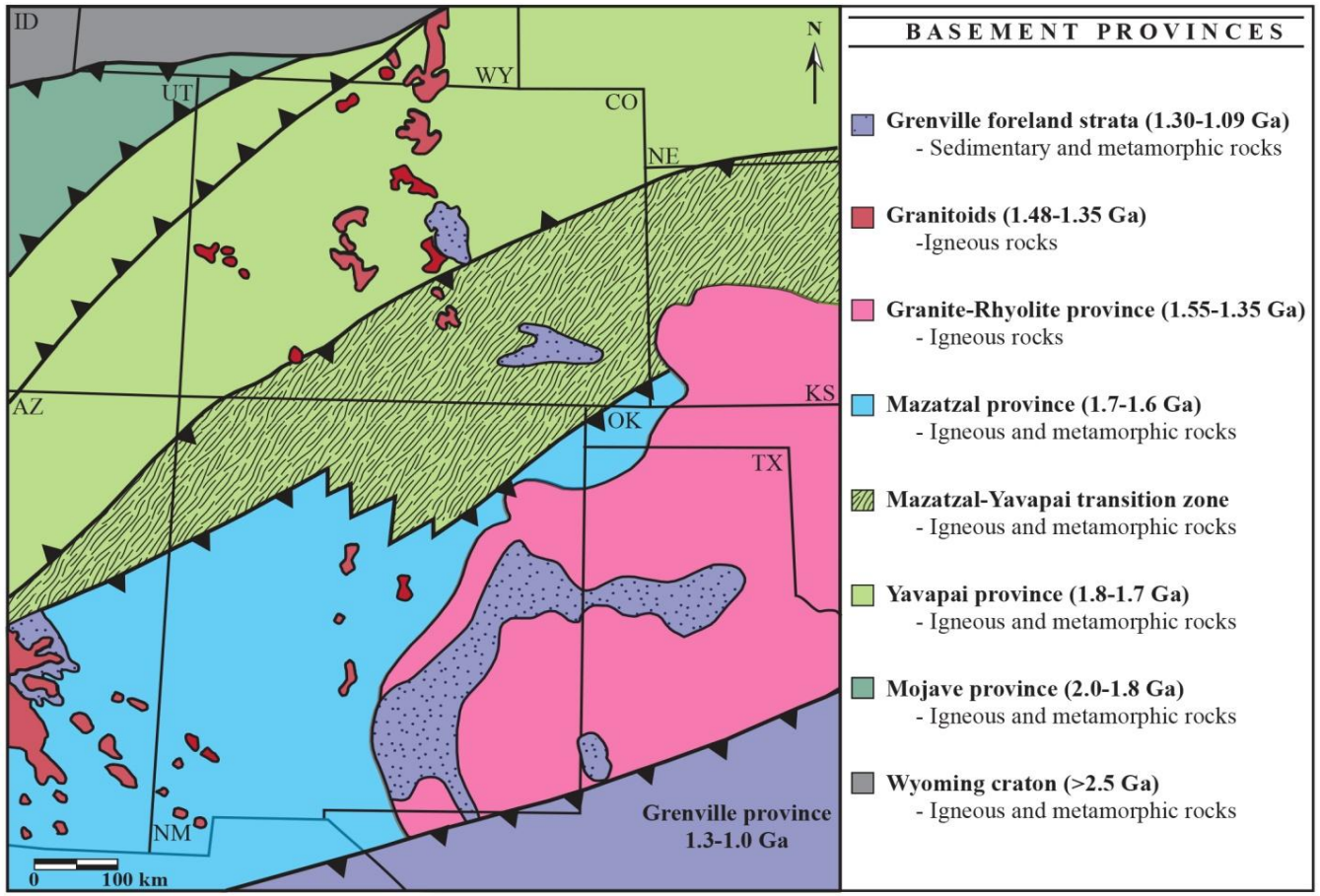
Detrital Zircon Geochronology

Detrital Zircon Geochronology

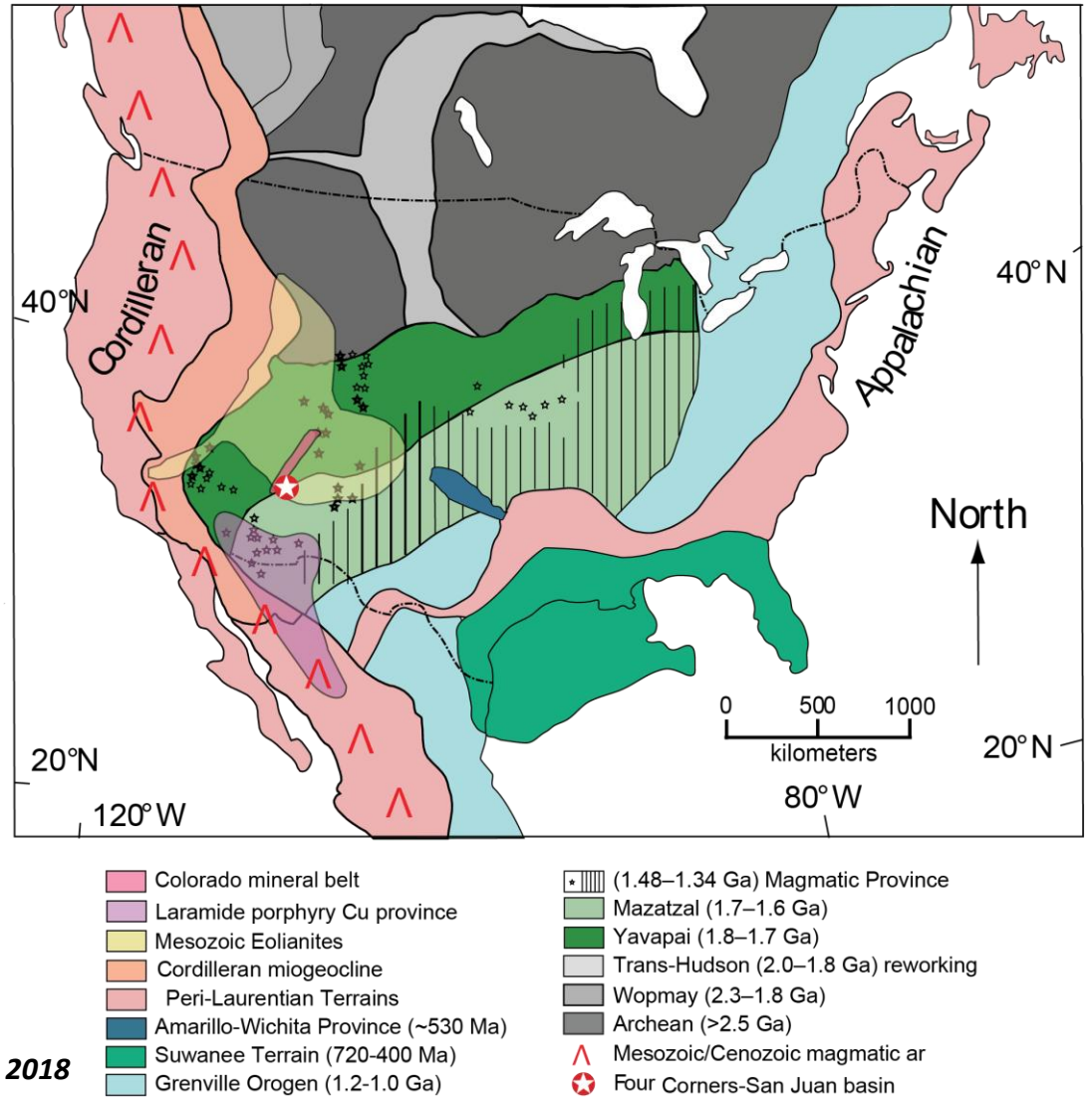


Sharman, et al.. (2017)





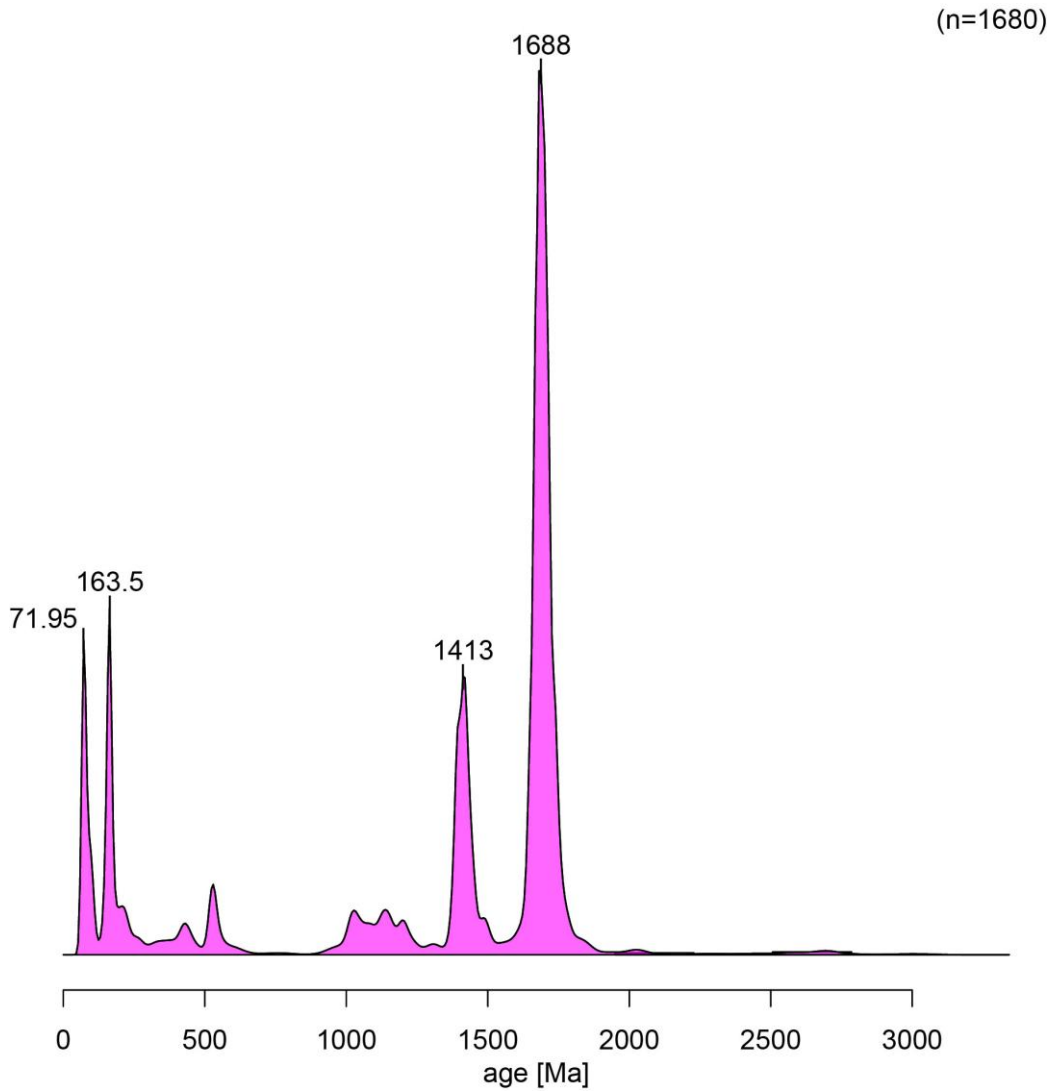
Modified from Karlstrom et al., 2004



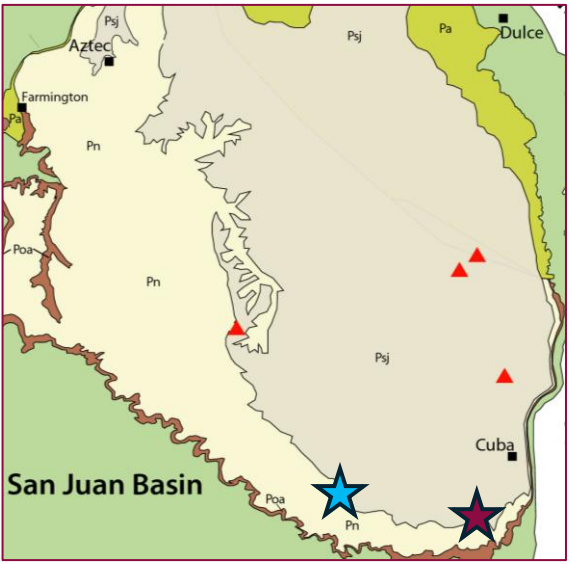
Pecha et al., 2018

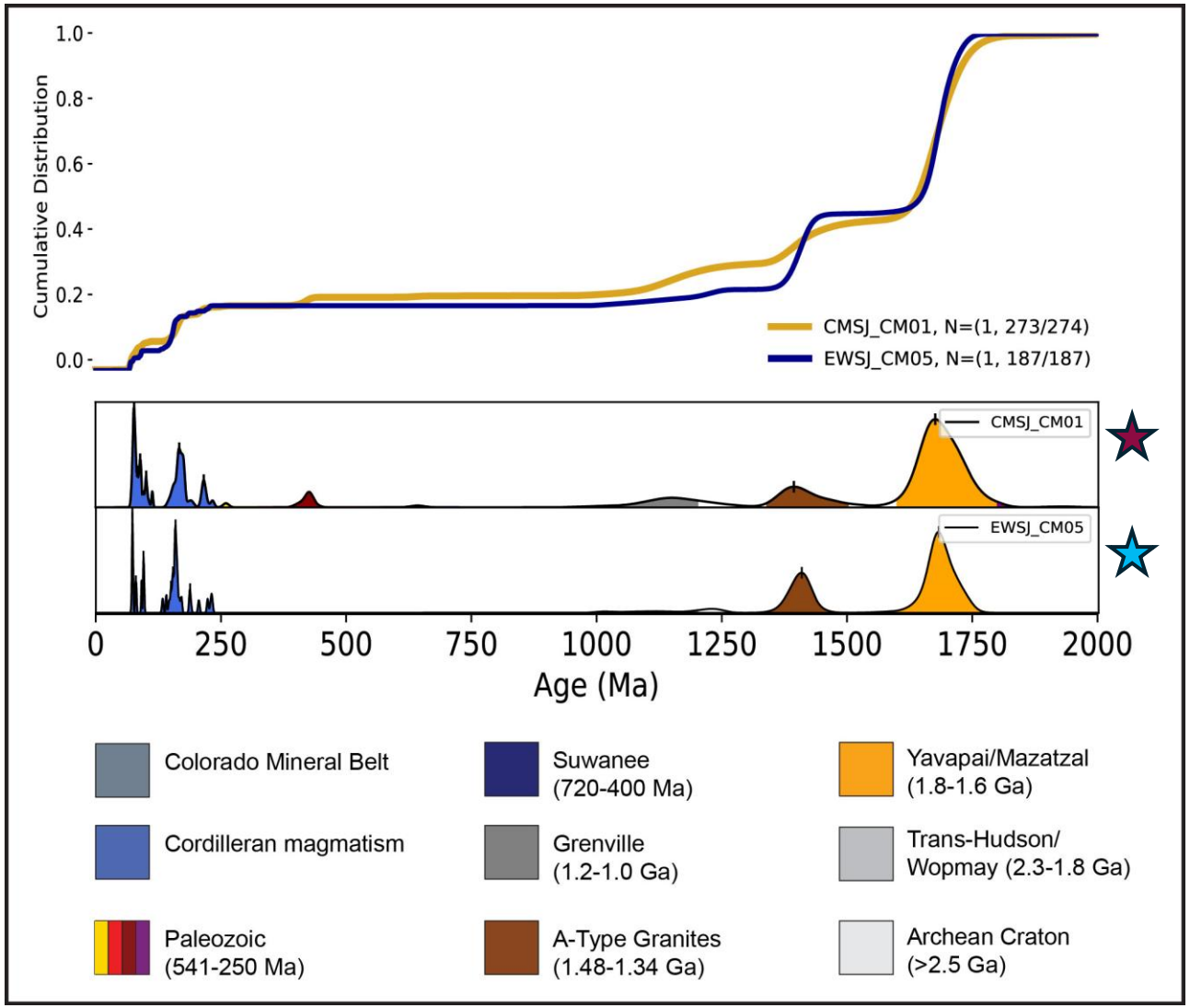
San Jose Formation

- Composite PDP
- Primary age Peaks:
  - Mazatzal/Yavapai
- Secondary Peaks:
  - Cordilleran Arc
  - Colorado Mineral Belt
- Youngest grains:
  - 65 Ma



Cuba Mesa Member



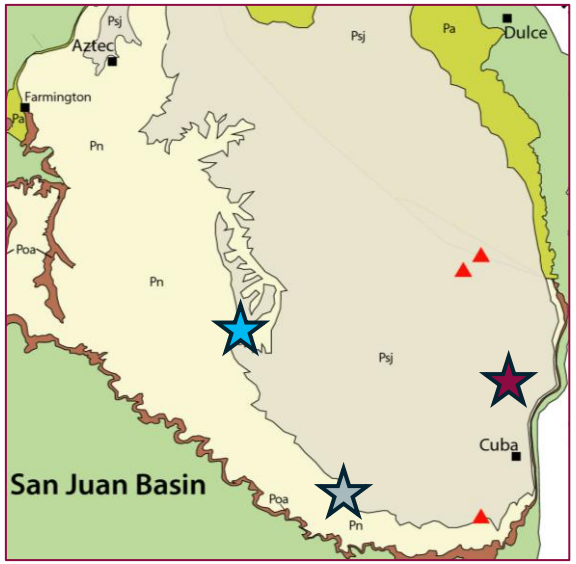


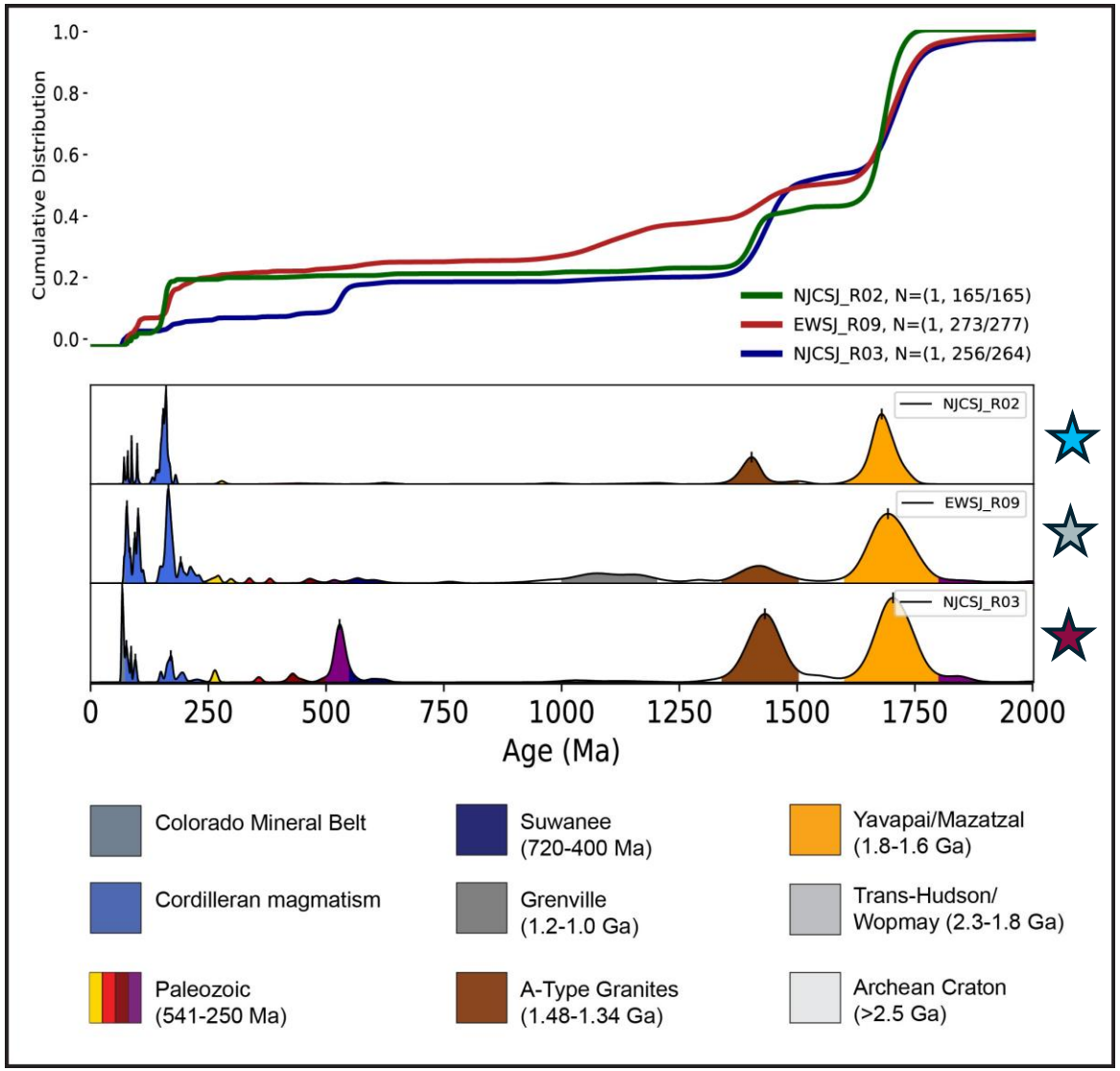
- Mazatzal/Yavapai
  - ~55%
- A-Type Granites
  - ~15-20%
- Cordilleran Arc/ CMB
  - ~20%
- Grenville
  - ~9%

- Similar age signatures across the basin

- Small Paleozoic signature in the east

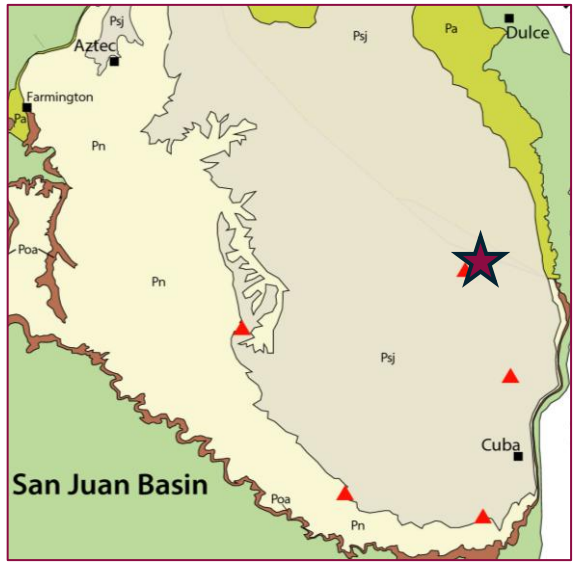
Regina Member

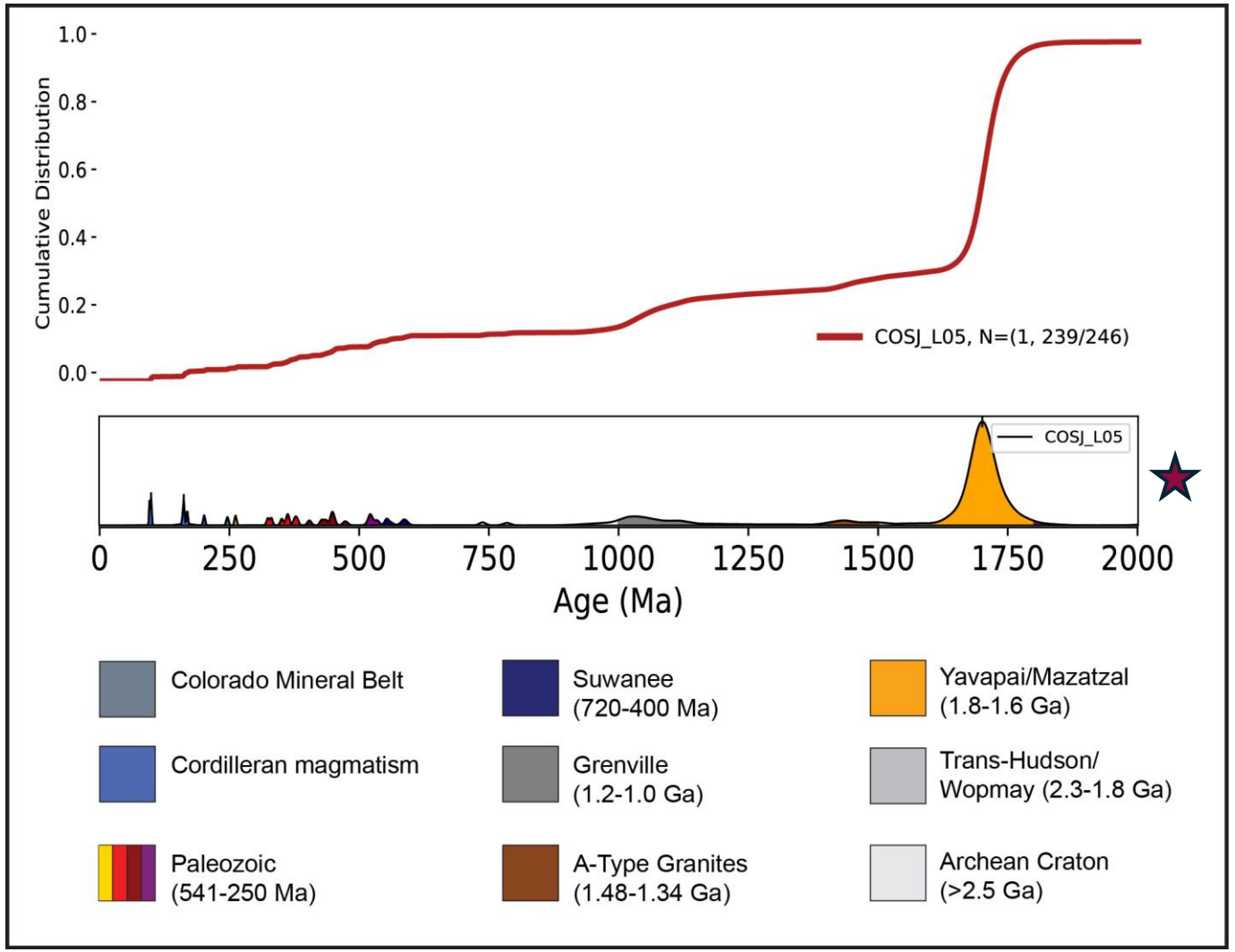




- Mazatzal/Yavapai
  - ~55%
- A-Type Granites
  - ~5-15%
- Cordilleran Arc/ CMB
  - ~20%
- Grenville
  - ~5%
- Age signatures vary across the basin
- Small Paleozoic signature in the east
  - ~8%

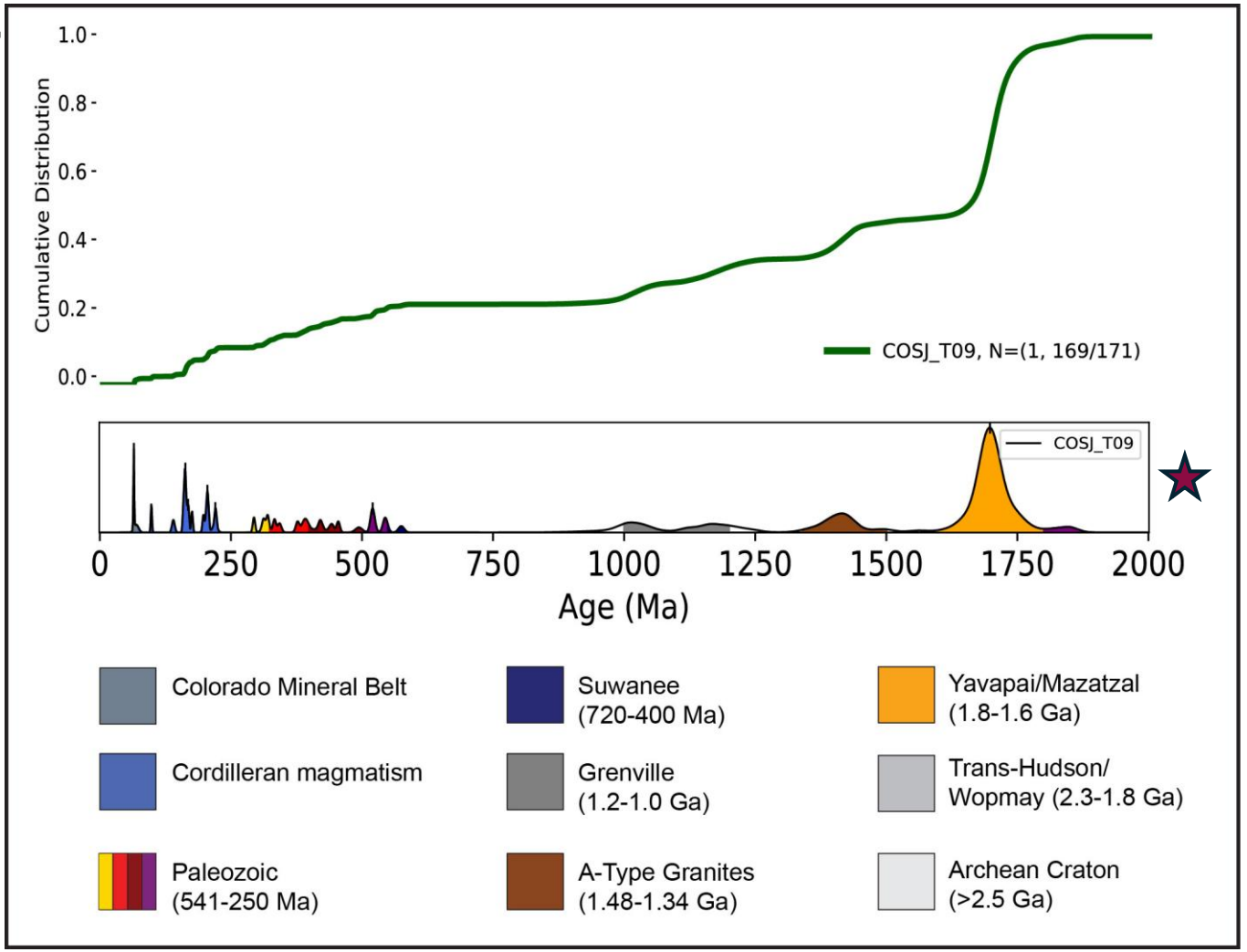
Llaves Member





- Mazatzal/Yavapai
  - ~70%
- A-Type Granites
  - ~5%
- Cordilleran Arc
  - ~4%
- Grenville
  - ~11%
- Paleozoic
  - ~6%

Tapacitos Member



- Mazatzal/Yavapai
  - ~50%
- A-Type Granites
  - ~11%
- Cordilleran Arc
  - ~8%
- Grenville
  - ~12%
- Paleozoic
  - ~12%

Key Take Aways

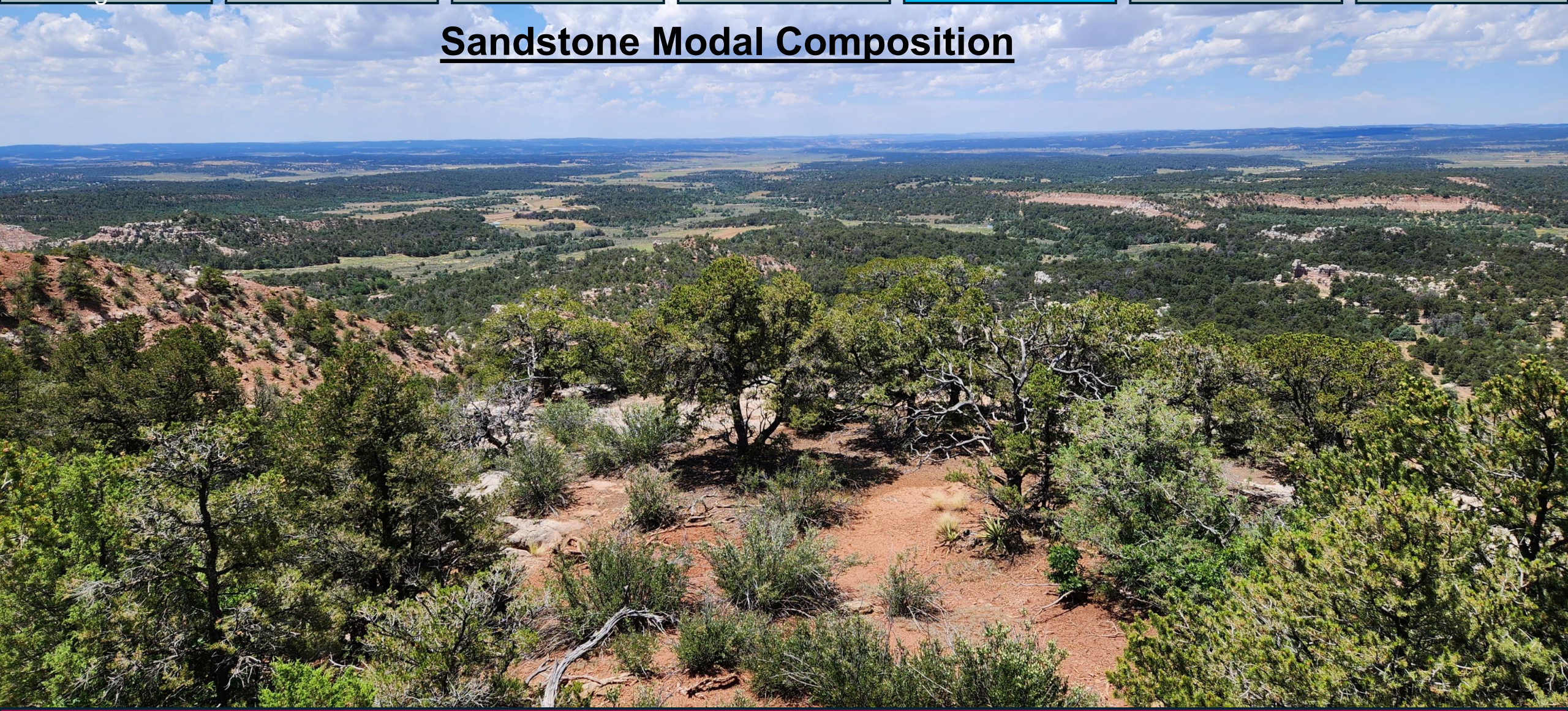
Key Observations

- Cuba Mesa/ Regina Members:
  - Yavapai/Mazatzal and A-Type Granites
    - ~55%
  - Cordilleran Arc
    - ~15%
  - Muted Paleozoic Intrusives
- Llaves/ Tapacitos Members:
  - Yavapai/Mazatzal and A-Type Granites
    - ~65%
  - Muted Grenville and Paleozoic Intrusives
    - ~12% and 6% (respectively)
- Cuba Mesa/Regina and Llaves/Tapacitos
  - Near identical age signatures (Respectively)

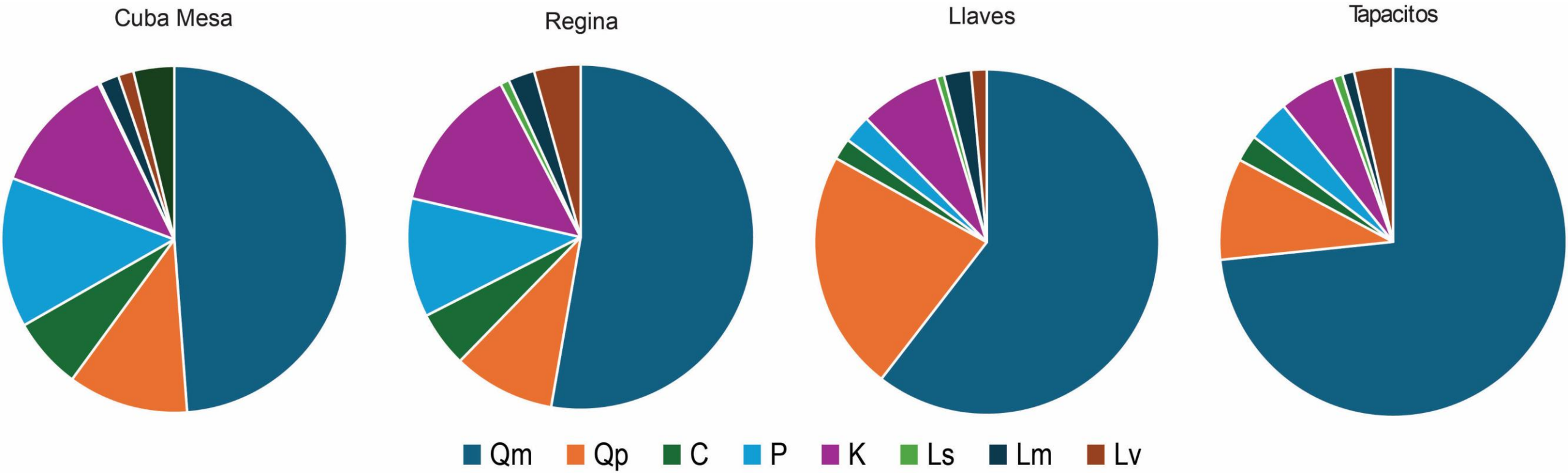
Provenance

- Cuba Mesa/Regina:
  - Basement source areas (Primary)
  - Cordilleran Arc source areas (Secondary)
  - Increased local basement input in the eastern margin of the SJB
- Llaves/Tapacitos:
  - Basement source areas (Primary)
  - Cordilleran Arc source areas (Absent)

Sandstone Modal Composition

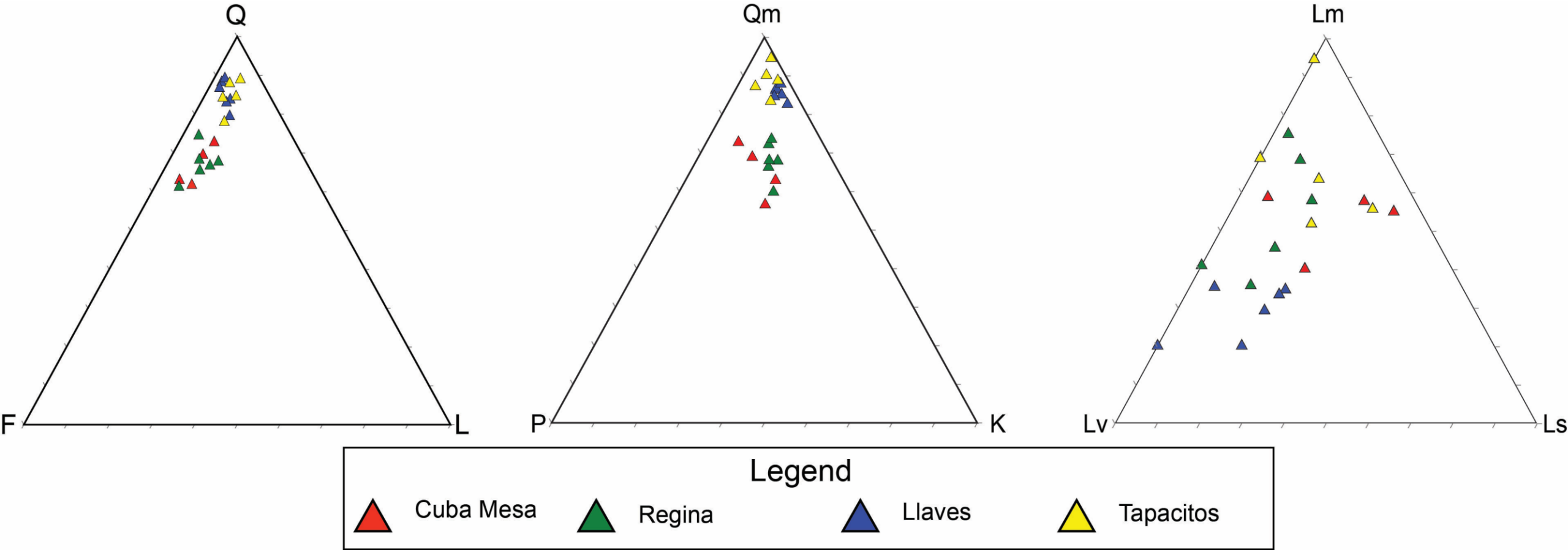


San Jose Formation



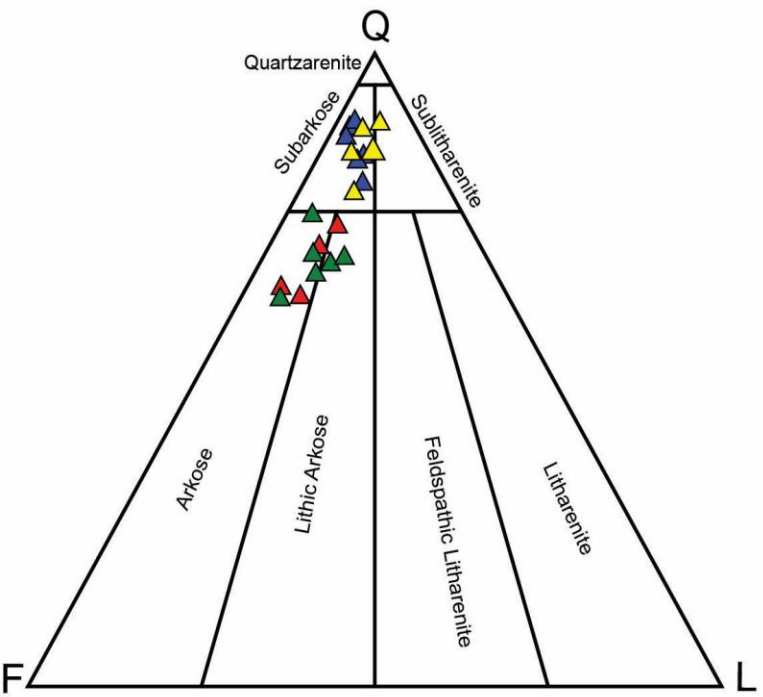
Valenzuela et al., In Press

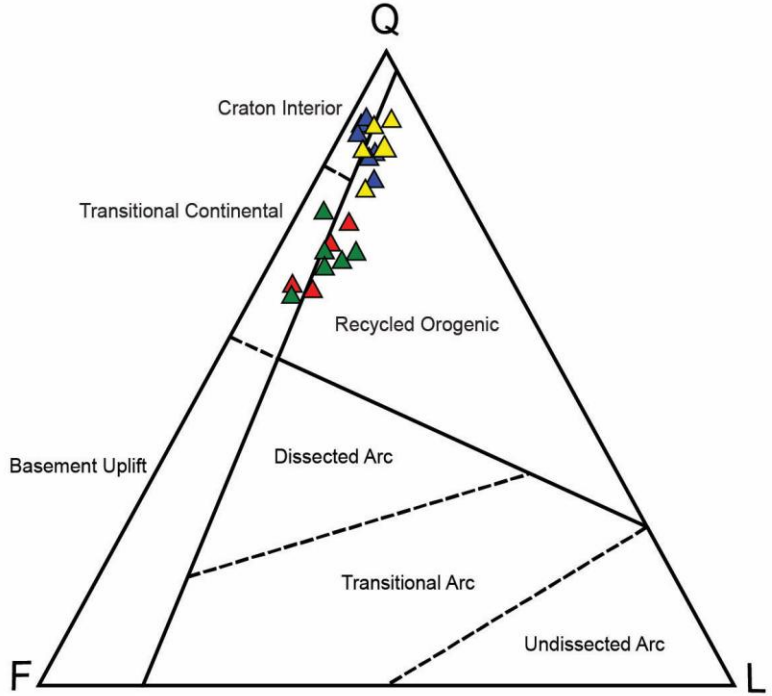
San Jose Formation

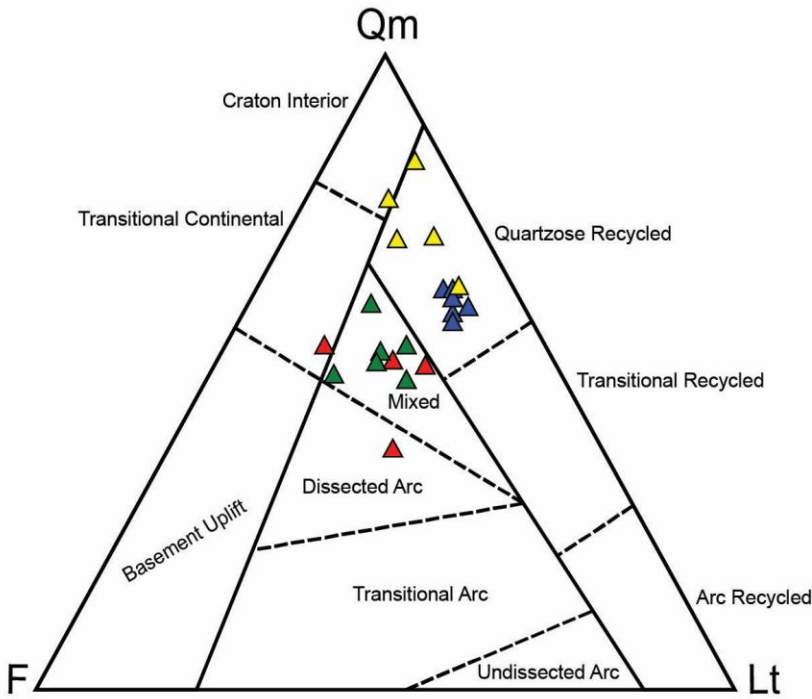


Valenzuela et al., In Press

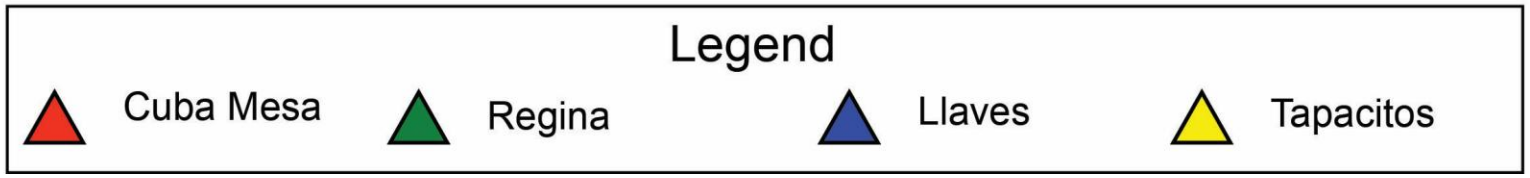
San Jose Formation







Dickinson et al., 1983



Valenzuela et al., In Press

Key Take Aways

Key Observations

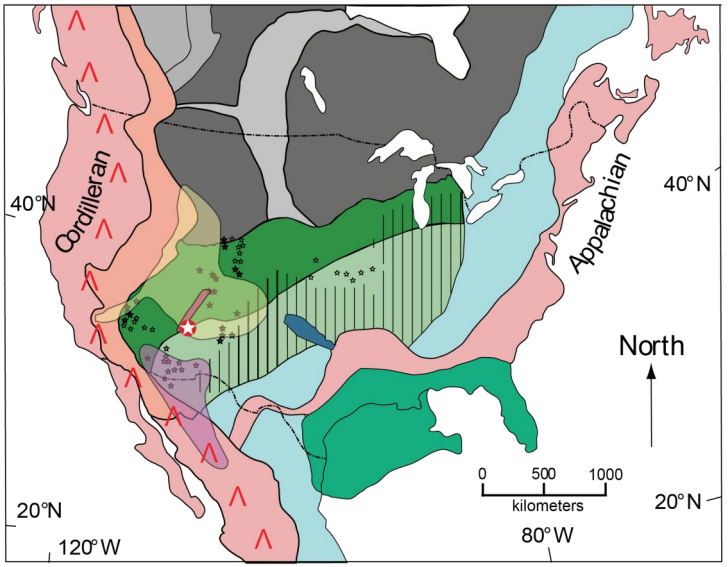
- San Jose Formation
  - Quartz-rich mature Sandstones
  - Lithic fragments show no distinct patterns
  - Cuba Mesa/Regina and Llaves/Tapacitos plot into 2 distinct compositional zones and provenance fields

Provenance

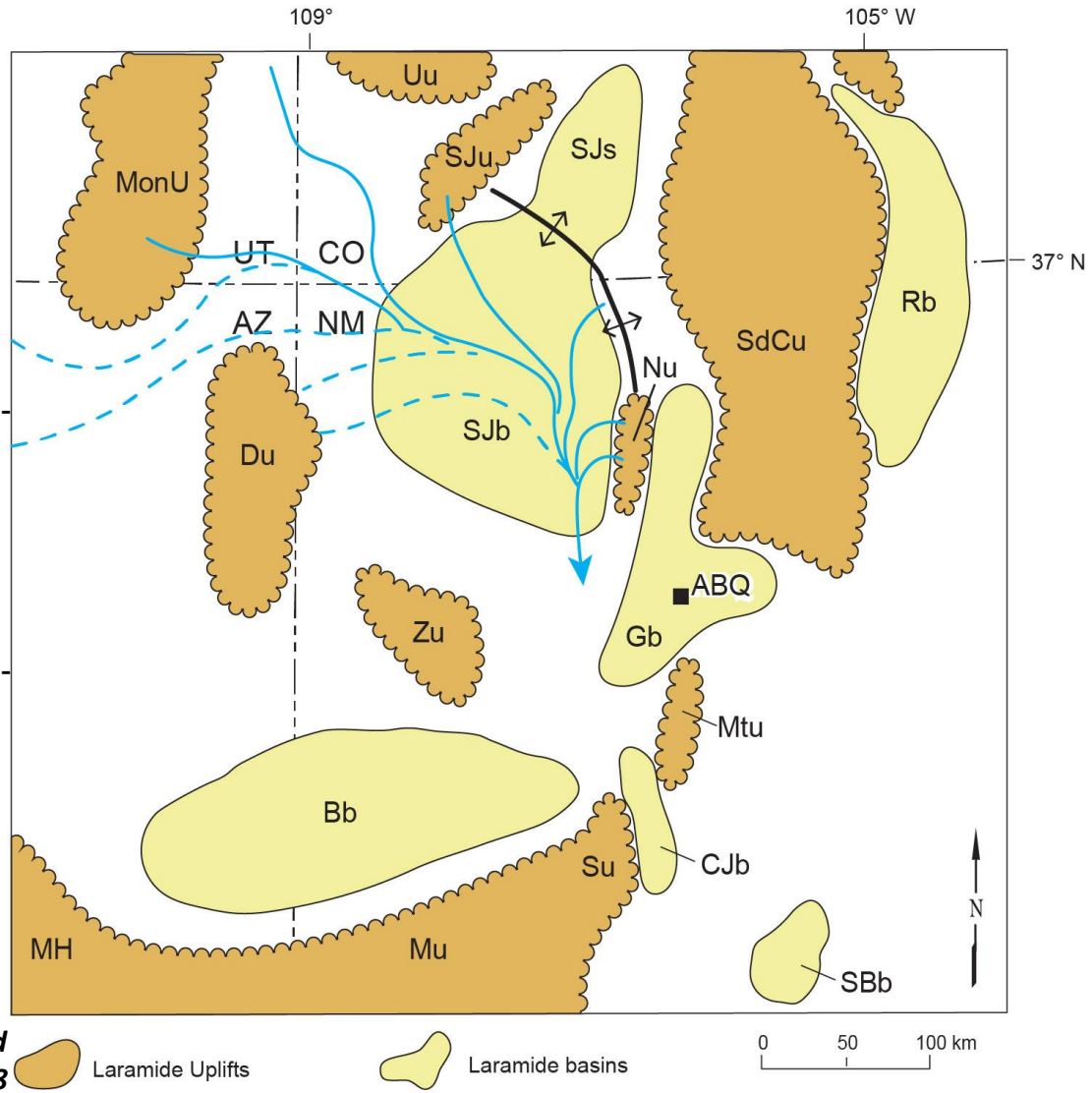
- Cuba Mesa/Regina:
  - Transitional Continental/Recycled Orogenic
    - Mix of basement and arc
- Llaves/Tapacitos:
  - Craton Interior/Recycled Orogenic
    - Basement source areas (Primary)

Valenzuela et al., In Press

Cuba Mesa/Regina Members



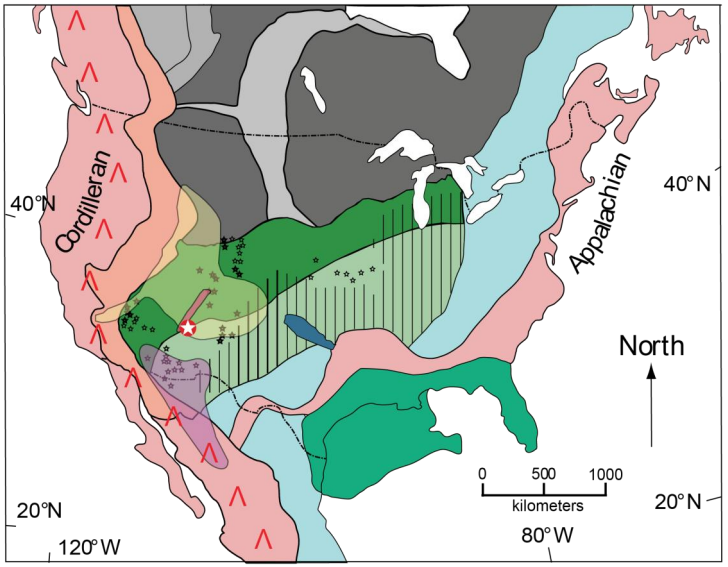
Pecha et al., 2018



Modified from Cather, 2004; and Pecha et al., 2018

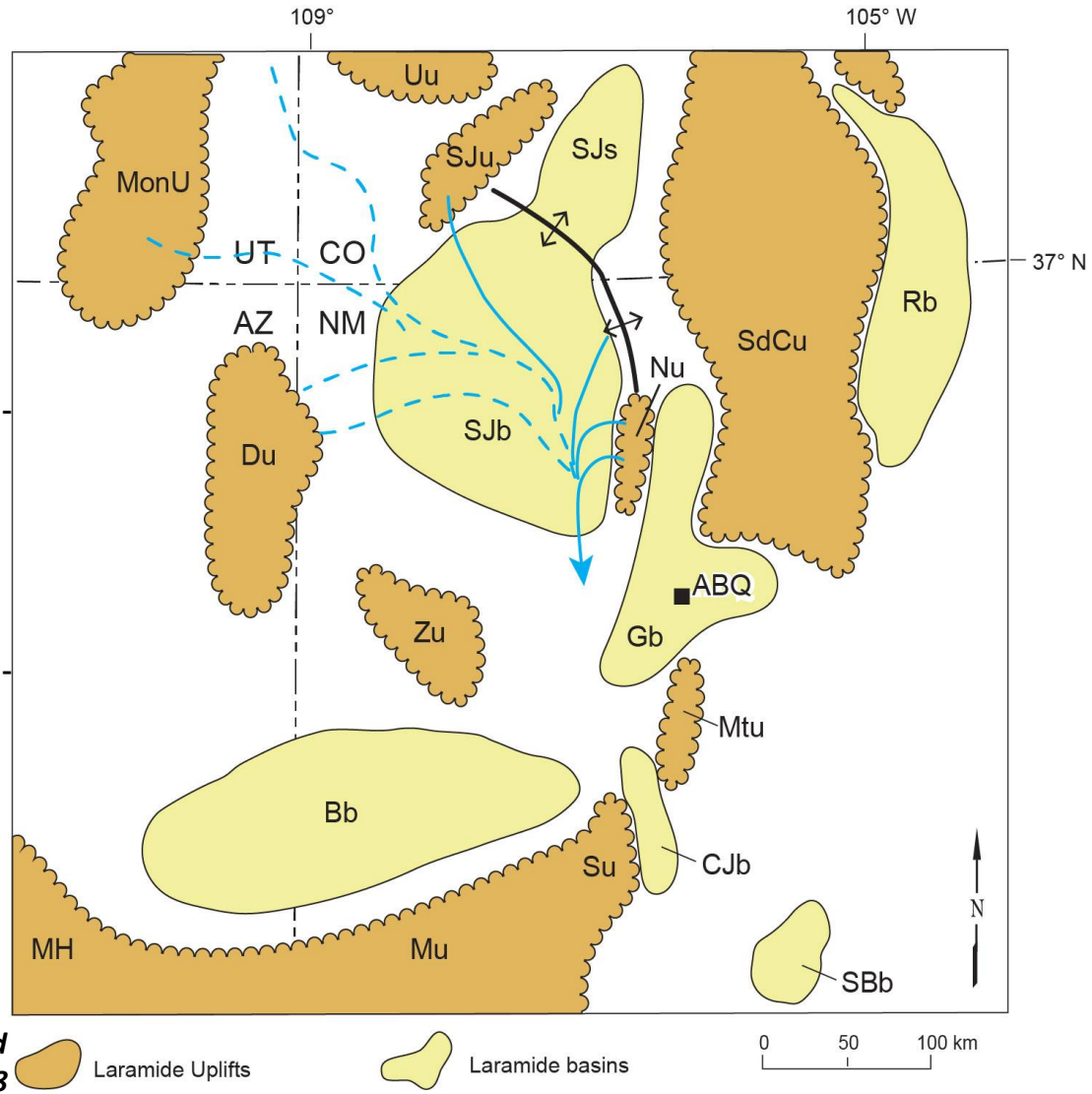
- Sed/Strat
  - Seds sourced more regionally
- Detrital Zircon
  - Basement source areas (Primary)
  - Cordilleran Arc source areas (Secondary)
  - Increased local basement input in the eastern margin of the SJB
- Modal Composition
  - Transitional Continental/Recycled Orogenic
  - Mix of basement and arc

Llaves/Tapacitos Members



Colorado mineral belt
Laramide porphyry Cu province
Mesozoic Eolianites
Cordilleran miogeocline
Peri-Laurentian Terrains
Amarillo-Wichita Province (~530 Ma)
Suwanee Terrain (720-400 Ma)
Grenville Orogen (1.2-1.0 Ga)
(1.48–1.34 Ga) Magmatic Province
Mazatzal (1.7–1.6 Ga)
Yavapai (1.8–1.7 Ga)
Trans-Hudson (2.0–1.8 Ga) reworking
Wopmay (2.3–1.8 Ga)
Archean (>2.5 Ga)
Mesozoic/Cenozoic magmatic ar
Four Corners-San Juan basin

Pecha et al., 2018



Modified from Cather, 2004; and Pecha et al., 2018

- Sed/Strat
  - Seds sourced more regionally
- Detrital Zircon
  - Basement source areas (Primary)
  - Cordilleran Arc source areas (Absent)
- Modal Composition
  - Craton Interior/Recycled Orogenic
  - Basement source areas (Primary)

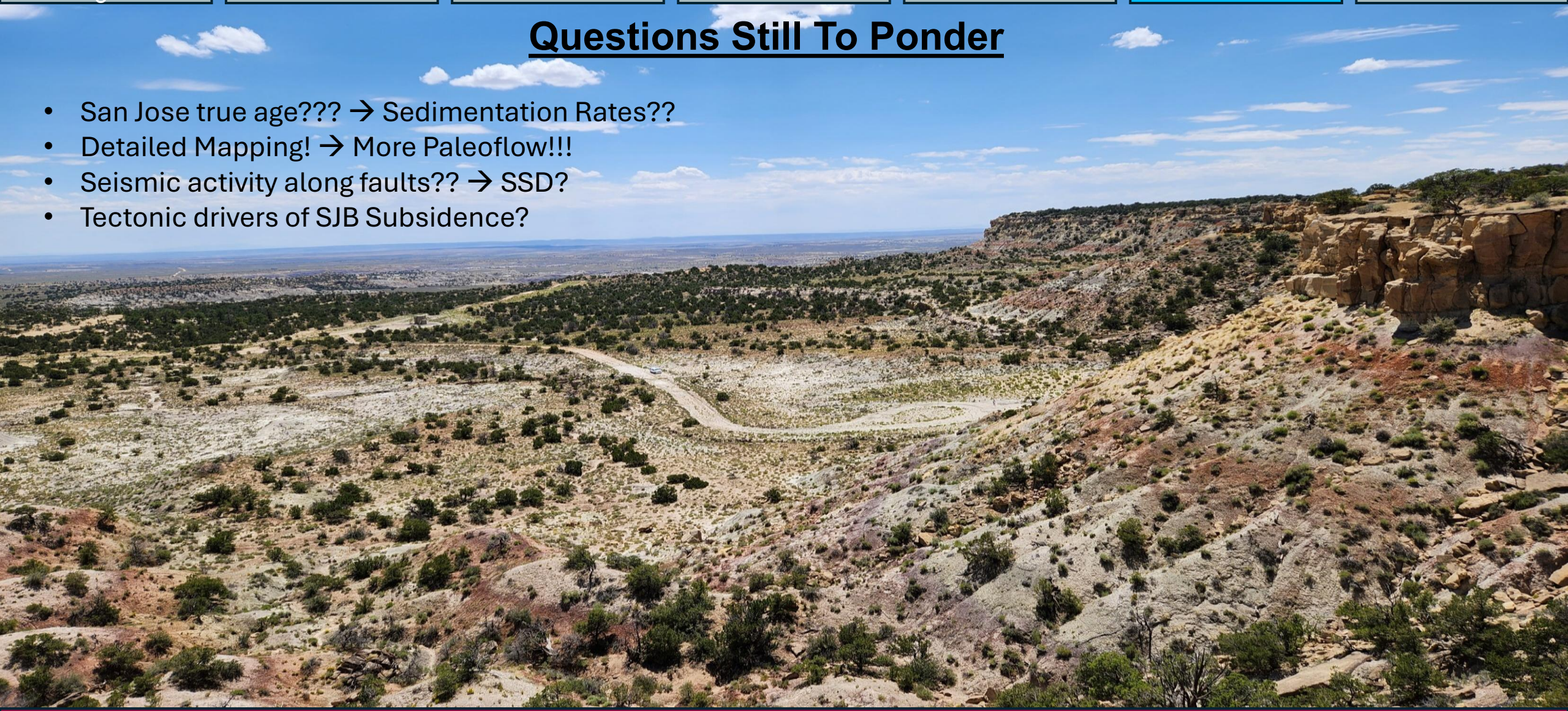
Over-Arching Conclusions

Over-Arching Conclusions

- The San Jose exhibits depositional styles of a vertically aggrading fluvial system, with little to no lateral channel migration and long-lived floodplains.
- Detrital zircon geochronology and sandstone modal comp. support the interpretation that Eocene strata were derived from local Laramide uplifts with minor contributions from far field western inputs.
- Detrital zircon geochronology did not provide any insight on maximum depositional ages of the San Jose as the youngest grains found were ~65 Ma.
- The Cuba Mesa/Regina exhibit near identical lithological traits, modal composition, and geochronologic signatures → These members could be combined to a single formation member.

Questions Still To Ponder

- San Jose true age??? → Sedimentation Rates??
- Detailed Mapping! → More Paleoflow!!!
- Seismic activity along faults?? → SSD?
- Tectonic drivers of SJB Subsidence?



- Matt Heizler, and Julia Ricci at the New Mexico Bureau of Geology
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- My graduate student cohort
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  - Brian Hampton
  - Nancy McMillan
  - Jeff Amato
  - Kevin Hobbs
  - Dan Dugas

Thank You!!

Questions?