Lithospheric structure in the Northwest South America: constraining the problem with receiver functions and other geophysical observations

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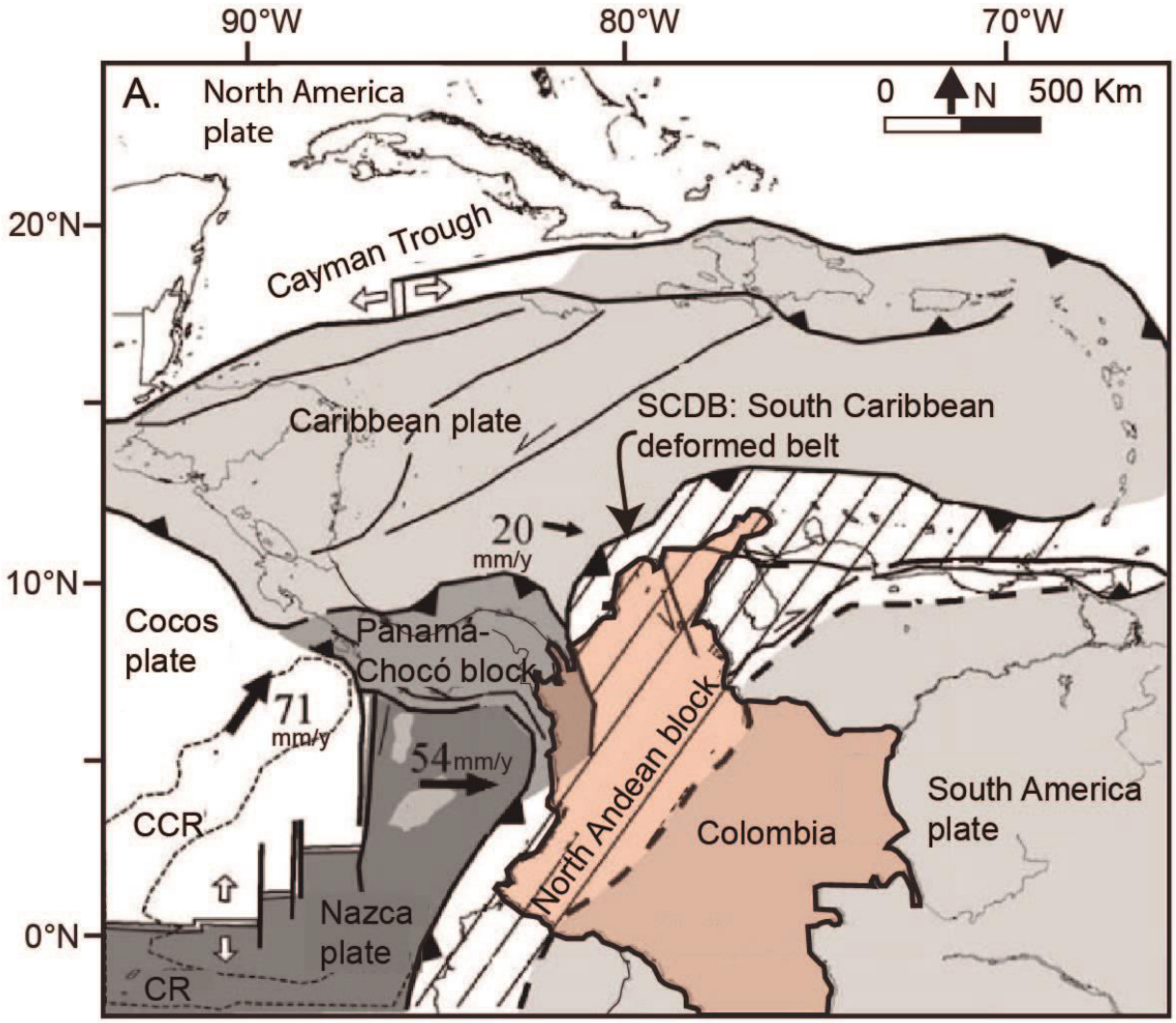
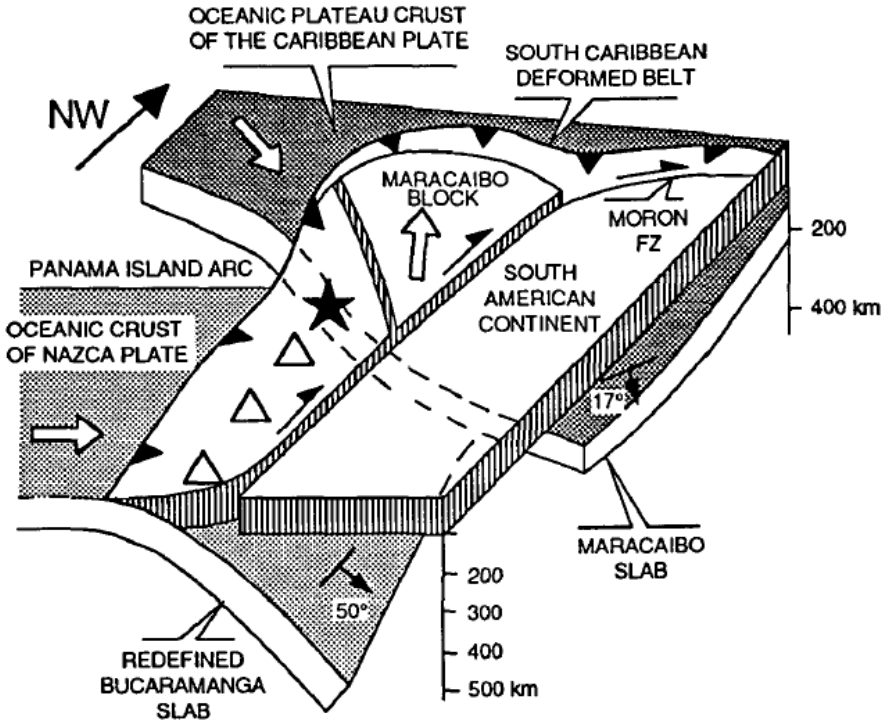
General tectonic setting



Three major tectonic plates and at least two blocks

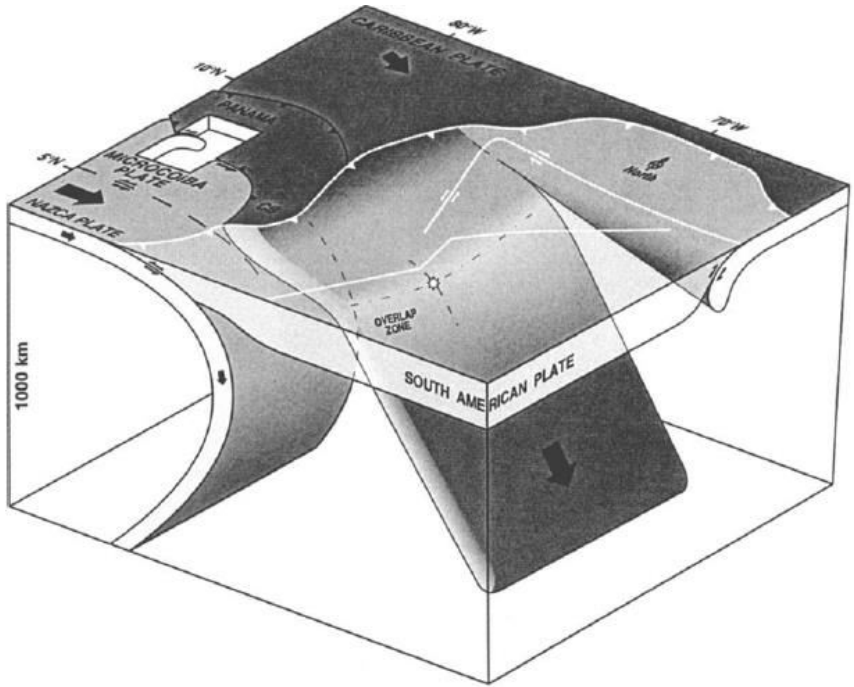
Figure from *Cortés and Angelier [2005], Lara et al. [2013]*

Evolution of the ideas of Caribbean and Nazca Plates at the northernmost Andes

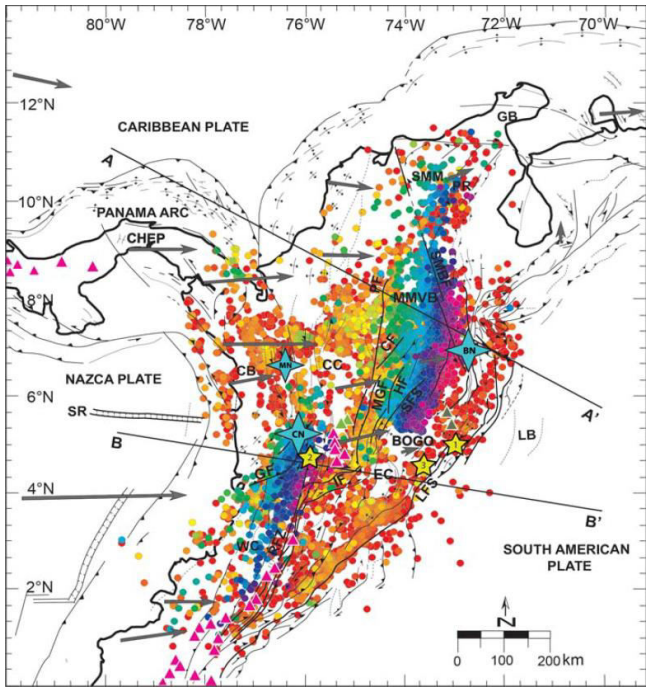


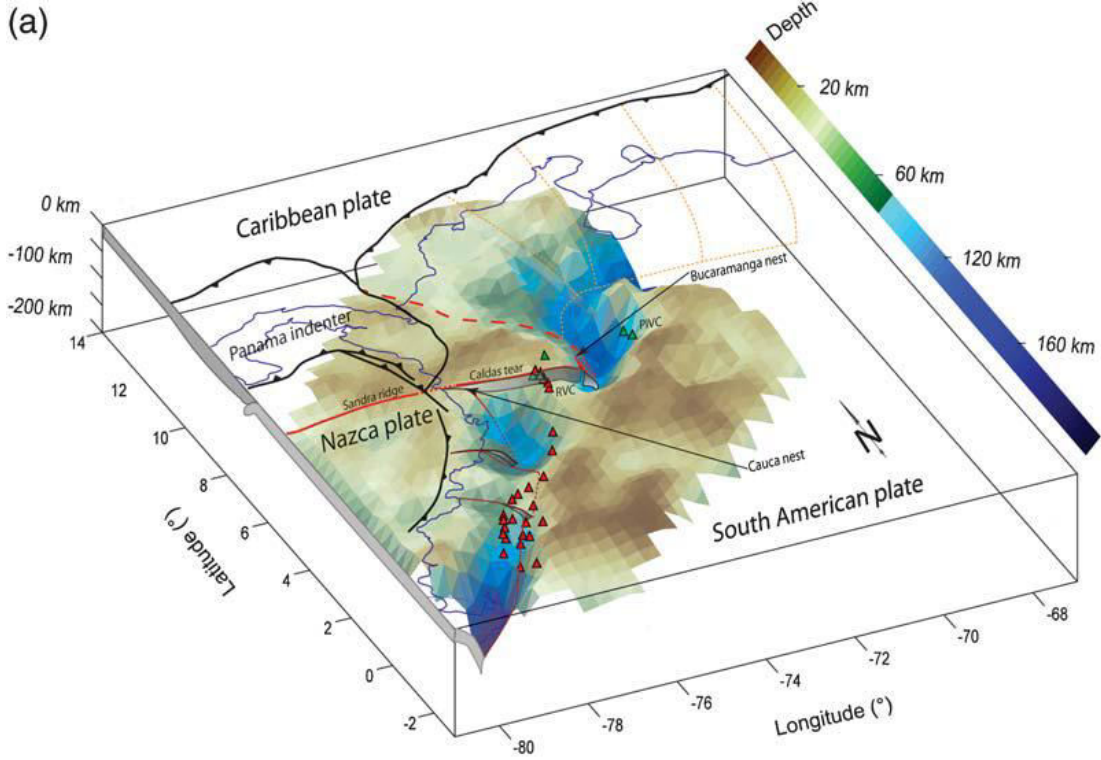
Van der Hilst and Mann [1994]: Maracaibo and Bucaramanga Slabs. Connection between Bucaramanga Slab and Nazca Plate

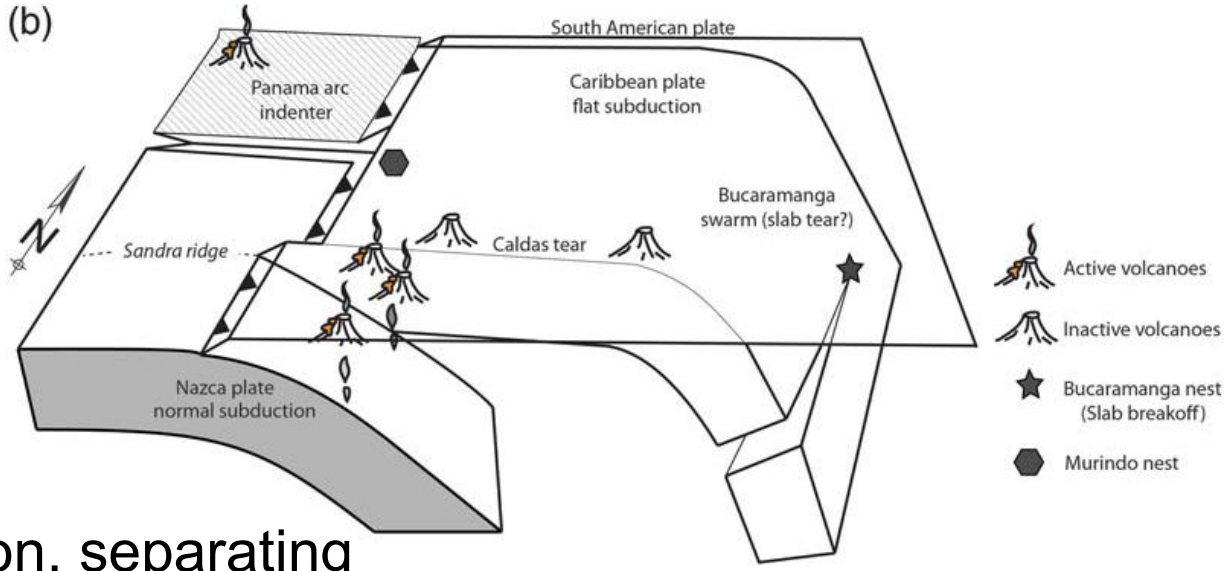
Taboada et al. [2000]: Caribbean, Paleo-Caribbean and Nazca Slabs. Bucaramanga nest associated with Paleo-Caribbean Slab



Evolution of the ideas of Caribbean and Nazca Plates at the northernmost Andes



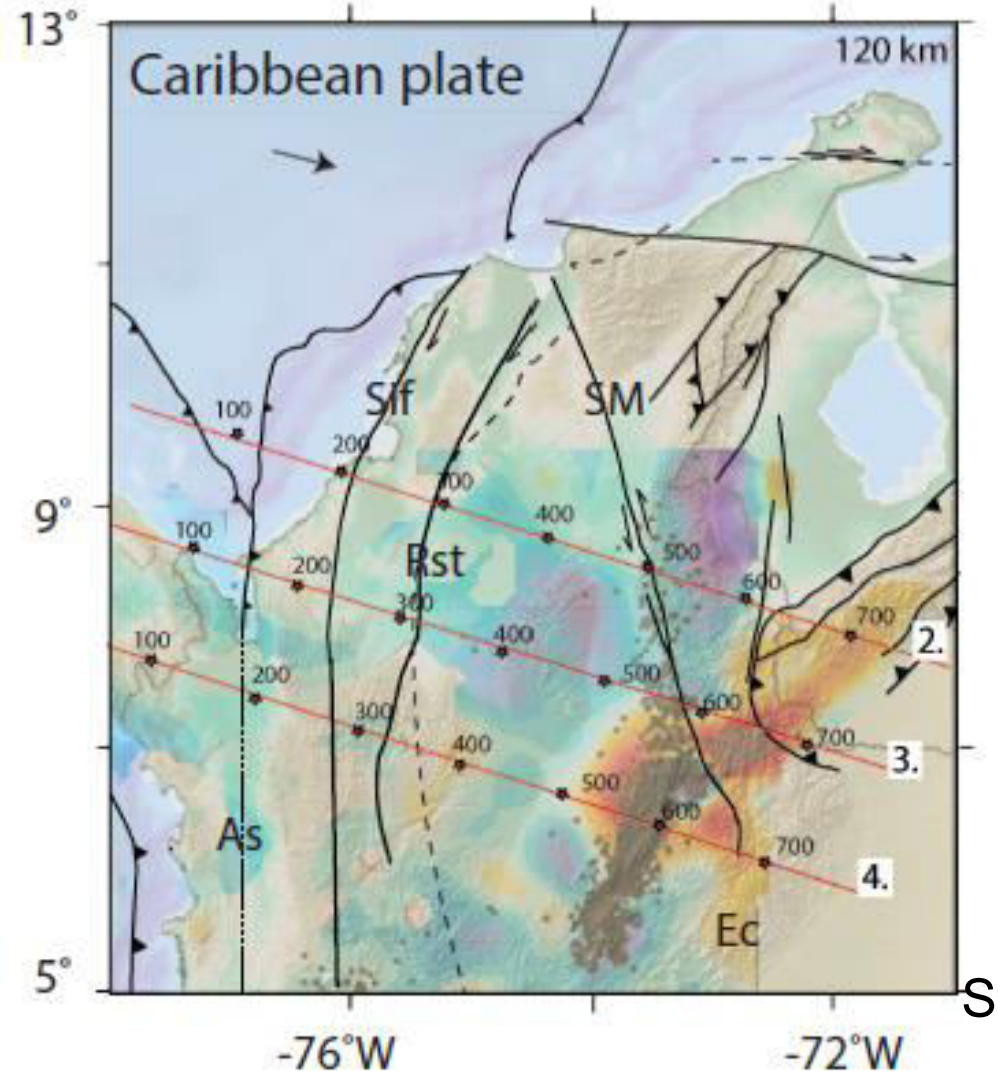


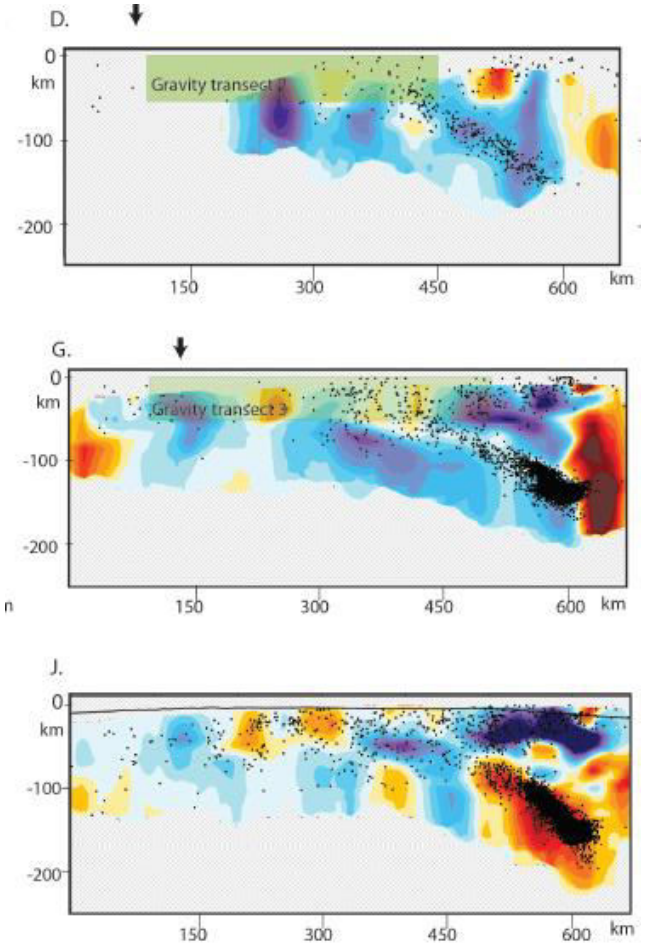


Slab tear in a W-E direction, separating Nazca and Caribbean segments

Vargas and Mann [2013]

Interaction between Panama and the North Andes Block Still unclear





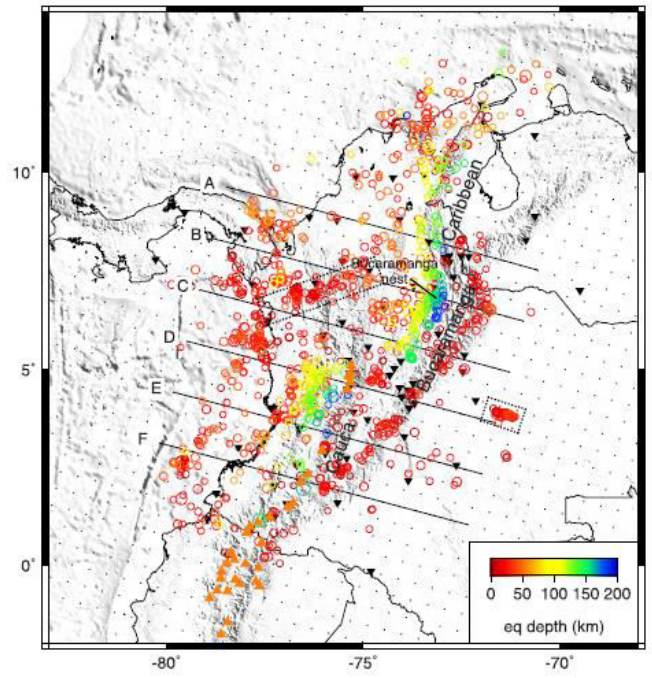
Still unclear – Seismicity is probably the most suggestive of flat subduction

Bernal- Olaya et al. [2015]

Volcanic Arc?

Flat slab in NW South America?

Still unclear – Seismicity is probably the most suggestive of flat subduction



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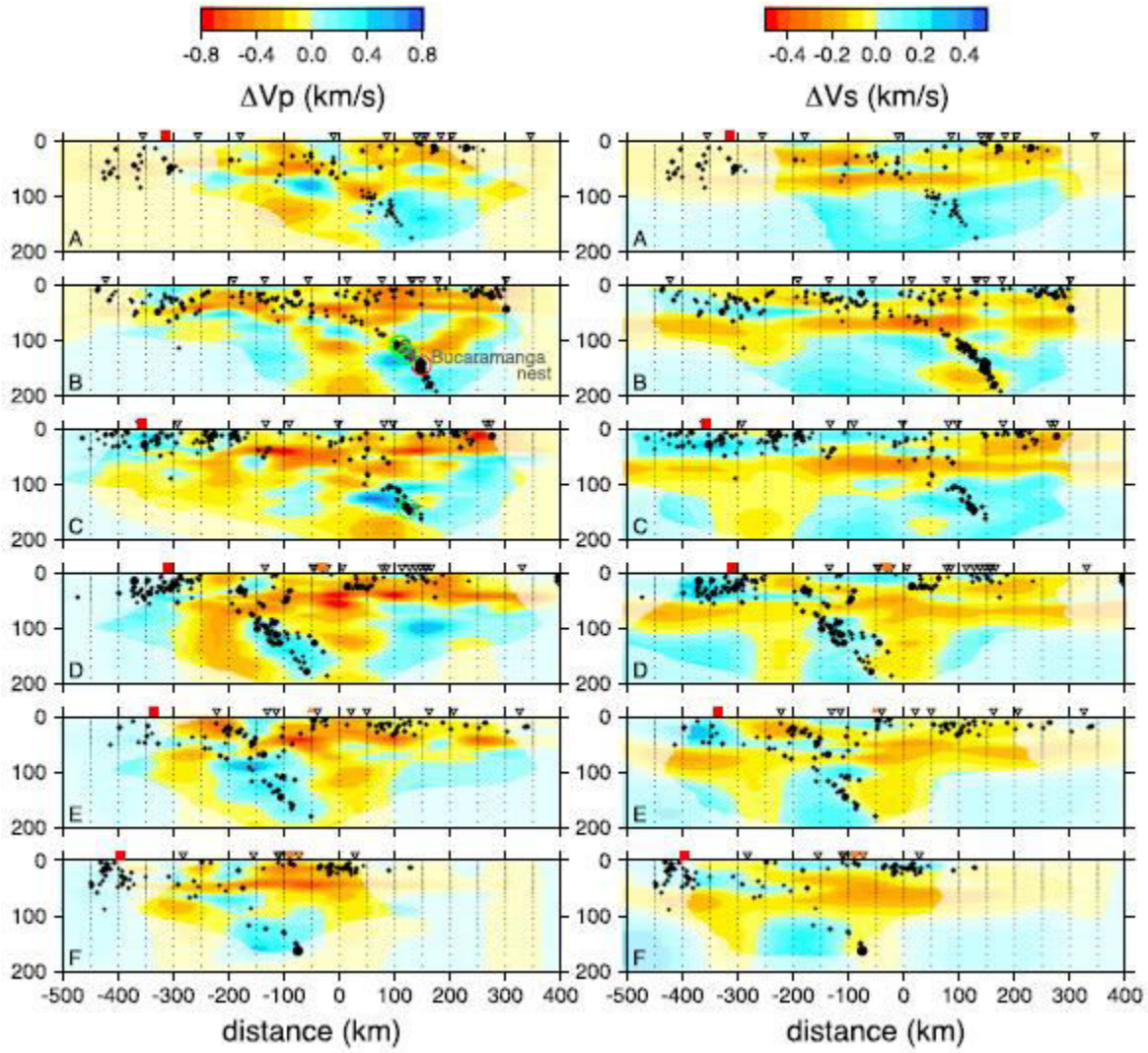


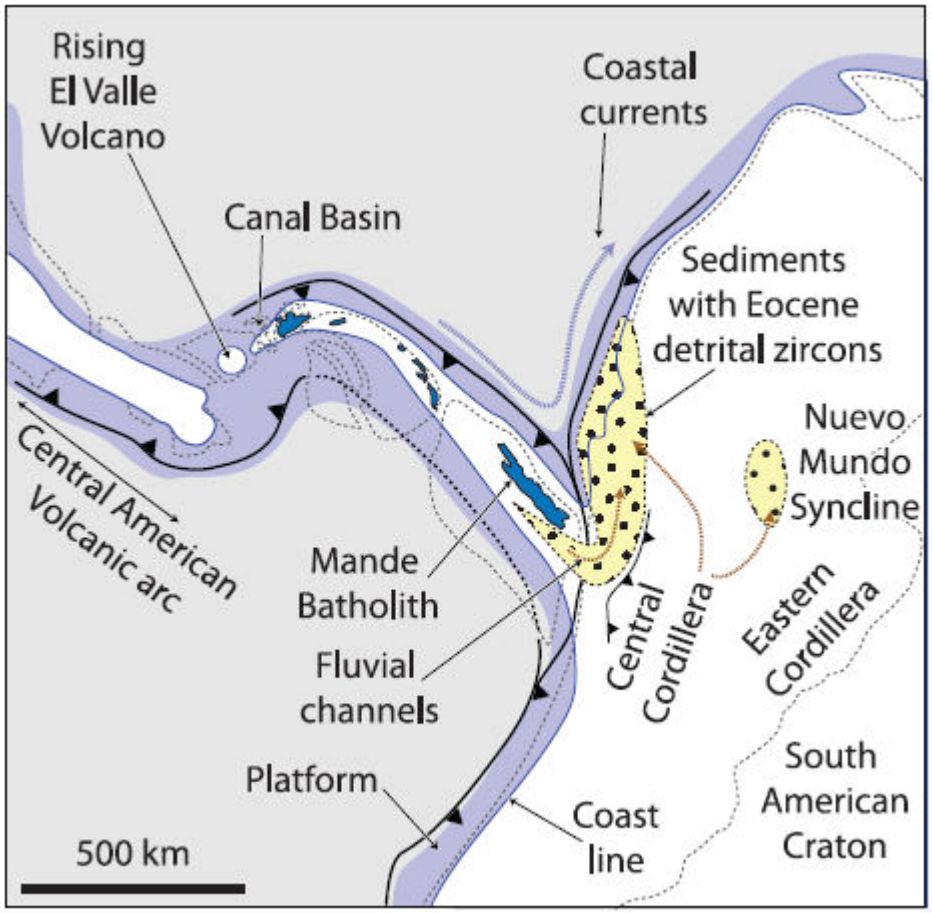
Syracuse et al. (2016)

From seismic velocities is hard to infer

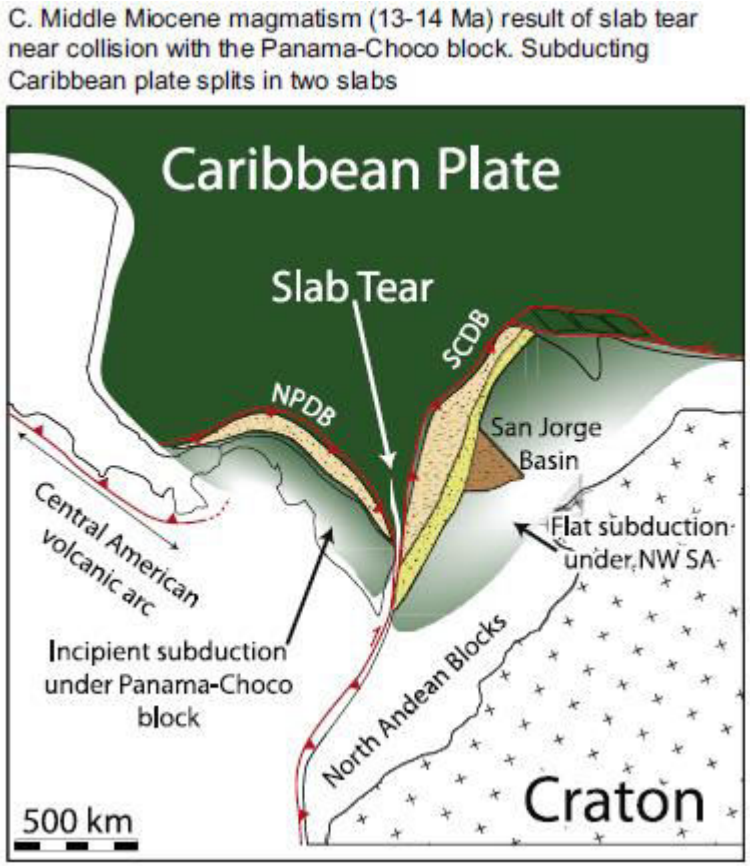
What about Panama?

It collides between 13 and 15 Ma

Miocene vulcanism near Monteria: Tear in the Caribbean plate related with the Collision *[Lara et al., 2013]*



Montes et al. [2015]:
Paleogeography between 13-15 Ma

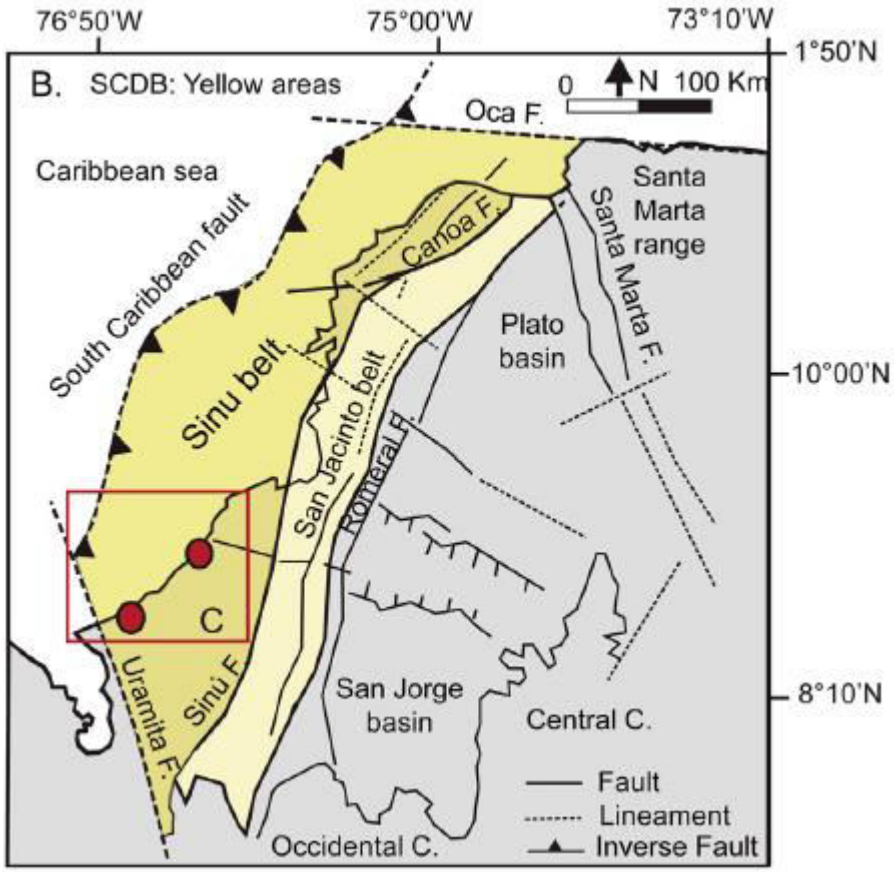


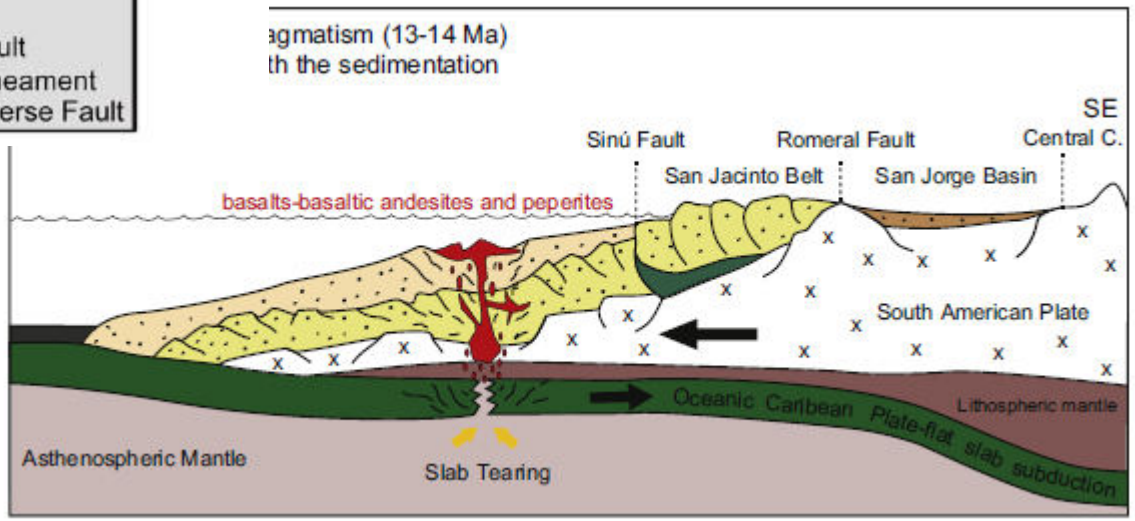
Lara et al. [2013]

Flat slab in northern Colombia?

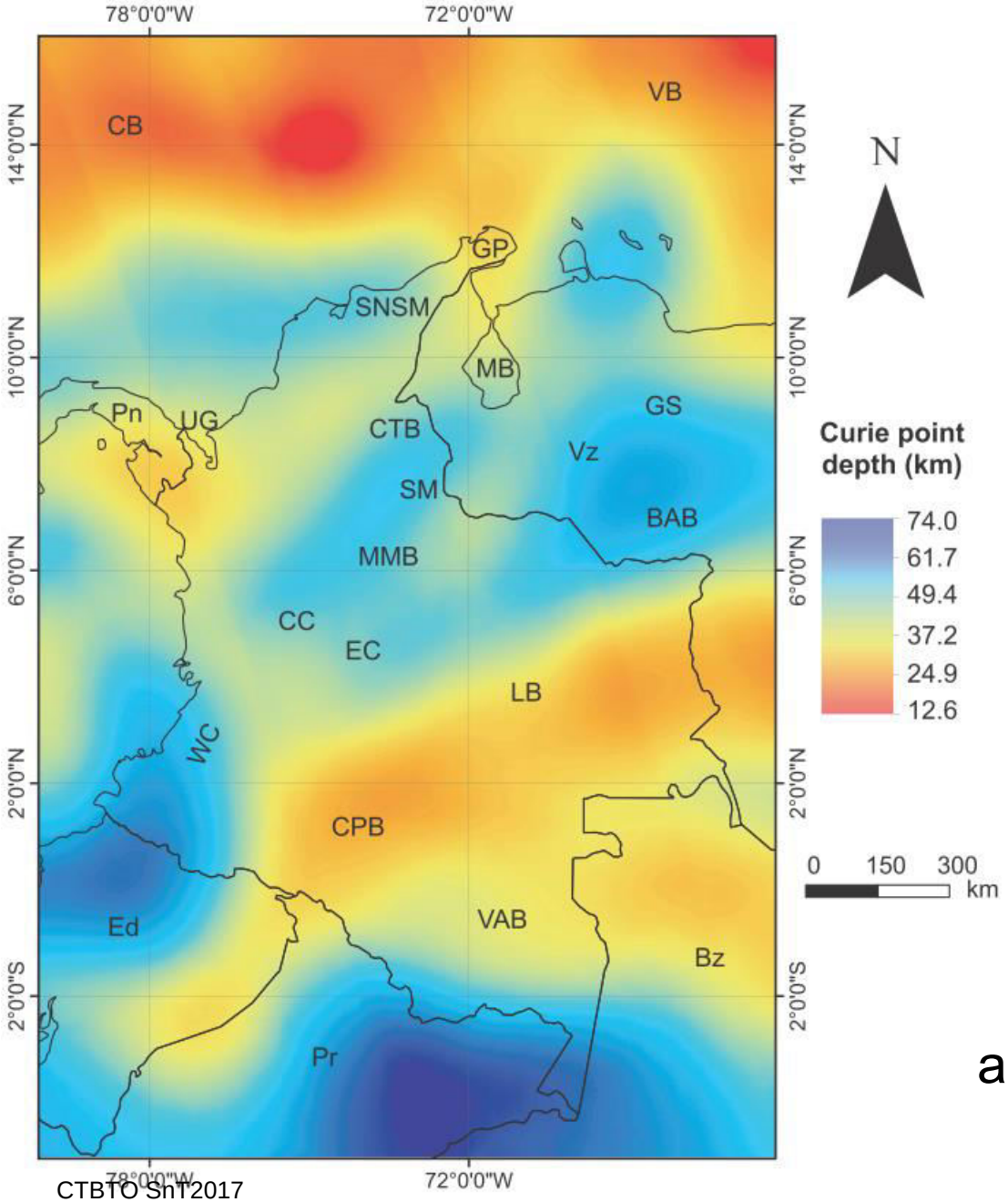
Lara et al. [2013]: Middle miocene vulcanism near Montería

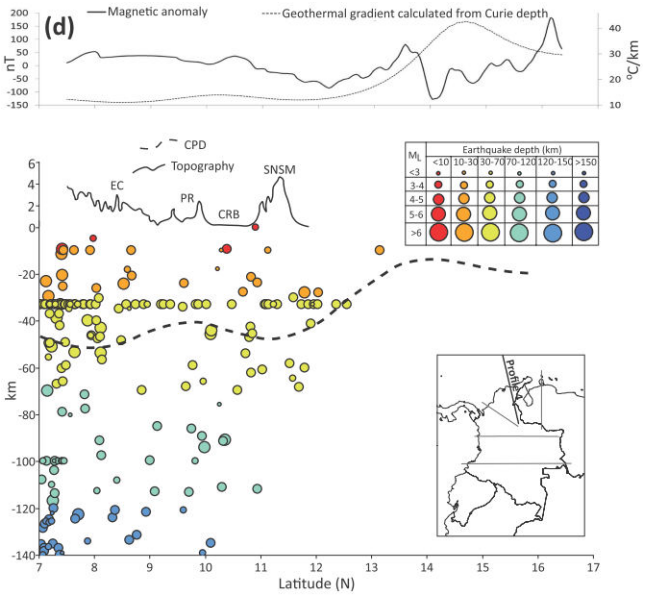
Geochemistry is suggestive of a tear in the Caribbean Plate as it subducts South America at a low angle ("Asthenospheric melting with some slab input")





Thermal structure



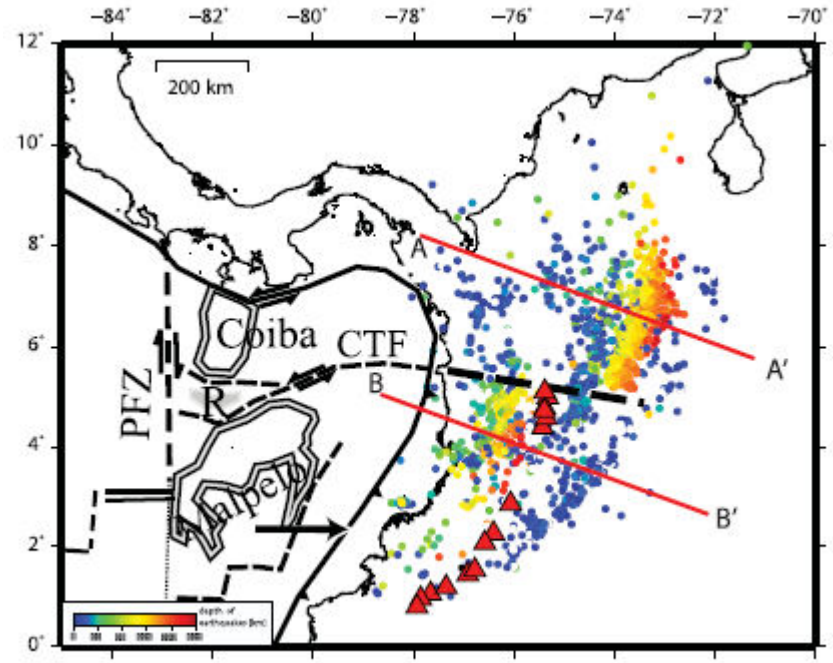


Constrasting CPD anomalies in the Caribbean

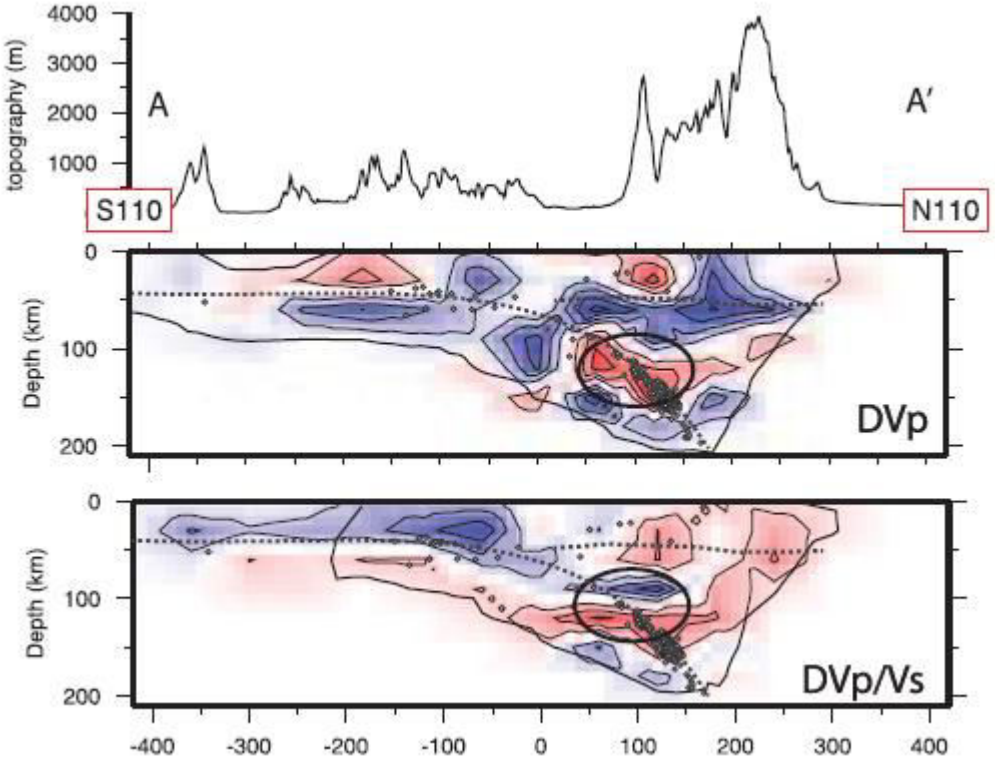
Vargas et al. [2015]

Flat slab in NW South America?

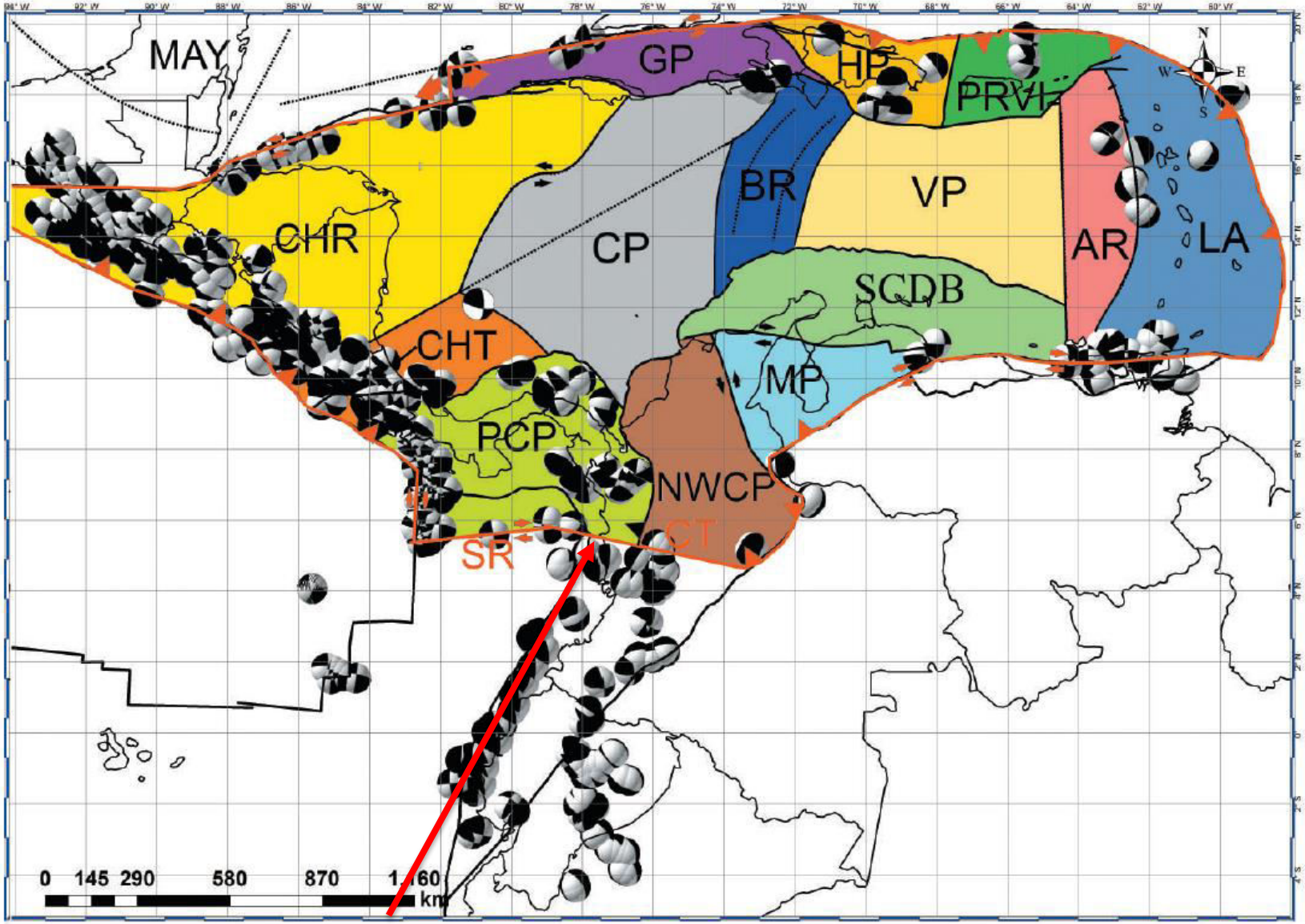
Still unclear – Seismicity is probably the most suggestive of flat subduction



Chiarabba et al. [2015] claim that a contrast in velocity tomography suggests the flat-slab. Such contrast was not obtained by *Syracuse et al. [2016]*



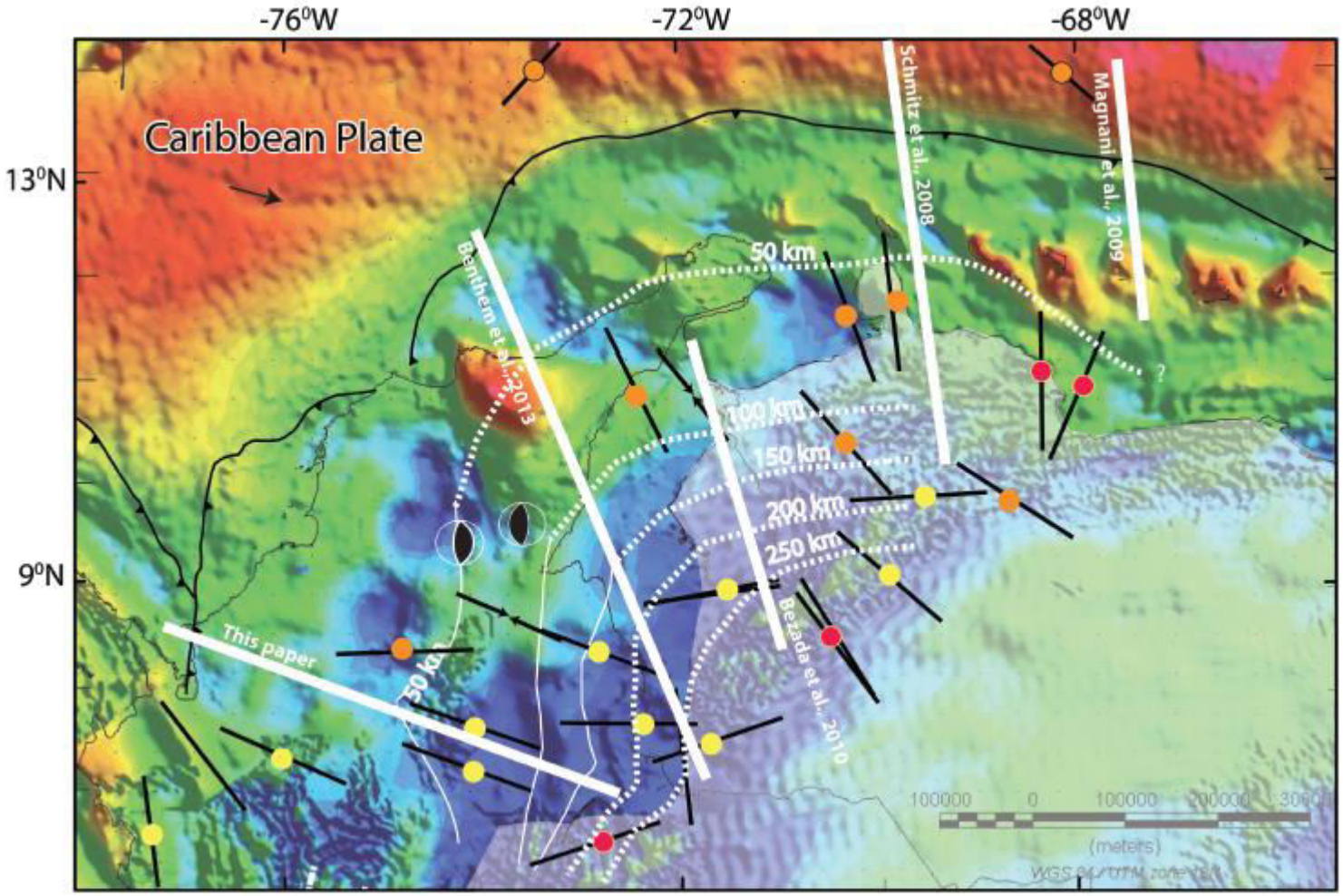
Evolution of the ideas of Caribbean and Nazca Plates at the northernmost Andes



Southern border of the Caribbean plate or tear? *Salazar and Vargas [2015]*

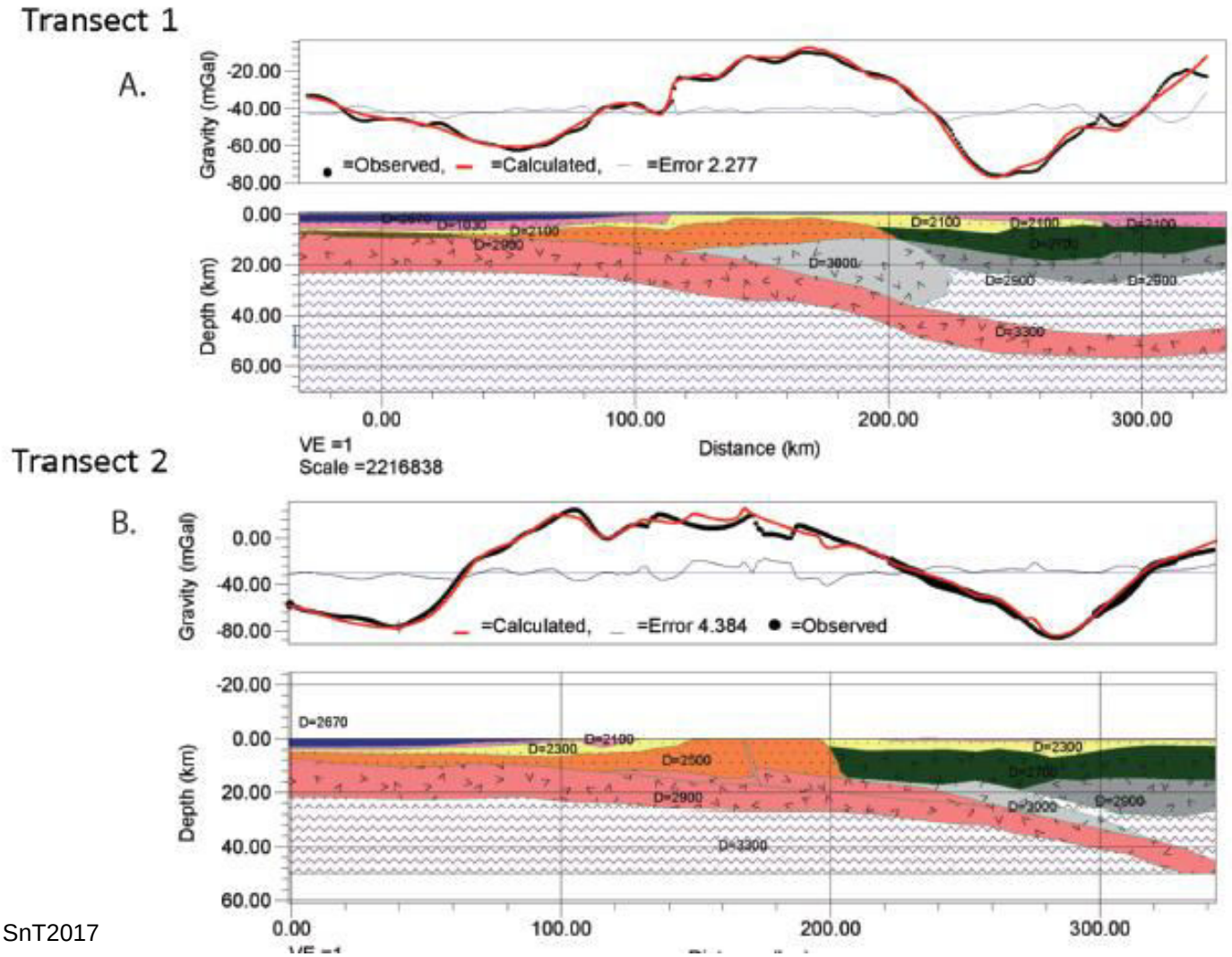
Flat slab in NW South America?

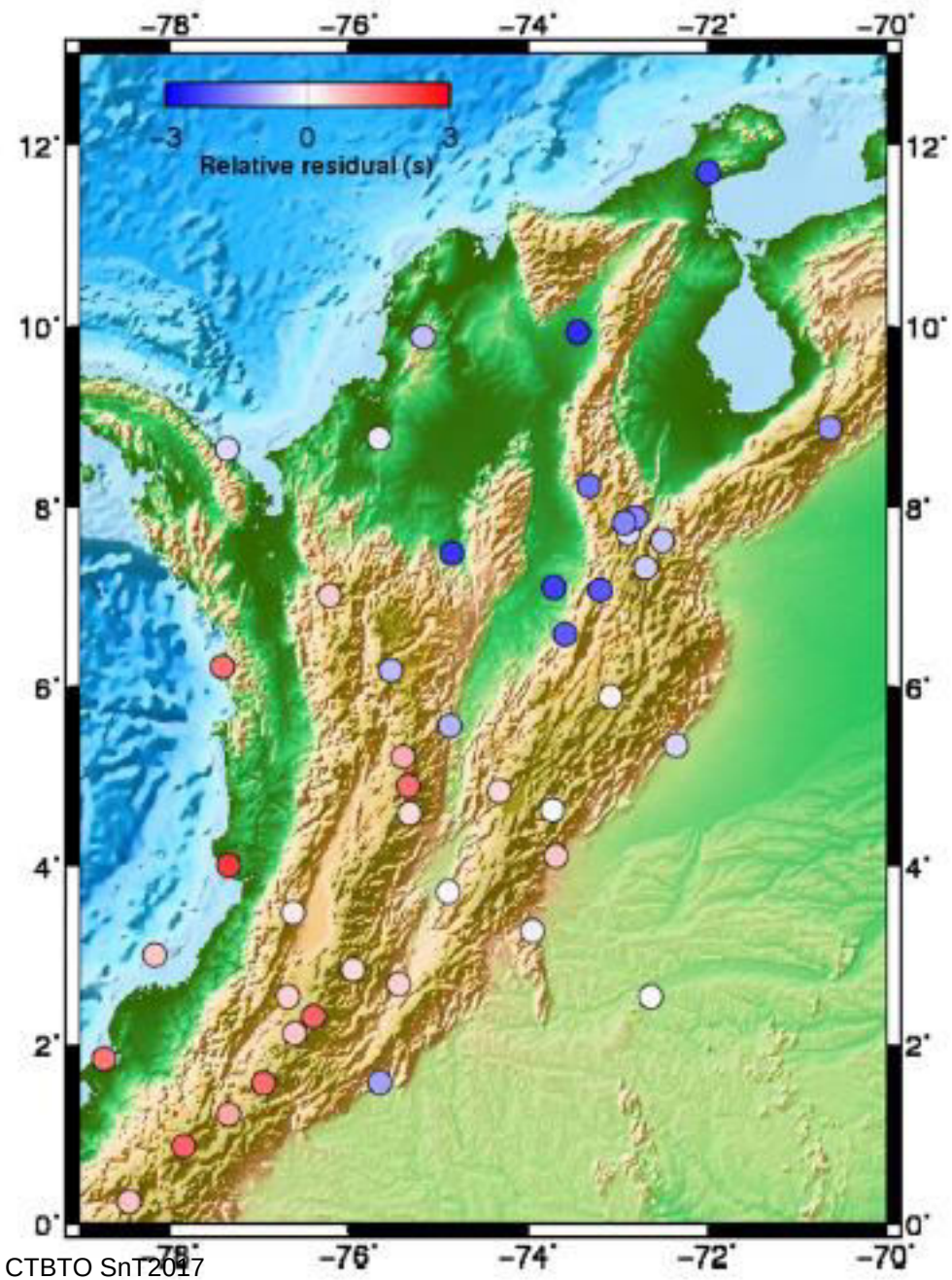
Consistent with gravity data – *Bernal-Olaya et al. [2015]*



Flat slab in NW South America

Consistent with gravity data – *Bernal-Olaya et al. [2015]*



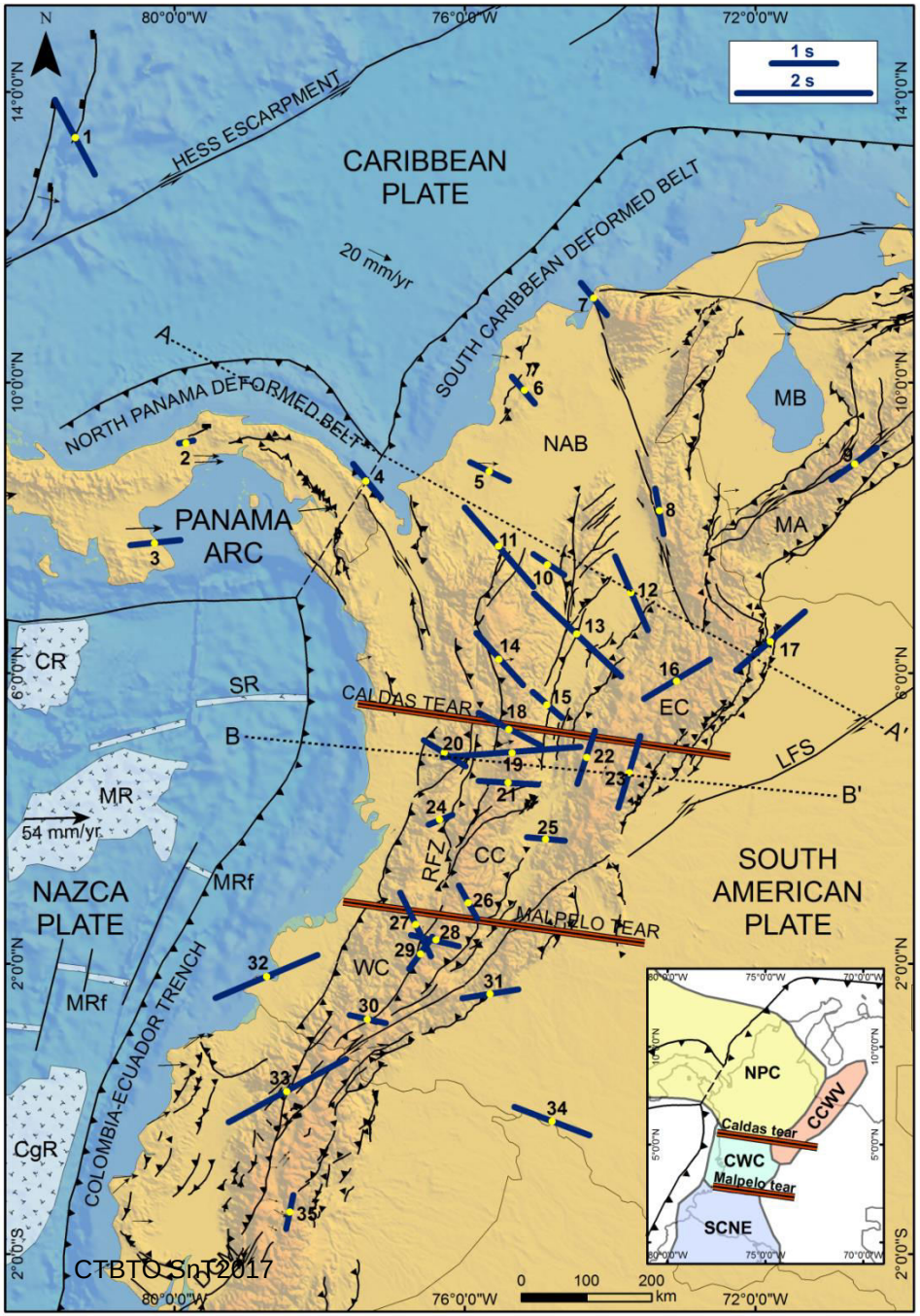


Flat slab in NW South America

Negative delay times of teleseismic events in northern Colombia

Relatively cold upper mantle (Fast velocities)

Yarce et al. [2014]


CARIBBEAN PLATE
SOUTH CARIBBEAN DEFORMED BELT
NORTH PANAMA DEFORMED BELT
HESS ESCARPMENT
20 mm/yr
PANAMA ARC
NAB
MB
MA
EC
CC
WC
CR
SR
MR
54 mm/yr
NAZCA PLATE
MRf
CgR
COLOMBIA-ECUADOR TRENCH
CALDAS TEAR
MALPELO TEAR
RFZ
LFS
SOUTH AMERICAN PLATE
A
A'
B
B'
1 s
2 s
NPC
CCWV
Caldas tear
CWC
Malpelo tear
SCNE
0 100 200 km
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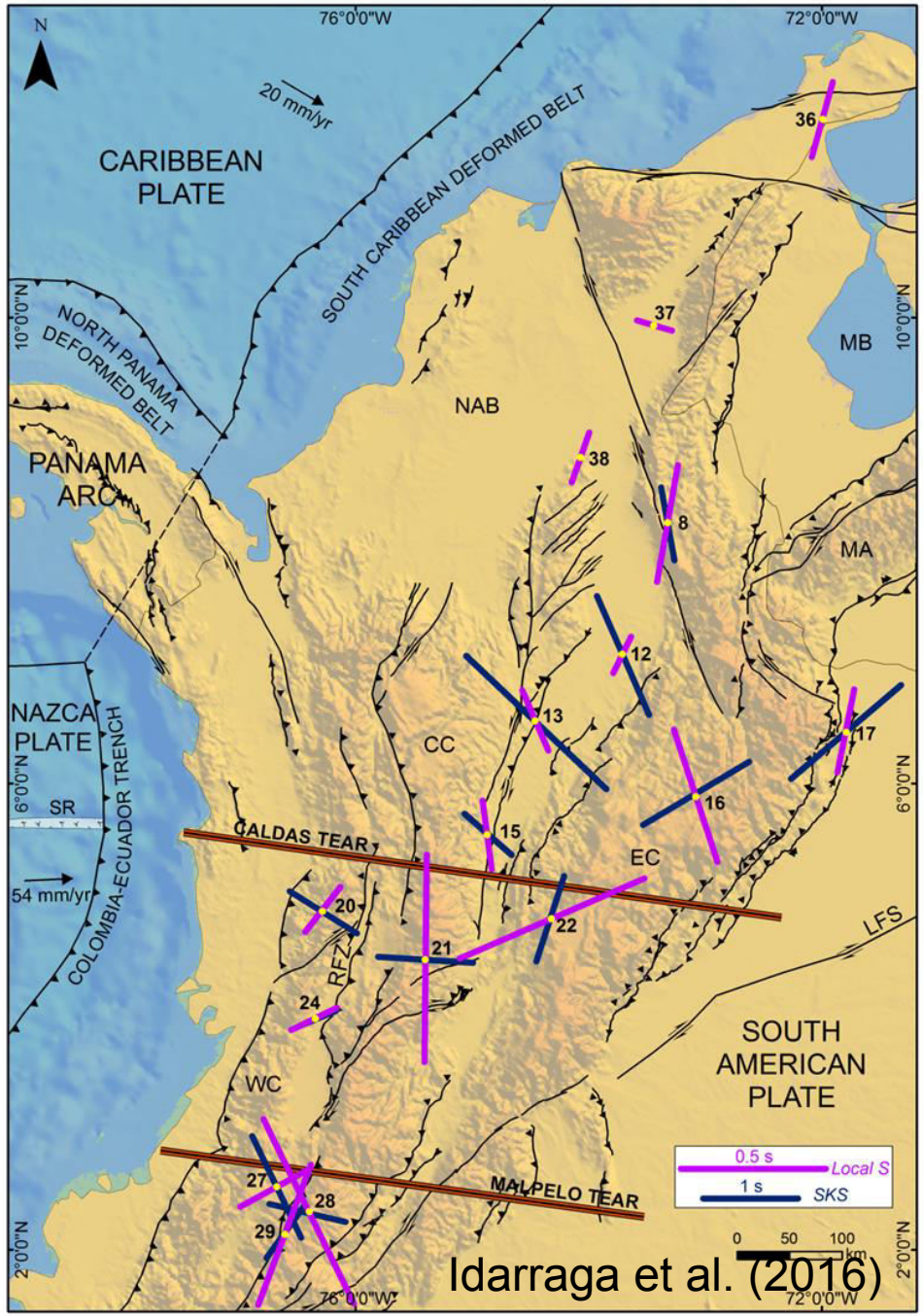
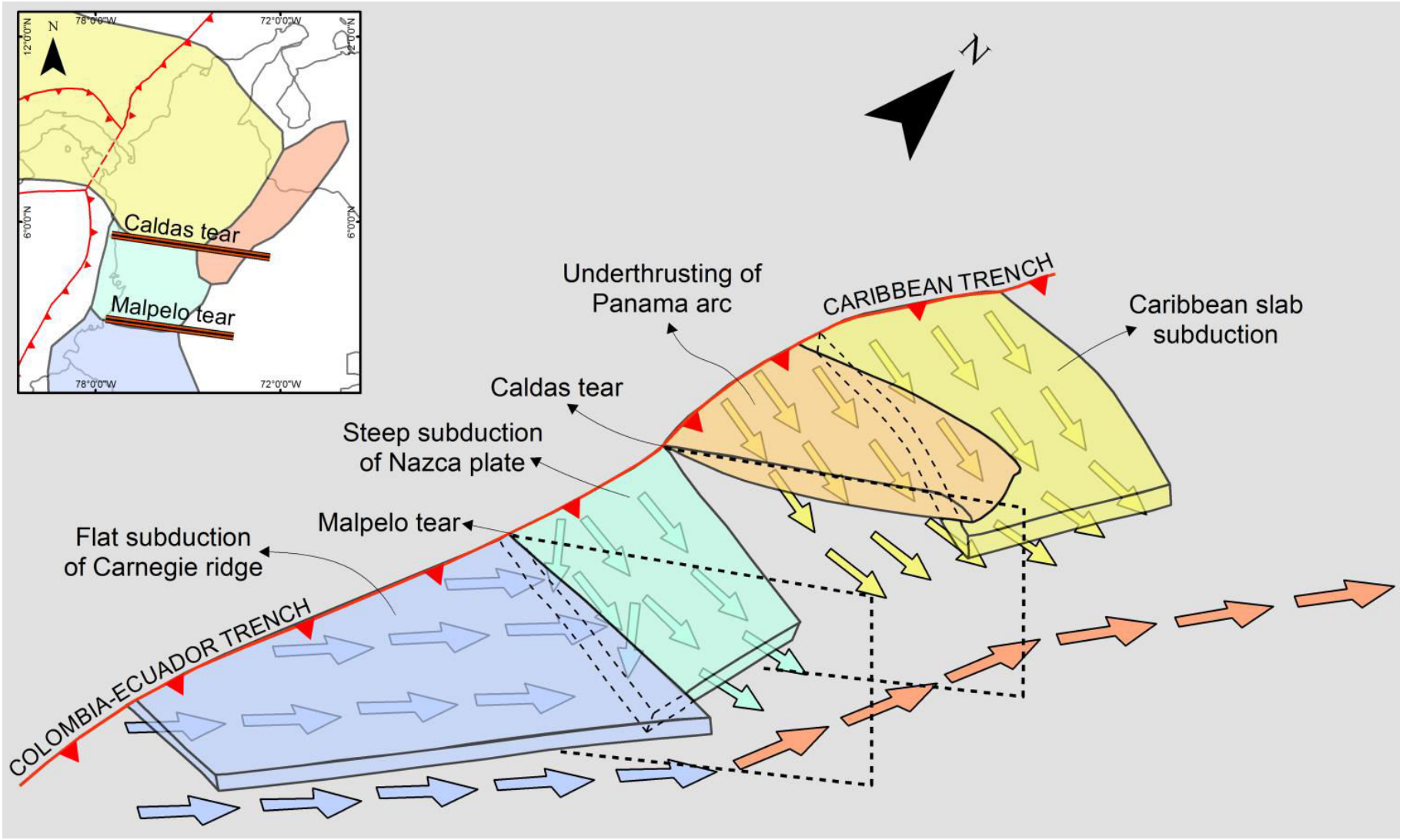
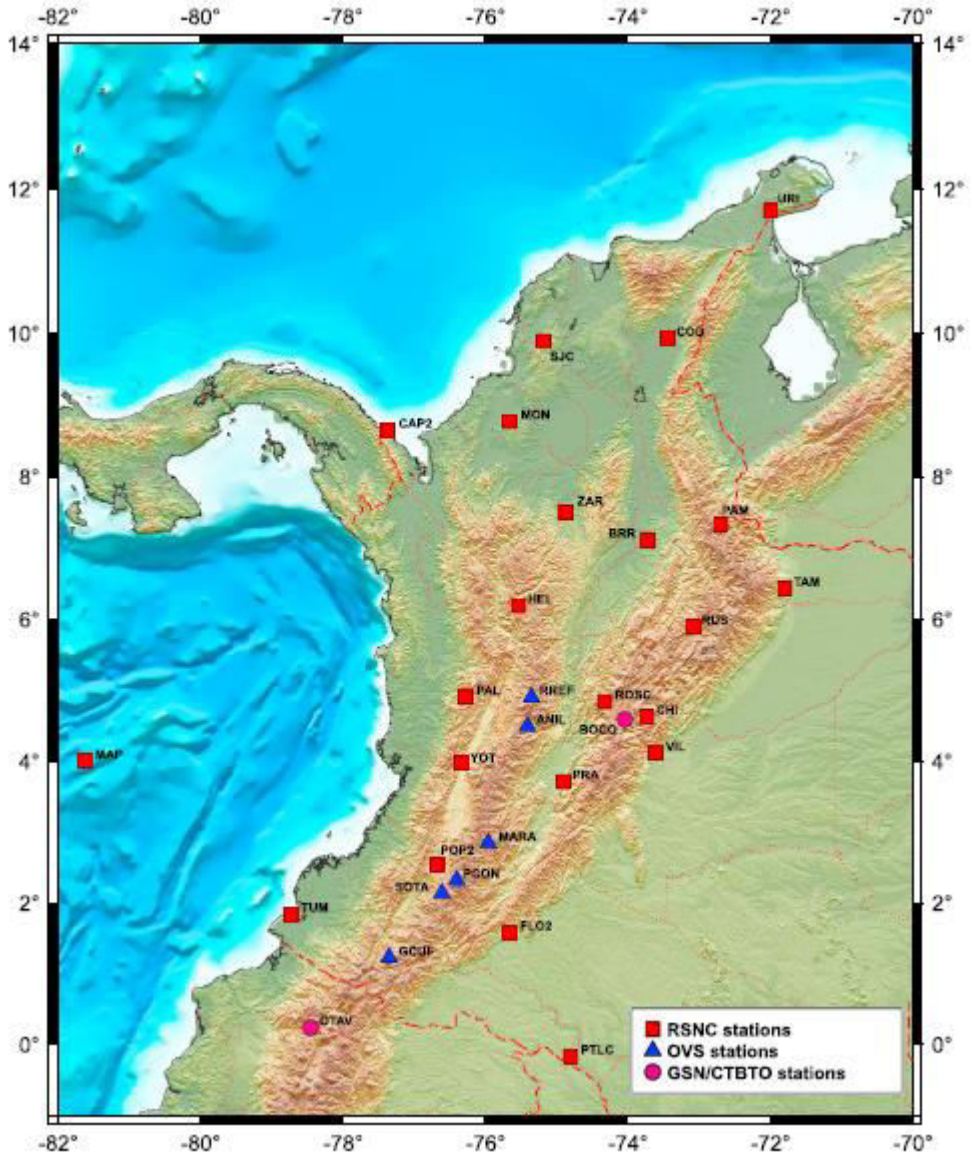

CARIBBEAN PLATE
SOUTH CARIBBEAN DEFORMED BELT
NORTH PANAMA DEFORMED BELT
20 mm/yr
PANAMA ARC
NAB
MB
MA
EC
CC
WC
SR
54 mm/yr
NAZCA PLATE
COLOMBIA-ECUADOR TRENCH
CALDAS TEAR
MALPELO TEAR
RFZ
LFS
SOUTH AMERICAN PLATE
0.5 s
Local S
1 s
SKS
0 50 100 km
Idarraga et al. (2016)



Idarraga et al. (2015)

Receiver function analyisis for crustal thicknesses



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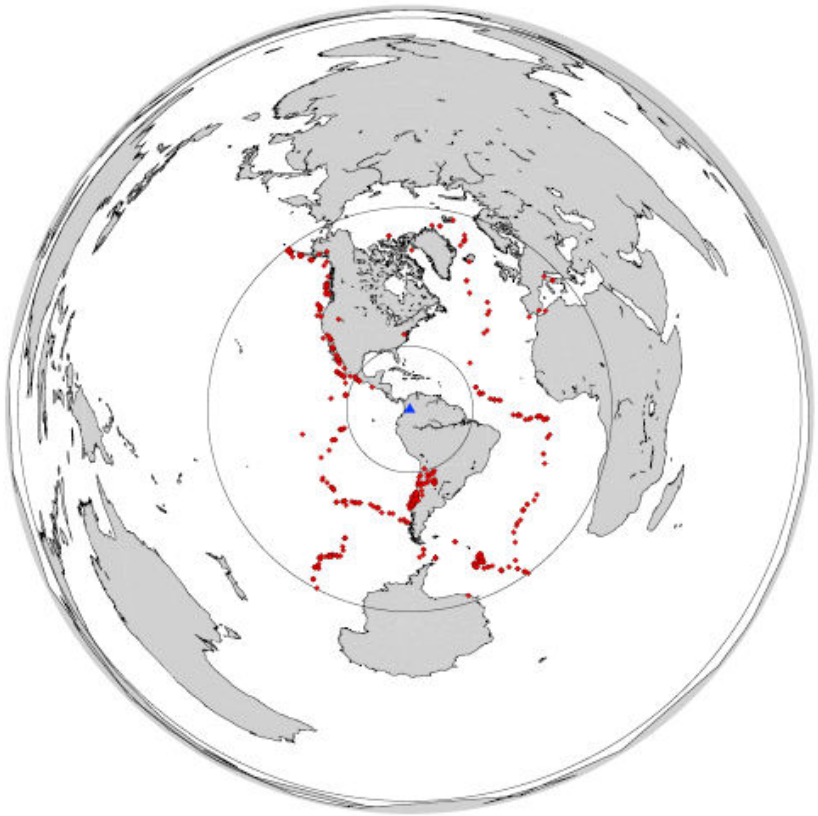
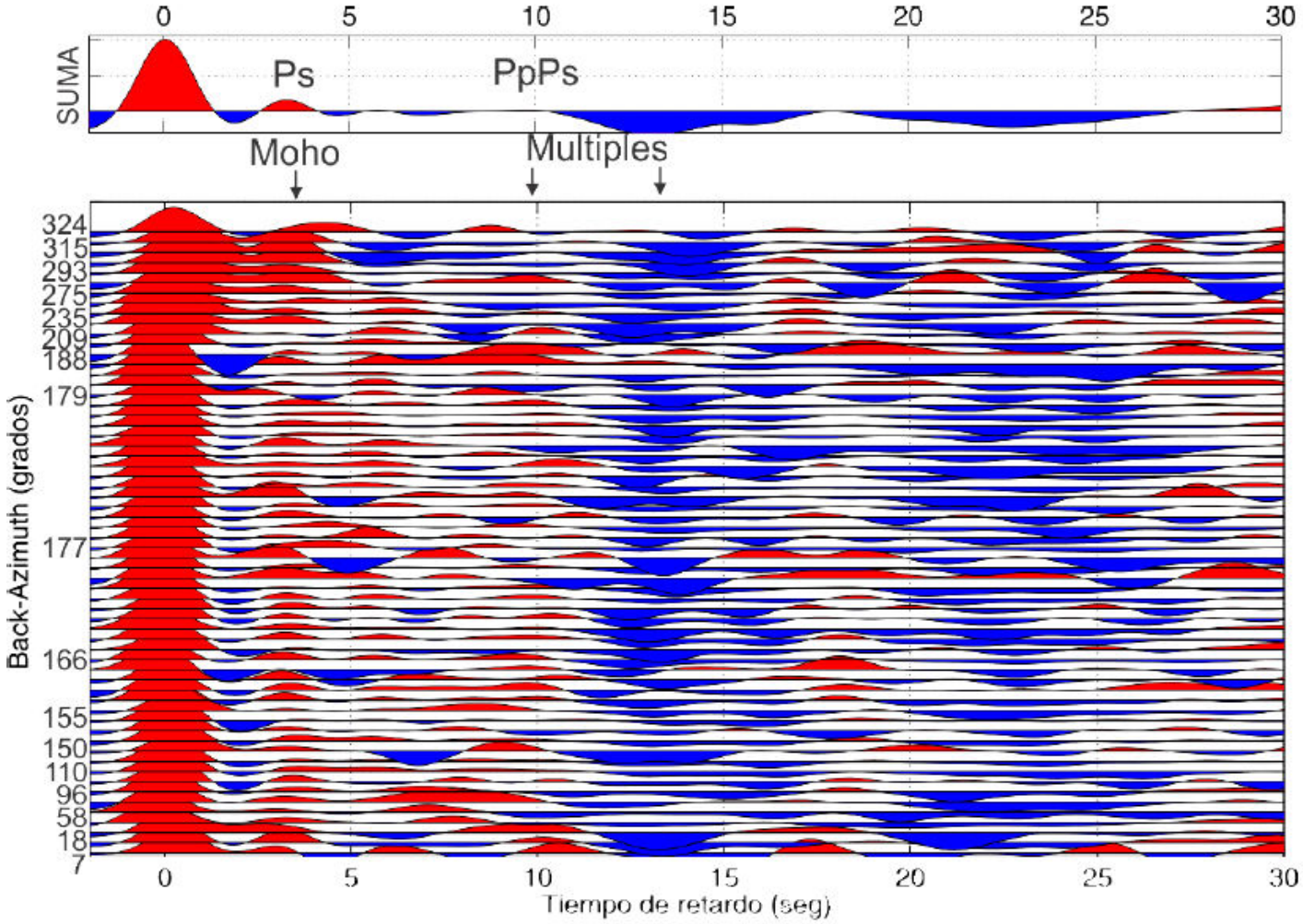
Stations and data set for P-to-S receiver functions – Moho depth



Poveda et al. [2015]

P-to-S receiver functions

Station MONTERIA

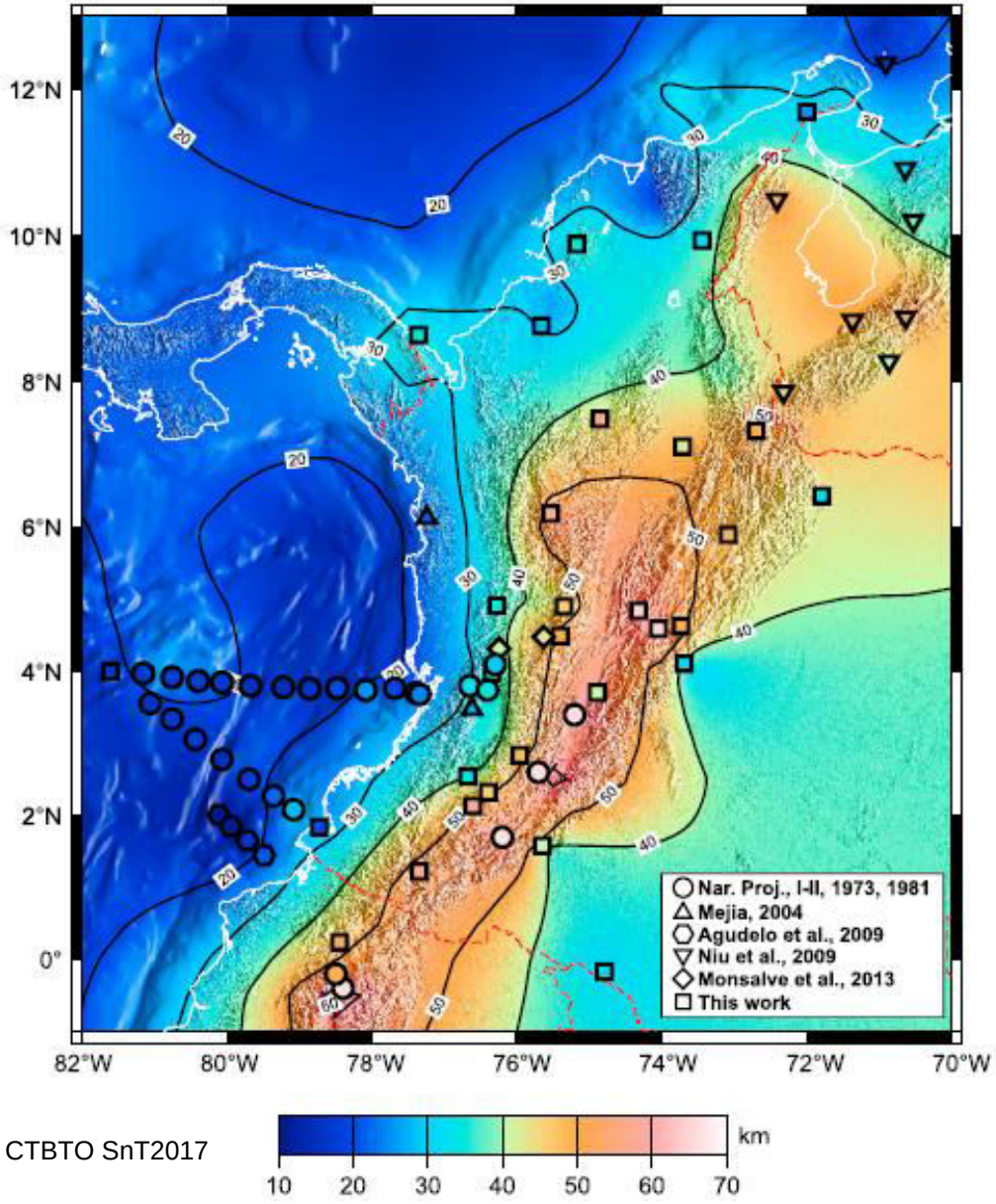


Seismograms where the source and instrument/site effects have been taken out

Moho depth at ~26 km

Poveda et al. [2015]

P-to-S receiver functions

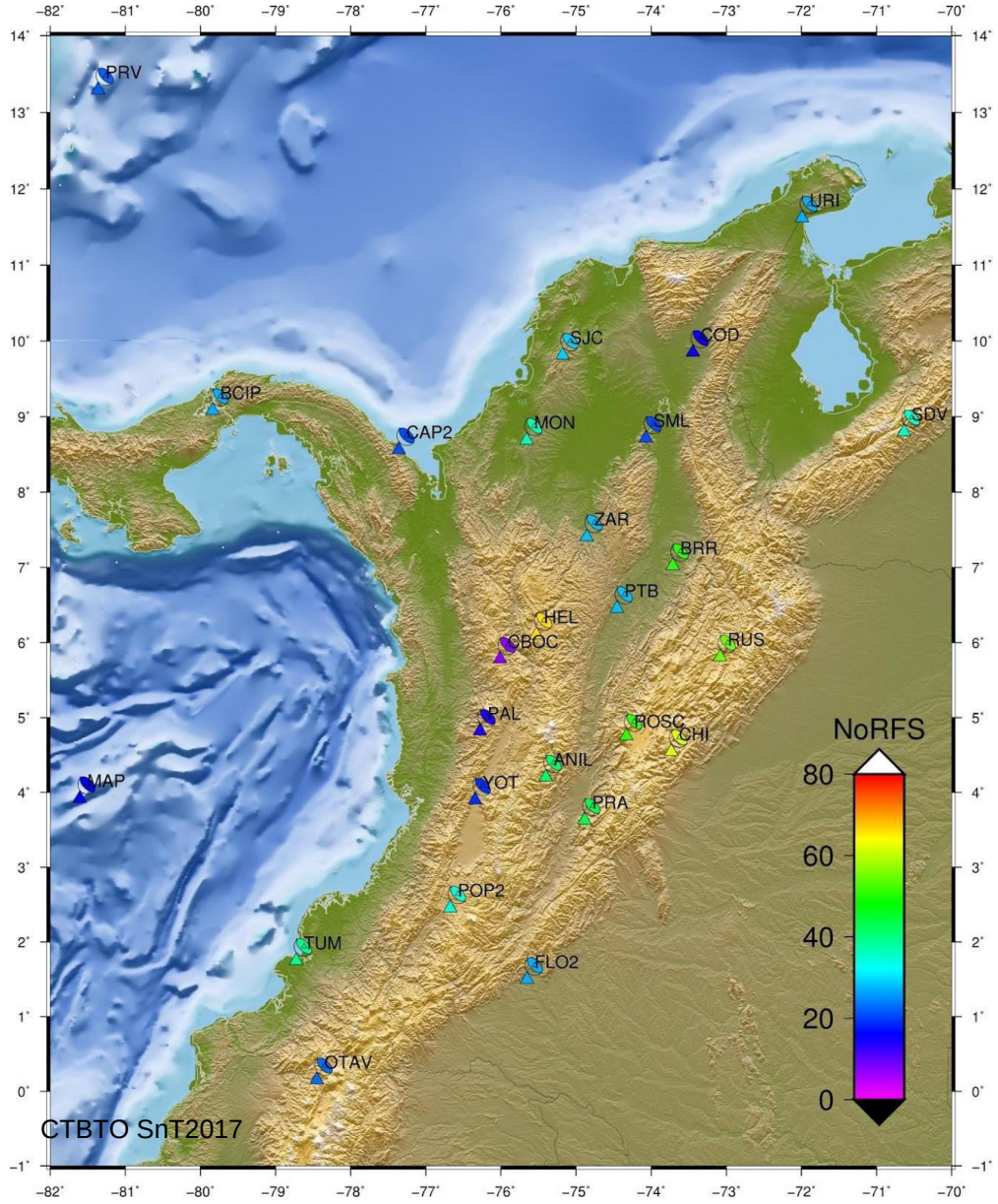


Interpolated results – Moho depth

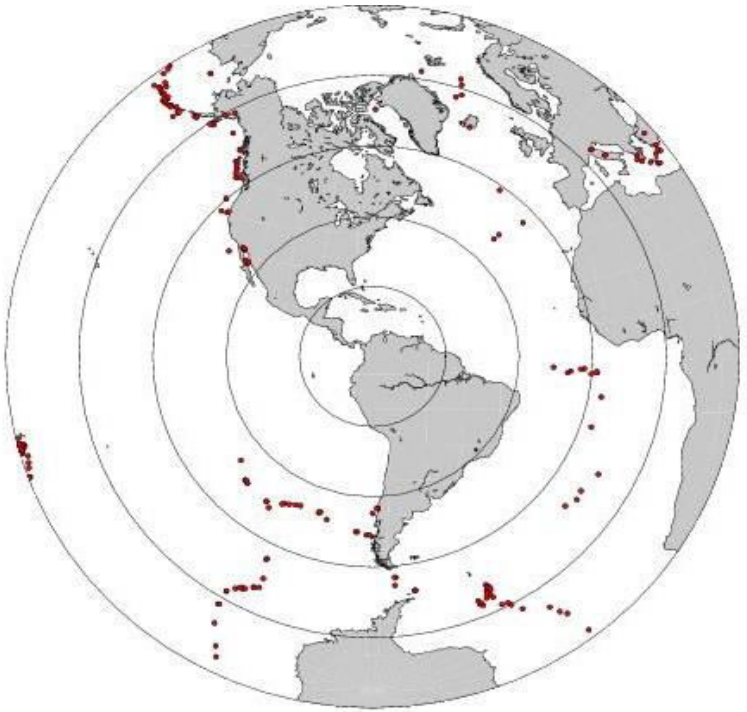
Crustal thickness in Northwestern Colombia – Relatively thin crust beneath the Caribbean Plate

Poveda et al. [2015]

Receiver function analyisis for lithospheric thicknesses



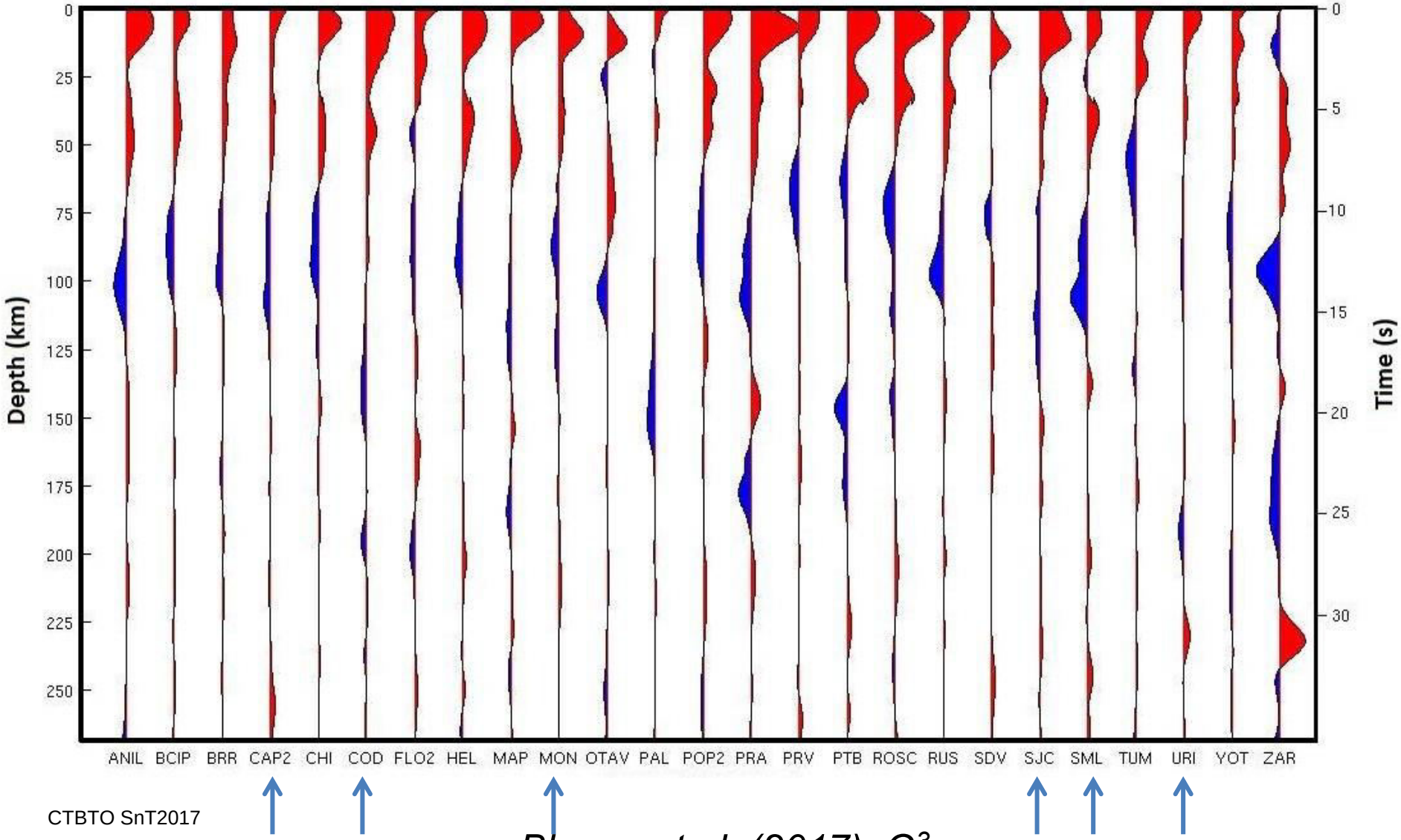
Stations and data set for S-to-P receiver functions – LAB depth



Modified from Blanco et al., (2017), G³

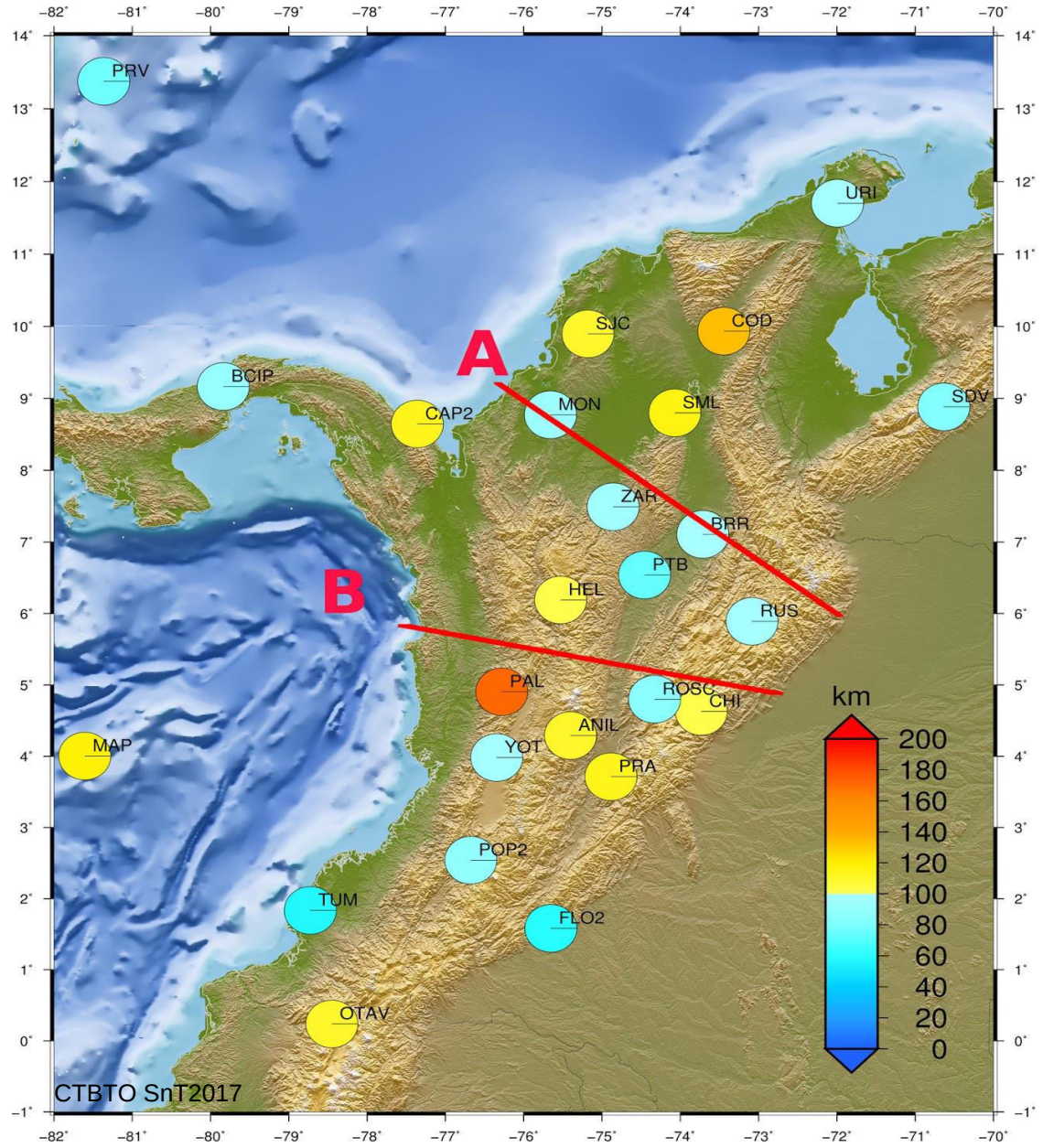
S-to-P receiver functions

S-to-P: Blue (negative) sidelobes may correspond to LAB depth



Blanco et al. (2017), G³

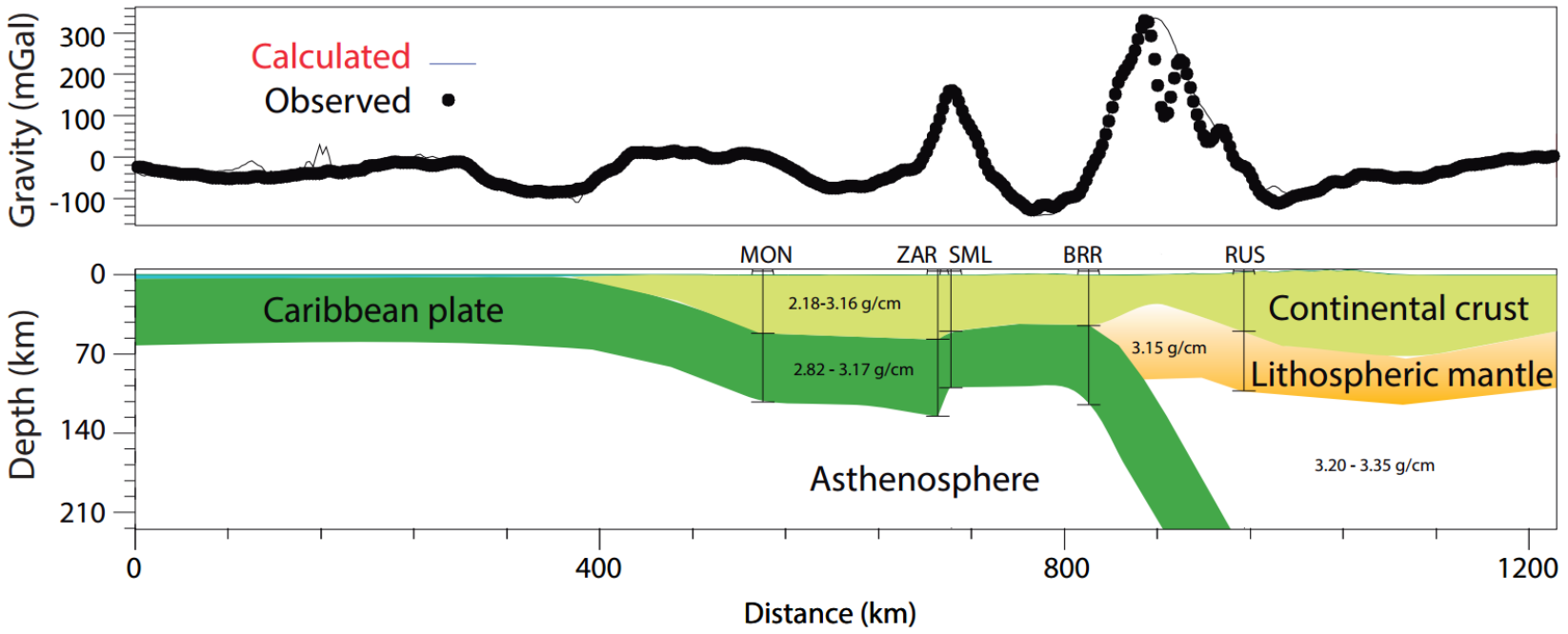
S-to-P receiver functions



LAB depths per station: Not simple correlation with geographic or tectonic provinces

Modified from Blanco et al. (2017), G³

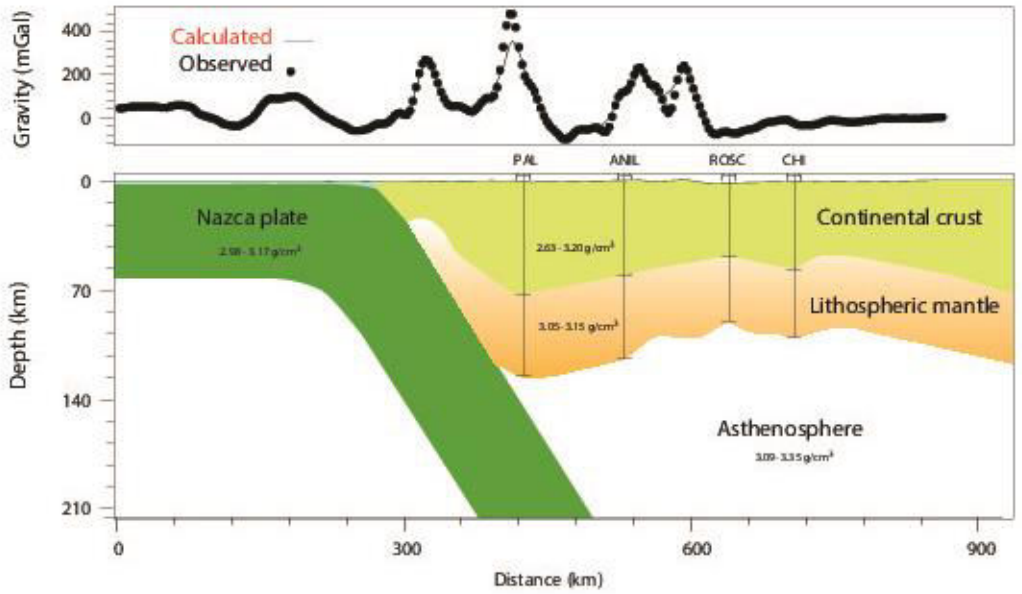
Plate configuration from the Caribbean Coast to the southeast (our idea)



Modified from Blanco et al. (2017), G³

Lithospheric thickness in the Caribbean coastal plains: Continental crust + subducted oceanic plate (Mantle lithosphere absent in between both) – Consistent with gravity

Plate configuration southern of the Caldas tear (our idea)



Modified from Blanco et al. (2017), G³

Lithospheric thickness in the Nazca plate: Normal subduction
Consistent with gravity

Concluding remarks

- Several pieces of evidence indicate flat subduction of the Caribbean Plate beneath Northern Colombia
- At least three posible lithospheric tears have been interpreted based on a large amount of data and methods
- There might be a flat segment of the Nazca Slab? Or the Caldas tear correspond to the southern border to the Caribbean plate?
- In the Caribbean coastal plains of Colombia, a very thin continental crust should be on top of a subducted oceanic plate (Caribbean – Oceanic Plateau), in the absence of an asthenospheric wedge.

Thanks a bunch!!