

Lithospheric strength: a potential controlling factor over differential subsidence in the Early Triassic Sonoma Foreland Basin (western USA)?

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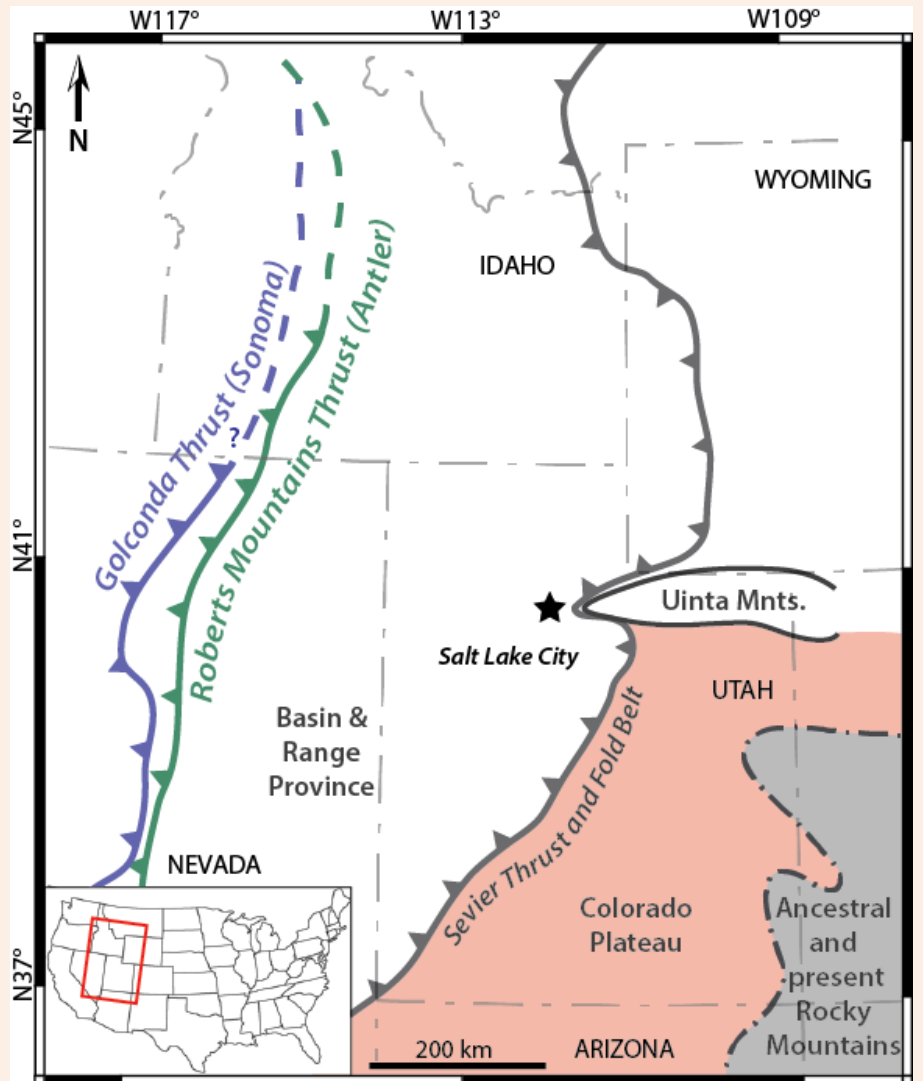
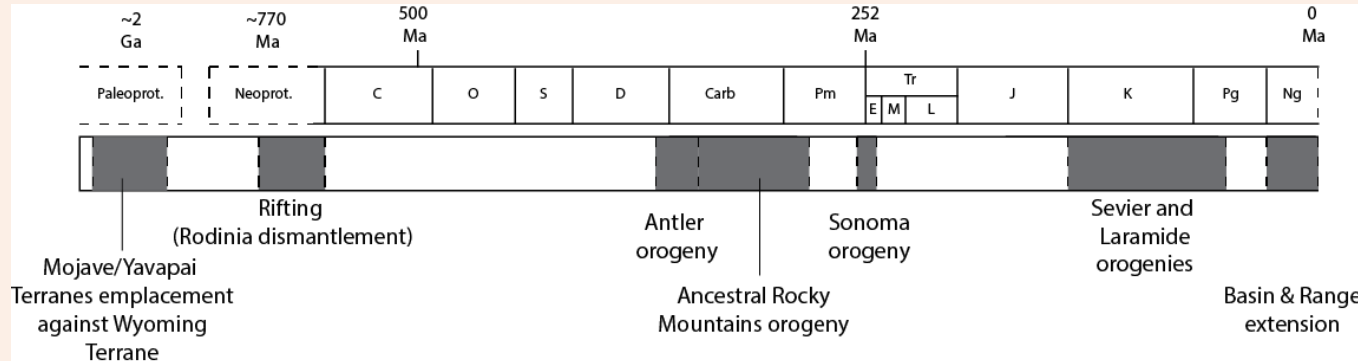
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Introduction and localization

Long and complex tectonic history of the Eastern Great Basin

Many **now obliterated** orogenic features



After Caravaca et al., subm.

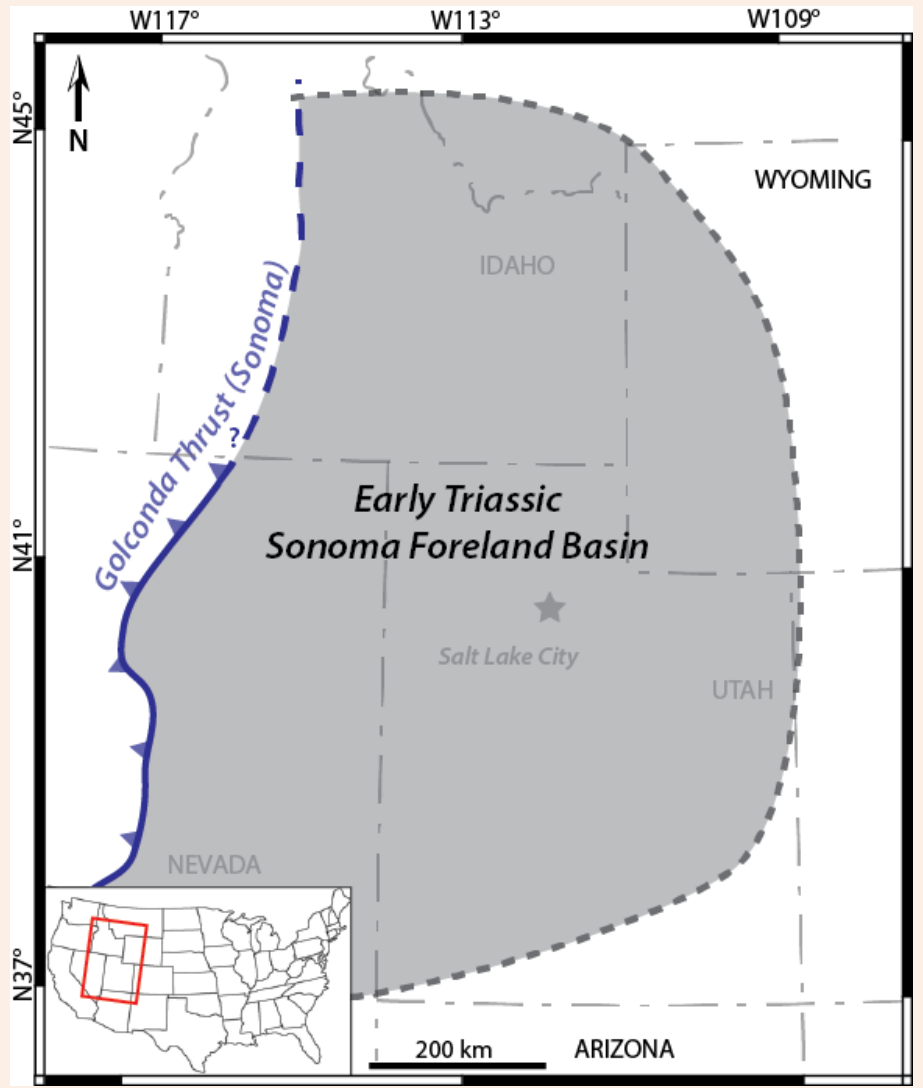
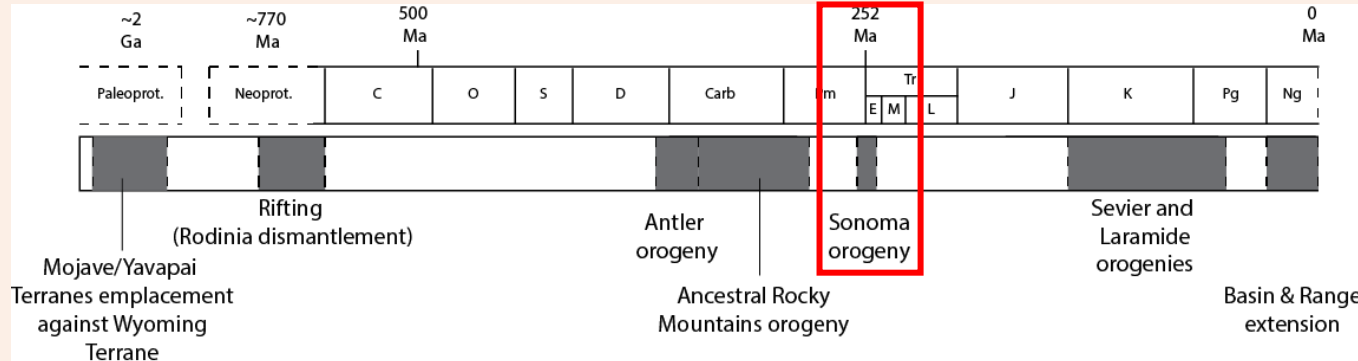
Introduction and localization

Long and complex tectonic history of the Eastern Great Basin

Many now obliterated orogenic features

⇒ Focus on the **Sonoma orogeny**
(~252 Ma at the **Permian-Triassic Boundary**)

⇒ **Sonoma Foreland Basin**
formed by emplacement of **Golconda Allochthon**

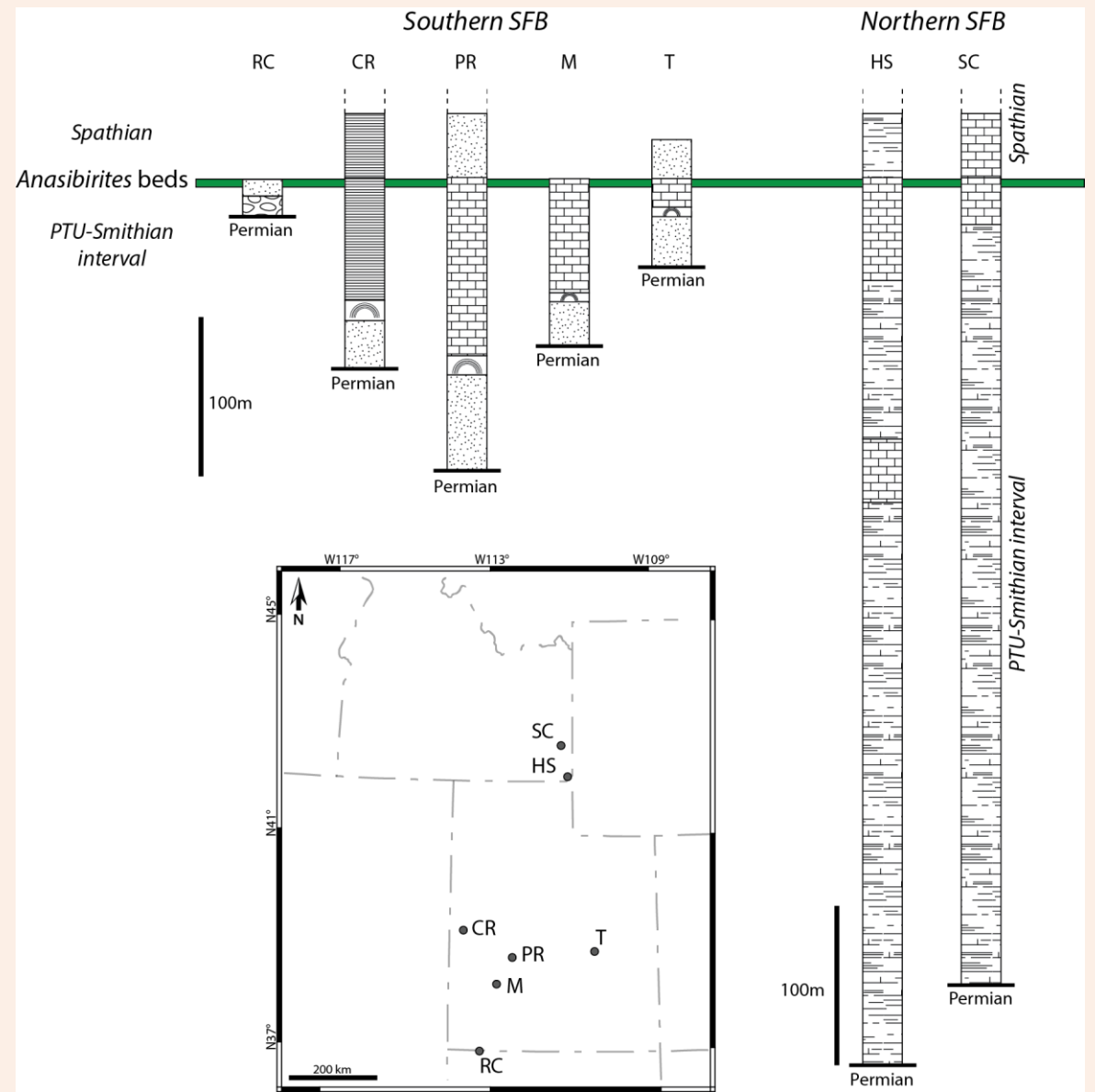
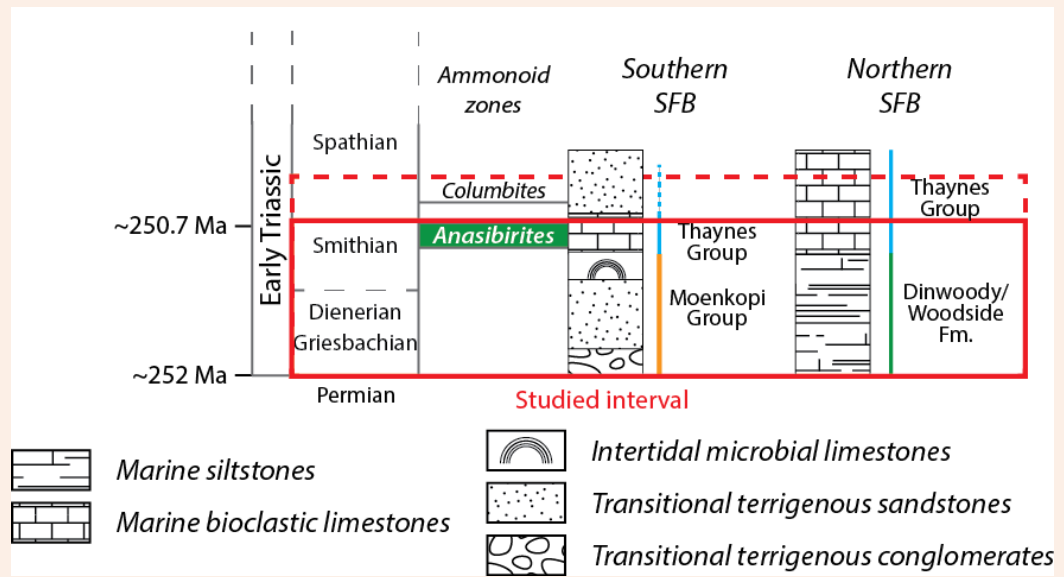


After Caravaca et al., subm.

Introduction and localization

Sonoma Foreland Basin (SFB)

- ⇒ **Excellent fossil and sedimentary record** of the aftermath of the end-Permian mass-extinction
- ⇒ **PT unconformity-Smithian interval** (PTU; ~1,3 Myr-long)
- ⇒ **Marked discrepancies** in term of facies and thicknesses between **northern and southern parts**



Methods

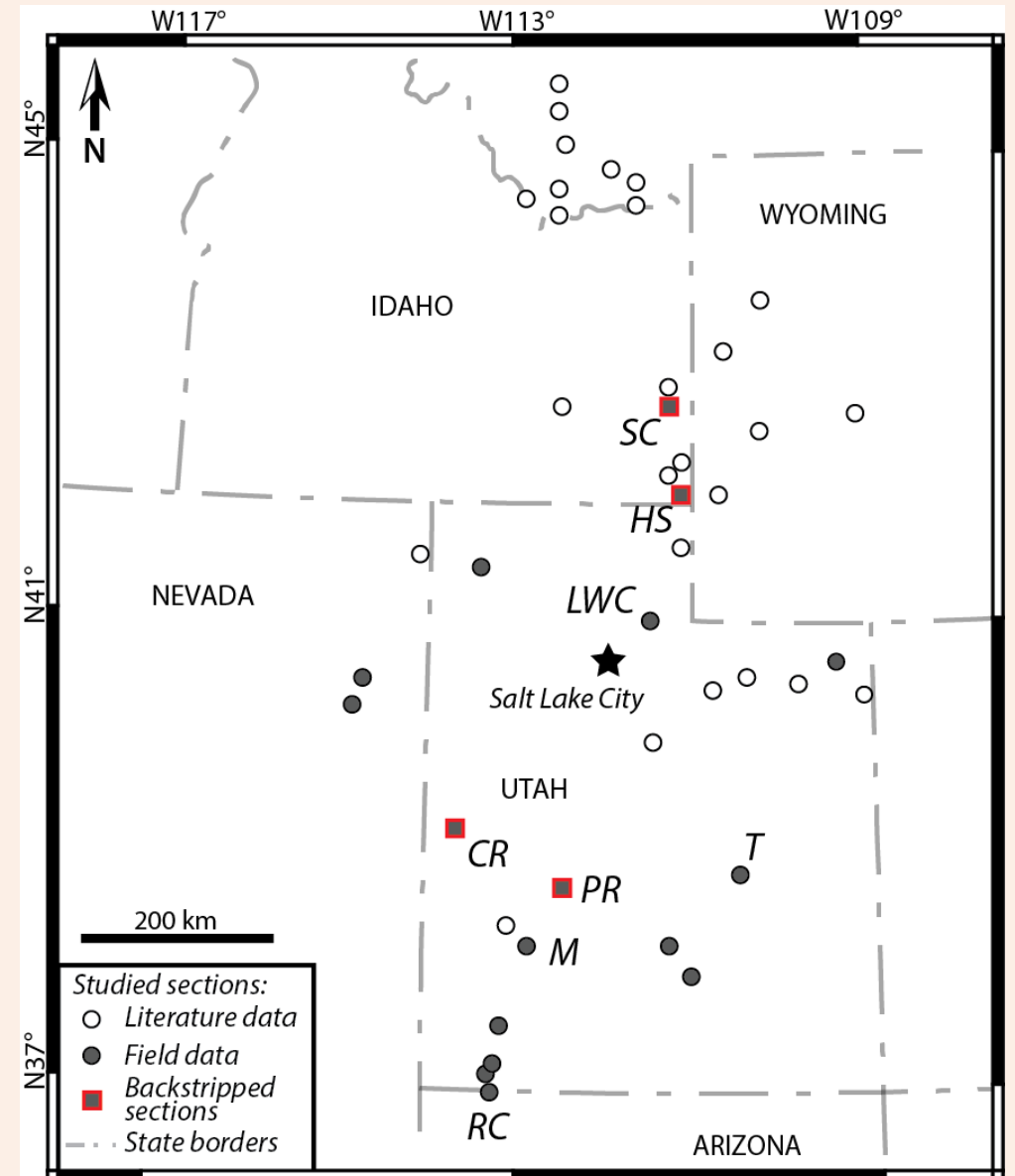
Focus on these record discrepancies and their origin

⇒ **Integrated basin-scale study**

Using sedimentology, paleontology, cartography, GIS spatialization

Dataset:

- **43 selected sections** after literature and field work
- **High time-resolution biostratigraphic framework** based on ammonoids biozonation (after Brayard *et al.*, 2013)



After Caravaca *et al.*, subm.

Methods

Focus on these record discrepancies and their origin

⇒ Integrated basin-scale study

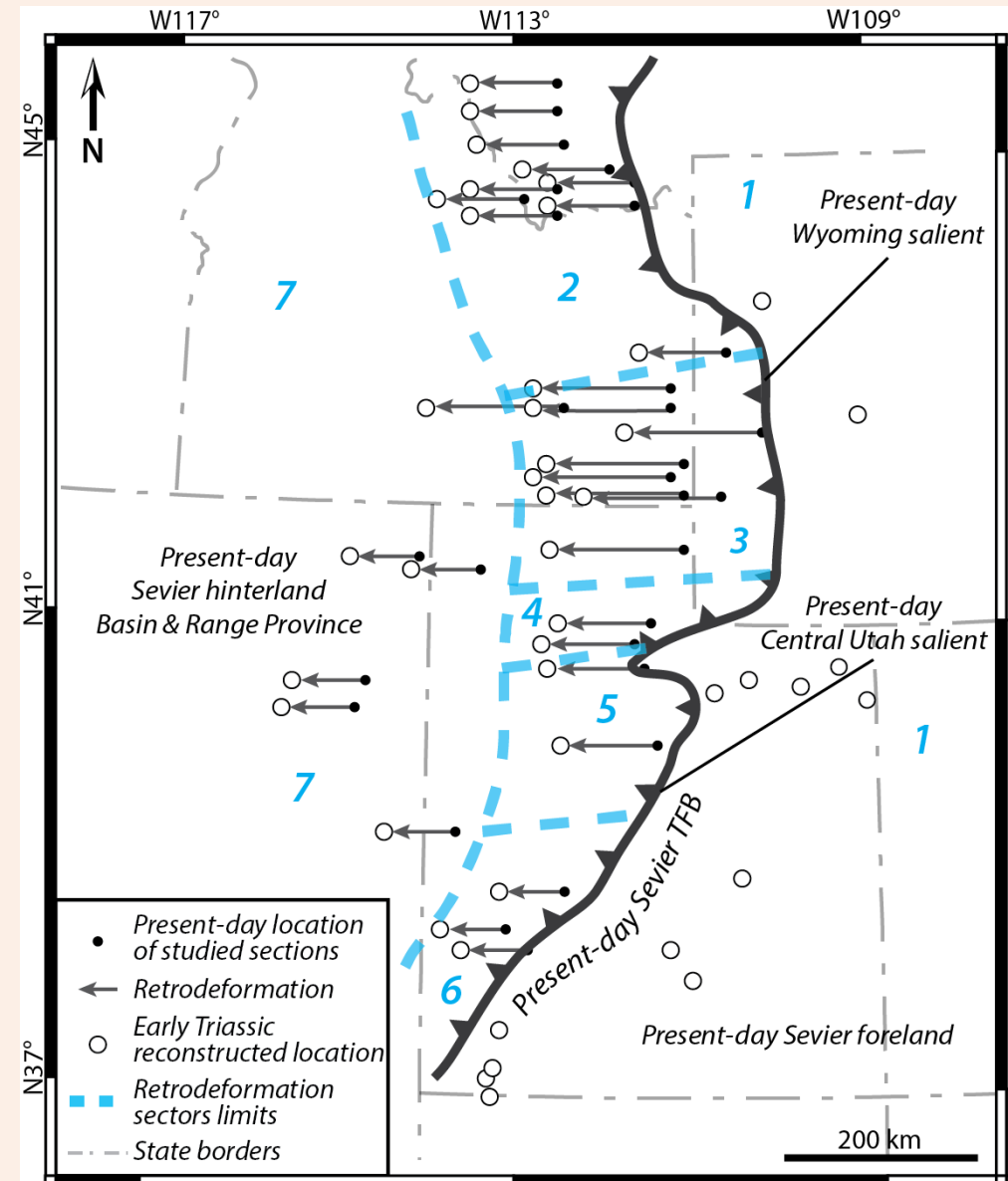
Using sedimentology, paleontology, cartography, GIS spatialization

Dataset:

- 43 selected sections after literature and field work
- High time-resolution biostratigraphic framework (after Brayard *et al.*, 2013)

Palinspastic reconstructions:

- **Necessary to obtain an unbiased view** of the area during the Early Triassic
- **Original location** of the sections within the basin



After Caravaca *et al.*, *subm.*

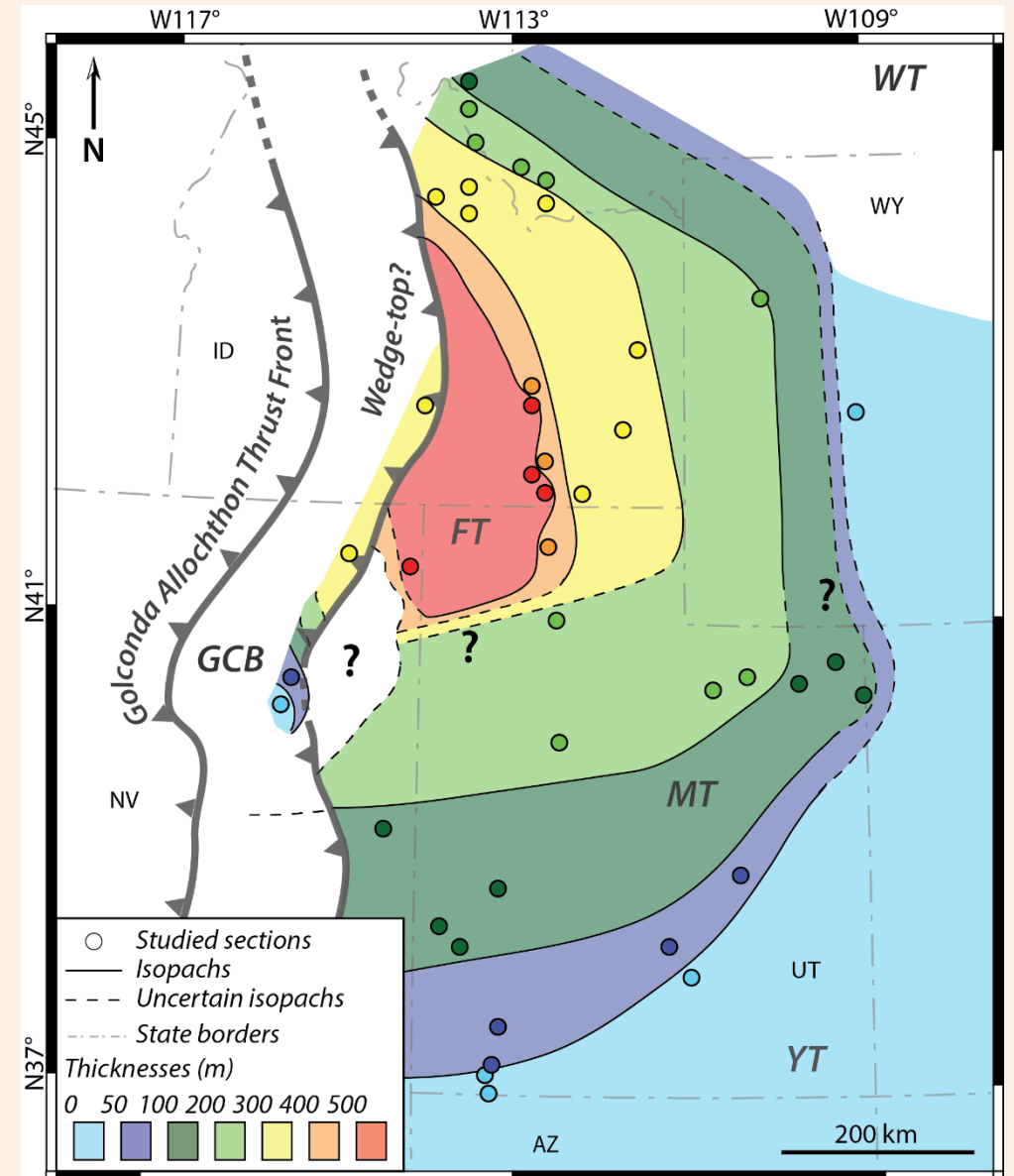
Results: thickness variations in the basin

Isopach map of the PTU-Smithian interval

⇒ Spatial distribution of sedimentary thickness

2 different areas in the basin:

- **Northern high thickness zone** (>300 up to ~550m thick)
- **Southern low thickness zone** (~10 up to 250m thick)



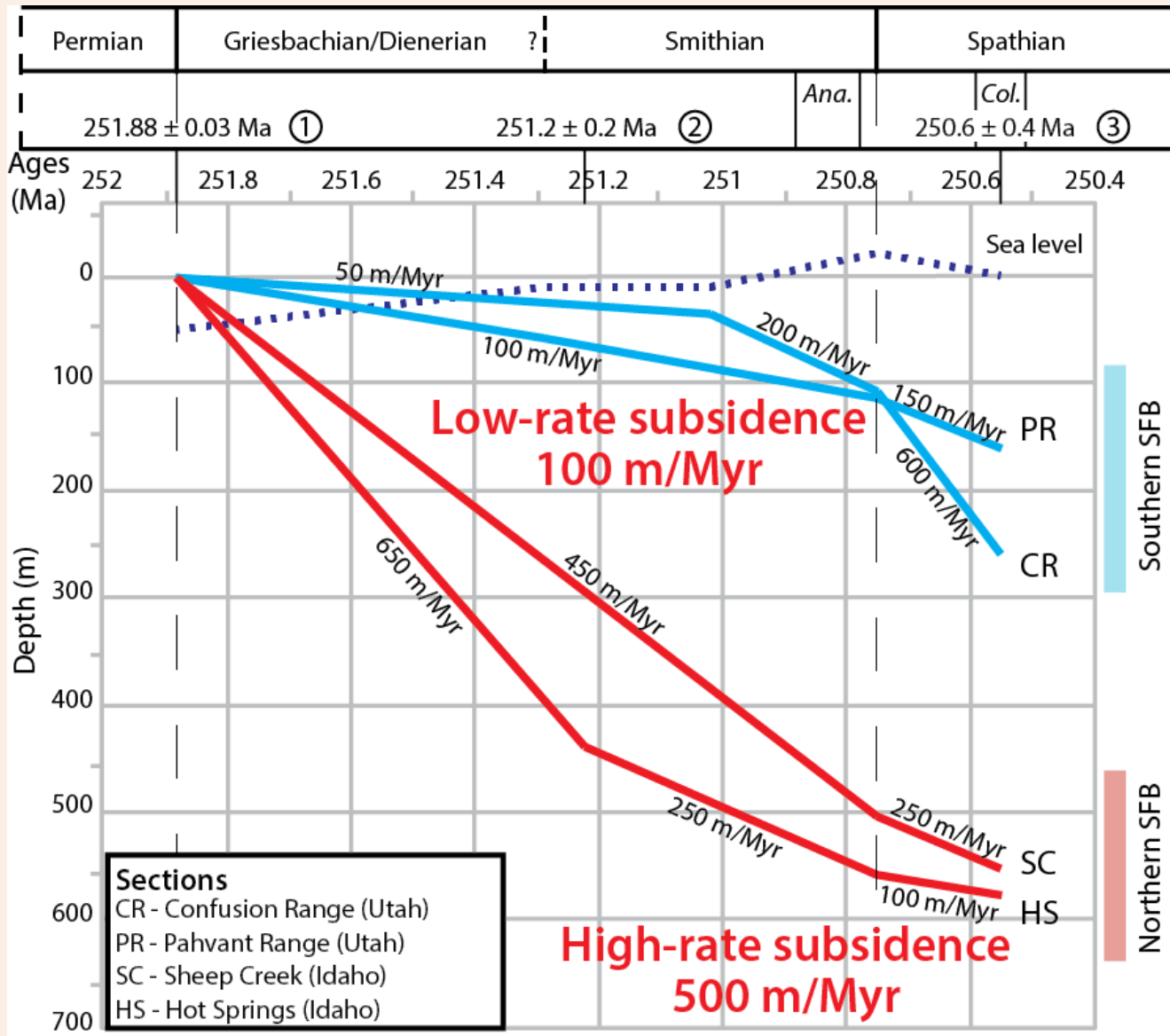
Results: subsidence variations in the basin

Backstripping analysis of the PTU-Smithian interval

- ⇒ Tectonic subsidence is preponderant
- ⇒ Shape: characteristic of a foreland basin

Differential subsidence in the basin:

- Northern high-rate subsidence
- Southern low-rate subsidence



After Caravaca et al., subm.



What are the mechanisms controlling this differential subsidence observed in the Early Triassic Sonoma Foreland Basin?

Hypotheses

- Sedimentary overload?

Sedimentary loading should be in southern SFB
⇒ **at variance with our results**

Southern SFB

Northern SFB



Coarse terrigenous of the Moenkopi Group
(conglomerates and sandstones)
($d \sim 2.5$ to 2.8 kg/cm^3)
Topped by metric beds of **microbial limestones**
($d \sim 2.6$ to 2.8 kg/cm^3)

Dominated by **fine marine siltstones** of the
Woodside and Dinwoody Fm.
($d \sim 2.3$ to 2.7 kg/cm^3)

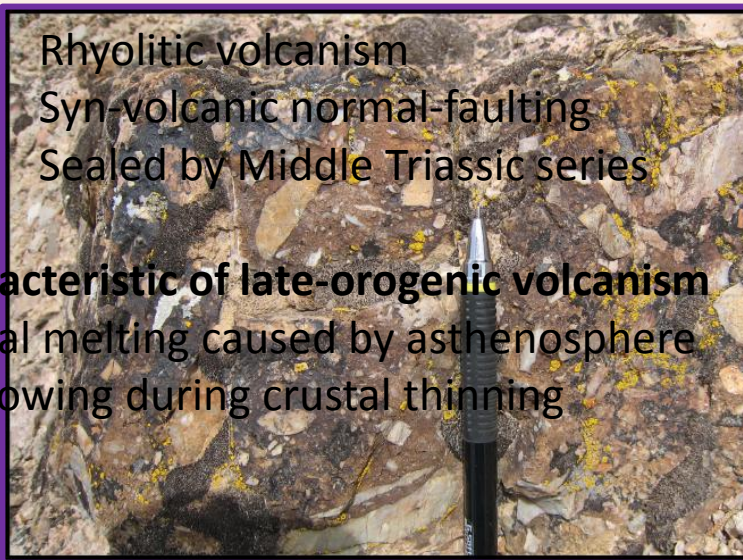
Hypotheses

- Differential topographic loading?

Golconda Allochthon remains in central Nevada:

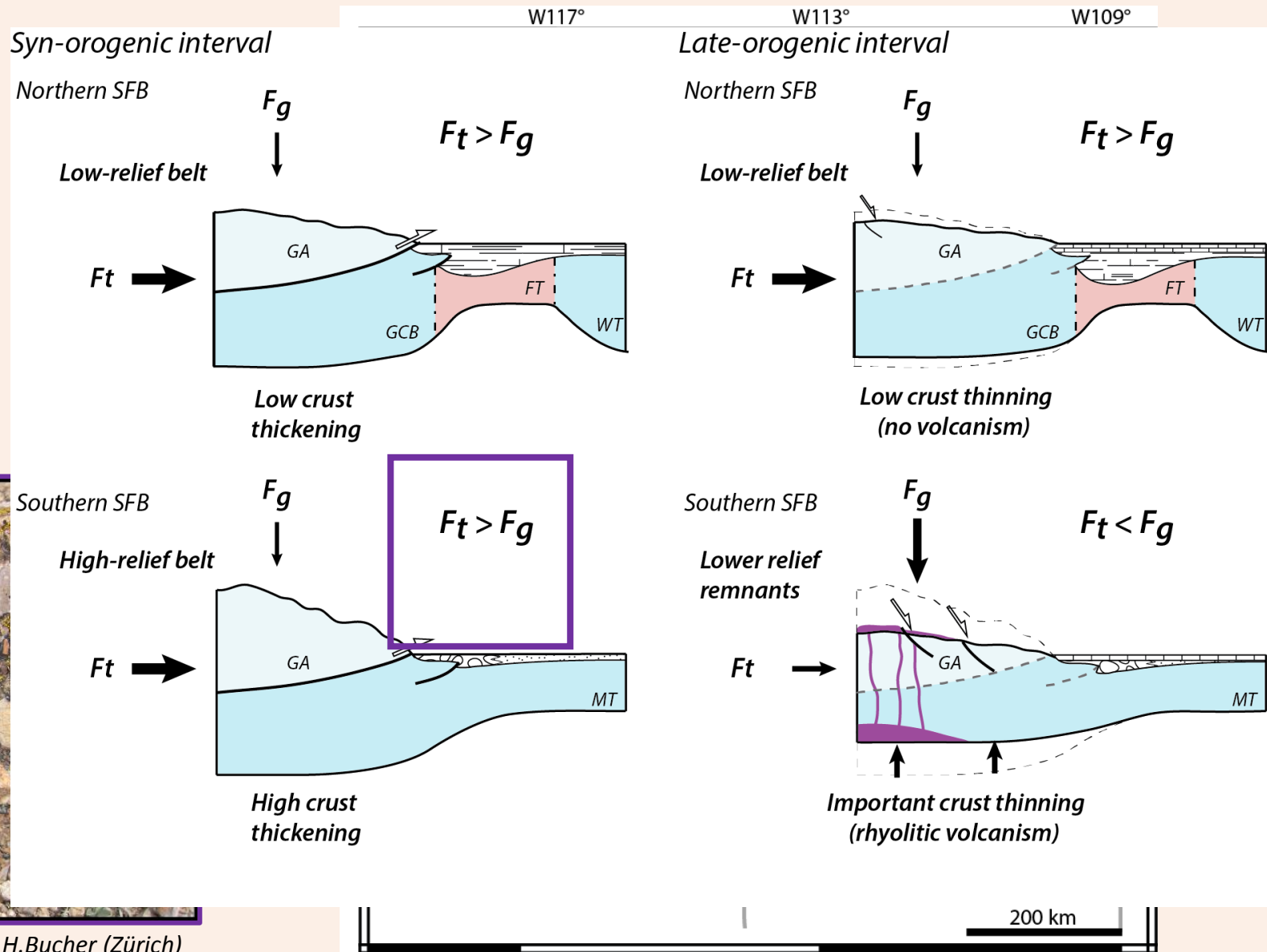
⇒ Presence of coarse conglomerates in West-central SFB

⇒ Presence of Koipato volcanics in Southwest SFB



⇒ **Characteristic of late-orogenic volcanism**
Partial melting caused by asthenosphere shallowing during crustal thinning

Photo courtesy of H. Bucher (Zürich)



Caravaca et al., subm.

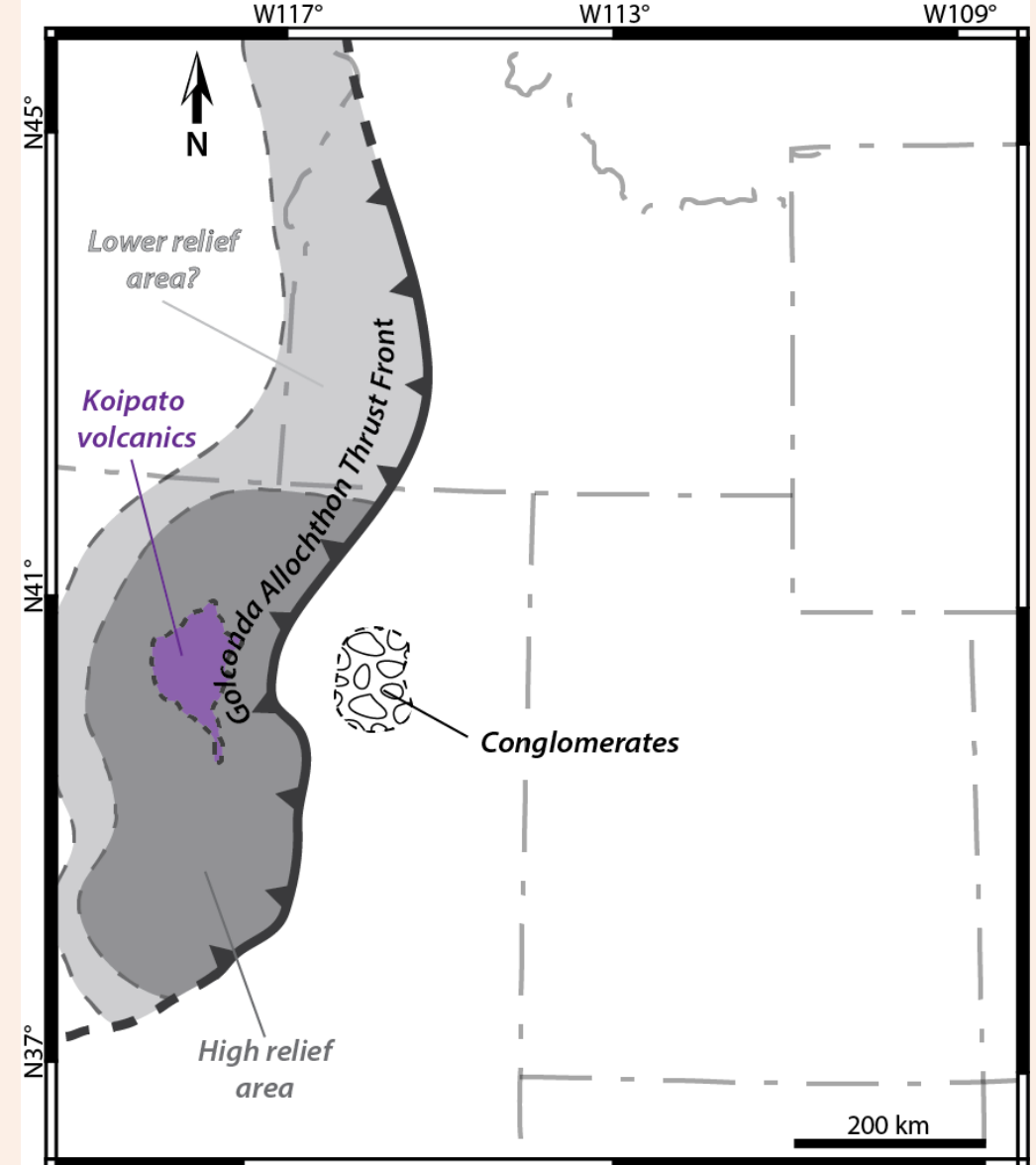
Hypotheses

- Differential topographic loading?

Highest relief in South-central Golconda front

⇒ **Cannot rule out impact of the topographic load**

⇒ **Not the main controlling factor**



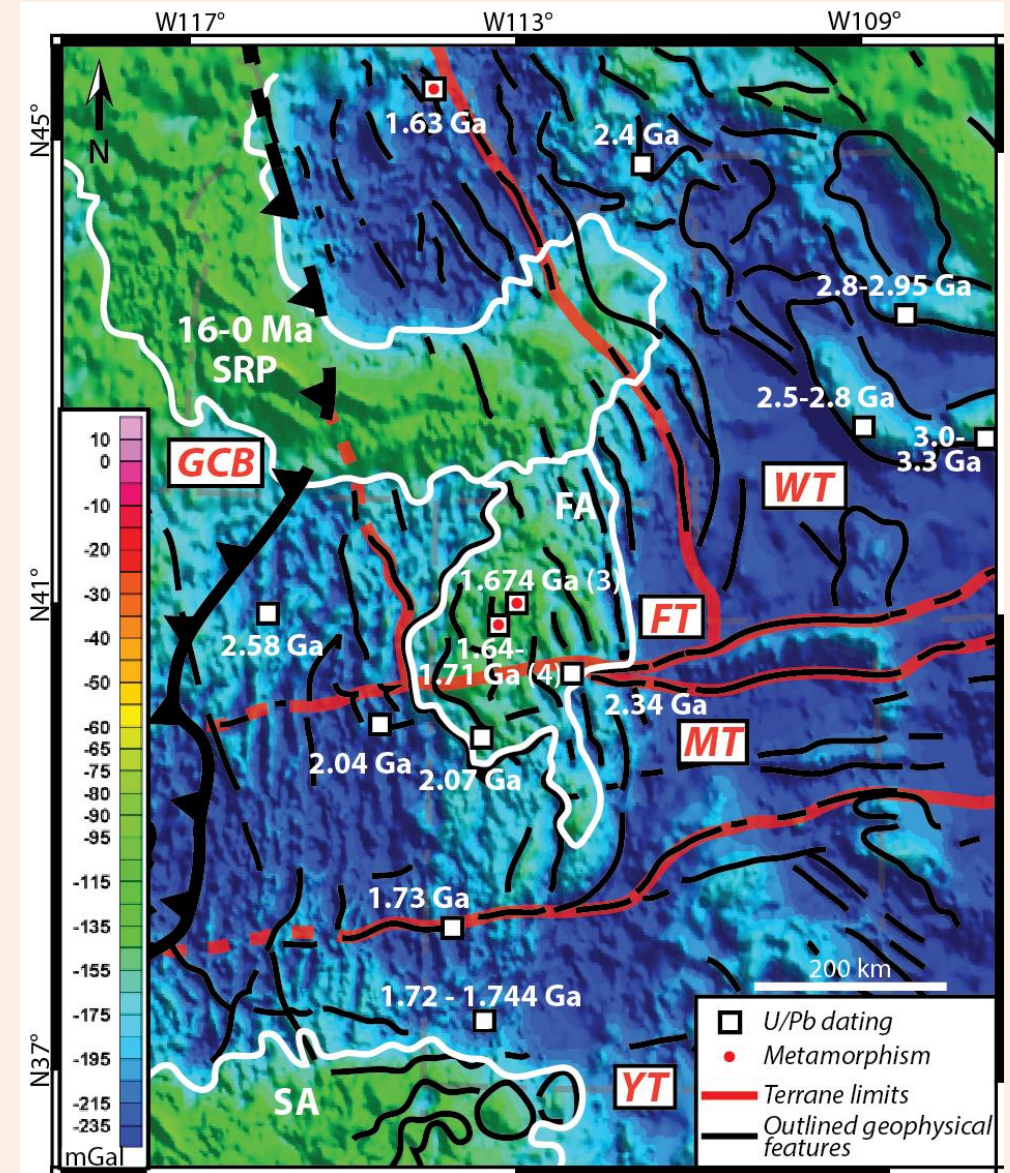
Hypotheses

- *Differential rheological resistance?*

⇒ **New local terrane maps from literature and geophysical data**

- **Five terranes identified, with different ages:**

- Archean Wyoming Terrane (WT)
- Archean Grouse Creek Block (GCB)
- Paleoproterozoic Mojave Terrane (MT)
- Mesoproterozoic Yavapai Terrane (YT)
- Mesoproterozoic Farmington Terrane (FT)



Hypotheses

- *Differential rheological resistance?*

⇒ Strong lithospheres

Oldest (>1.7 Ga), coldest and more rigid, **resistant to flexuration**

- WT, GCB, MT

⇒ Weak lithosphere

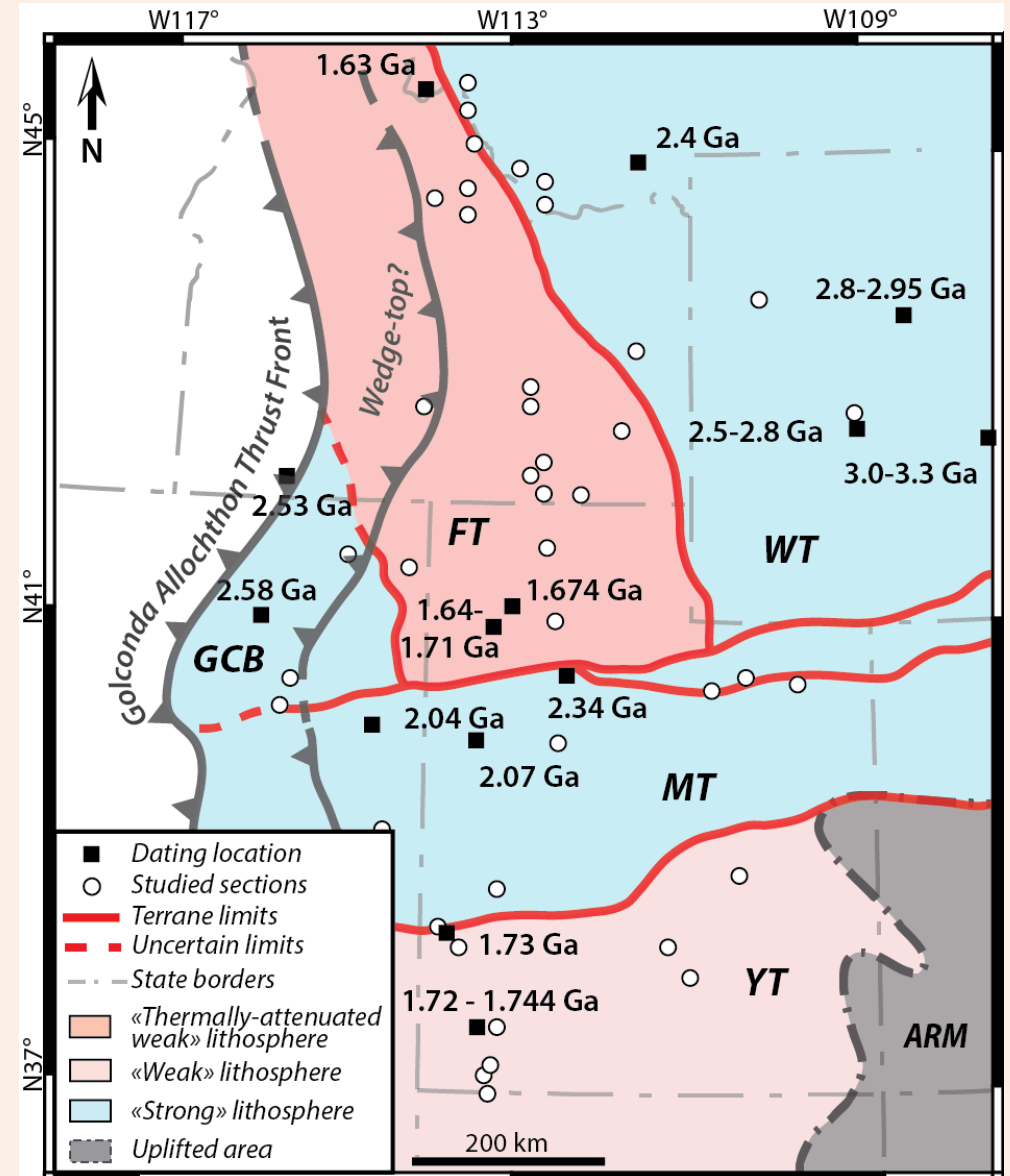
Juvenile (<1.6 Ga), warmer and **less rigid**, more prone to deformation and flexuration

- YT

⇒ Thermally-attenuated weak lithosphere

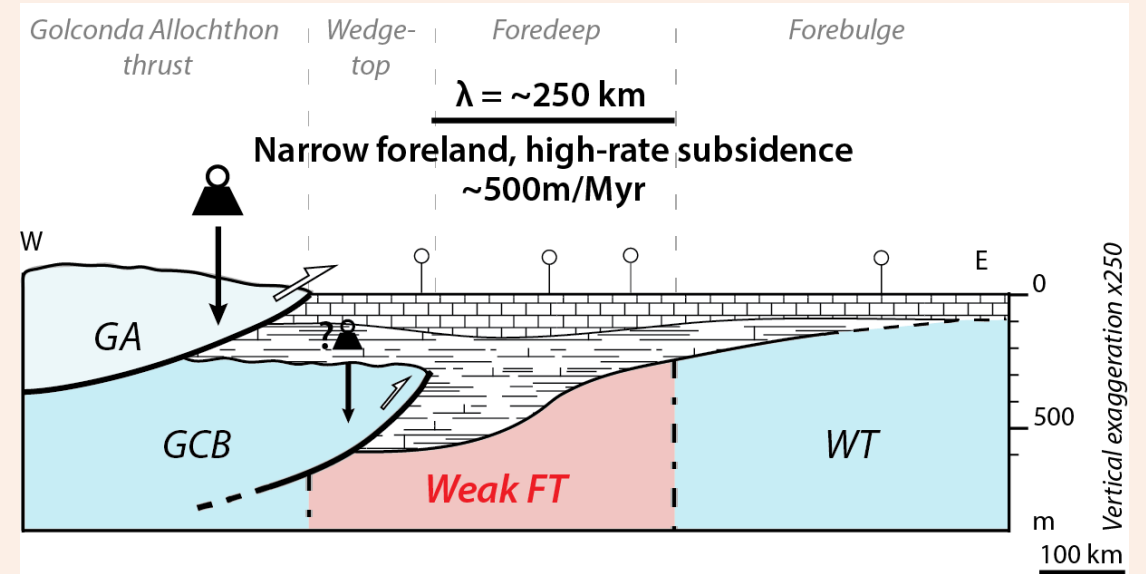
Underwent at least one **intense thermal metamorphism event** (~1,6 Ga)

- FT (Mobile belt)

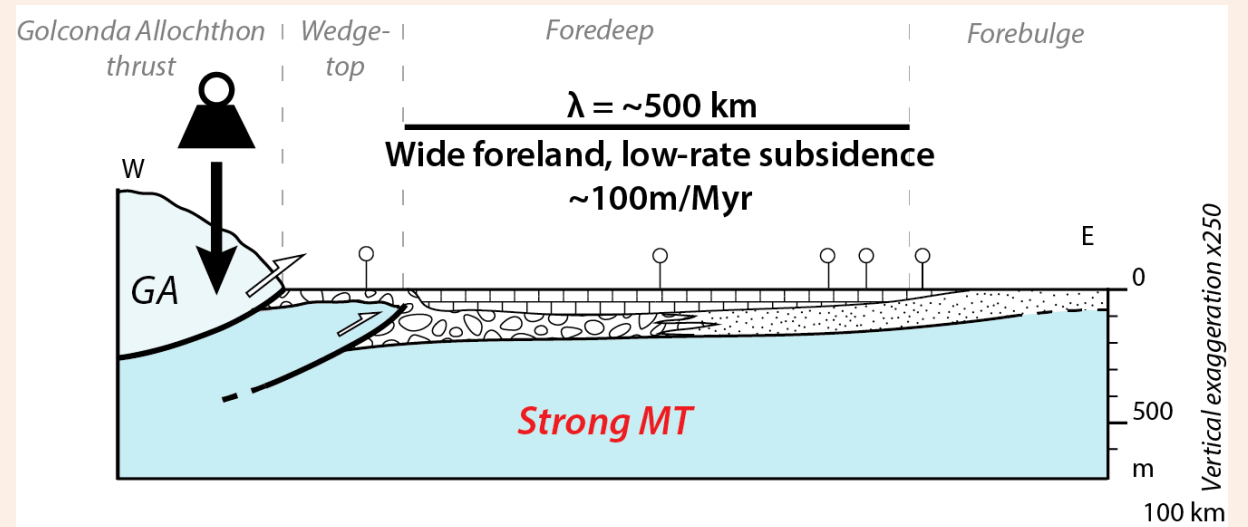


Proposed model

⇒ **Highest thicknesses and accommodation rates** in northern SFB above **Weak-attenuated** terrane



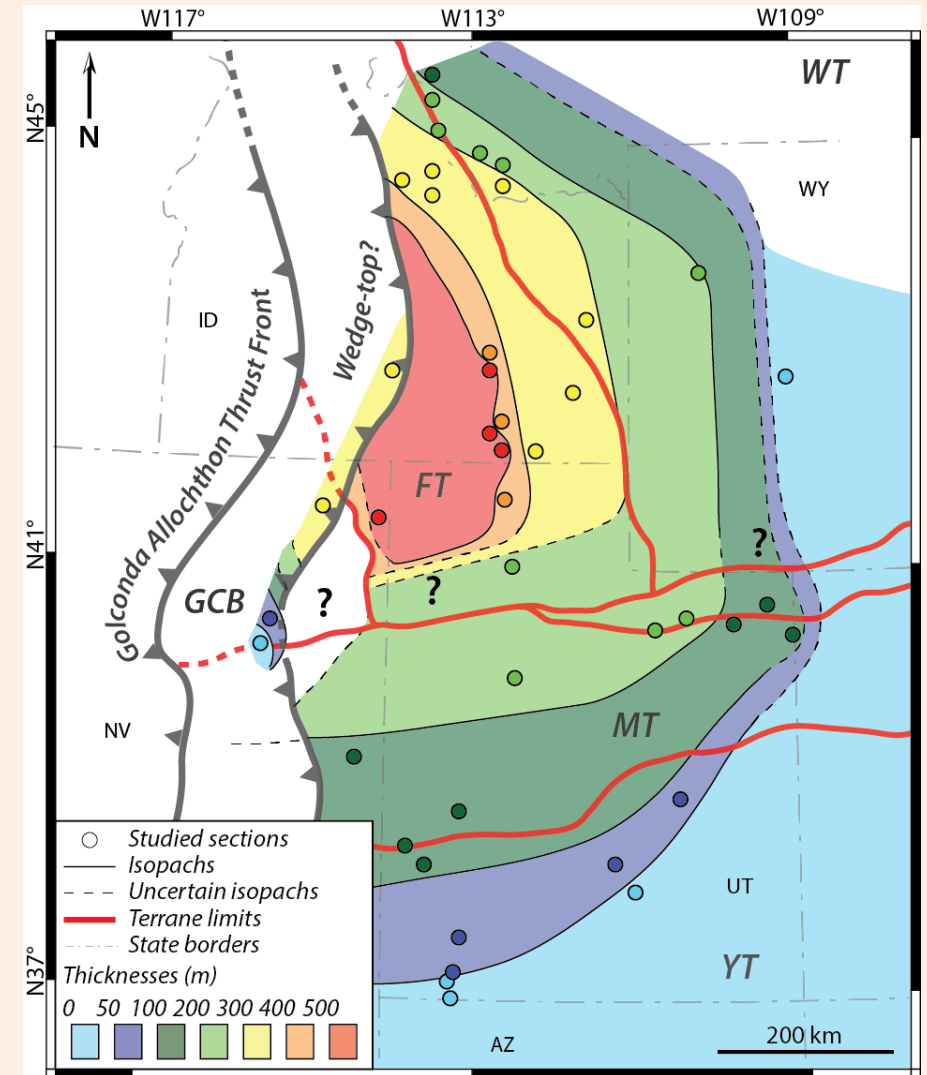
⇒ **Lowest thicknesses and accommodation rates** in southern and eastern SFB above **Strong** terranes



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Conclusion

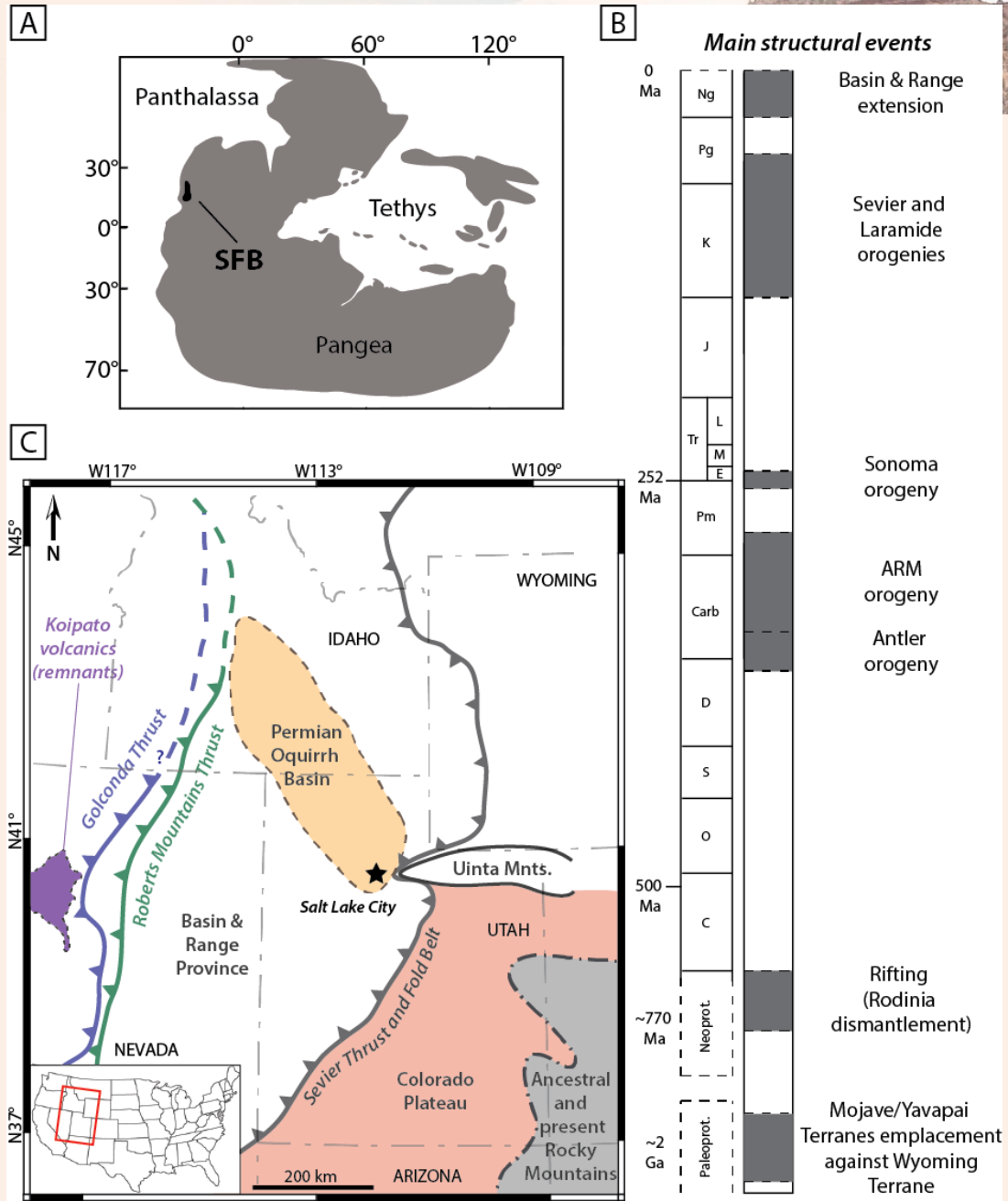
- Early Triassic **Sonoma Foreland Basin**: two parts with **differential tectonic subsidence**
- Controlling mechanisms?
 - **Negligible** sedimentary overloading
 - **Weak impact of the topographic loading**
 - **Rheological behaviour** of the basement is likely the main controlling factor
- **Lithospheric strength**: a major controlling factor on **flexuration**, and consequently on the **differential tectonic subsidence in the basin**



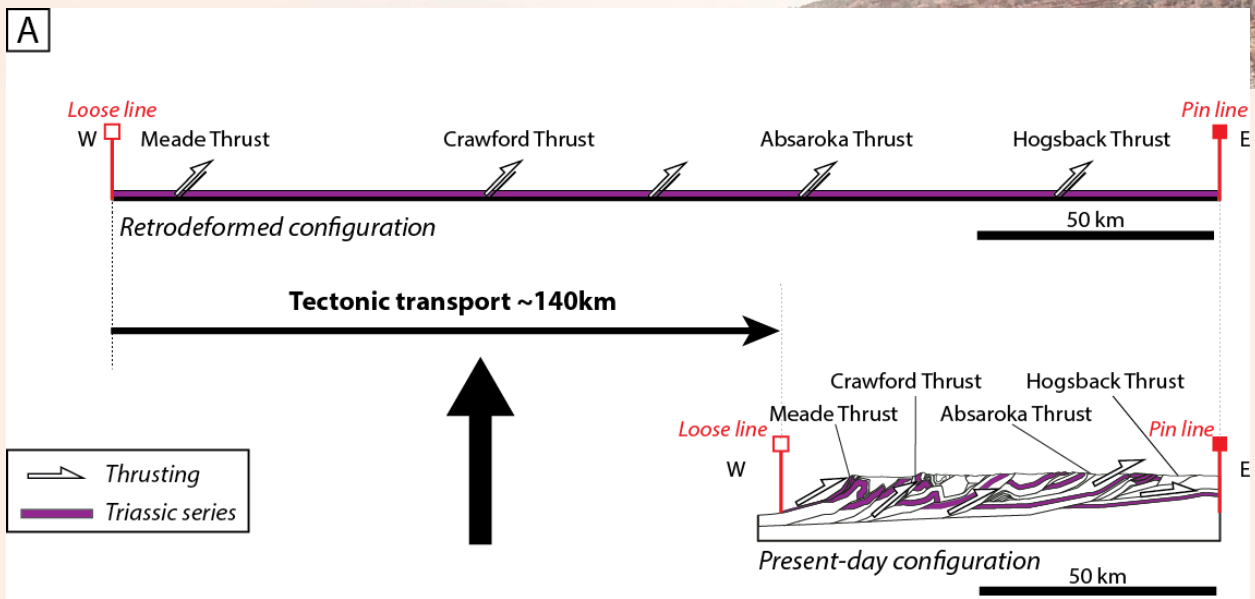
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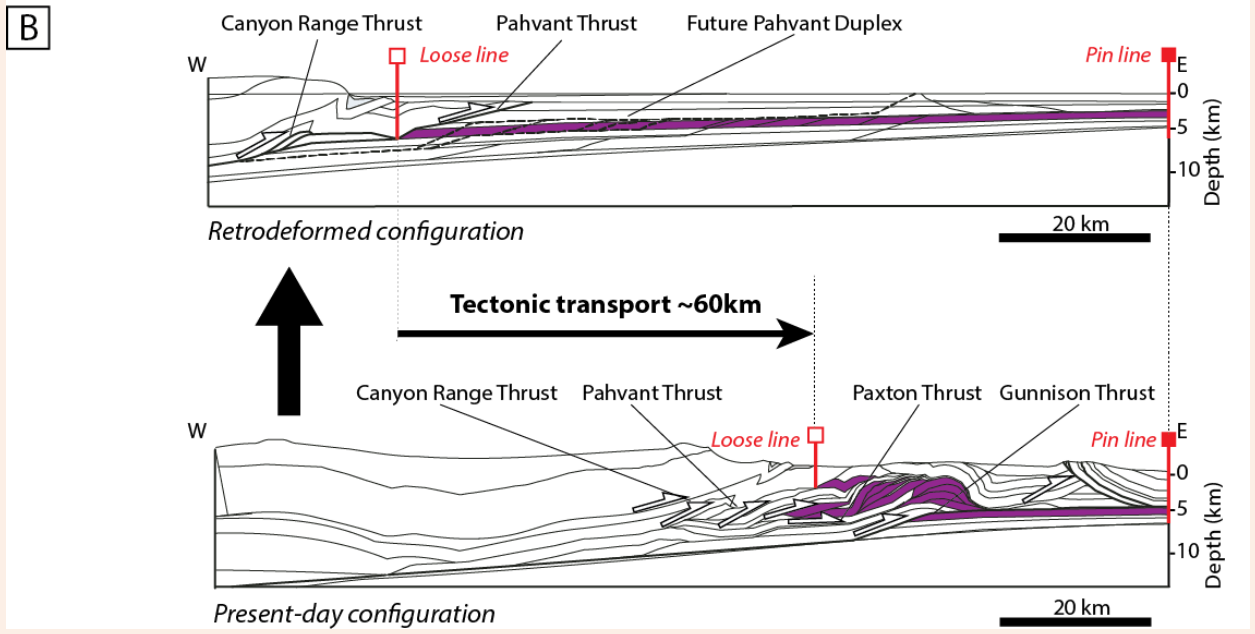
Supplements



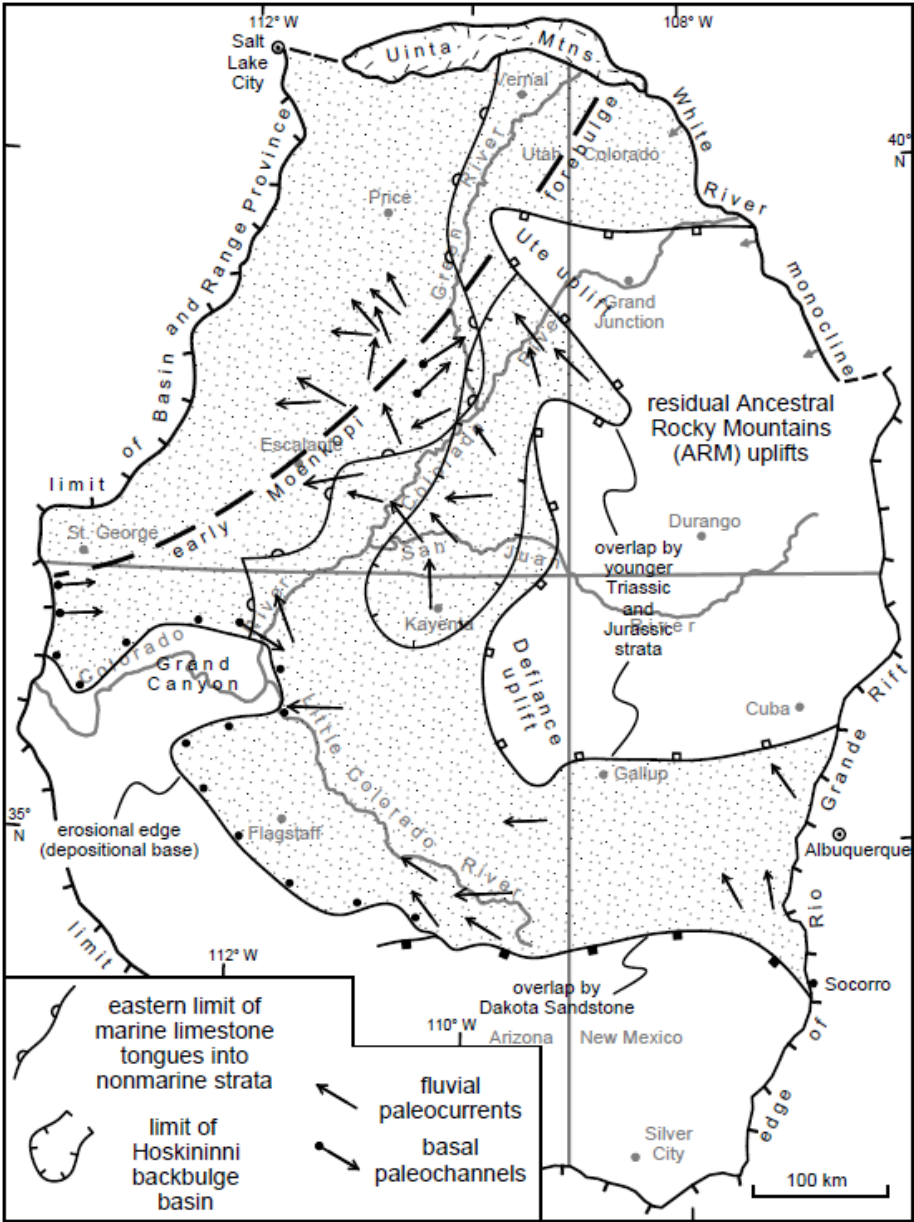
Caravaca_et_al_figure_1



Retrodeformation method



Perspectives: depositional settings



W.R. Dickinson, Pers. comm.

Oldest lithospheres are:

- Thicker and colder than juvenile counterparts (due to R* elements depletion)
 - More buoyant ($d^{\circ} < d^{\circ}$ juvenile lithosphere)
- ⇒ More rigid and resistant to flexuration

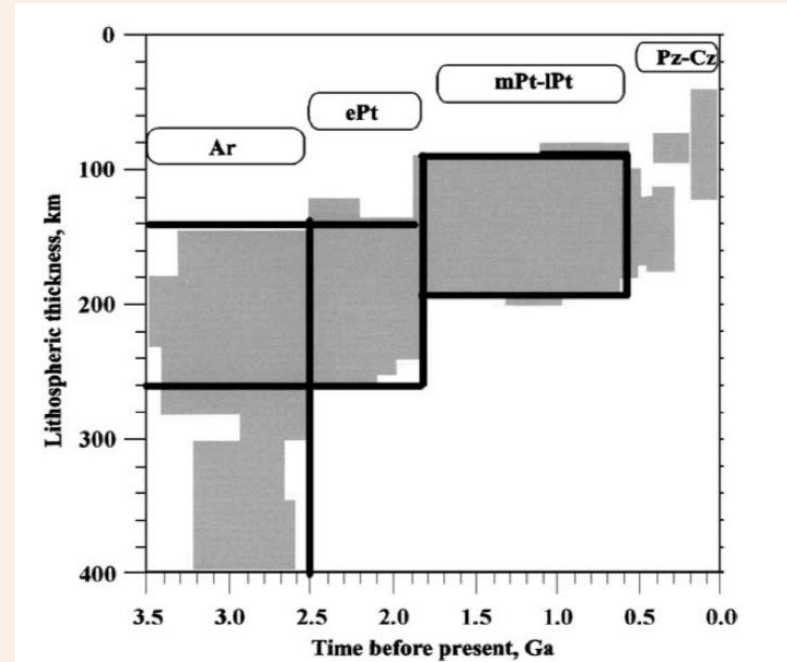
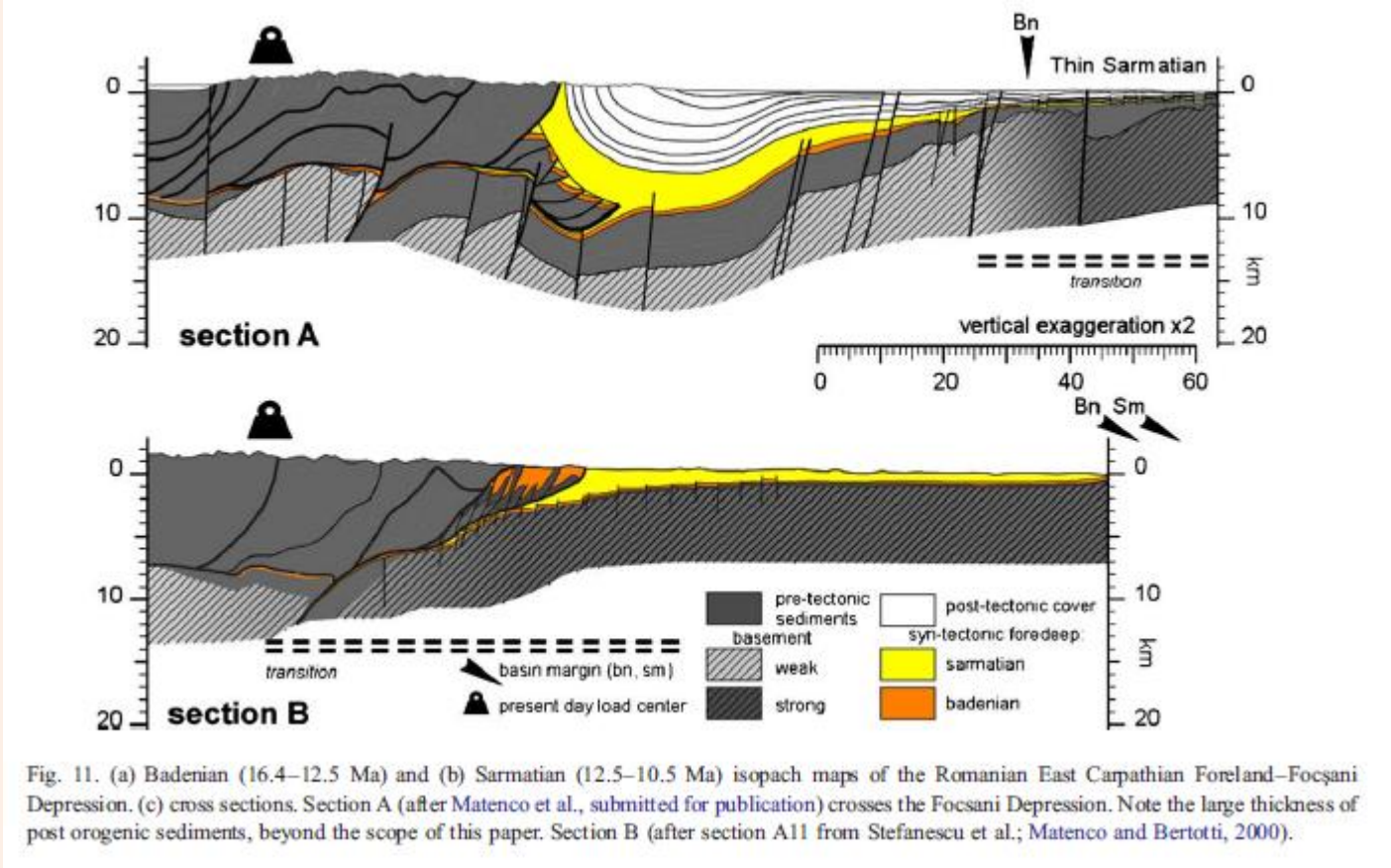
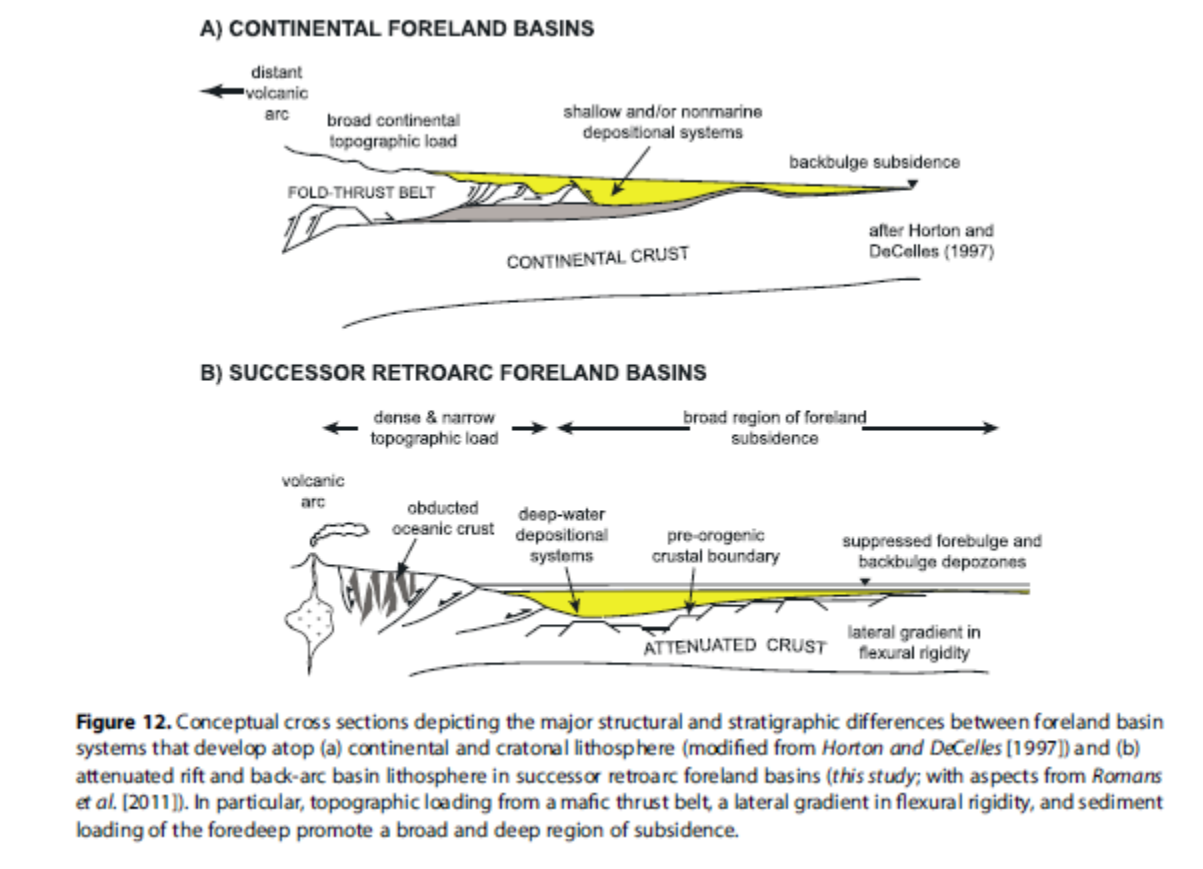


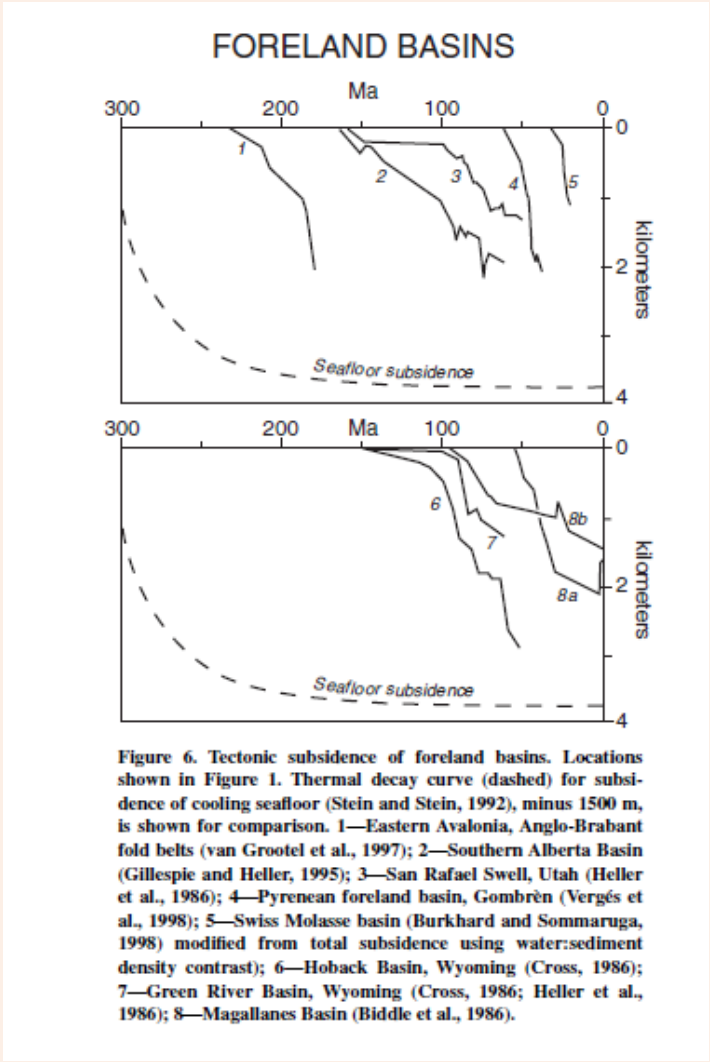
Fig. 2. Lithospheric thermal thickness versus geologic age of the continental lithosphere. The Archean lithosphere has bimodal thickness distribution centered at ~ 350 and ~ 220 km. Gray area shows the lithospheric thickness estimates derived from thermal data (Artemieva and Mooney, 2001). Key: Ar—Archean; ePt, mPt, lPt—early, middle and late Proterozoic, respectively; Pz—Paleozoic; Cz—Cenozoic.

Carpathians, differential subsidence after rheology

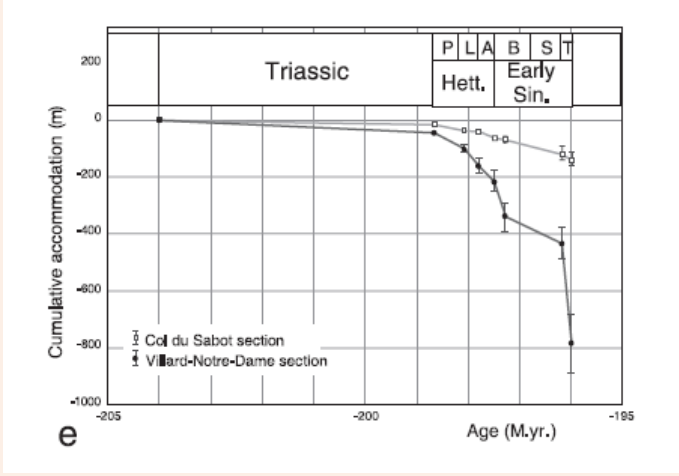


Magallanes basin, differential subsidence after rheology (attenuated lithosphere)

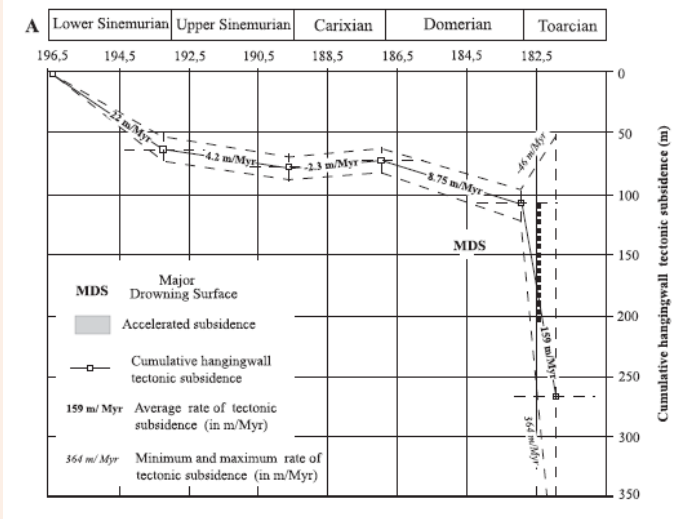




Xie & Heller, 2009



Chevalier et al, 2003



Lachkar et al., 2009

Perspectives: depositional settings

Depositional settings distributions between the *Owenites* and *Anasibirites* ammonoids biozones (middle Smithian)

Striking **differences between southern and northern parts** of the basin:

⇒ **Differences between paleontological and sedimentological record**

⇒ **Paleogeography to be reconstructed** using this integrative set of data

⇒ **Impact of lithospheric control**

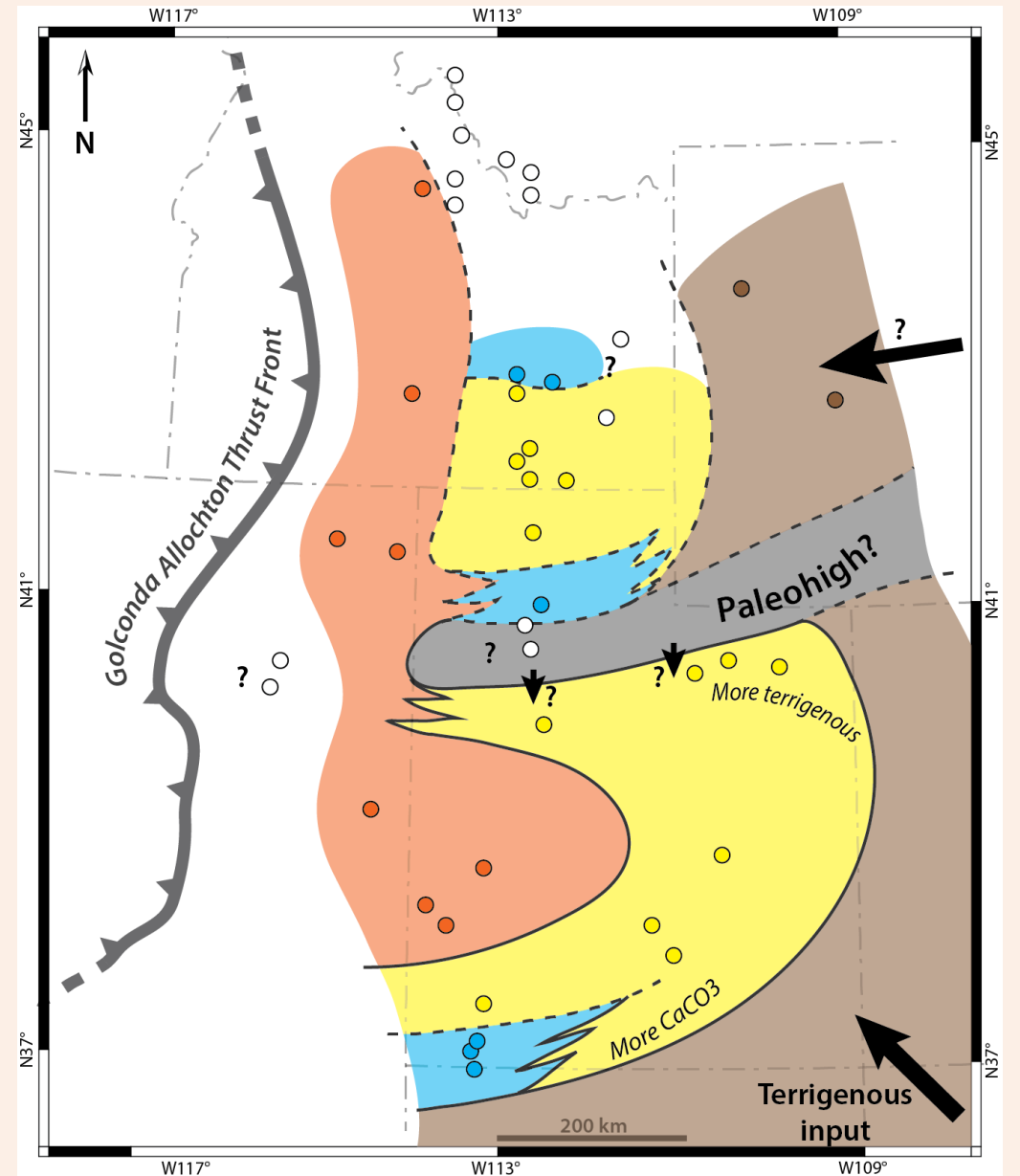
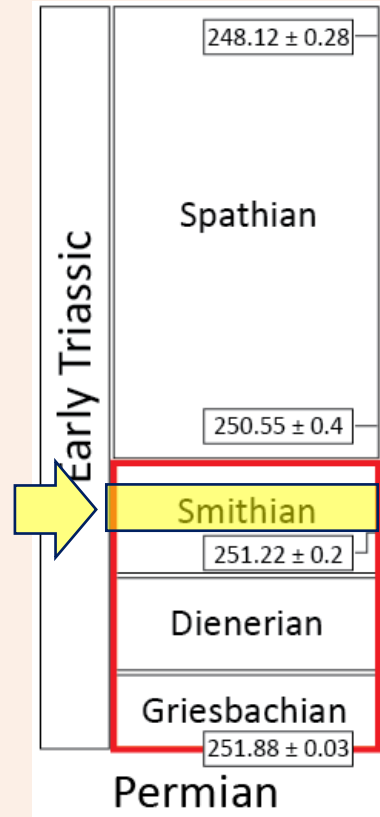
Depositional settings:

Orange: Deep subtidal

Yellow: Shallow subtidal

Blue: Subtidal to intertidal (microbial carb.)

Brown: Transitional/coastal (red beds)



Preliminary results