Radiometric ages of the Caribbean crustal provinces to constrain its tectonic history

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Structure and Tectonics Seminar

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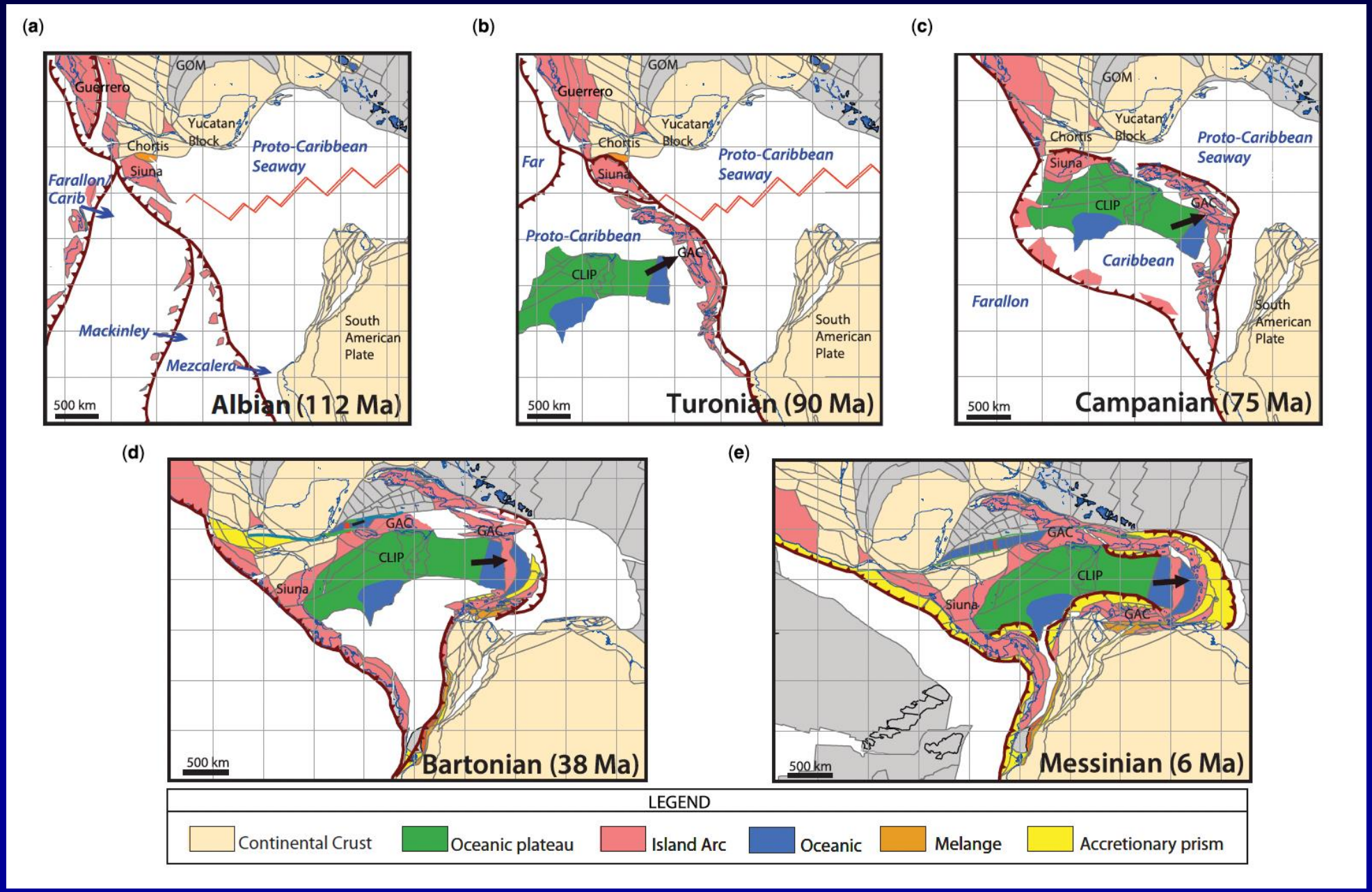
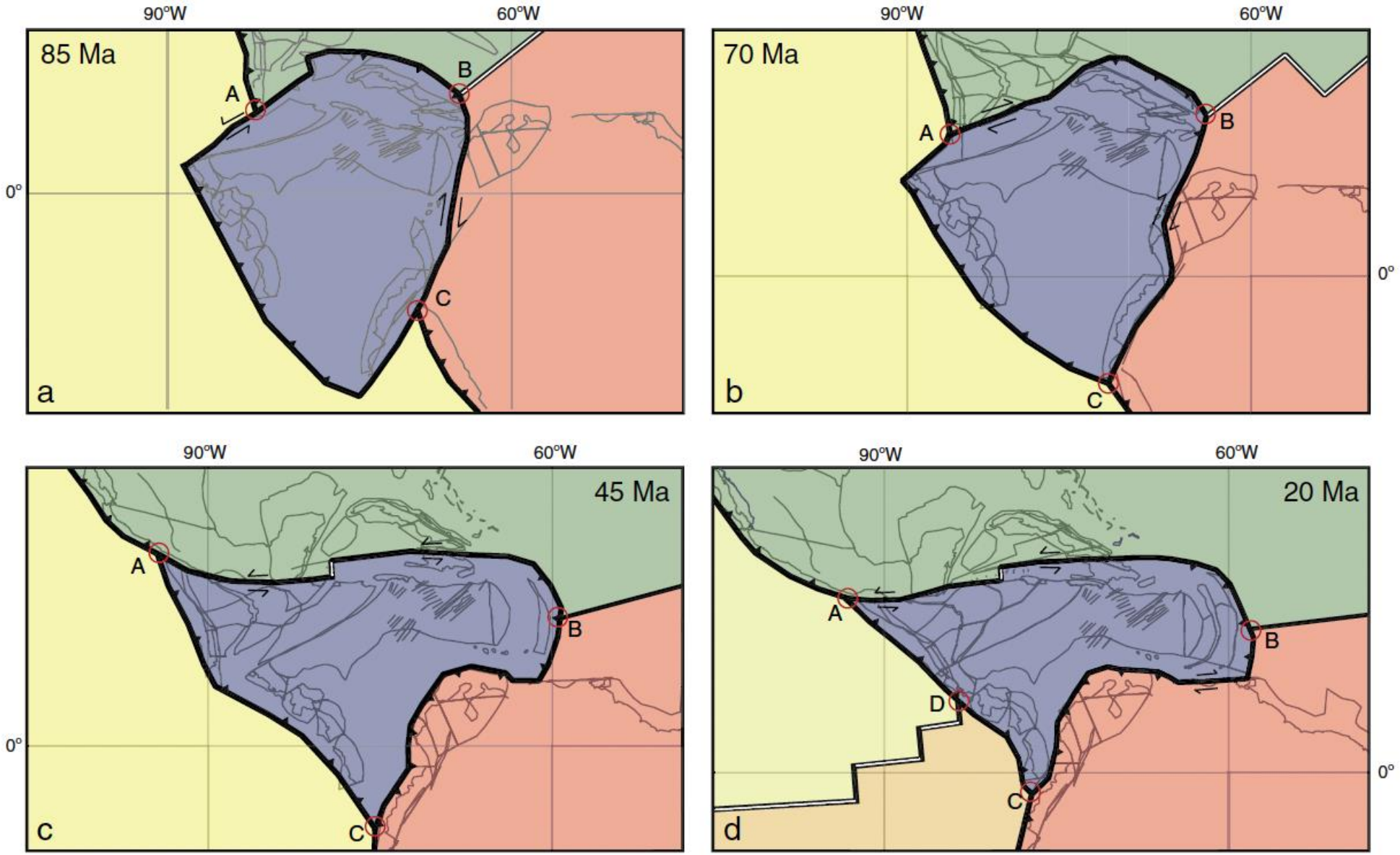
UNIVERSITY OF HOUSTON

Pacific-derived Caribbean plate with arc polarity reversal



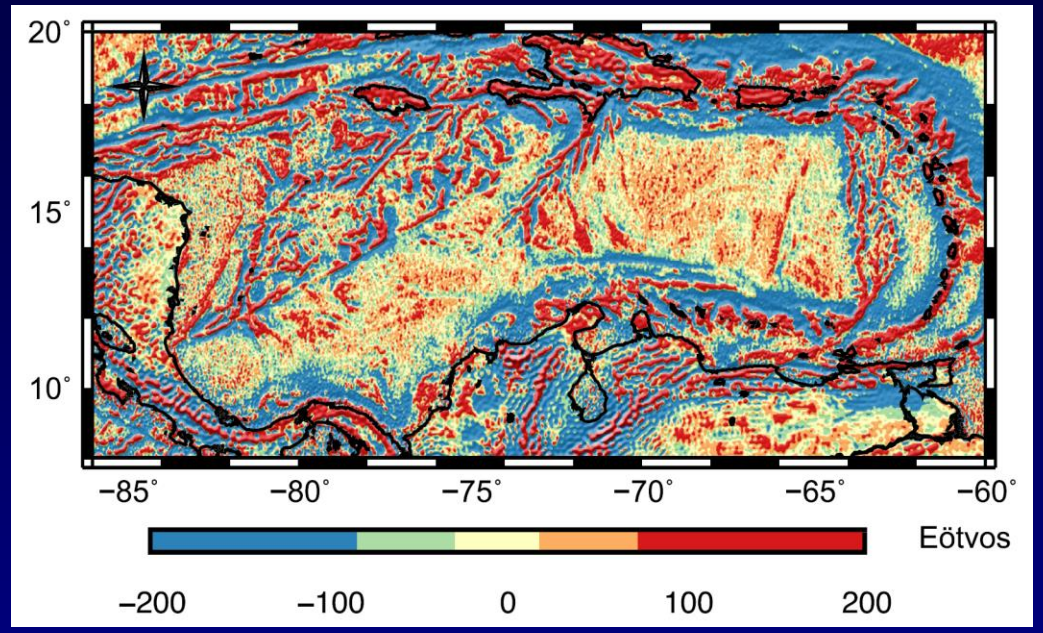
Romito and Mann (2020)

Pacific-derived Caribbean plate with no arc polarity reversal

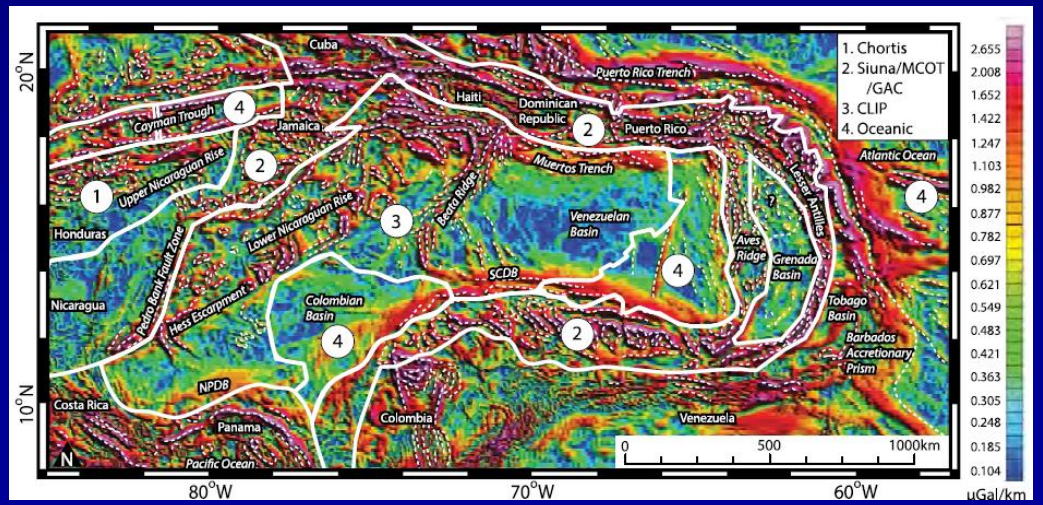


Boschman et al., (2014)

Dating the four crustal types of the Caribbean plate



Garcia-Reyes & Dyment (2021)



Romito & Mann (2020)

1. **Caribbean Large Igneous Provinces - CLIP**

   ~139 Ma to 111 Ma (Nicoya Complex)
   ~95 Ma to 82 Ma
   ~ 74 Ma to 69 Ma

2. **Great Arc of the Caribbean**

   ~132 Ma to 87 Ma
   ~77 Ma to 36 Ma

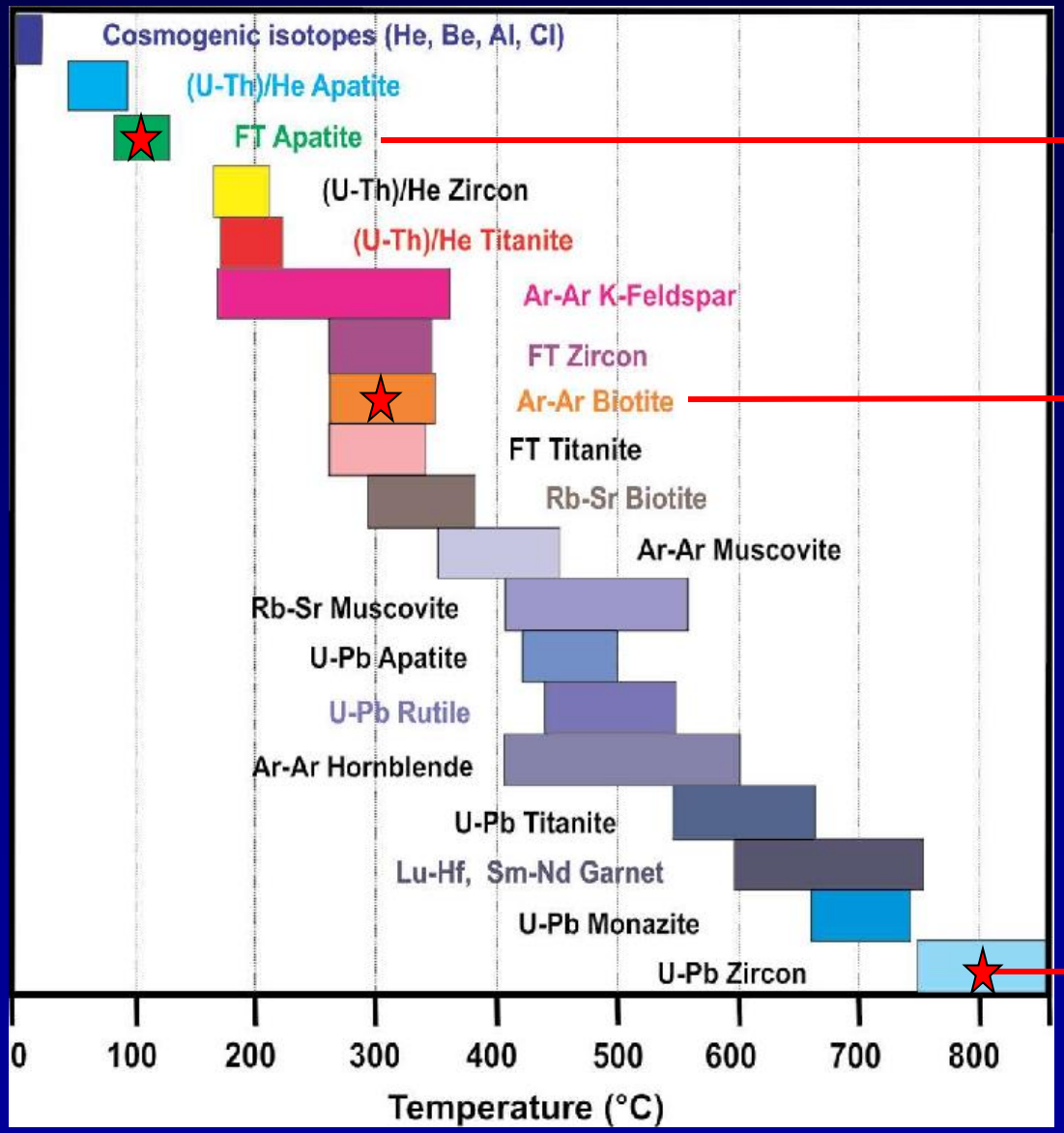
3. **Continental Magmatic Crust**

   ~120 Ma to 116 Ma
   ~77 Ma to 50 Ma

4. **Proto-Caribbean Oceanic Crust**

   ~137 Ma to 93 Ma

Isotope System – Geochronology and Thermochronology



60˚C - 120 ˚C

Low temperature method:
- Thermal history AFTA
- Collision and accretion

280˚C - 350 ˚C

$^{40}Ar/^{39}Ar$ (Biotite or WR)

<u>Volcanic event (basaltic rocks)</u>

750˚C - 900 ˚C

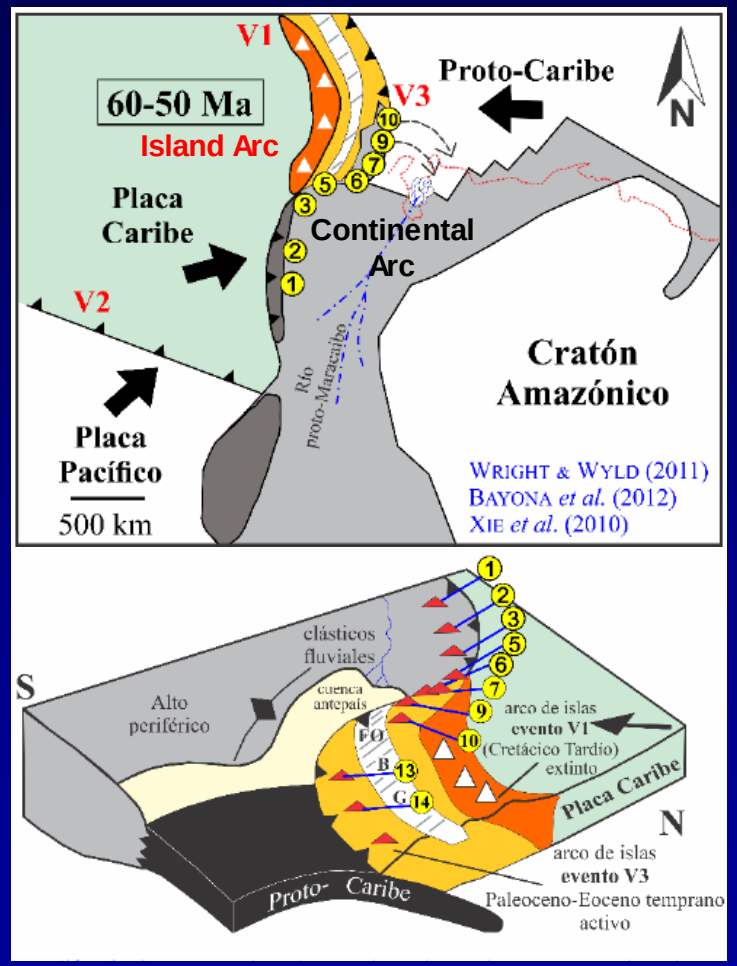
U/Pb LA-ICP-MS / SHRIMP / TIMS (Zircon/baddeleyite)

- **Magmatic Crystallization**
- **High-grade Metamorphic**

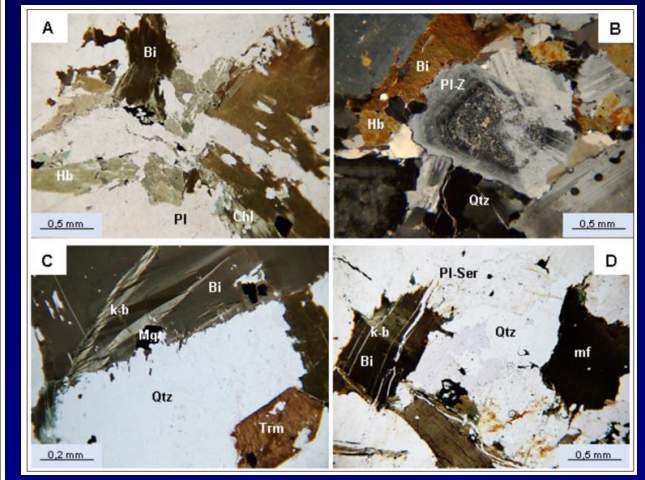
Singh et al., (2022)

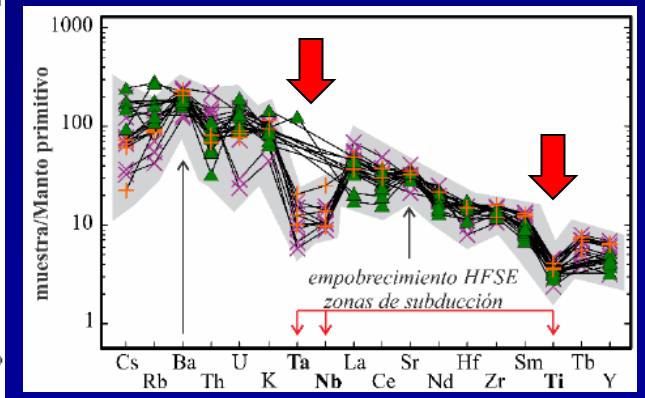
Dating Magmatic Rocks by U-Pb on zircon

Continental Magmatic Arc AND Volcanic Island Arc
Oblique collision – CLIP and NW South America

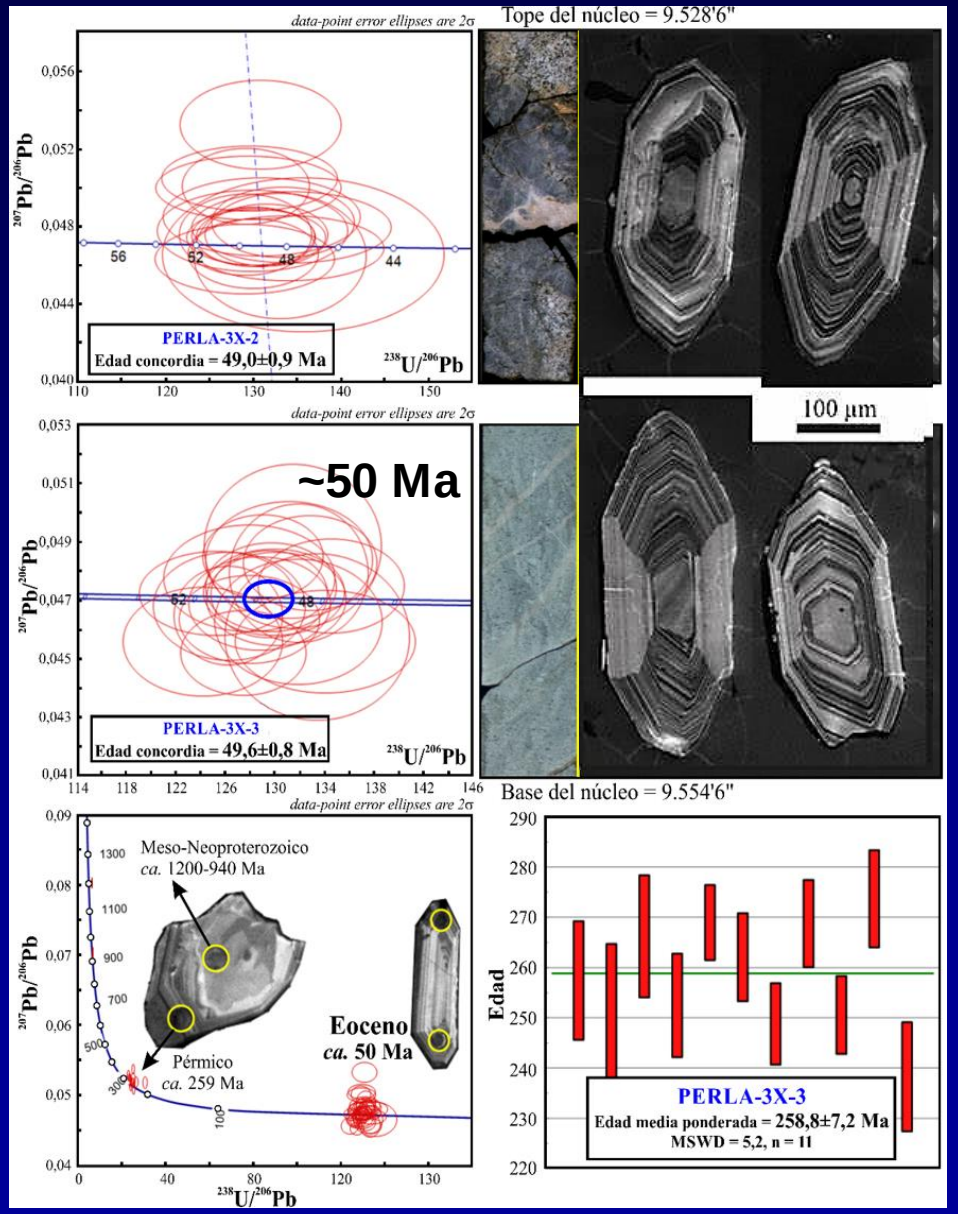


after Pindell (1999)



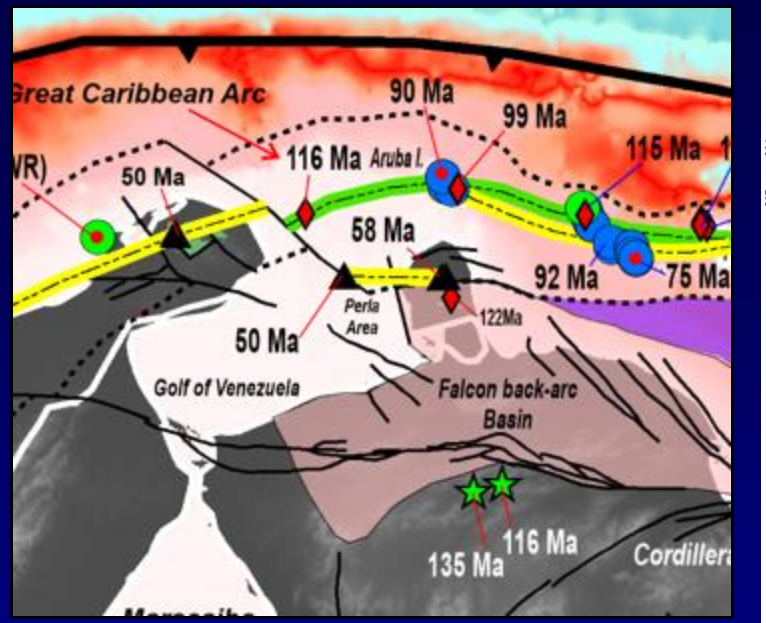


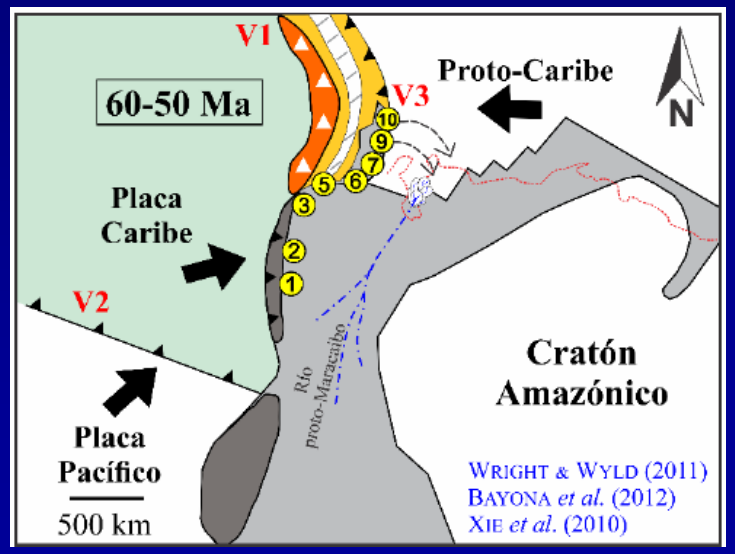
Typical geochemical signature from a subduction zone

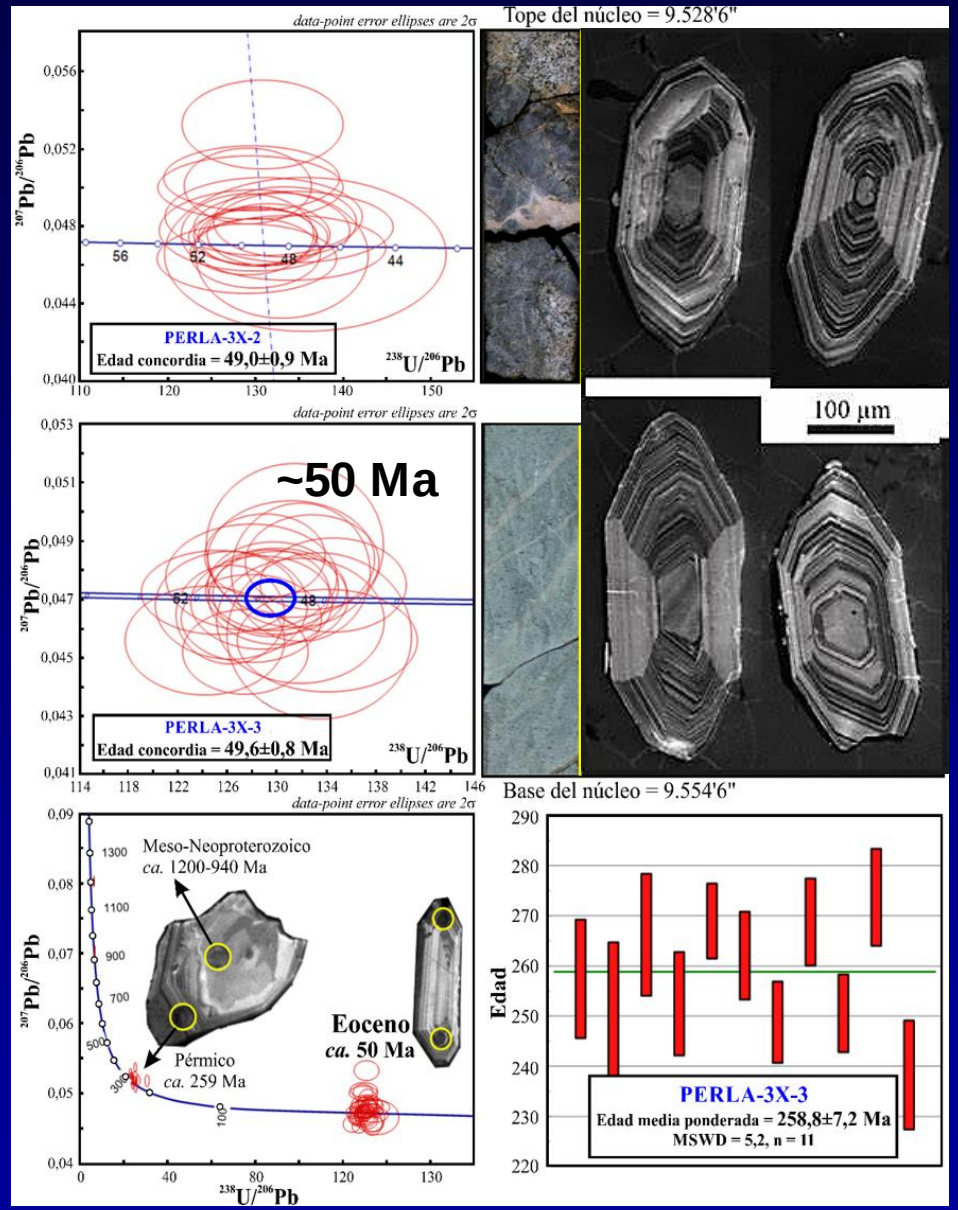


Baquero (2015)

Dating Magmatic Rocks by U-Pb on zircon

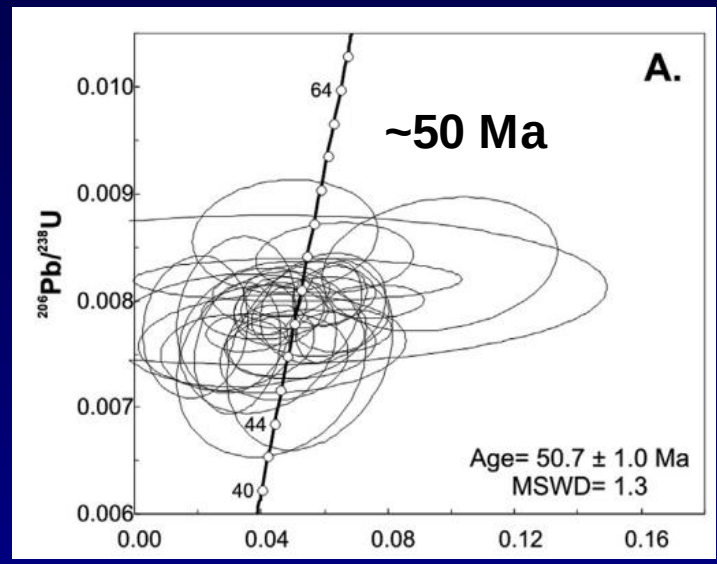






Baquero (2015)

U-Pb on zircon



Cardona et al., (2014)

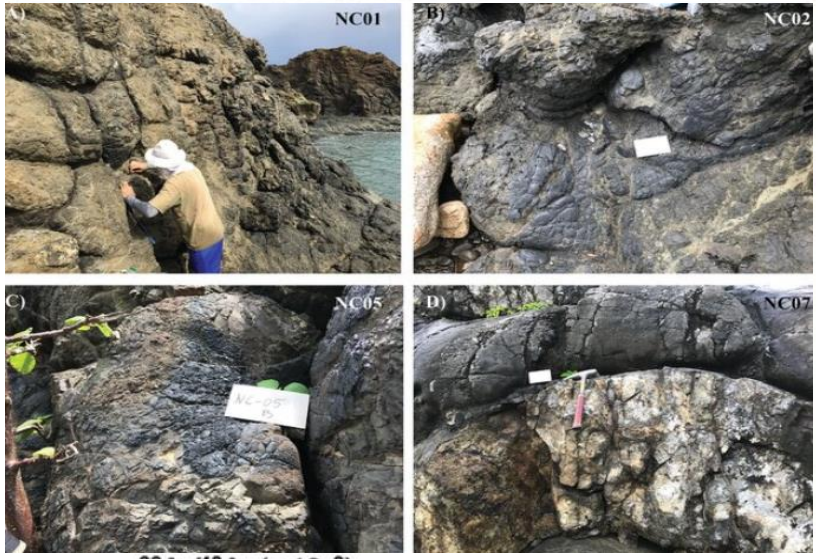
Parashi Stock

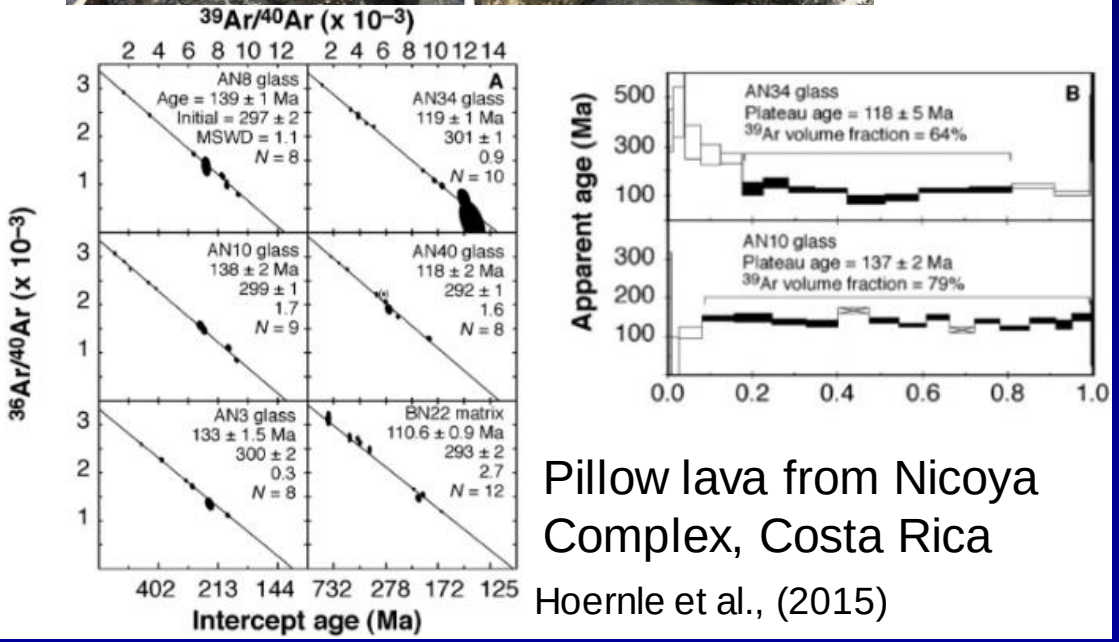
Early Eocene magmatism exposed in the Guajira Peninsula, Colombia

Volcanic Island Arc
Oblique collision – CLIP and NW South America

Dating Igneous Rocks by $^{40}Ar/^{39}Ar$ and U-Pb zircon

Di Chiara et al., (2021)



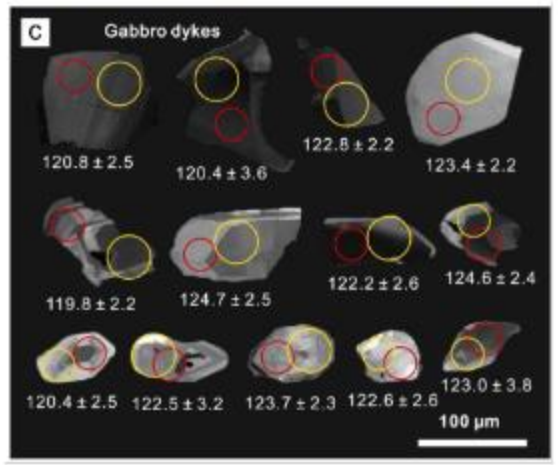


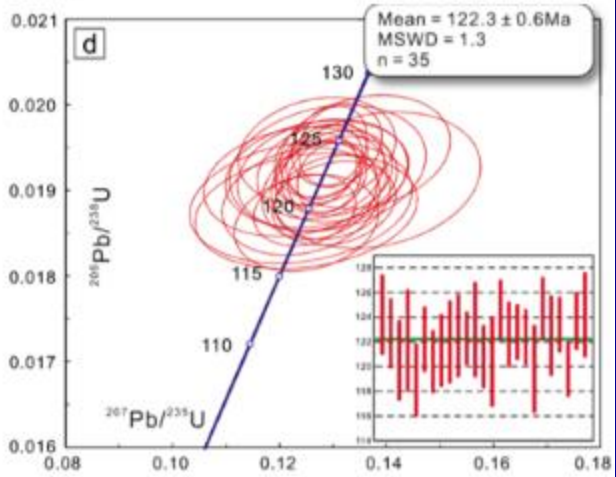
Pillow lava from Nicoya Complex, Costa Rica

Hoernle et al., (2015)

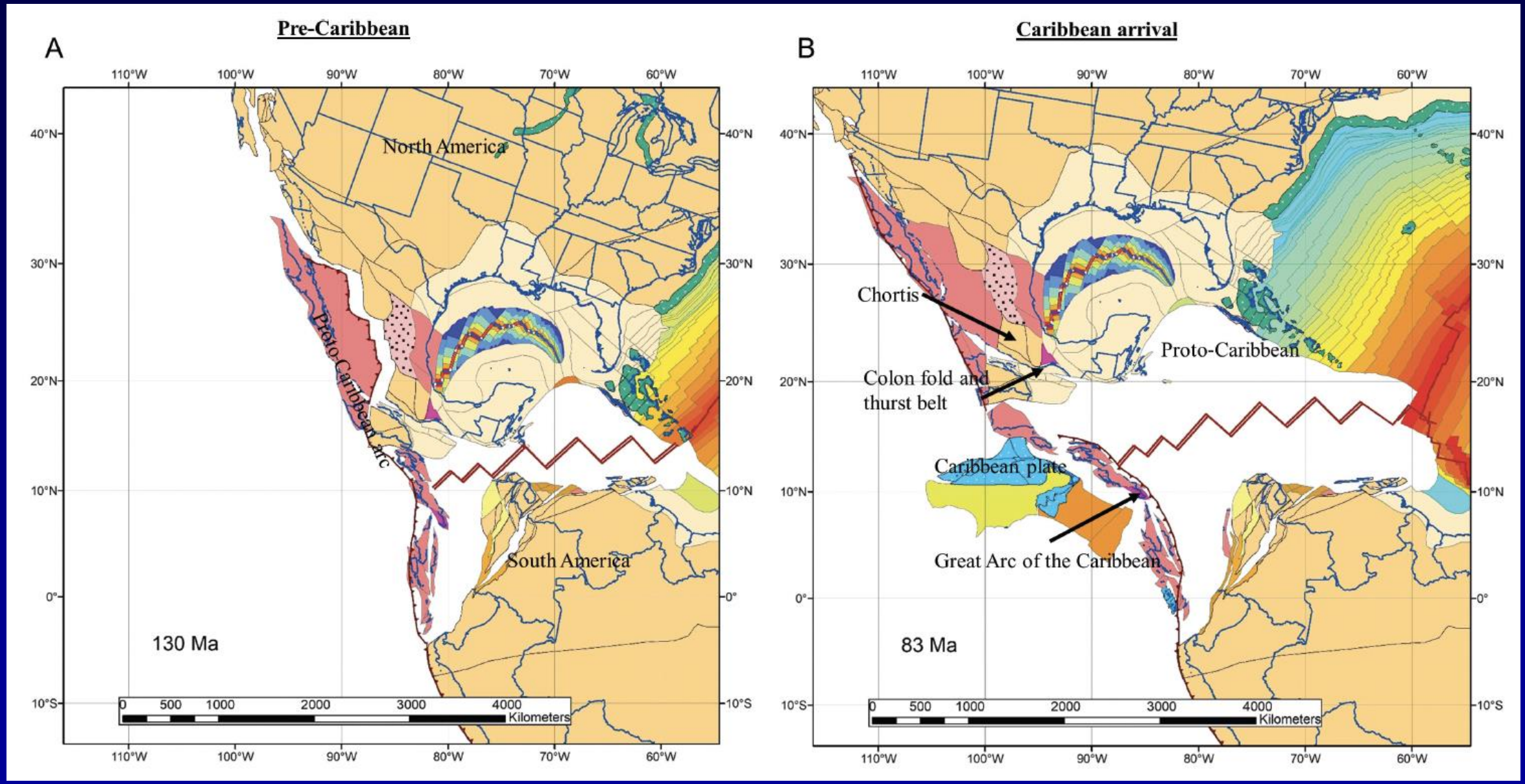
Gabbro dike from Cuba

Rui et al., (2022)



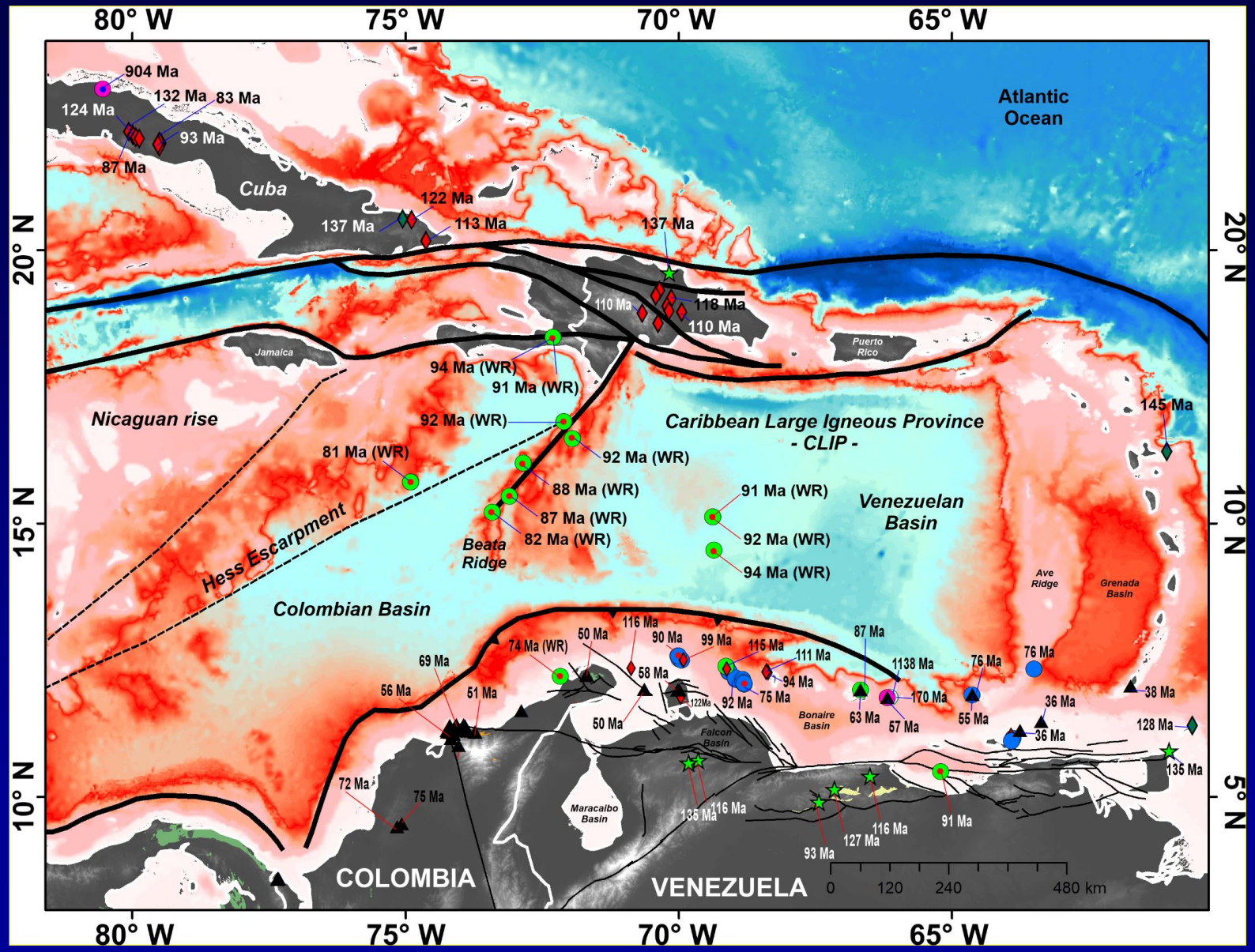


Objective 1: Compiling age data on the age of Proto-Caribbean crust (pre-CLIP)



Escalona et al., (2021)

Ages of the pre-CLIP and proto-Great Arc of the Caribbean



PRE-CLIP

- Proto-Caribbean plate during Late Jurassic to Early Cretaceous break-up of the Americas.

Trinidad: **135 Ma (Mafic volcanic breccia)**
Venezuela: **136 Ma to 116 Ma (Gabbro)**
Hispaniola (DR): **137 Ma (Gabbro)**

proto-GAC

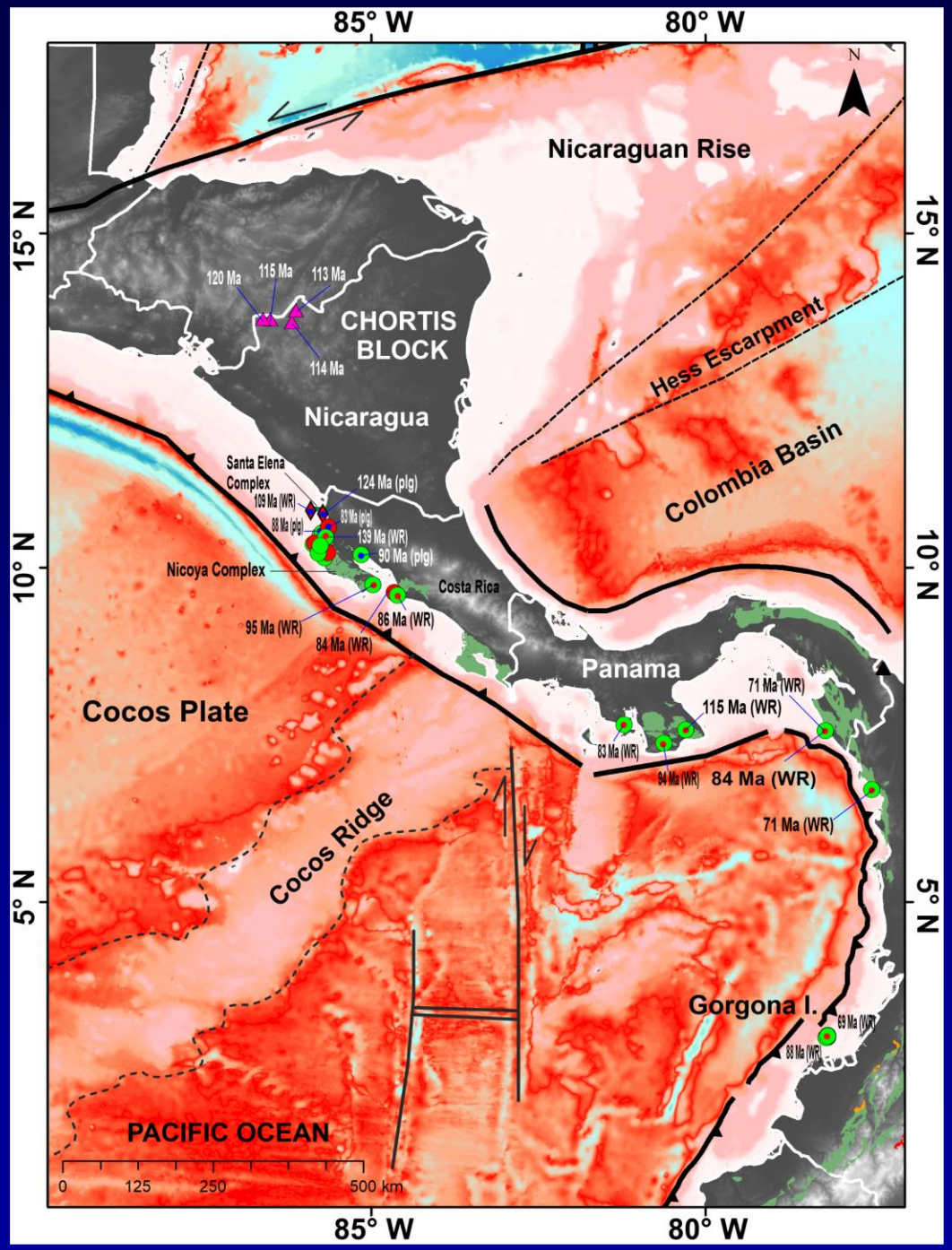
- Proto-Great Arc of the Caribbean during Early Cretaceous related to **NE-dipping OR NE-dipping** subduction initiation of the proto-Caribbean plate beneath the Farallon plate

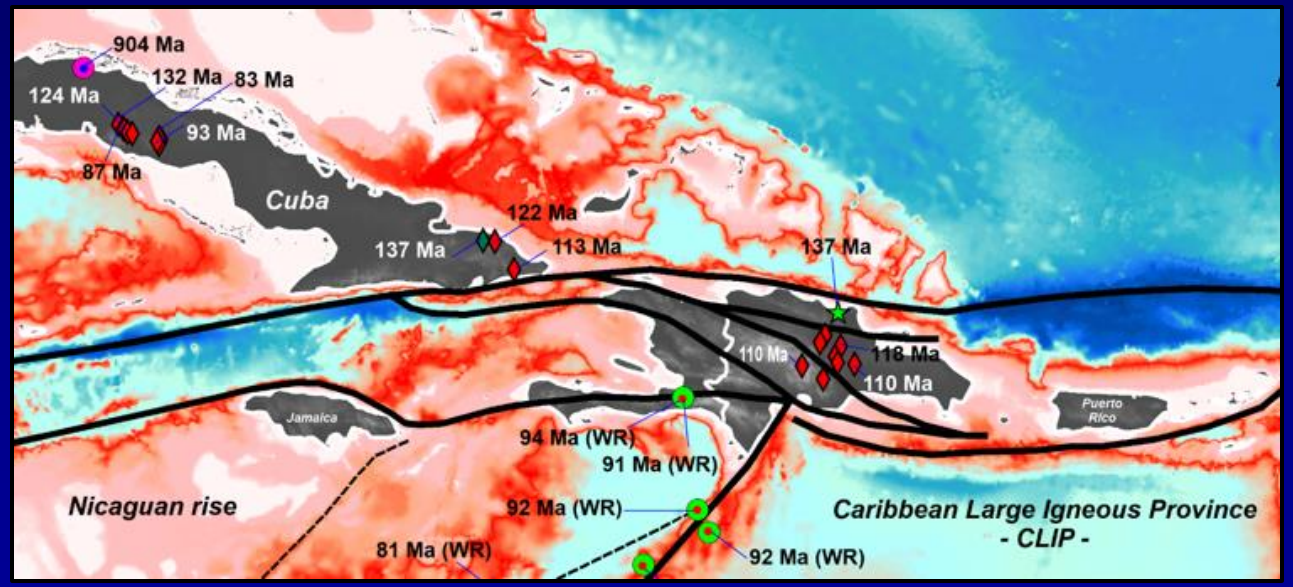
La Desidare Island, Lesser Antilles: **145 Ma**
Tobago Island: **128 Ma (mafic tuff)**
Eastern Cuba: **137 Ma (Gabbro)**

Ages of the GAC and proto-Caribbean crust

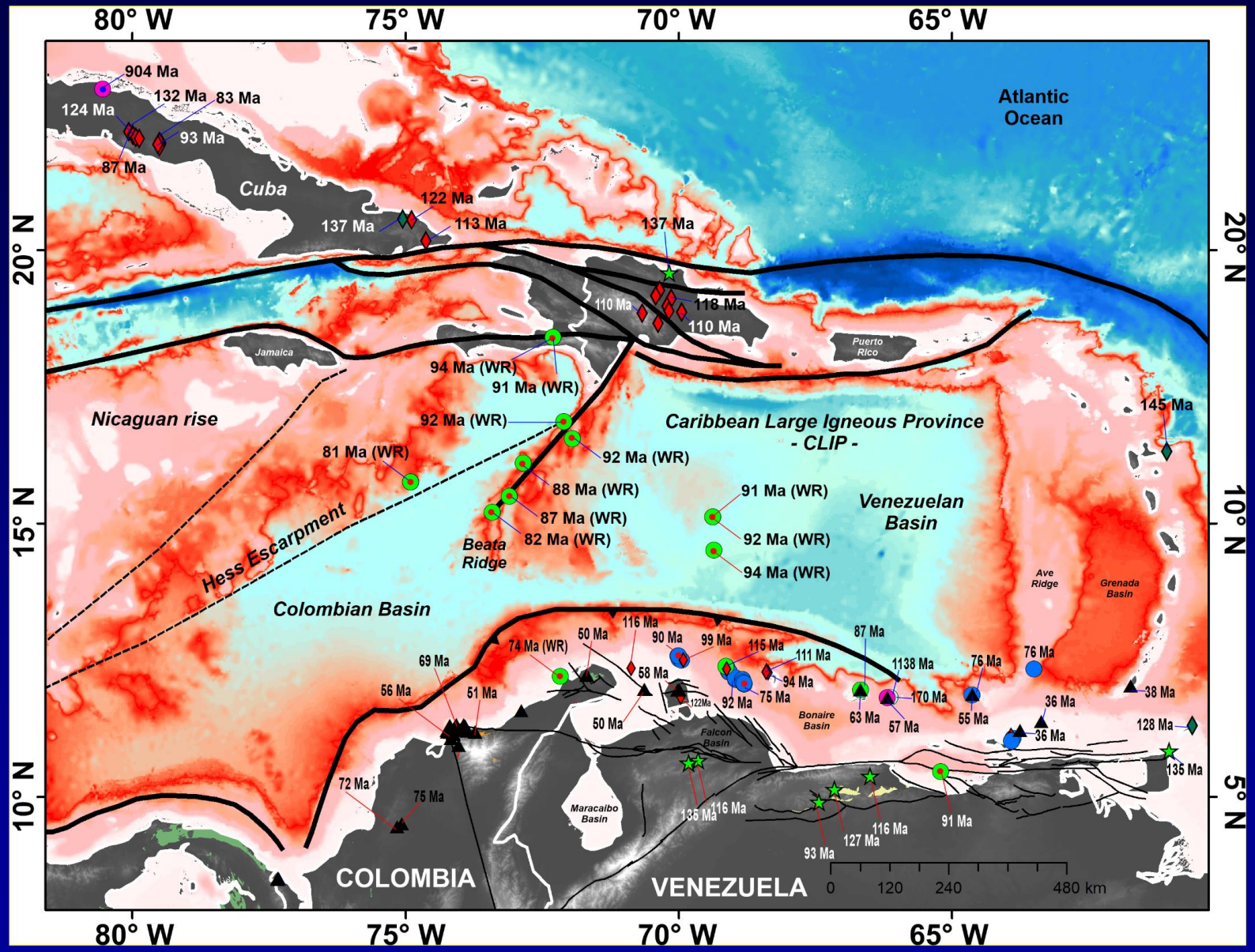
- Great Arc of the Caribbean during Early Cretaceous related to the subduction of the proto-Caribbean plate beneath the Farallon plate

Santa Elena Complex, Costa Rica: **124 Ma**
Santa Ana Complex, Paraguana Peninsula, Venezuela: **122 Ma**
Cuba: **132 Ma to 87 Ma**
Hispaniola (DR): **118 Ma to 110 Ma**





Ages of two stages of the GAC



- **1st stage:** Great Arc of the Caribbean during **Early Cretaceous** related to the subduction of the proto-Caribbean plate beneath the Farallon plate

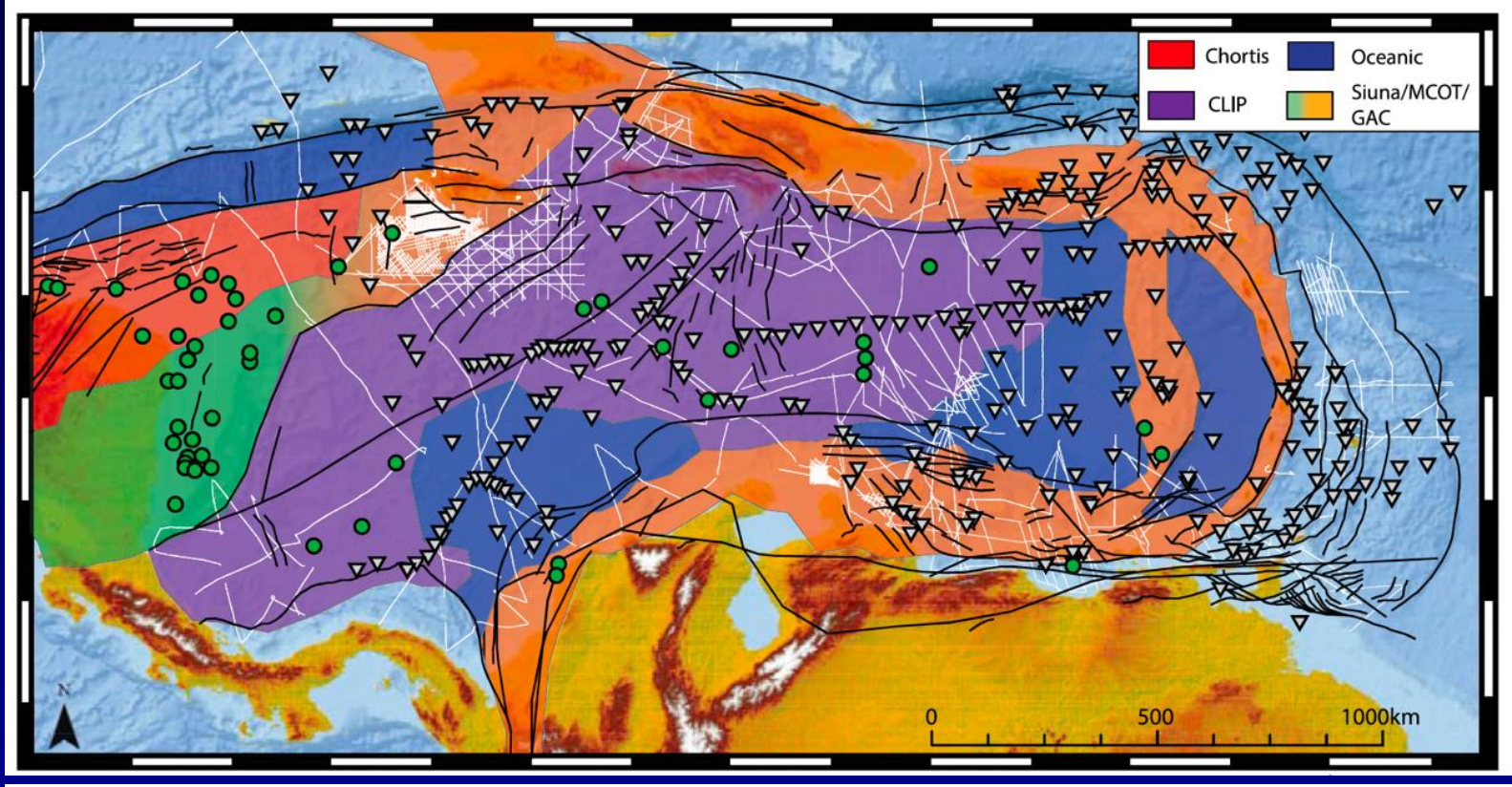
  Santa Elena Complex, Costa Rica: **124 Ma**
  Santa Ana Complex, Paraguana, Venezuela: **122 Ma**
  Cuba: **132 Ma to 87 Ma**
  Hispaniola (DR): **118 Ma to 110 Ma**
  Los Monjes Island, Venezuela: **116 Ma**
  Aruba: **99 Ma**
  Bonaire: **112 Ma to 95 Ma**
  Curacao: **115 Ma**
  Margarita Island:, Venezuela: **116 Ma to 106 Ma**

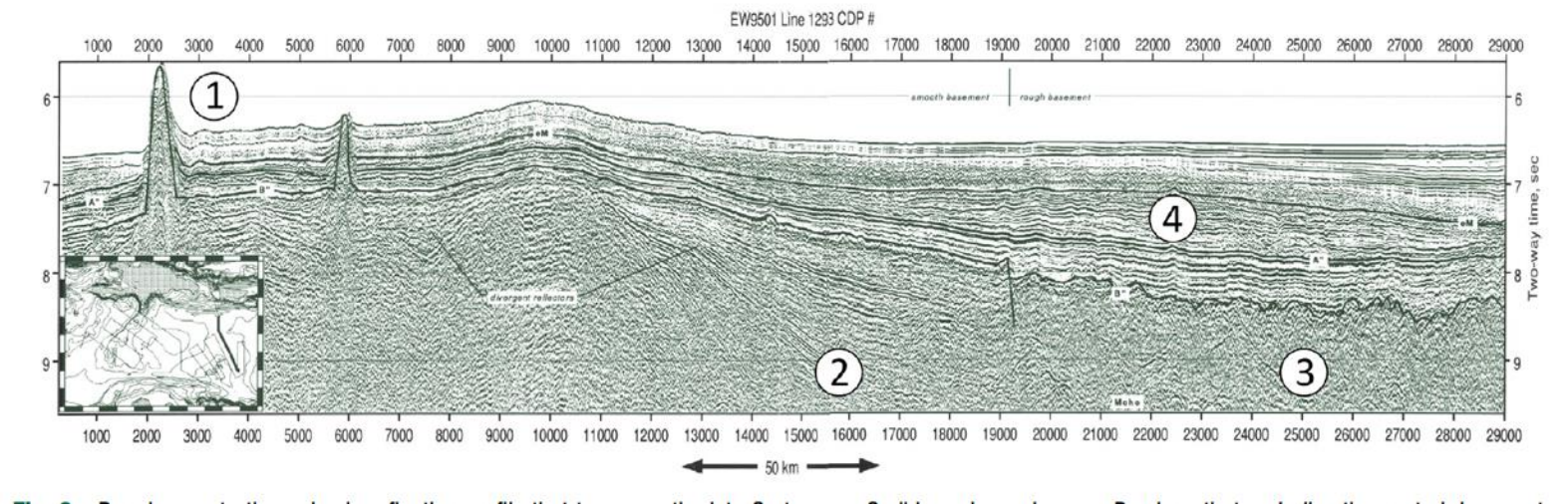
- **2nd stage:** Great Arc of the Caribbean during **Late Cretaceous to early Eocene** related to oblique collision and subduction of the Caribbean plate beneath the NW South America (Colombia) and subduction of the proto-Caribbean plate beneath the Caribbean plate (NW South America – Colombia and Venezuela)

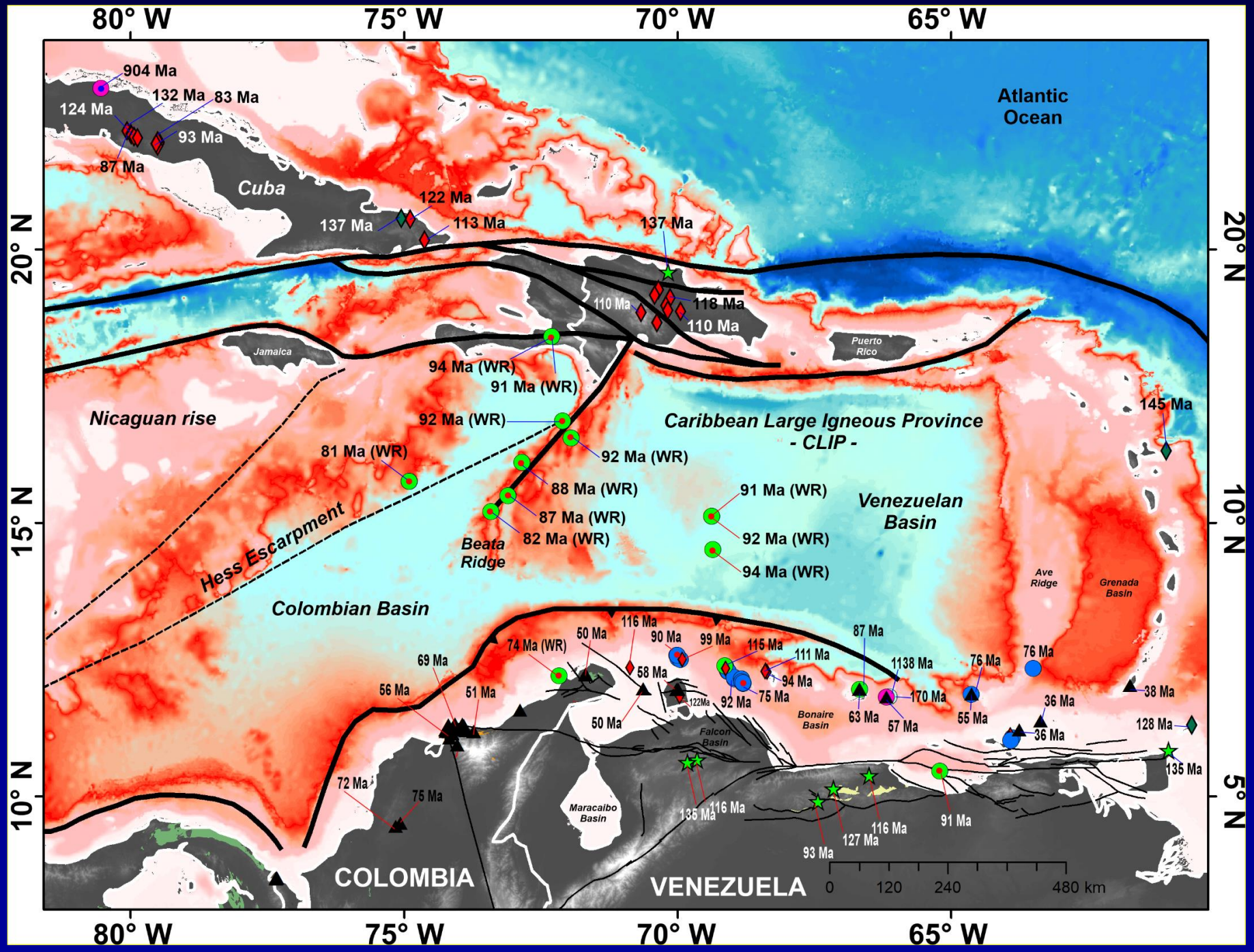
  Colombia: **77 Ma to 50 Ma**
  Perla basement (Gulf of Venezuela): **50 Ma**
  Paraguana Peninsula, Venezuela: **58 Ma to 55 Ma**
  Los Roques Island: **63 Ma**
  La Orchila: **57 Ma**
  La Blanquilla: **55 Ma**
  Los Frailes and Los Testigos islands: **36 Ma**
  Grenada island: **38 Ma**

Objective 2: Improve locations of CLIP ages and pulses in the central Caribbean

Romito & Mann (2020)







Ages of the CLIP Central Caribbean

- **1st Pulse**: CLIP during Early Cretaceous
  Nicoya Complex:
  139 Ma to 111 Ma

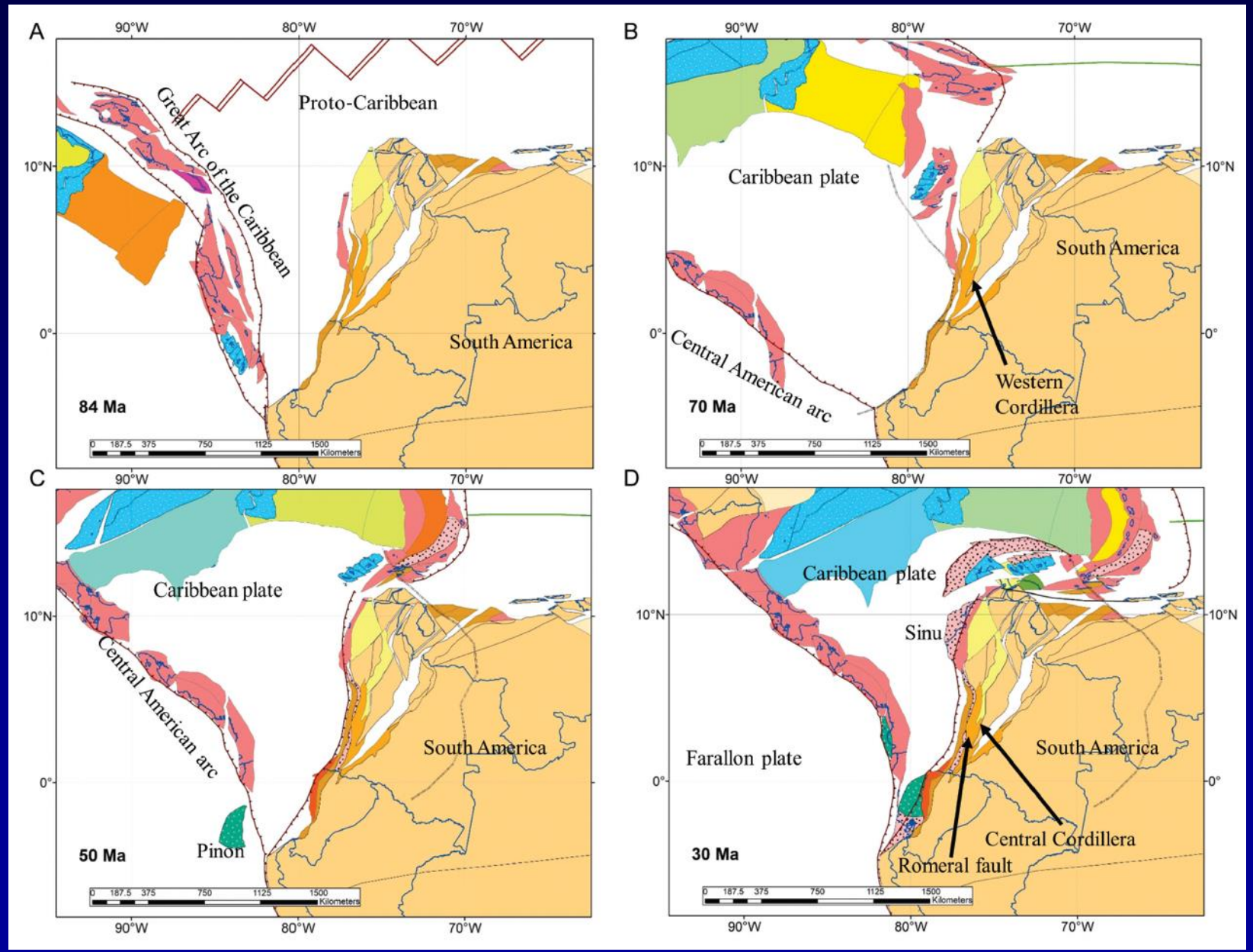
- **2nd Pulse**: CLIP during Late Cretaceous

  Venezuela Basin: **94 Ma to 91 Ma**
  Beata ridge: **92 Ma to 82 Ma**
  Haiti: **94 Ma to 91 Ma**

- **3rd Pulse**: CLIP during Late Cretaceous to Paleocene

  Cabo de la Vela, Colombia: **74 Ma**
  Gorgona Island, Colombia:
  88 Ma to 69 Ma

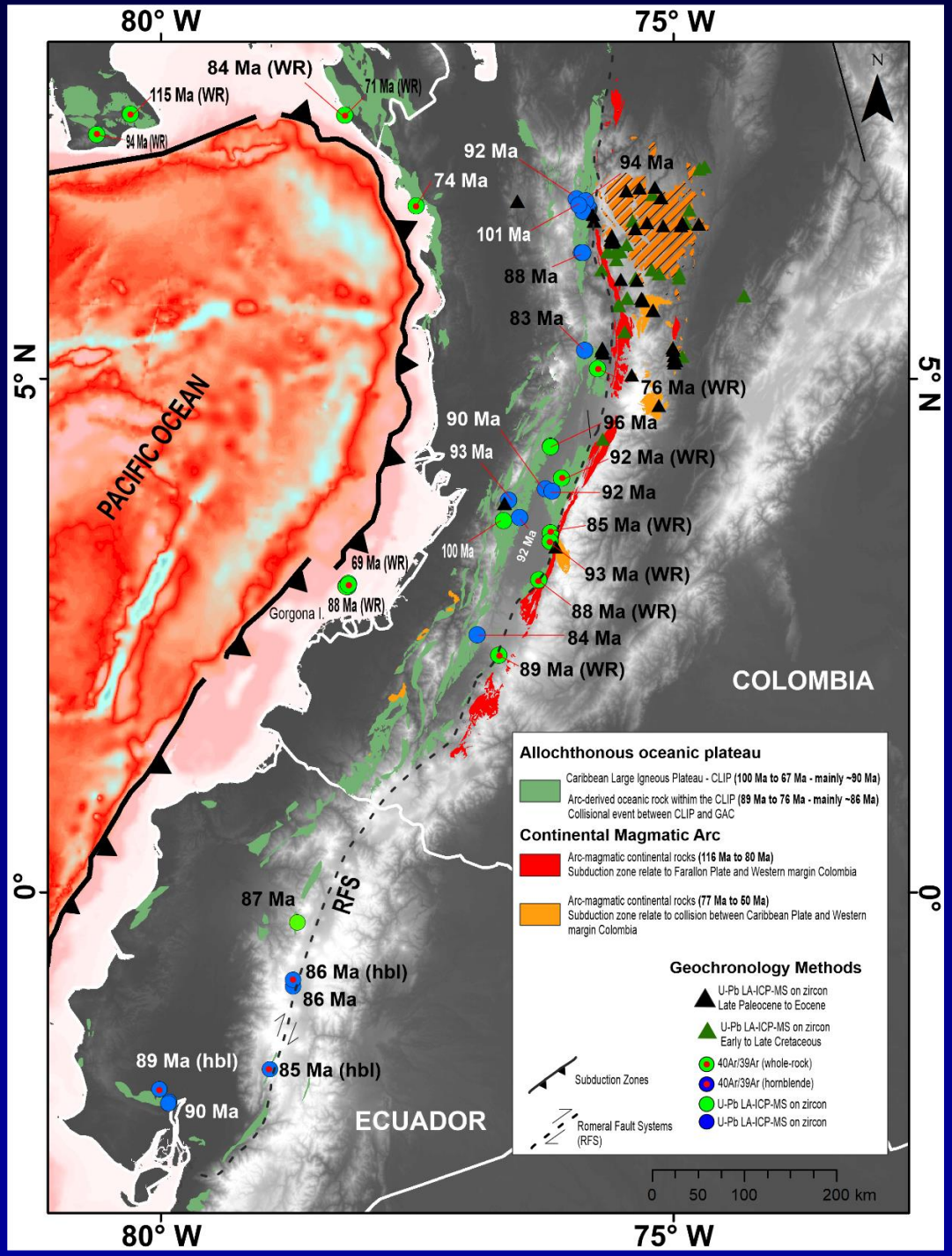
Objective 3: Compiling age data to solve tectonic problems in NW South America



1. <u>Continental arc in northern SOAM coeval to the Great Arc?</u>
2. <u>GAC sutured to this continental arc?</u>
3. CLIP sutured to continental arc and GAC?
4. Panama arc sutured to all three previous elements?

Watson and Escalona (2021)

Compiling age data to solve tectonic problems in NW South America



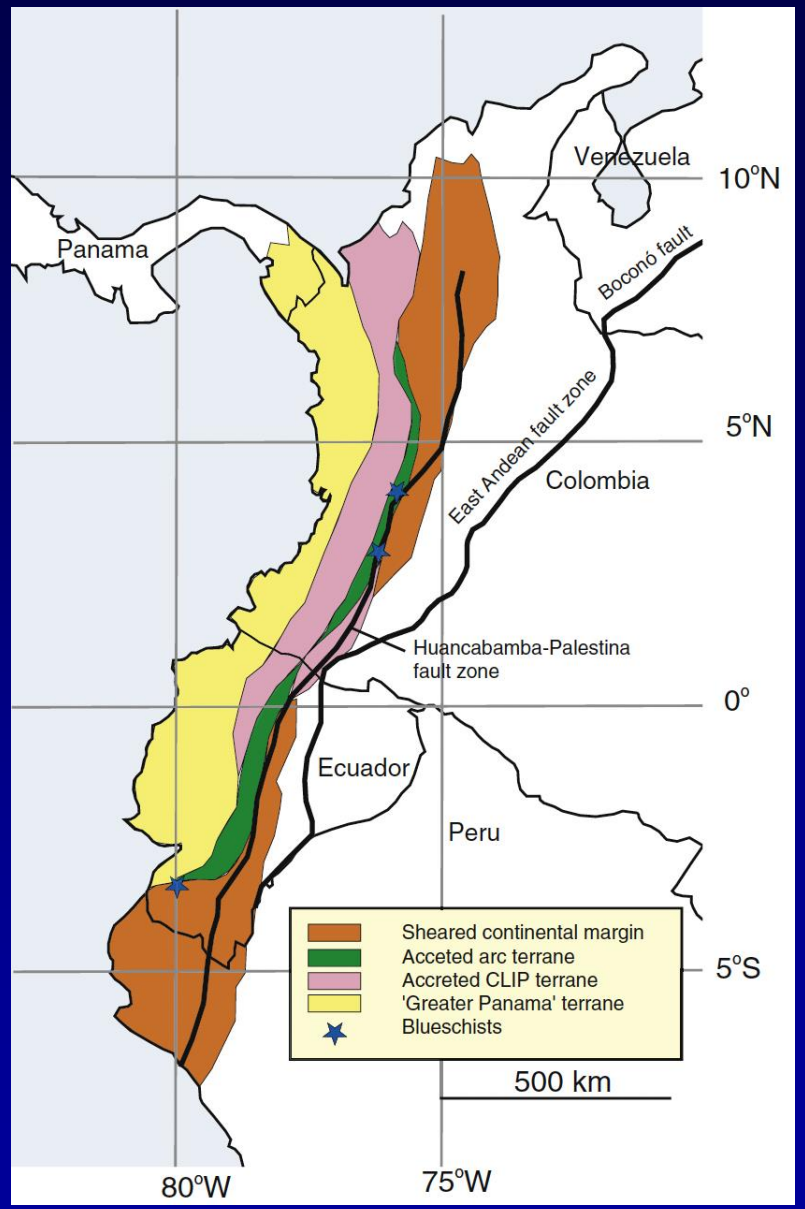
Continental arc in northern SOAM coeval to the Great Arc?

- Continental Arc during Early Cretaceous related to the subduction of the Farallon plate beneath the western margin of Colombia

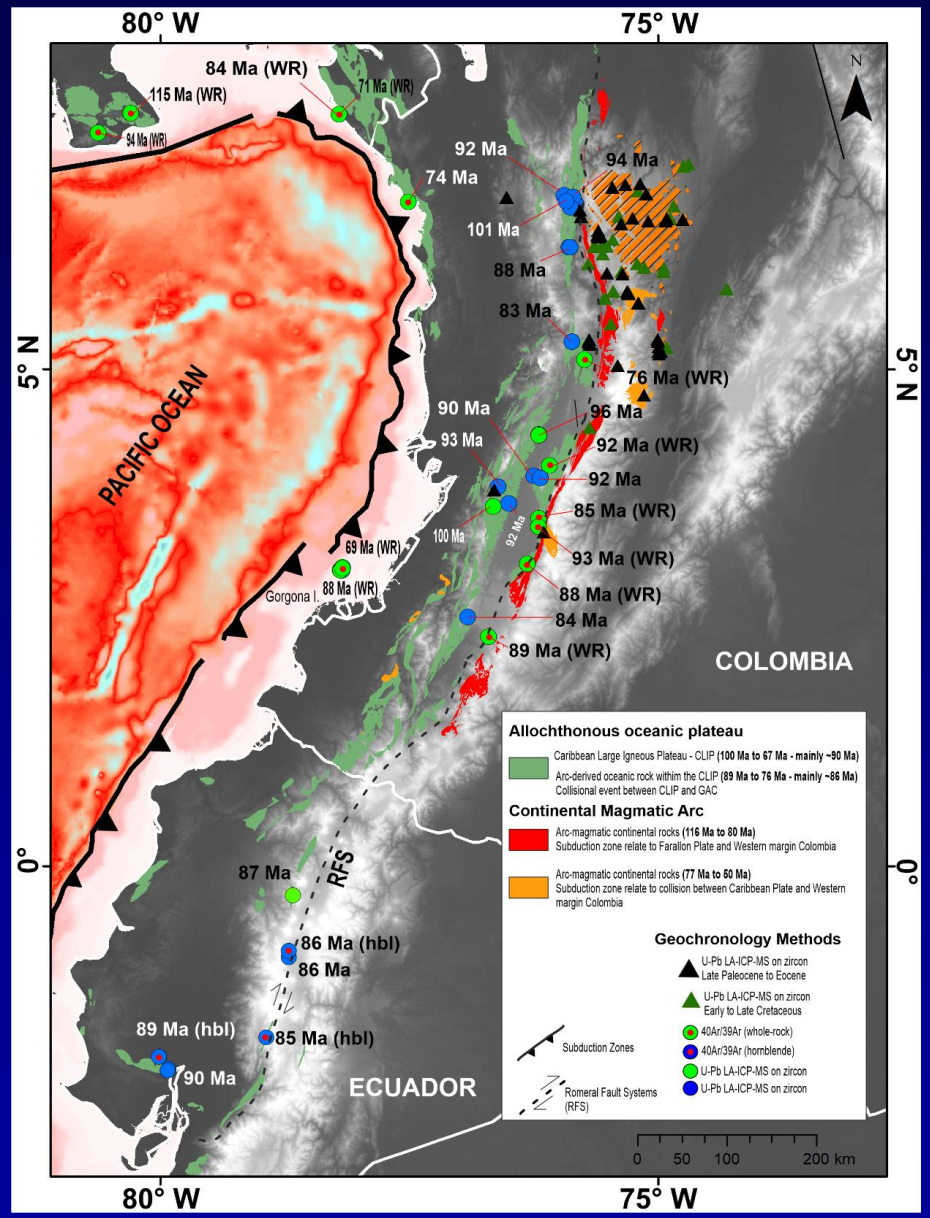
  Colombia (eastern Cordillera): **116 Ma to 80 Ma**

- These continental arc units are located eastern of the Romeral Fault System

Sutures of northwestern South America between the continent, older arc, GAC, CLIP and Panama



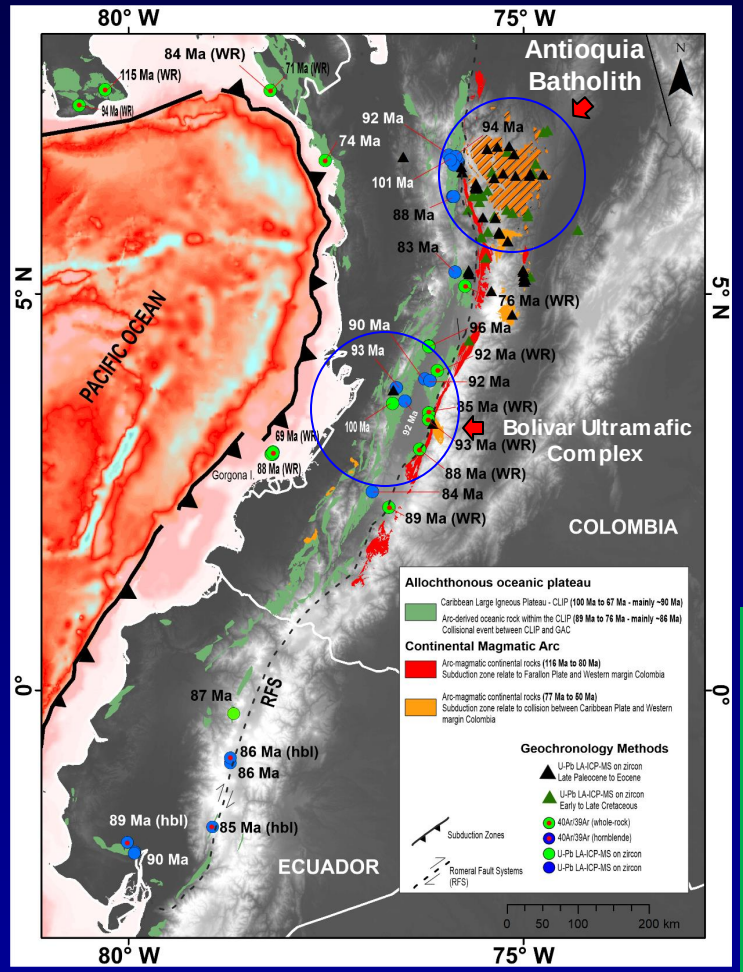
Boschman et al., (2014)

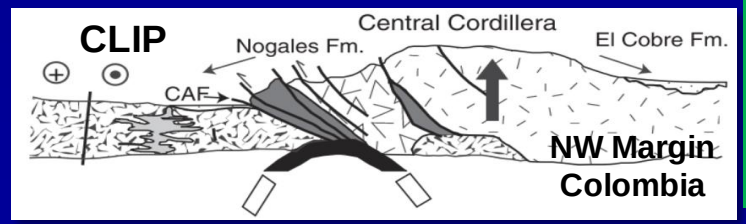


- Continental Magmatic Arc during Early Cretaceous at **116 Ma** Subduction Farallon plate beneath the western margin of SOAM
- Caribbean Large Igneous Province (CLIP) during Early Cretaceous at **115 Ma to 69 Ma**
- Arc-derived oceanic rock within CLIP during Late Cretaceous at **89 Ma to 76 Ma**, related to the collision between CLIP and Great Arc of the Caribbean
- Continental Magmatic Arc during Late Cretaceous to Eocene at **77 Ma to 50 Ma**, related to the oblique collision between CLIP and NW Margin SOAM
- The suture zone between CLIP/GAC and NW Margin South America is defined by the Romeral System Faults

Collision and accretion – 75 to 70 Ma

CLIP and NW Margin Colombia

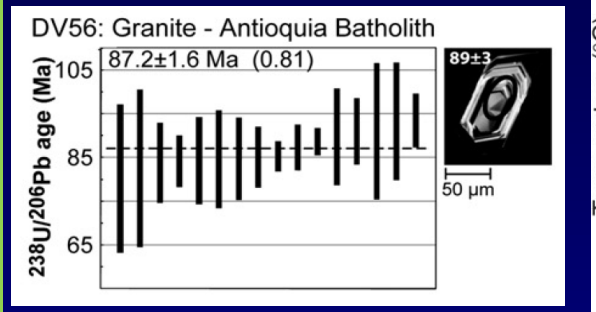


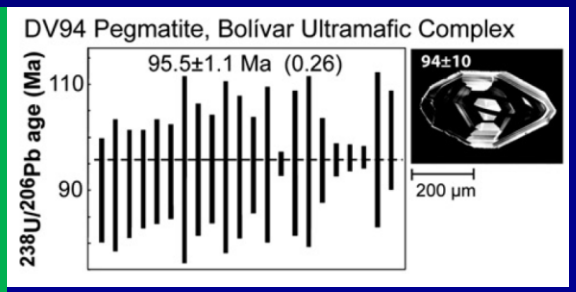


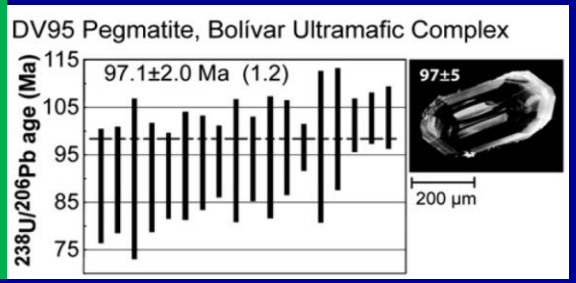
Continental Magmatic Arc

CLIP

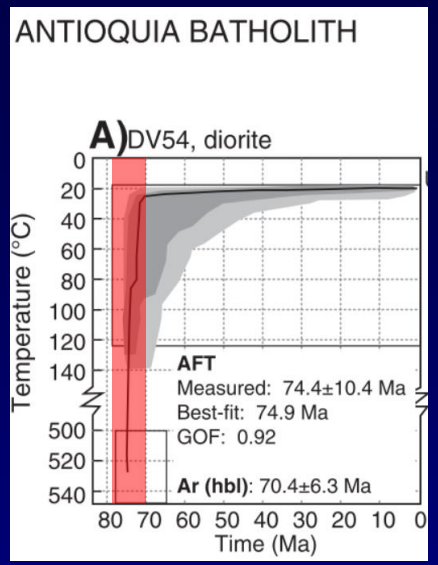
U-Pb on zircon

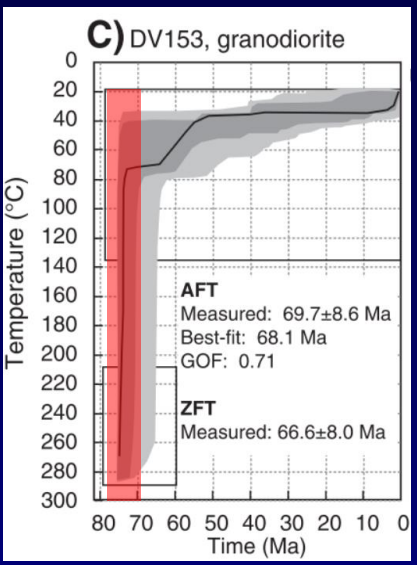




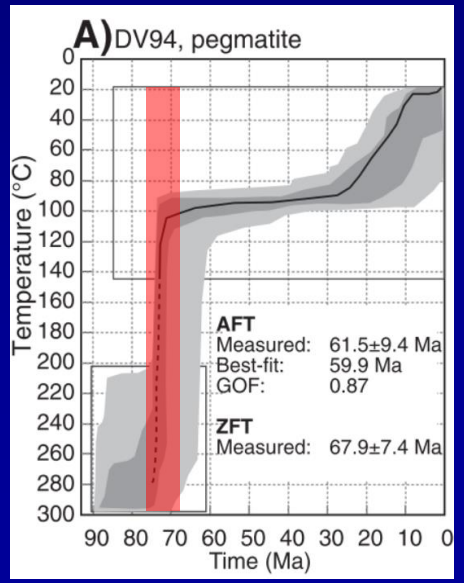


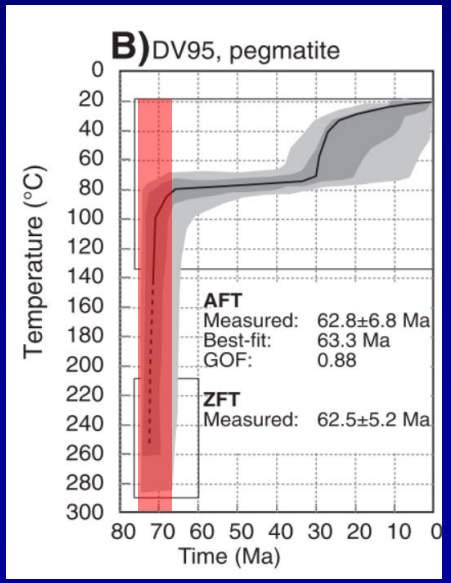
Thermochronology – AFTA



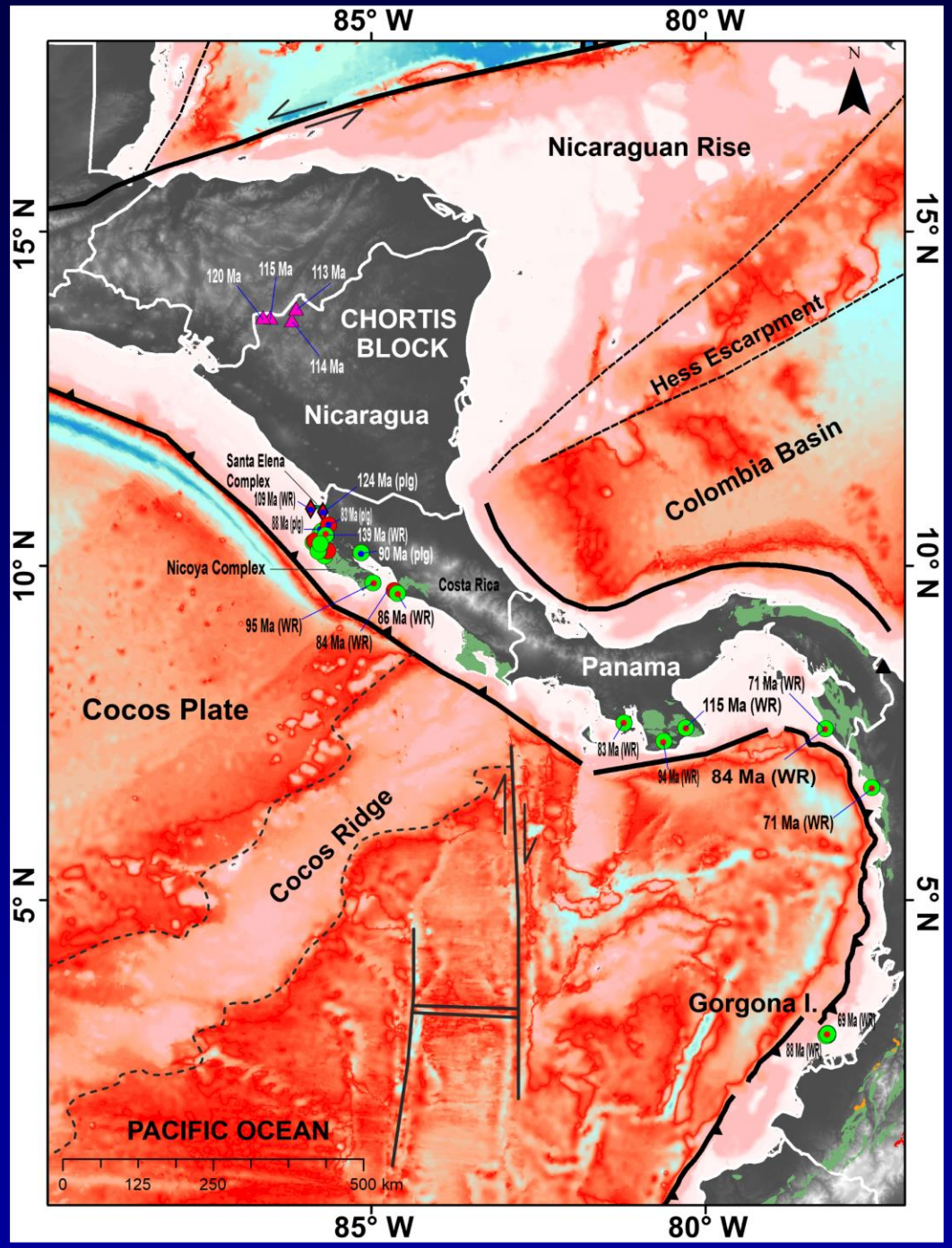


Apatite Fission Track Analysis





Villagomez et al., (2011)



1. **Panama arc sutured to all three previous elements?**
2. **Original crust of CLIP in Central America?**
3. **Number of CLIP pulses?**

- **1st Pulse CLIP or Old Oceanic Crust – Farallon plate**:
  CLIP during Early Cretaceous
  Nicoya Complex: **139 Ma to 111 Ma**
  Panama: **115 Ma**

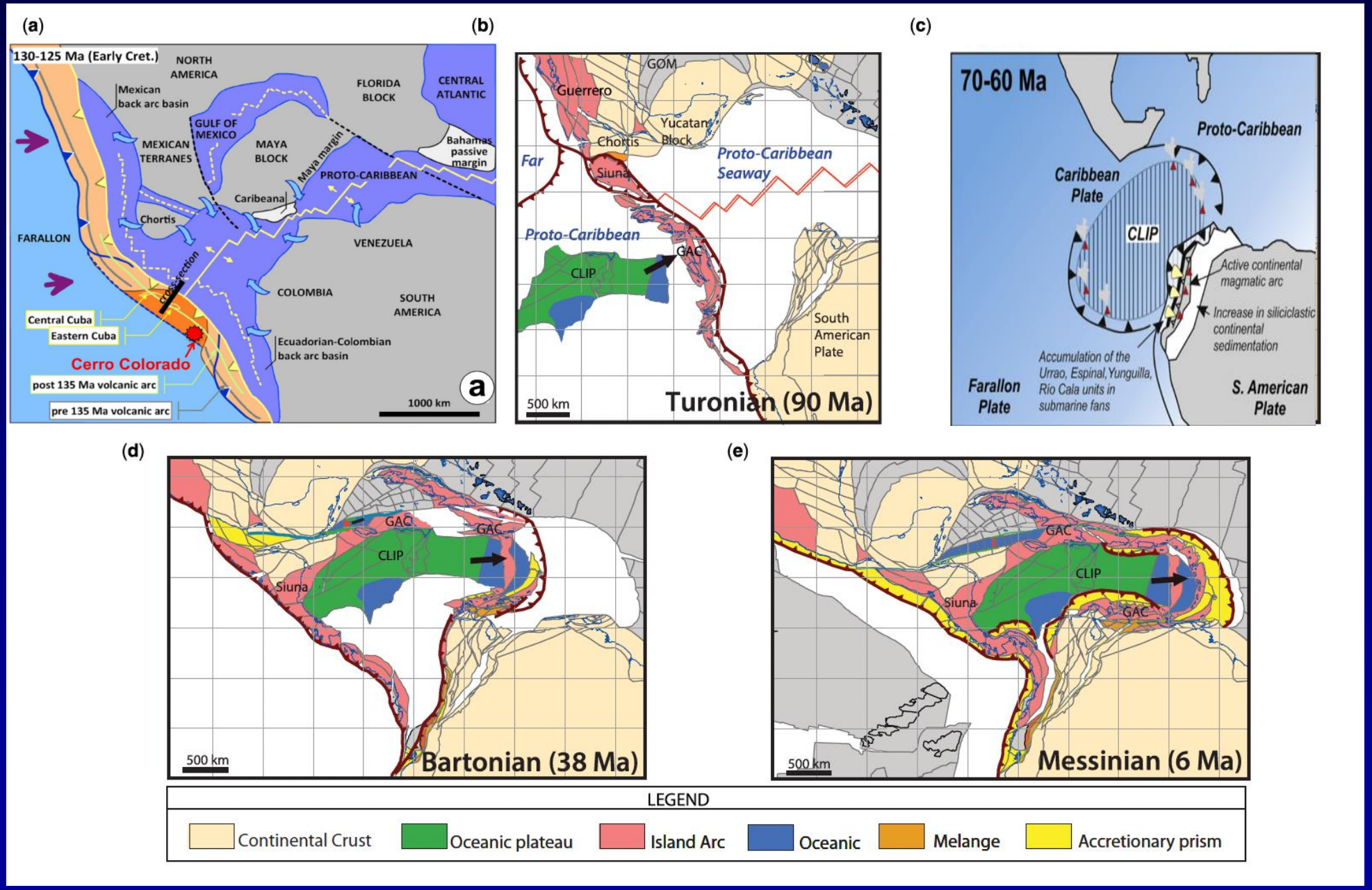
- **2nd Pulse**: CLIP during Late Cretaceous

  Costa Rica: **95 Ma to 91 Ma**
  Panama: **94 Ma to 82 Ma**

- **3rd Pulse**: CLIP during Late Cretaceous to Paleocene

  Choco - Panama block: **74 Ma to 71 Ma**

Summary



after Pindell & Kennan (2009), Proenza et al., (2018), Mendi et al., (2020), Romito and Mann (2020) and Pardo-Trujillo et al., (2020)