Tectonics and exhumation processes in the northern Andes

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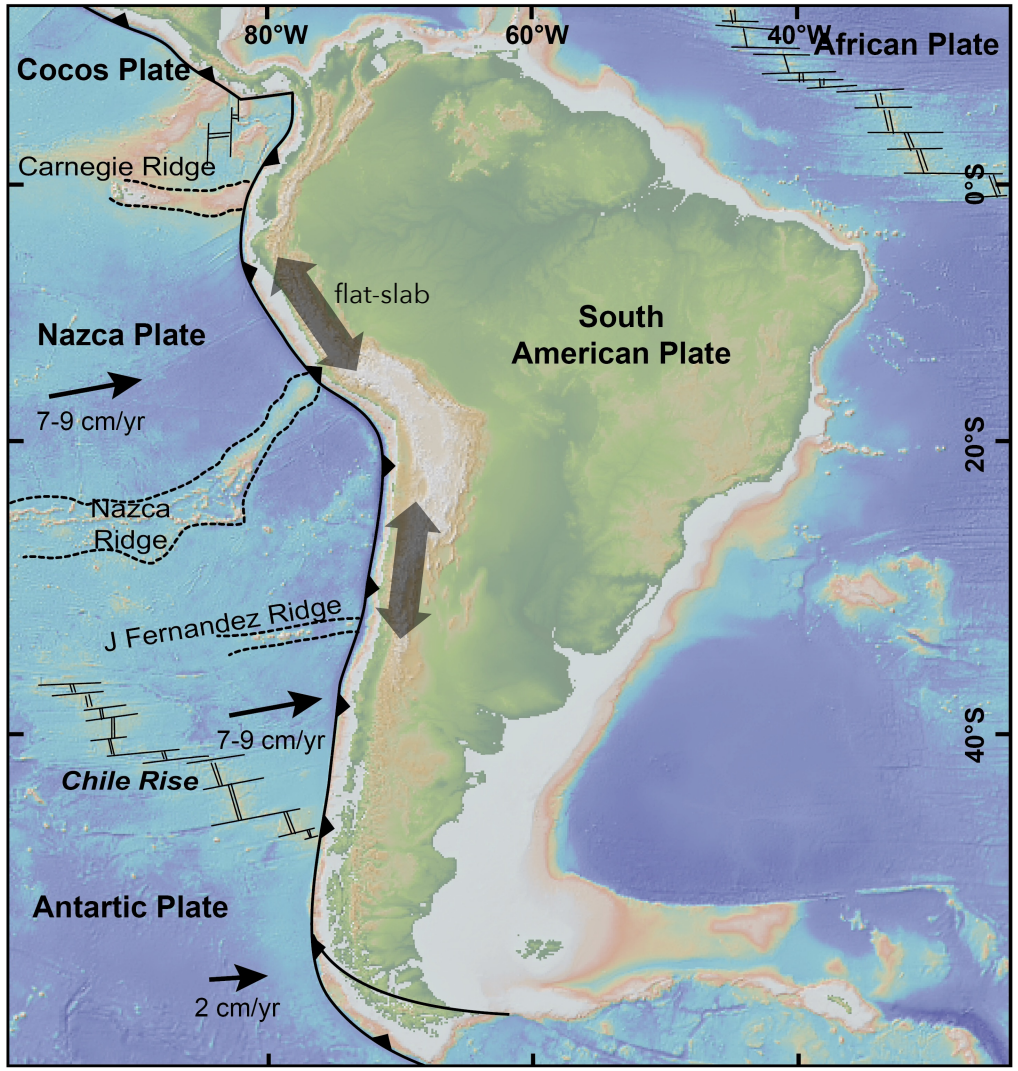
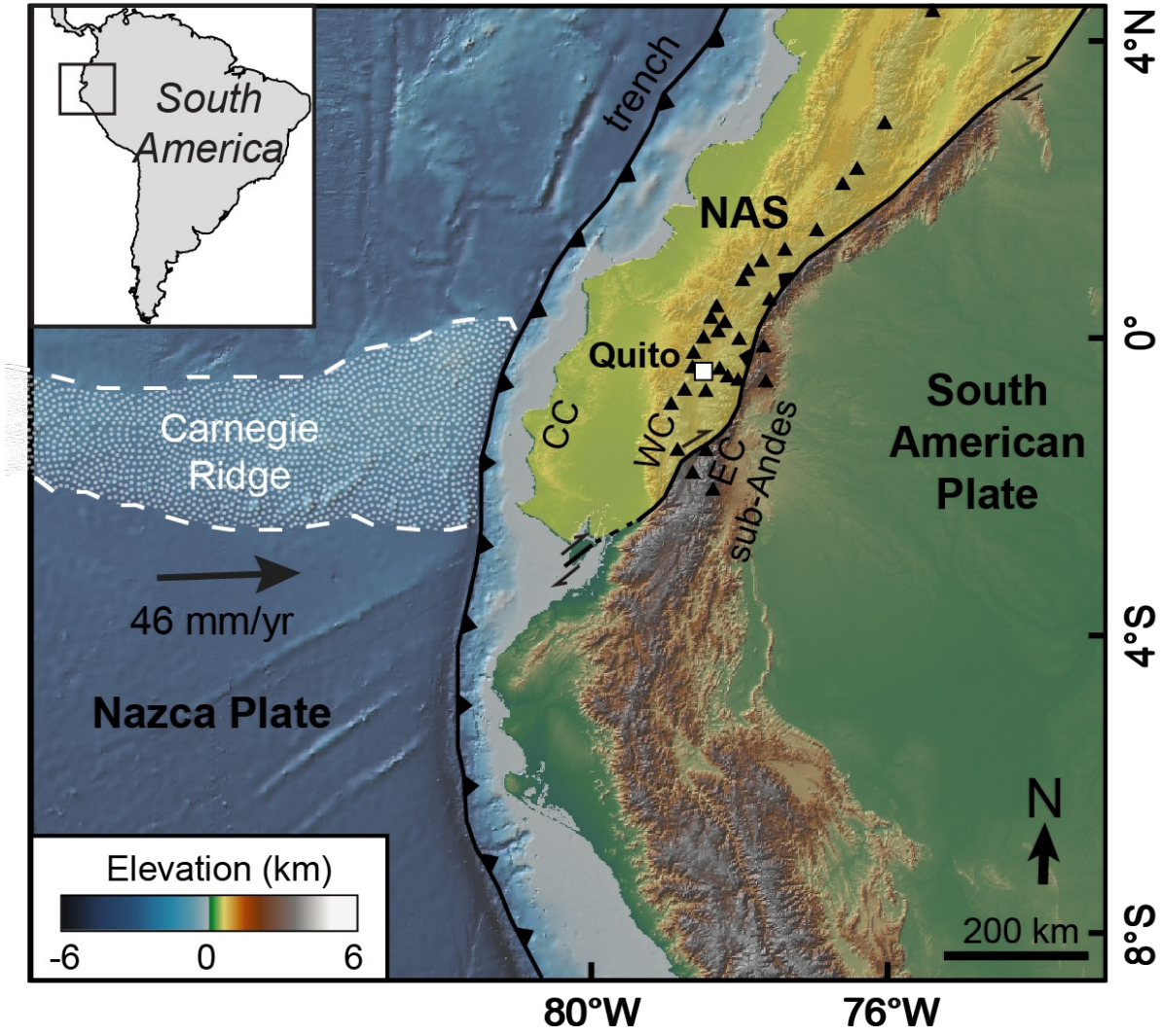
Geodynamic setting



- Subduction of the Nazca Plate (>200 Myr)
- Ridge subduction + flat-slabs

Respective role of flat-slab versus aseismic ridge subduction on topographic growth in the Andes?

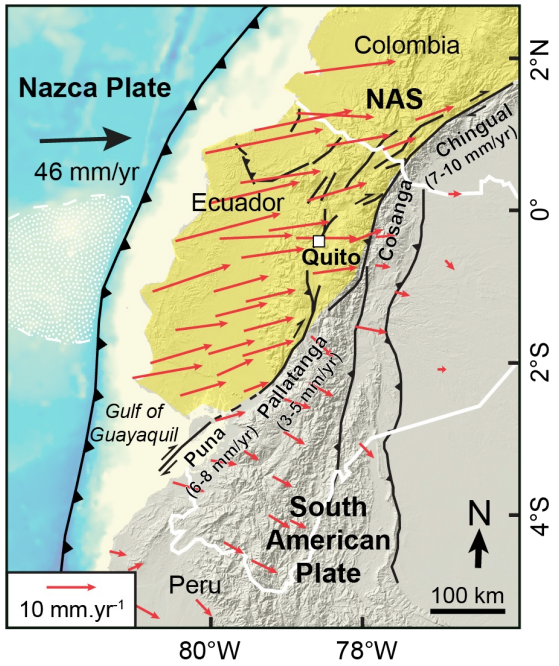
Geodynamic setting of the Ecuadorian Andes



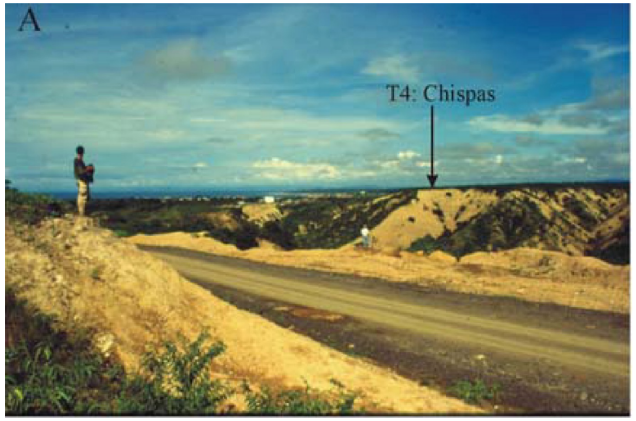
- Carnegie Ridge subduction
  - 200 km wide
  - Up to 2 km above ocean floor

Geodynamic setting of the Ecuadorian Andes

GPS data from Nocquet et al. (2014)



Marine terrace, Manta Peninsula (Pedoja, 2003)



High topographic relief in the Eastern Cordillera

- **Carnegie Ridge subduction**

  - Strong impact on: Tectonics (Baize et al., 2015, Alvarado et al., 2016)
  - Magmatism (e.g., Bourdon et al. 2003, Chiarada et al. 2021)
  - Quaternary coastal uplift (Pedoja et al. 2006)
  - Uplift and exhumation of the Eastern Cordillera? (Spikings et al. 2000, 2001)

Timing of onset of ridge subduction is still debated

Uplift and exhumation beyond the Eastern Cordillera?

Methods: Geochronology and thermochronology

Geochronology (zircon U-Pb dating)

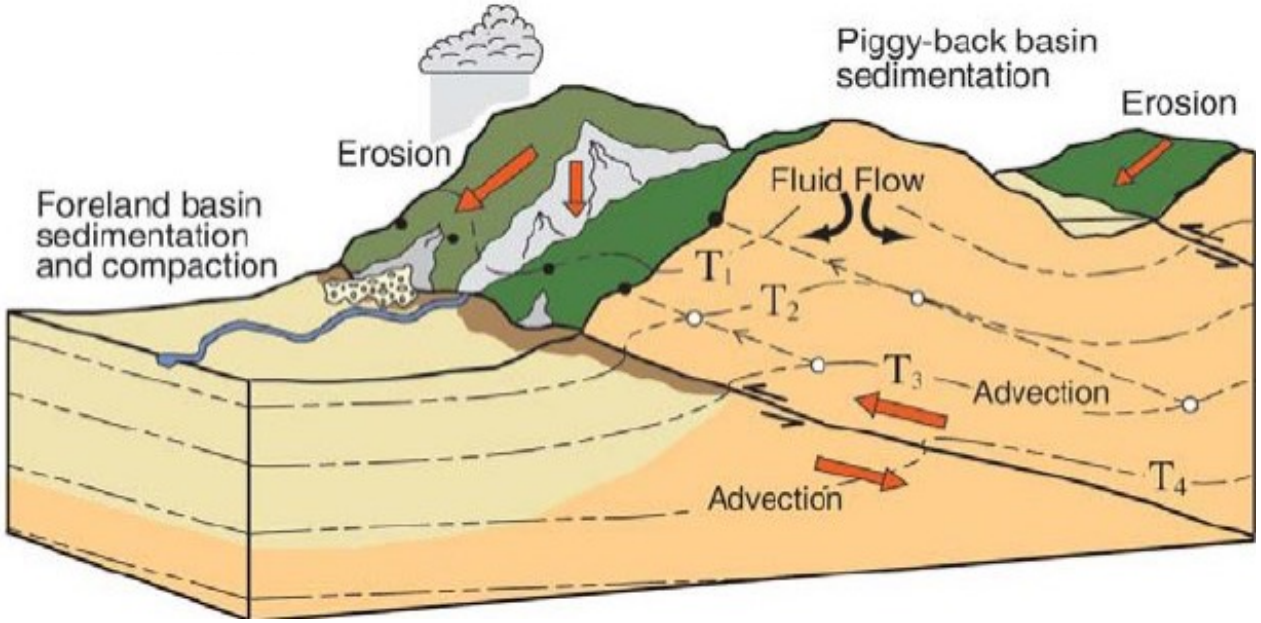
- Crystallisation ages

➡ **Timing of emplacement of plutonic rocks**

Low-temperature thermochronology

- Time-temperature histories of rocks
- Exhumation/burial histories

➡ **Timing of exhumation that can be related to rock uplift**

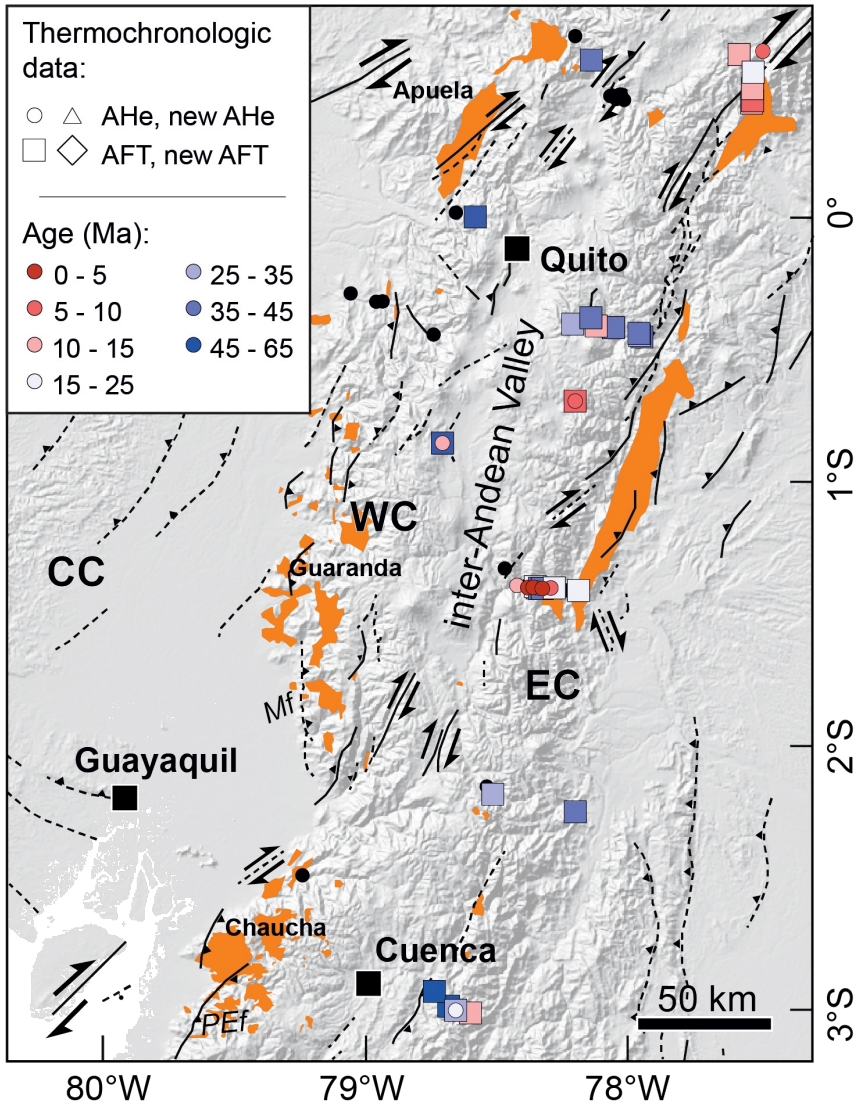


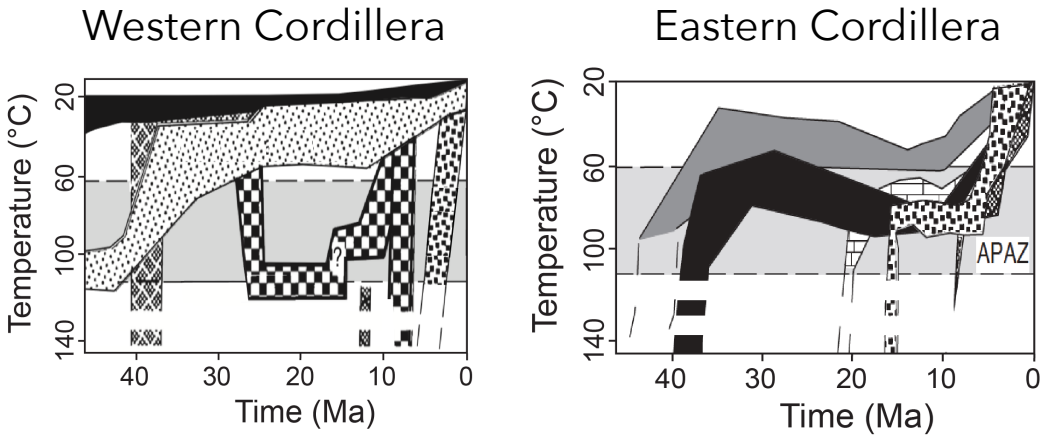
Processes controlling thermochronological ages in a compressive setting (Ehlers, 2005)

Thermochronometers:

⟶ Zircon (U-Th)/He (ZHe, 200-60°C)
⟶ Apatite fission tracks (AFT, 120-80°C)
⟶ Apatite (U-Th)/He (AHe, 80-50°C)

Existing thermochronological data in Ecuador

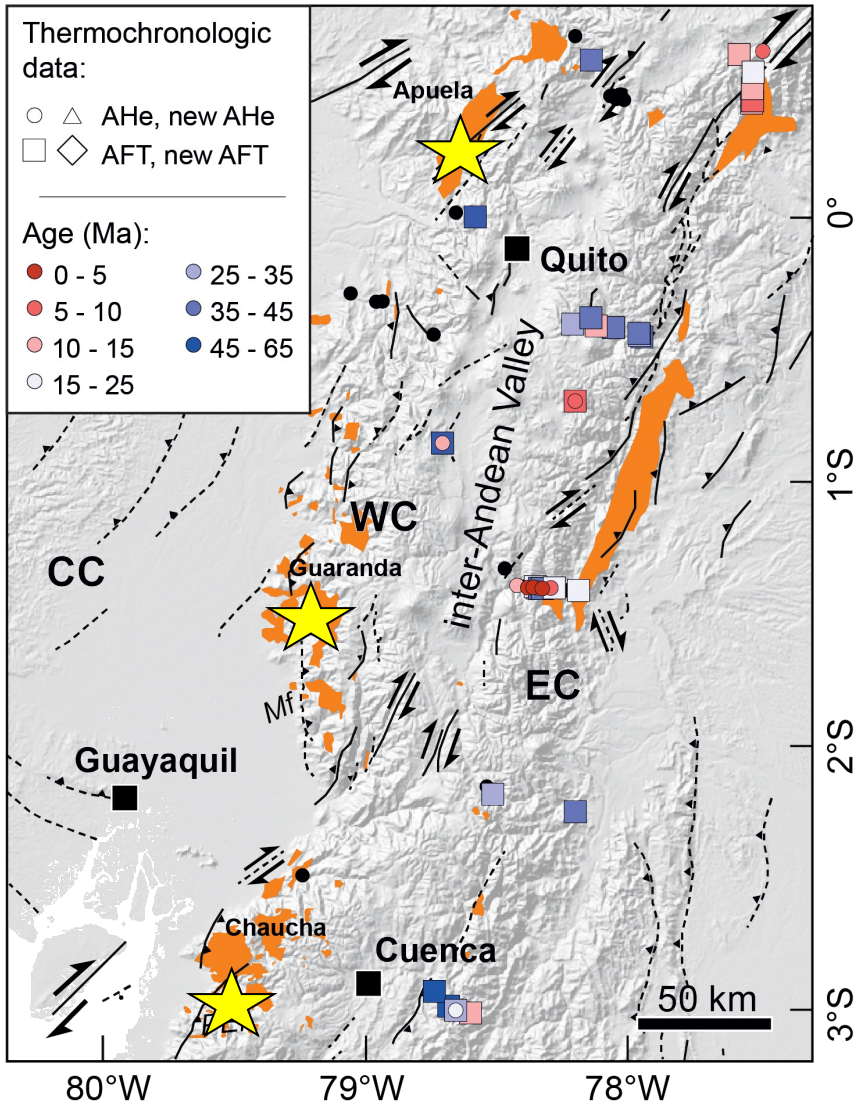




Spikings et al. (2005)

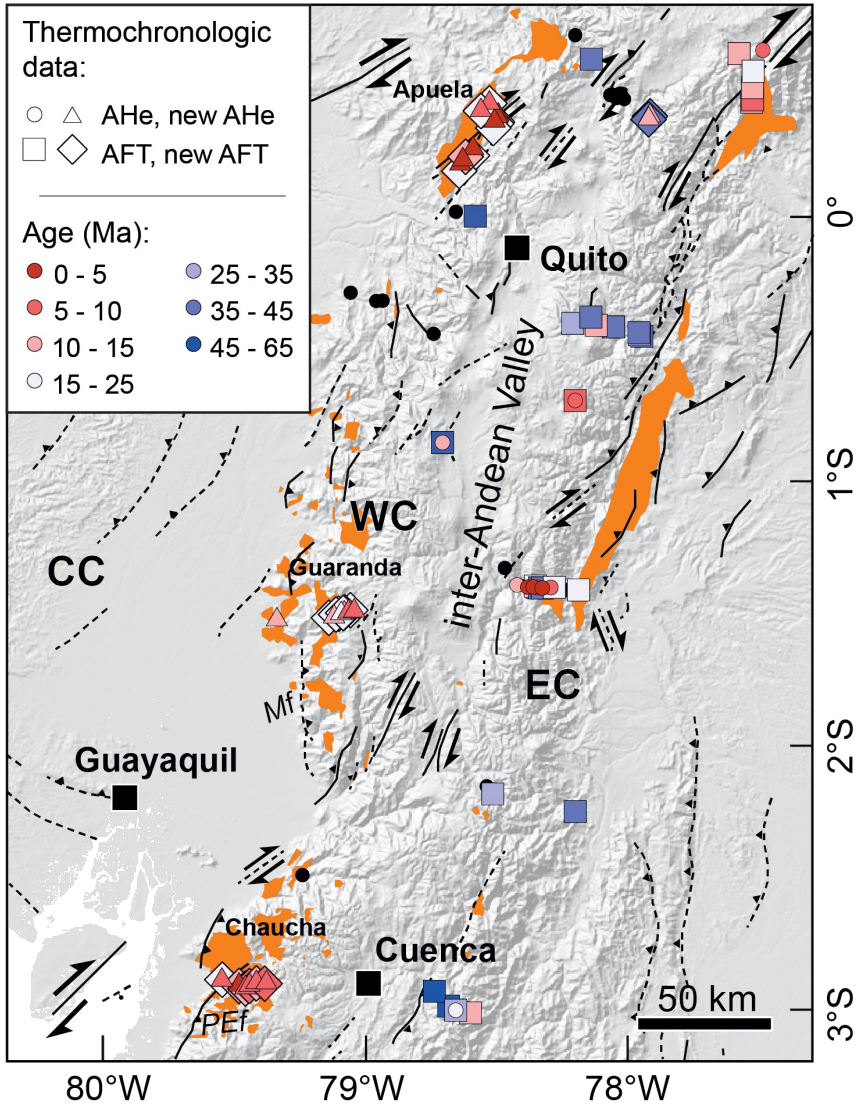
- Resolve different **cooling phases** in the **Eastern Cordillera** (Spikings et al., 2005)
- Data from the **coast** and **Western Cordillera** is only partially reset and **hard to interpret**

Sample location



- ✓ Plutonic rocks from the Western Cordillera
  1) Samples along structural cross-sections
  2) Vertical profiles

Thermochronological data

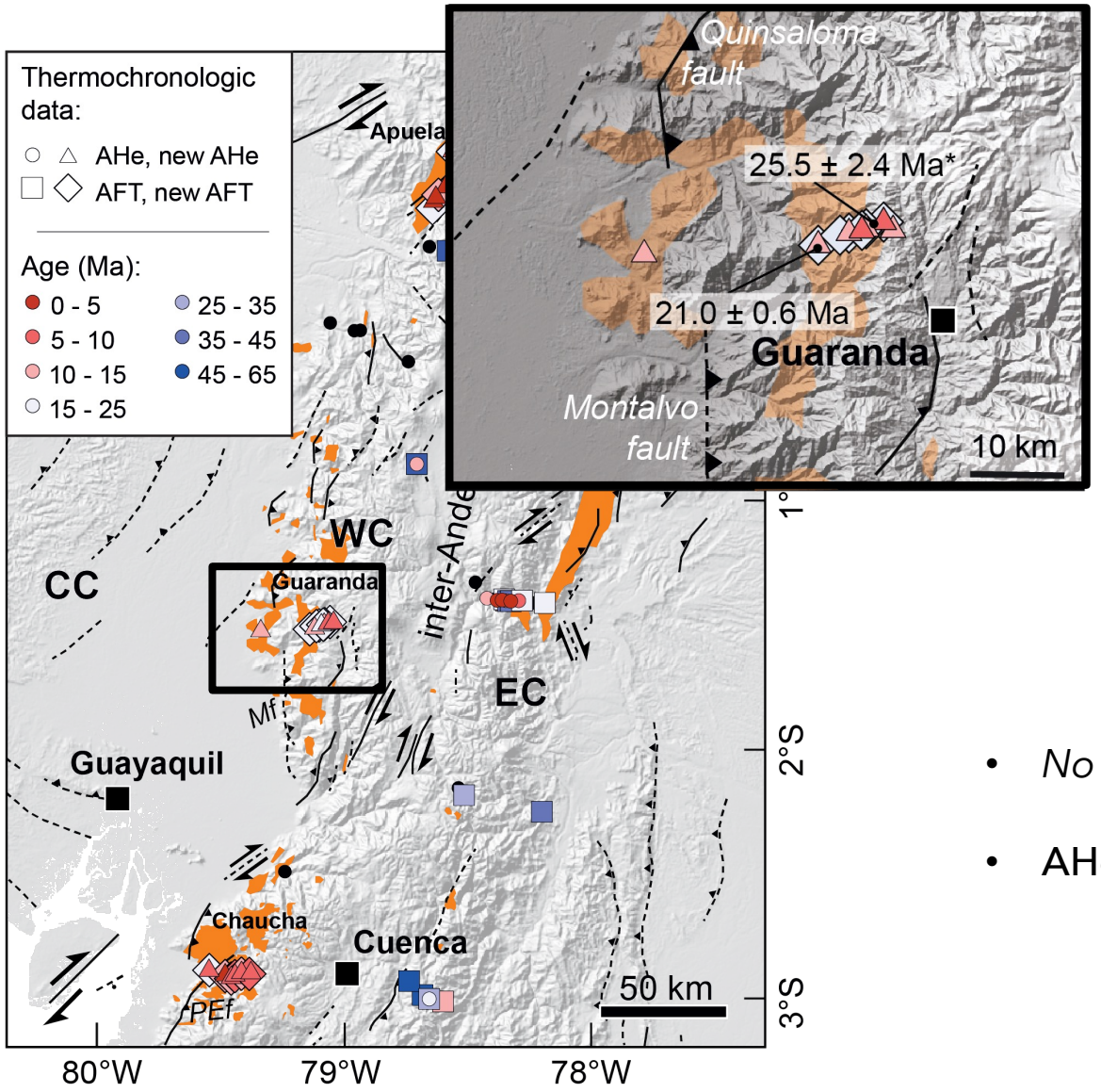


(Margirier et al., 2023)

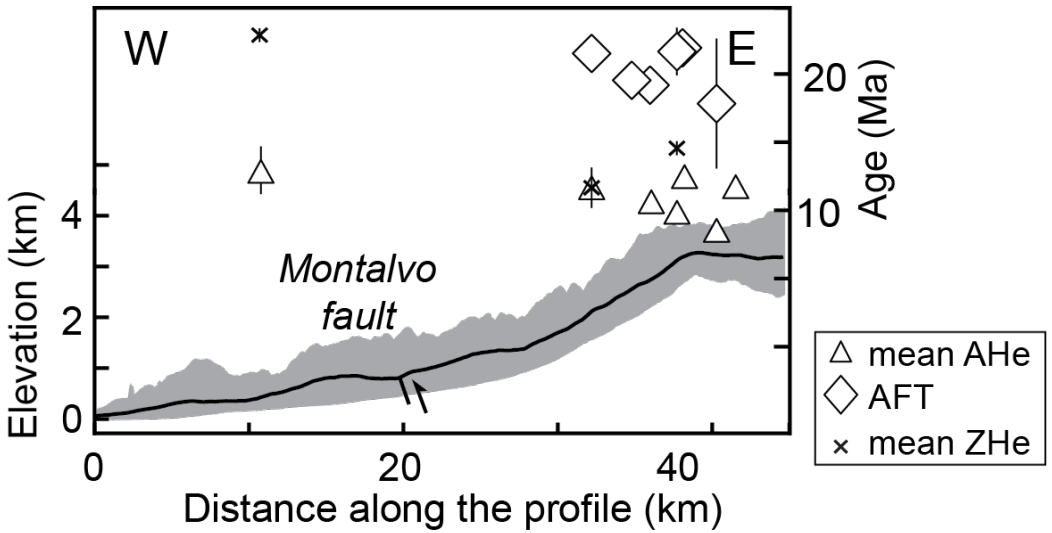
- ✓ Plutonic rocks from the Western Cordillera
  1) Samples along structural cross-sections
  2) Vertical profiles

- ✓ New AHe, AFT, ZHe data
- ✓ **Good spatial coverage of Ecuadorian Andes** together with other published data (Spikings et al., 2005, 2010)

Thermochronological data

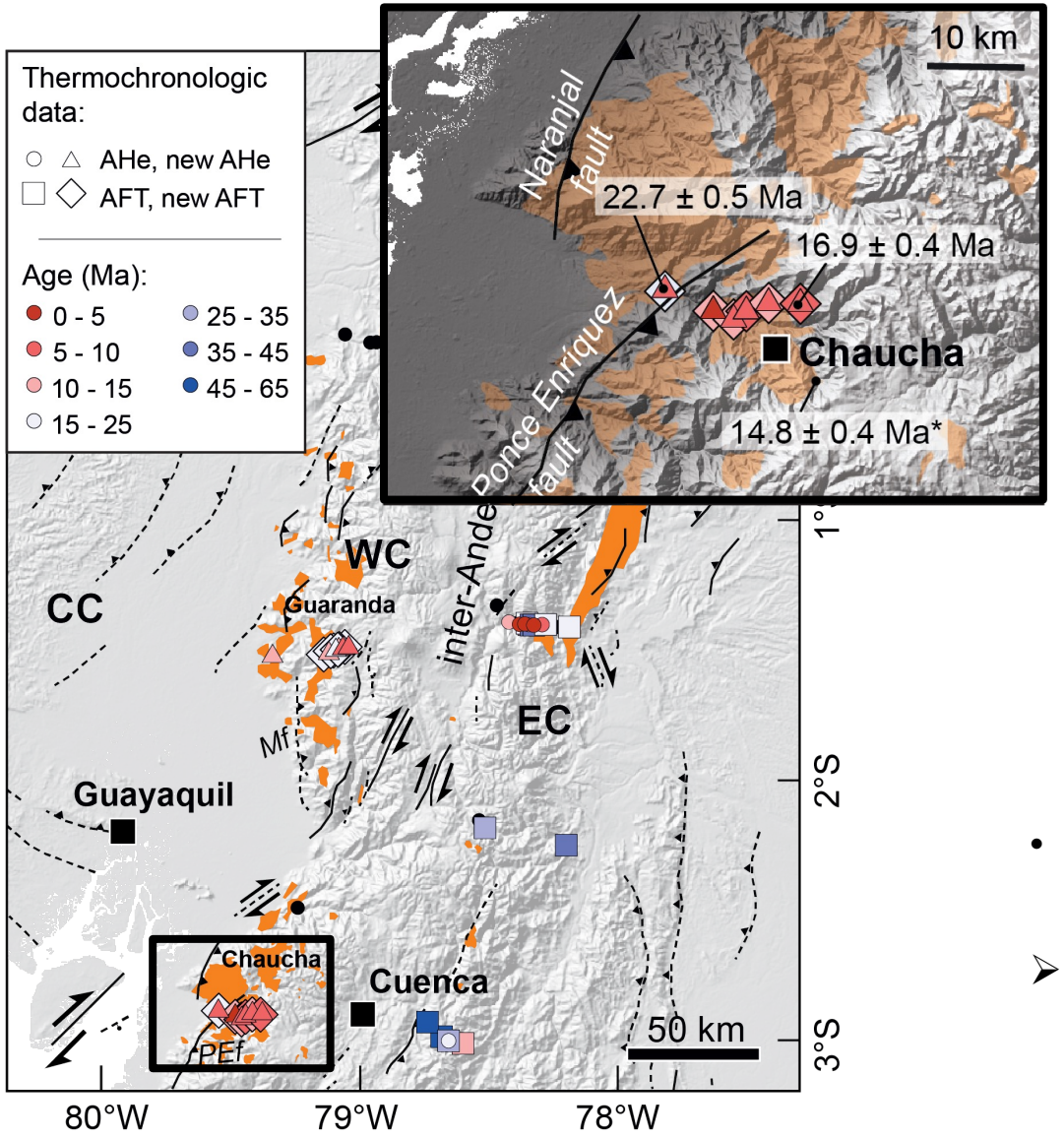


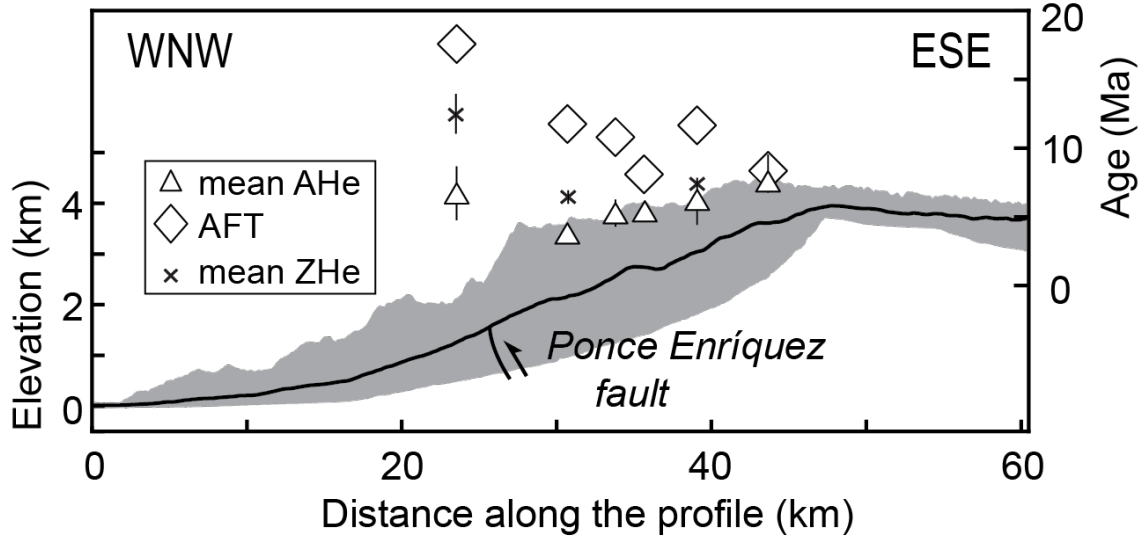
(Margirier et al., 2023)



- *No sample at low elevation in the Western Cordillera*
- AHe and ZHe ages are older in the footwall of Montalvo fault

Thermochronological data





- AHe, ZHe and AFT ages are older in the footwall of Ponce Enríquez fault

➢ **Exhumation related to tectonic activity**

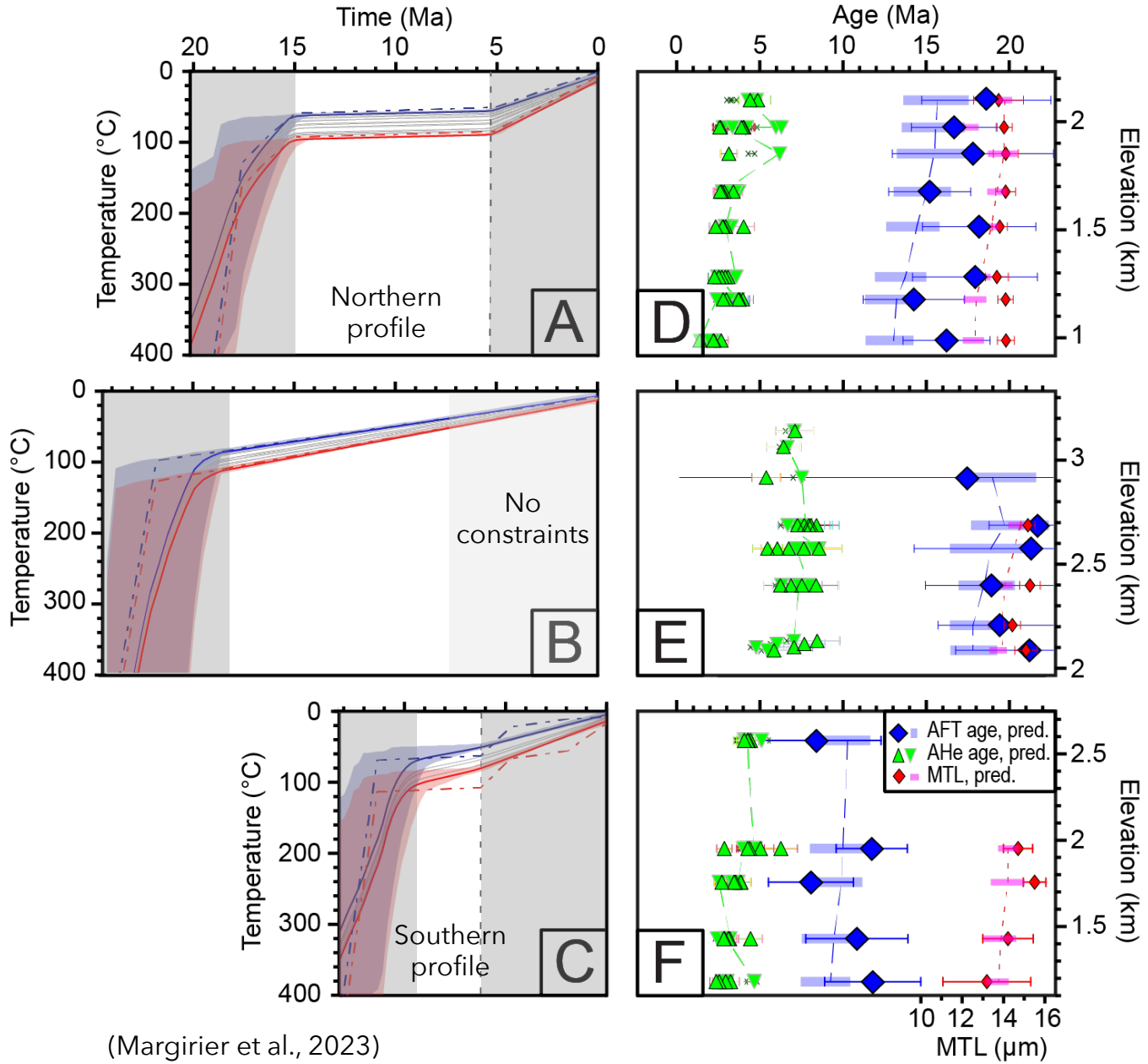
(Margirier et al., 2023)

Thermal histories from the Western Cordillera

QTQt software (Gallagher et al., 2012)
- Initial tT constrained from zircon U-Pb ages
- Input: AFT data + AHe ages

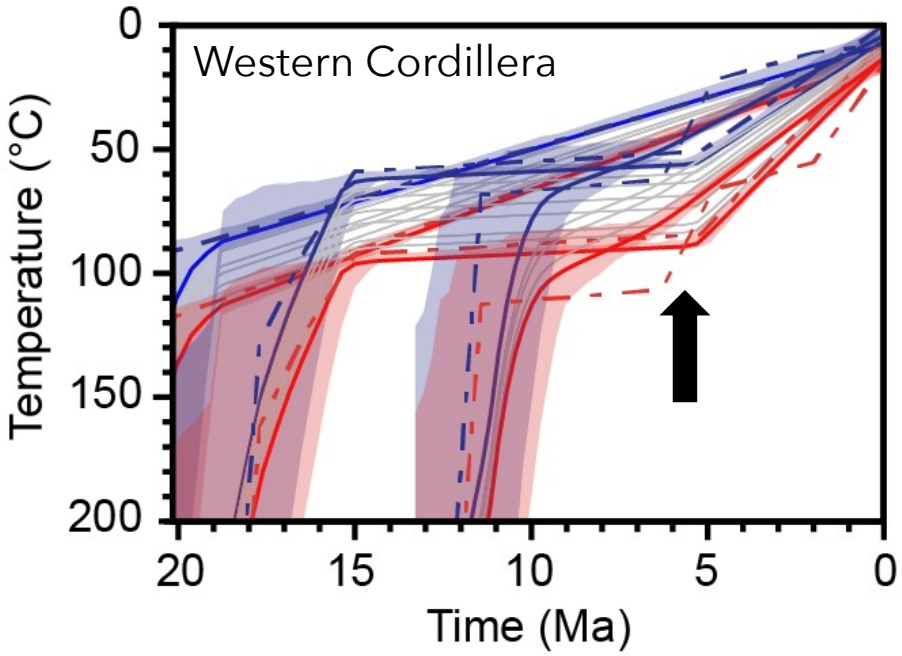
- Rapid cooling after intrusion emplacement
  - ➢ **Magmatic cooling**
- Quiescent phase
  - ➢ **Little exhumation**
- Second cooling phase starting at ~6 Ma
  - ➢ **Exhumation**

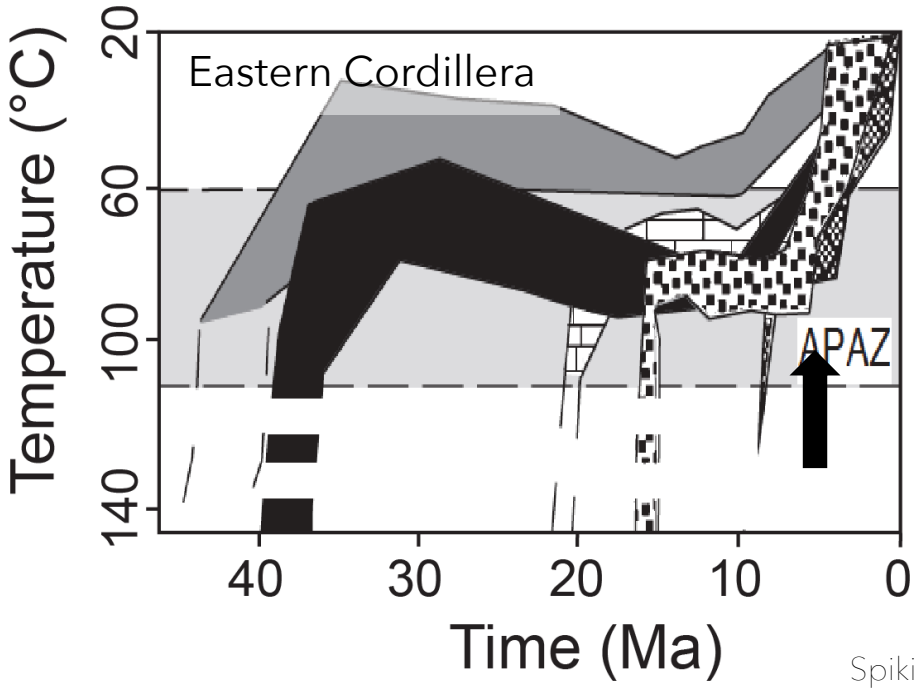
    ~0.5 km/Myr
    Exhumation = 3 km since 6 Ma



(Margirier et al., 2023)

Tectonic uplift and exhumation of the Ecuadorian Andes



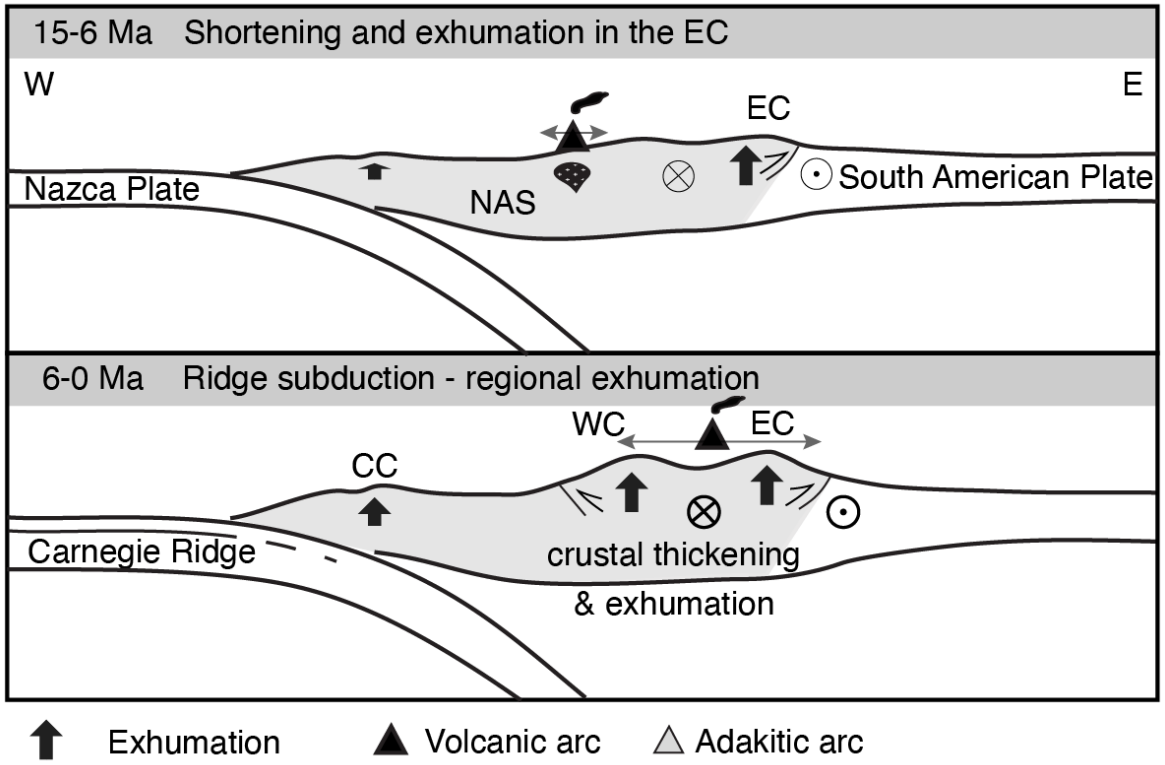


Spikings et al. (2005)

- **Uplift and exhumation in the Western Cordillera since ~6 Ma**
- Tectonic activity along **east dipping reverse faults**

- Western Cordillera exhumation // with **deformation and exhumation** along the **Eastern Cordillera** and the sub-Andes
  - ➢ **Regional exhumation**

Evolution of the Ecuadorian Andes since 15 Ma



(Margirier et al., 2023)

Keypoints

- AFT cannot resolve exhumation of intrusions in Ecuador
- Uplift and exhumation from 6-5 Ma in the Western Cordillera
- Increased coupling after the onset of Carnegie Ridge subduction at 6-5 Ma
  - ➢ Shortening and regional uplift in Ecuador

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Key Points:

- Thermochronological data reveal two cooling phases in the Western Cordillera of Ecuador, during the Miocene and after 6 Ma
- The onset of cooling at 6 Ma was associated with shortening, rock uplift, and exhumation in the Western Cordillera
- Mio-Pliocene exhumation was related to stronger coupling of the subduction interface due to the initial subduction of the Carnegie Ridge

Late Miocene Exhumation of the Western Cordillera, Ecuador, Driven by Increased Coupling Between the Subducting Carnegie Ridge and the South American Continent

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