

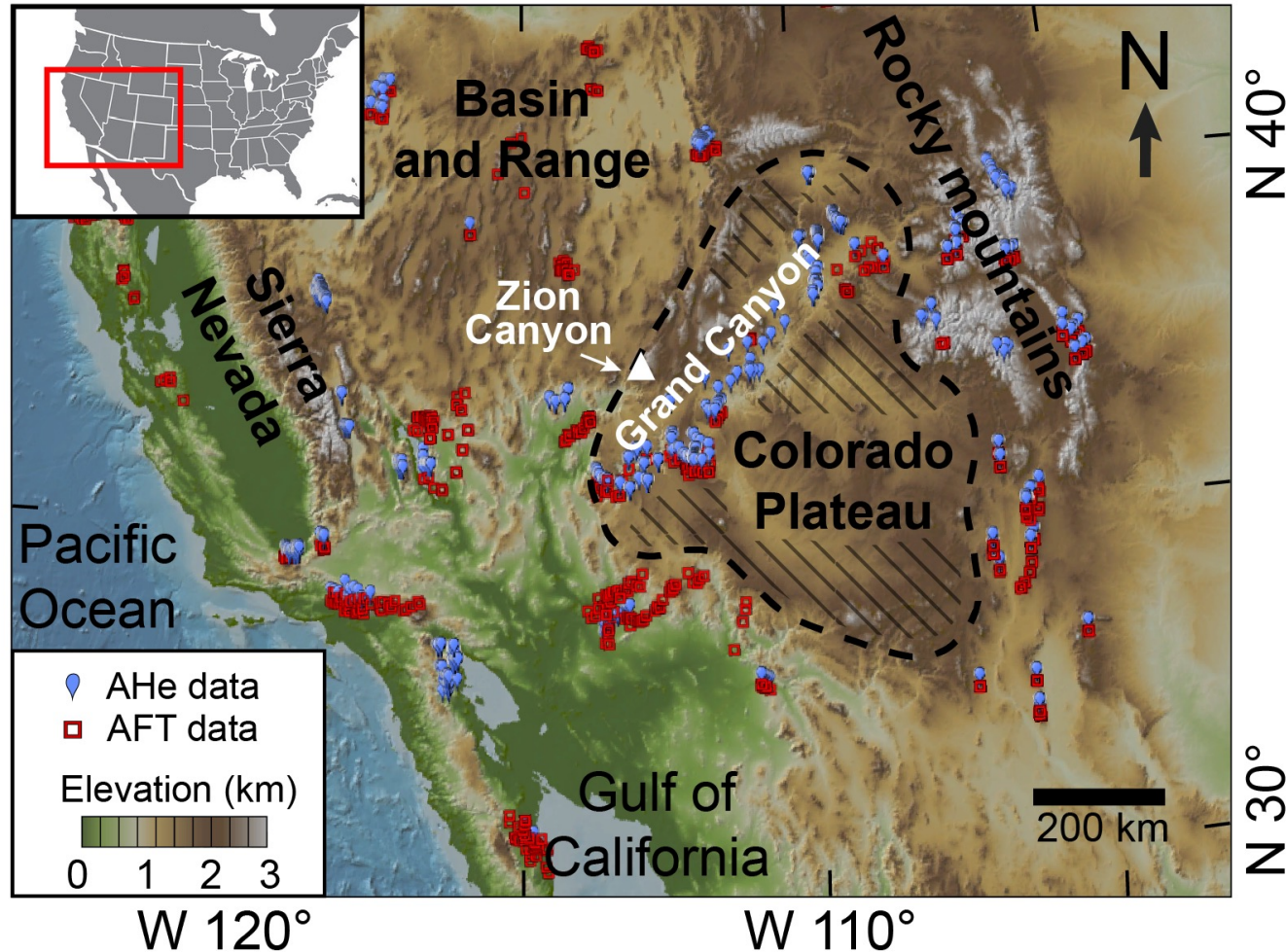
Timing of incision of the western margin of the Colorado Plateau, new thermochronological data from Zion Canyon

Audrey Margirier, Stuart Thomson, Peter Reiners



Colorado Plateau - Uplift and incision history

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- Elevation ~ 2000-2500 m
- Incision by the Colorado River system
- ✓ Extensive thermochronological data along the Grand Canyon
- × But not much in other places
- 3 uplift stages at 80-50 Ma, 35-15 Ma and 6-0 Ma (e.g., Karlstrom et al., 2014)
- Magnitude of each uplift phase and timing of incision are debated
- Processes driving uplift and incision?

Limitations of low-temperature thermochronology

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Temperature sensitivity of thermochronometers

- Apatite fission-track (AFT) = 120-80°C
- Apatite (U-Th-Sm)/He (AHe) = 90-50°C

Challenge of orogenic plateaus:

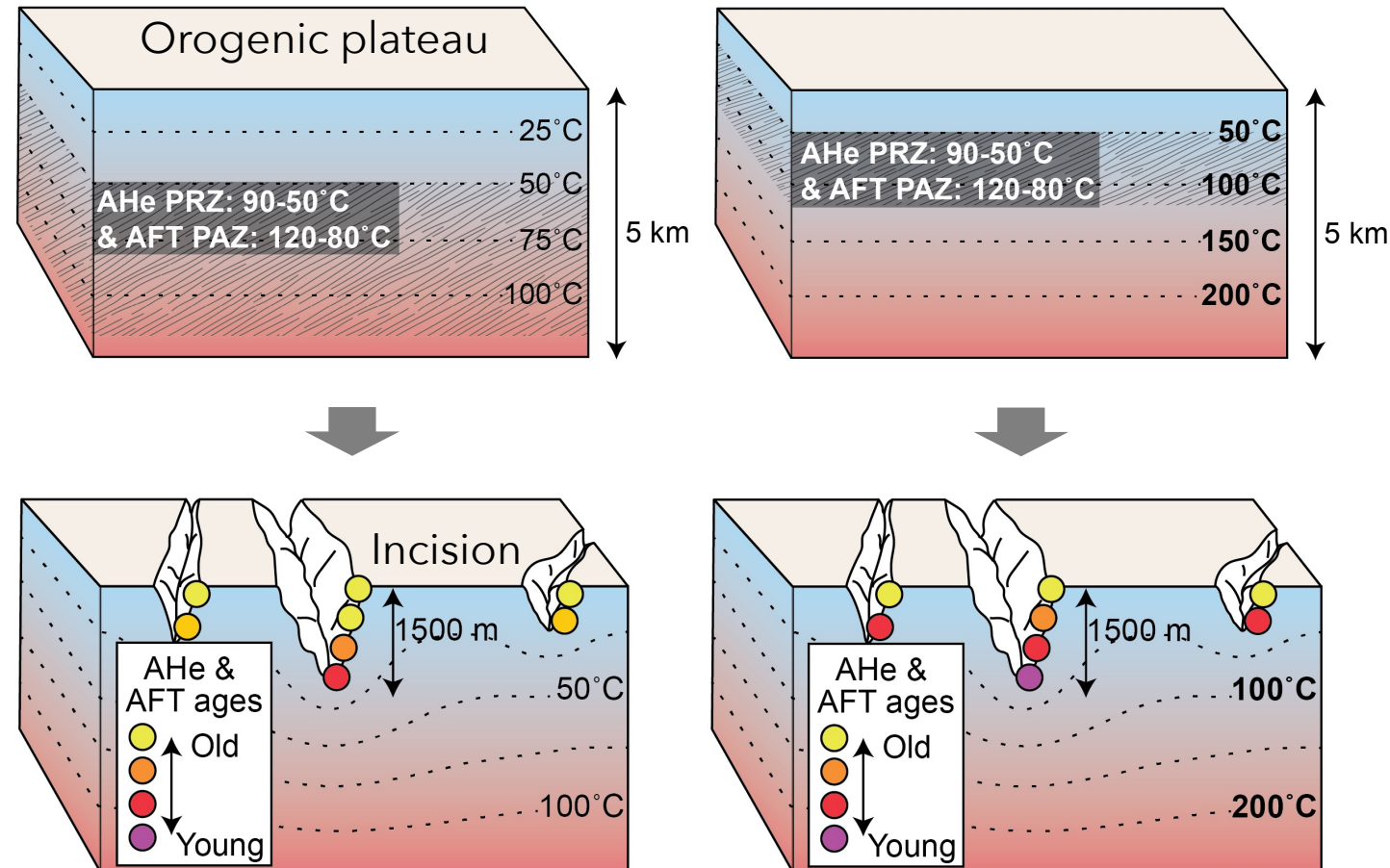
- Low magnitude exhumation

Colorado Plateau: canyons are only 800 - 1500 m deep

- Difficult to constrain incision using thermochronology

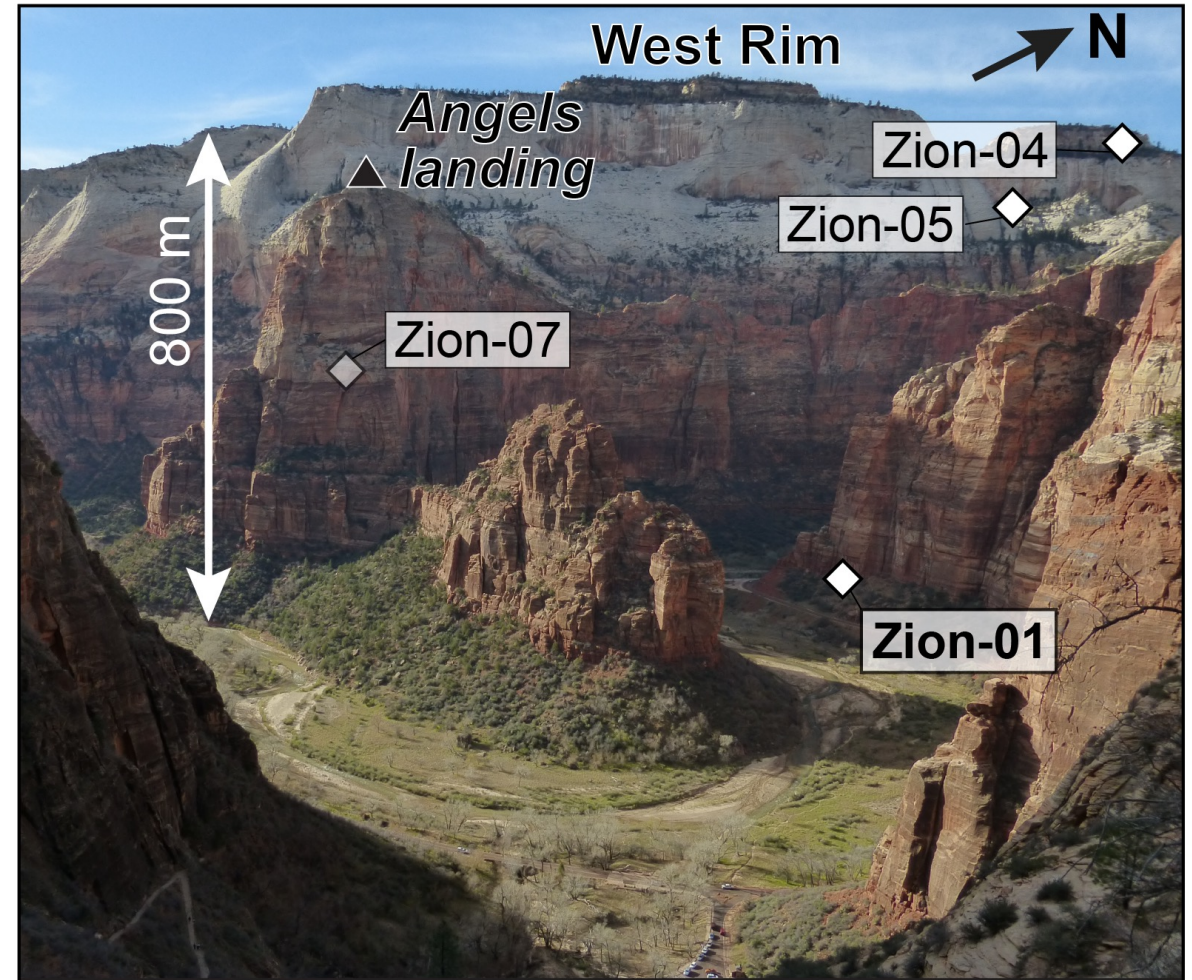
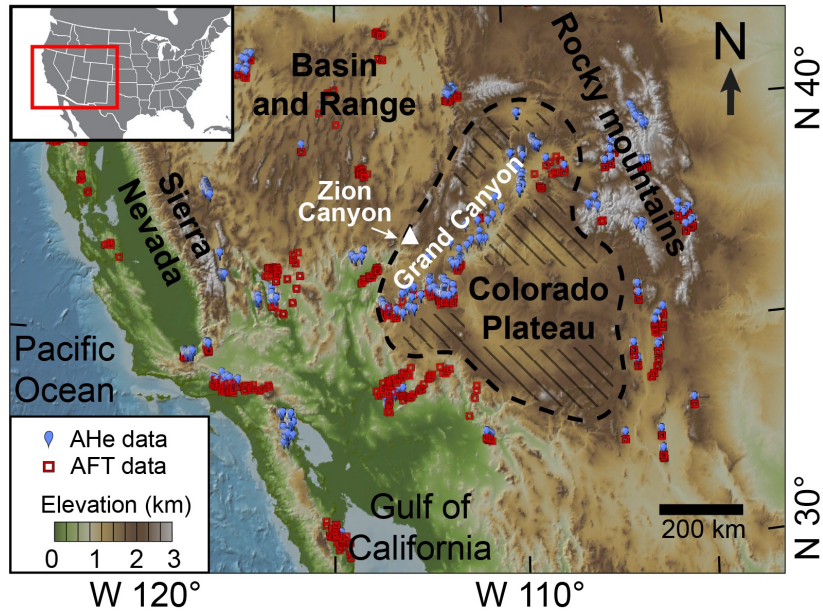
Hope:

- High geothermal gradient locally



Location of the study area: Zion Canyon

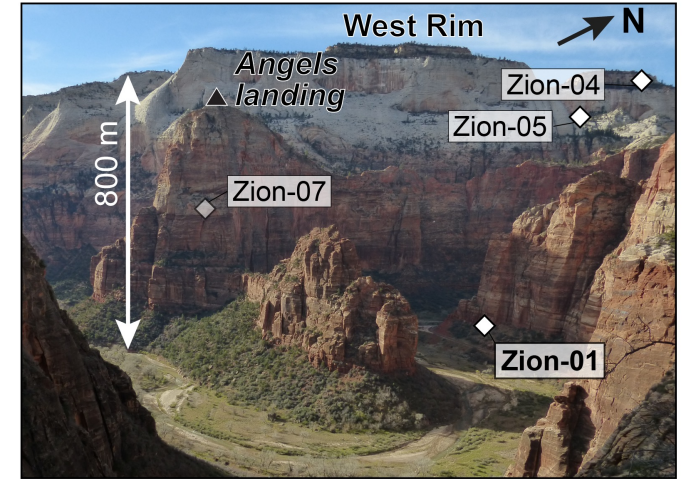
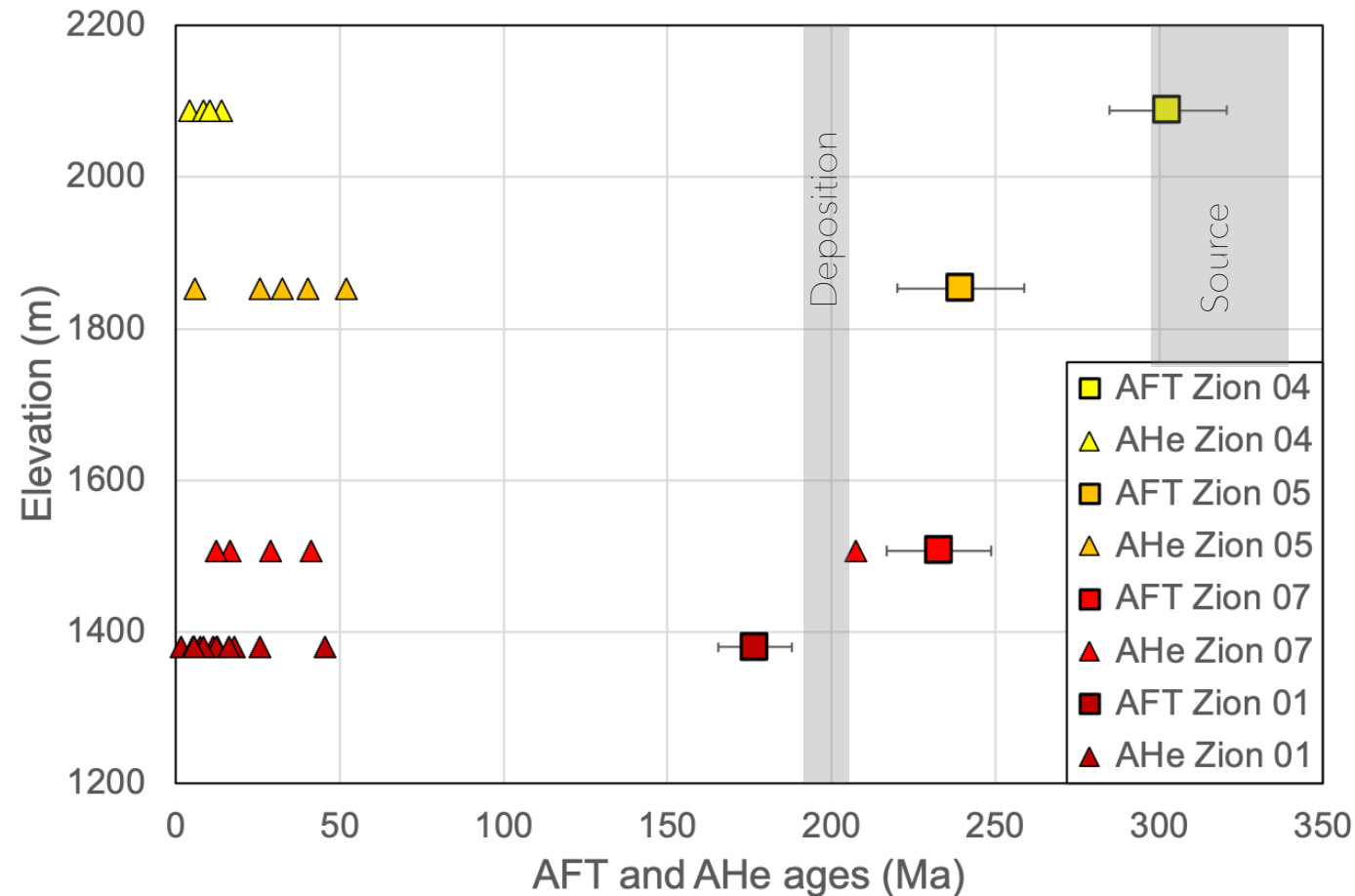
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- Geothermal gradient = $69^{\circ}\text{C}/\text{km}$ (Blackett, 2004)
- Sandstone (Navajo Formation) bearing apatites
 - Source = Appalachians
 - Deposition = 190 Ma

Results: Apatite fission track and apatite (U-Th-Sm)/He

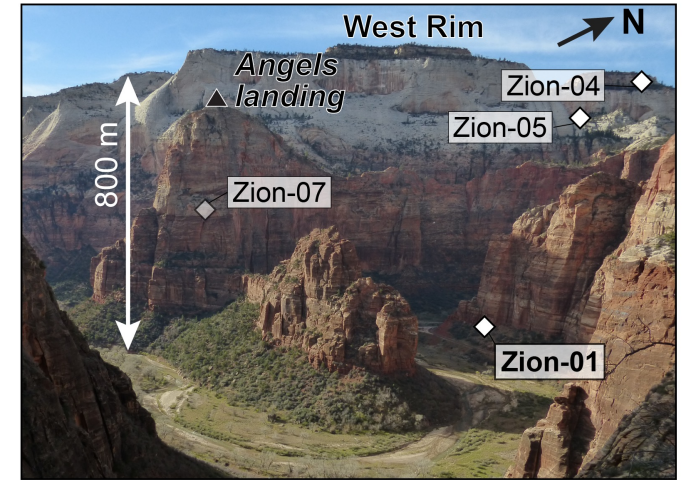
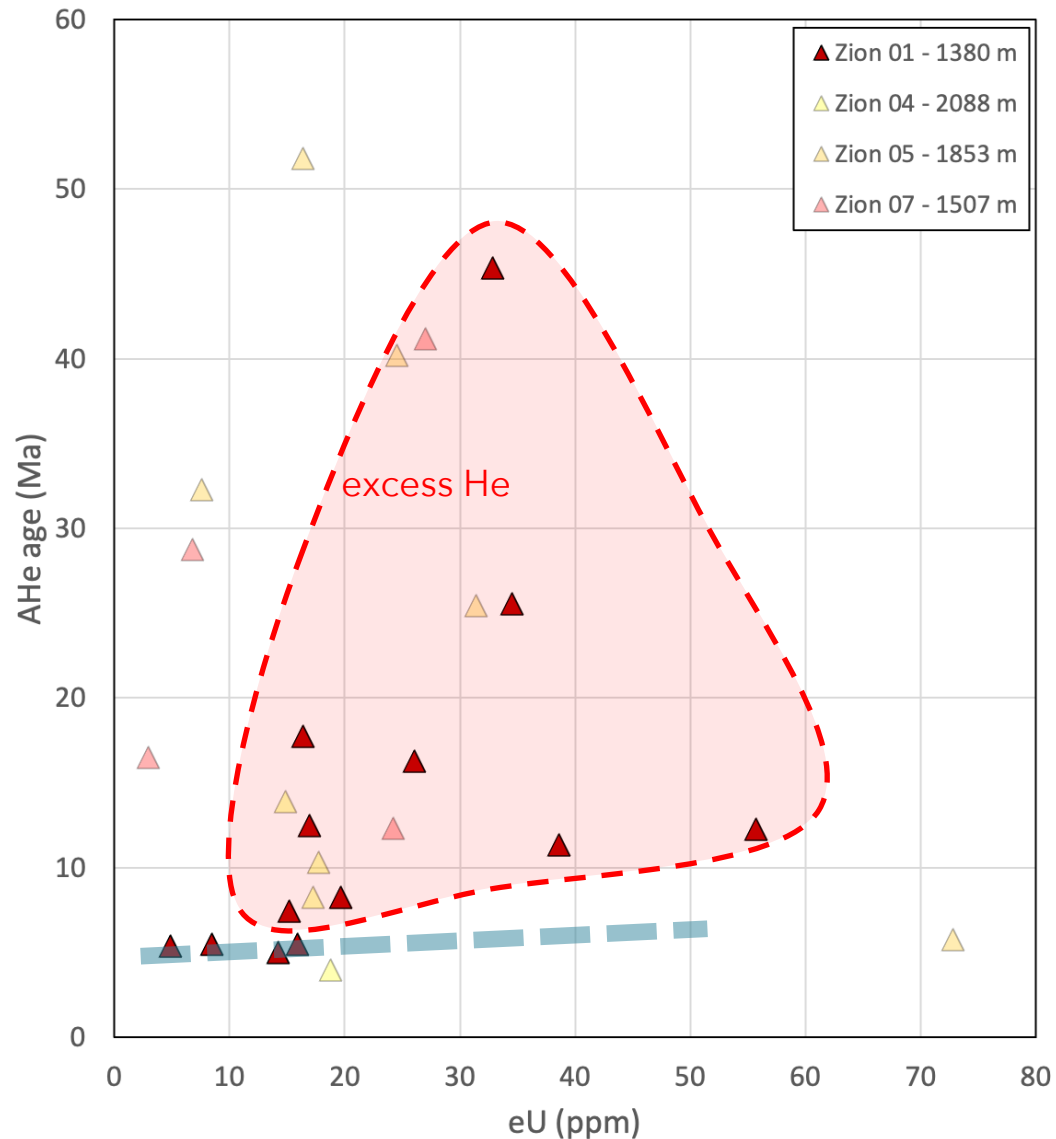
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- **140 Ma < AFT ages < 300 Ma**
 - *Most AFT dates are partially reset*
- **3 < AHe ages < 55 Ma**
 - *AHe ages are reset*
 - *Dispersion of AHe single grain ages*

Results: dispersion of AHe ages

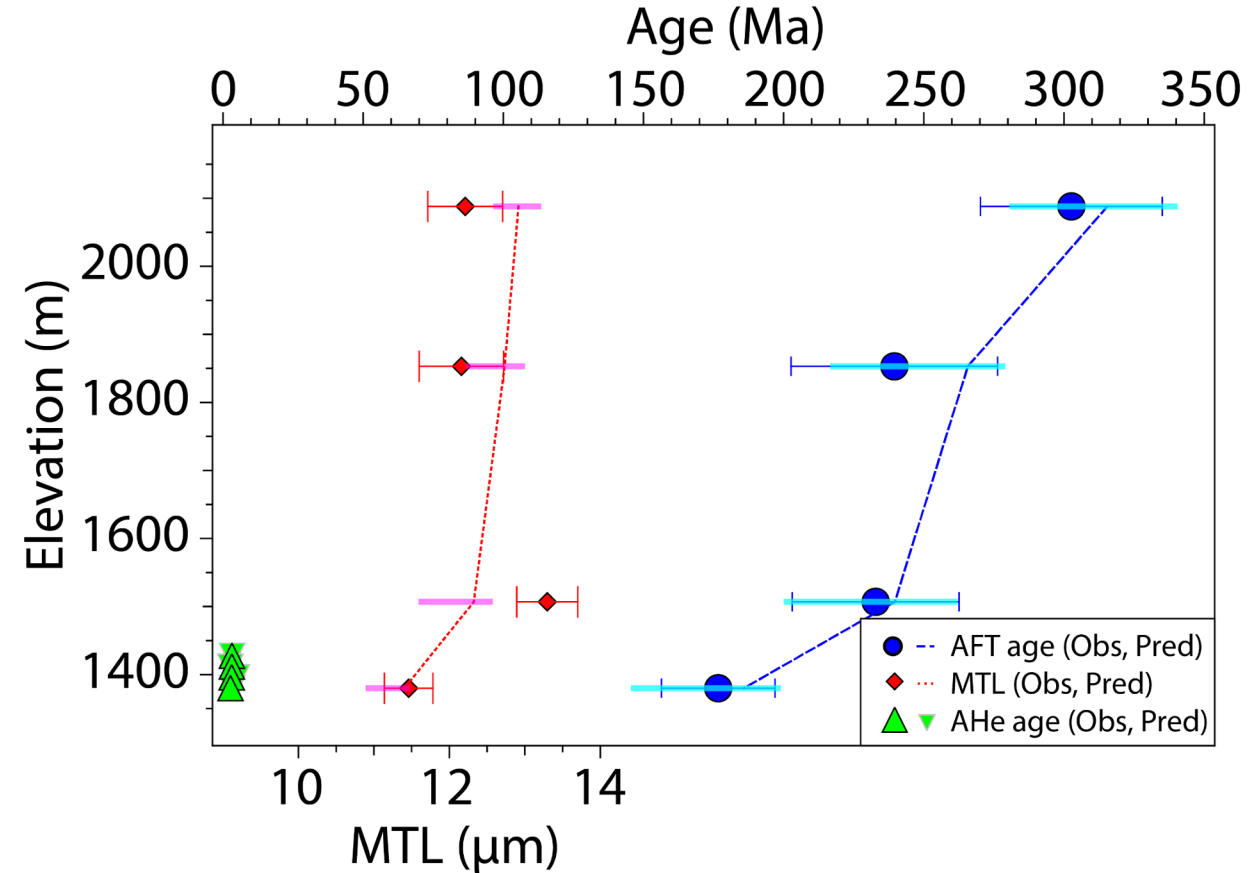
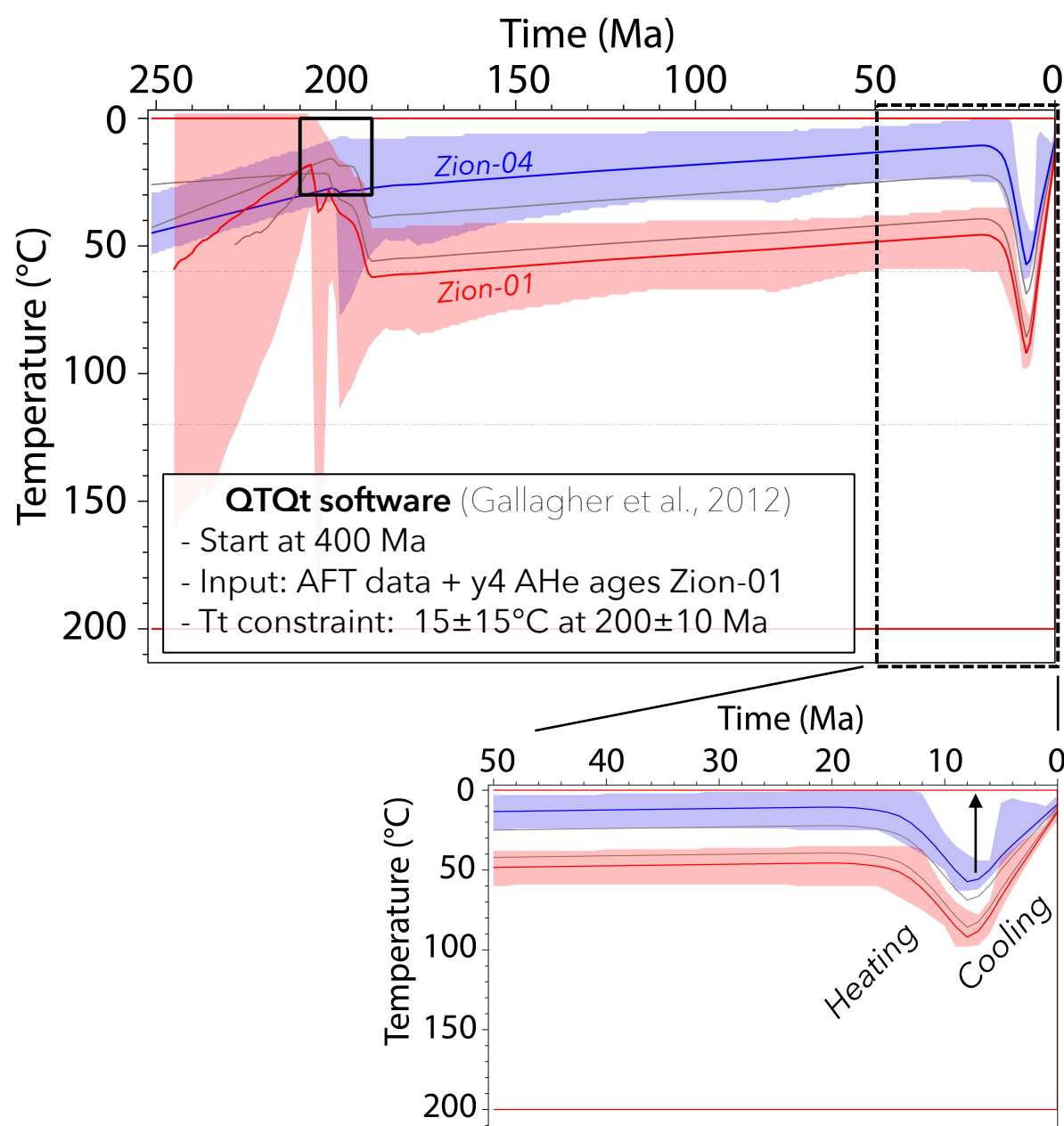
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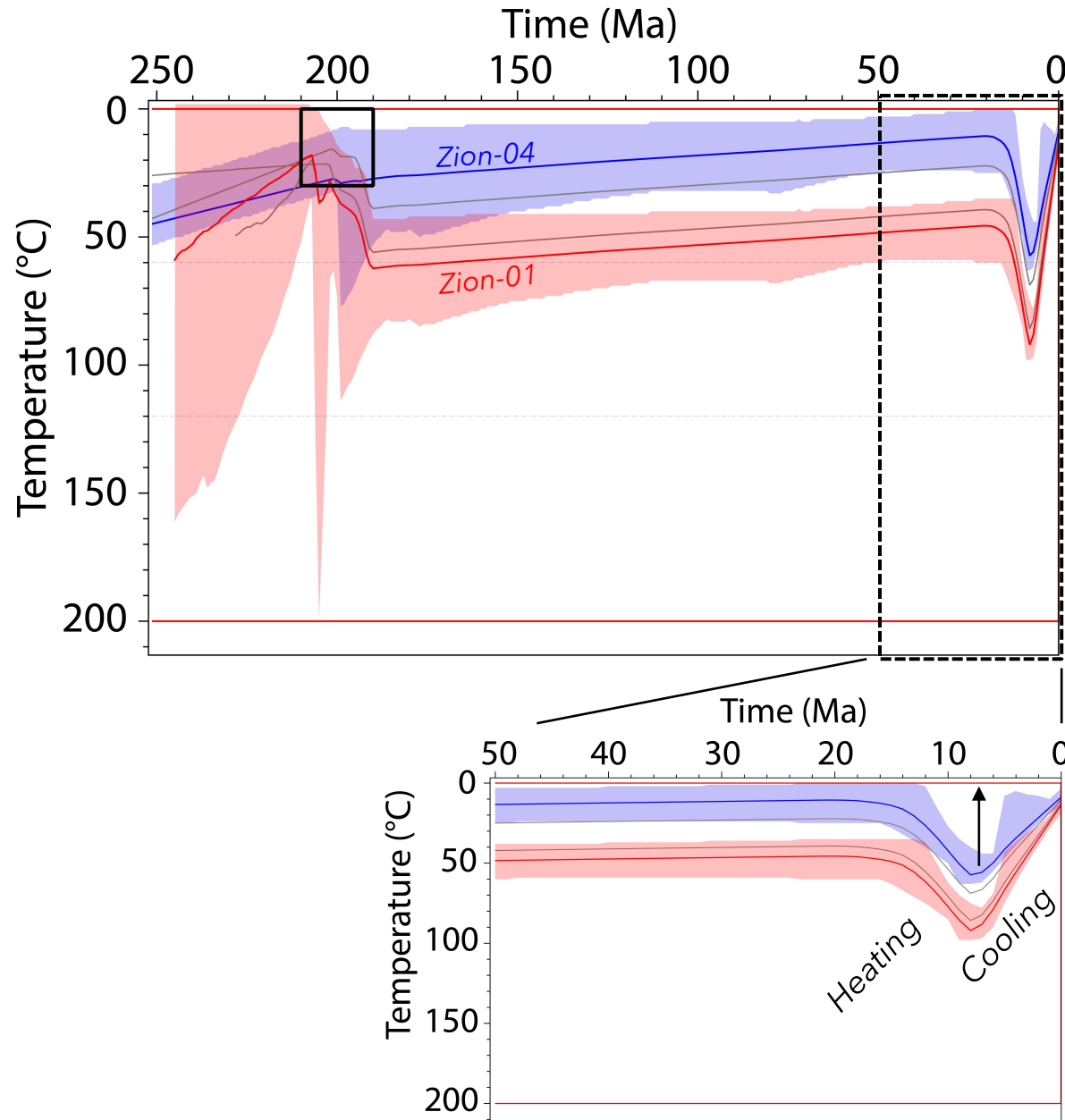
- Zion-04, 05, 07: **4-5 single-grains dated**
 - ✗ Impossible to see a correlation AHe age/eU
 - All dates are not geologically meaningful
- Zion-01: **13 single-grains dated**
 - ✓ AHe age/eU correlation + outliers with excess He
 - 4 younger AHe ages
 - Recent thermal history

Results: Thermal modeling

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- Predicted geothermal gradient = $50^\circ\text{C}/\text{km}$
- Long residence at $\sim 60\text{-}50^\circ\text{C}$
- Reheating since ~ 20 Ma
- Cooling starting at ~ 7 Ma



- **Cenozoic heating (20-7 Ma)**
 - Elevation of geothermal gradient // Basin and Range extension since 40 Ma (Dickinson 2002)
- **Cooling phase starting at ~7 Ma**
 - Onset of incision of Zion Canyon
 - *Exhumation rate = 140 - 200 m/Ma*
 - *Total exhumation since 7 Ma = 1000 - 1400 m*
- ✓ *Consistent with Quaternary incision rates of Virgin River (Walk et al., 2019)*

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Keypoints

- *High geothermal gradient* → AFT and AHe thermochronometers constrain canyon incision
- **Zion rocks recorded** reheating associated with **Basin and Range extension**
- **Zion Canyon incision** started at **~7 Ma**
- Incision of Zion Canyon after **tectonic uplift** along the **western margin of the Colorado Plateau**