Subduction in the Southern Caribbean

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BOLIVAR & GEODINOS Working group:

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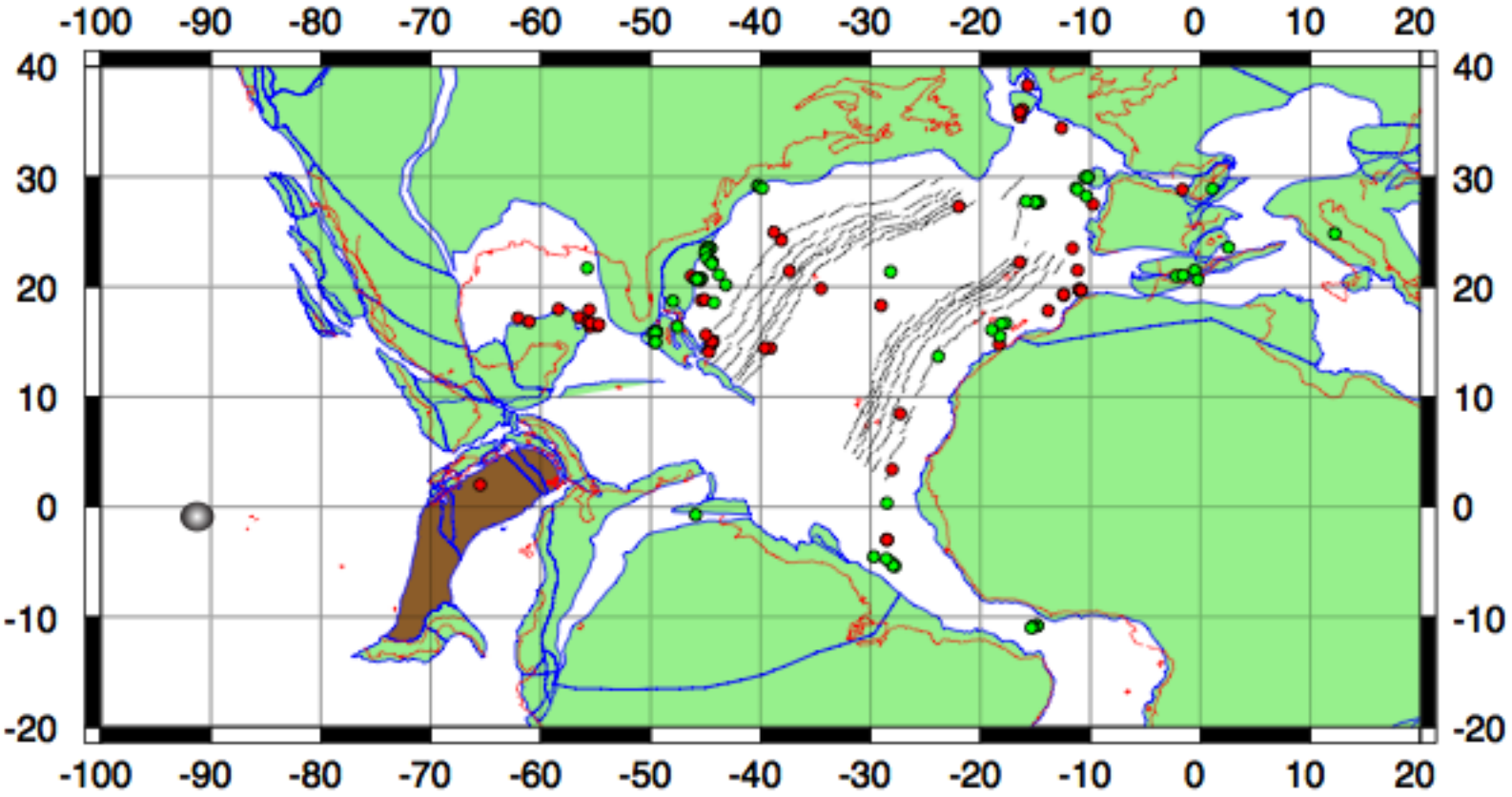
Scripps: F. Vernon
Students from Simon Bolivar, UCV

Outline

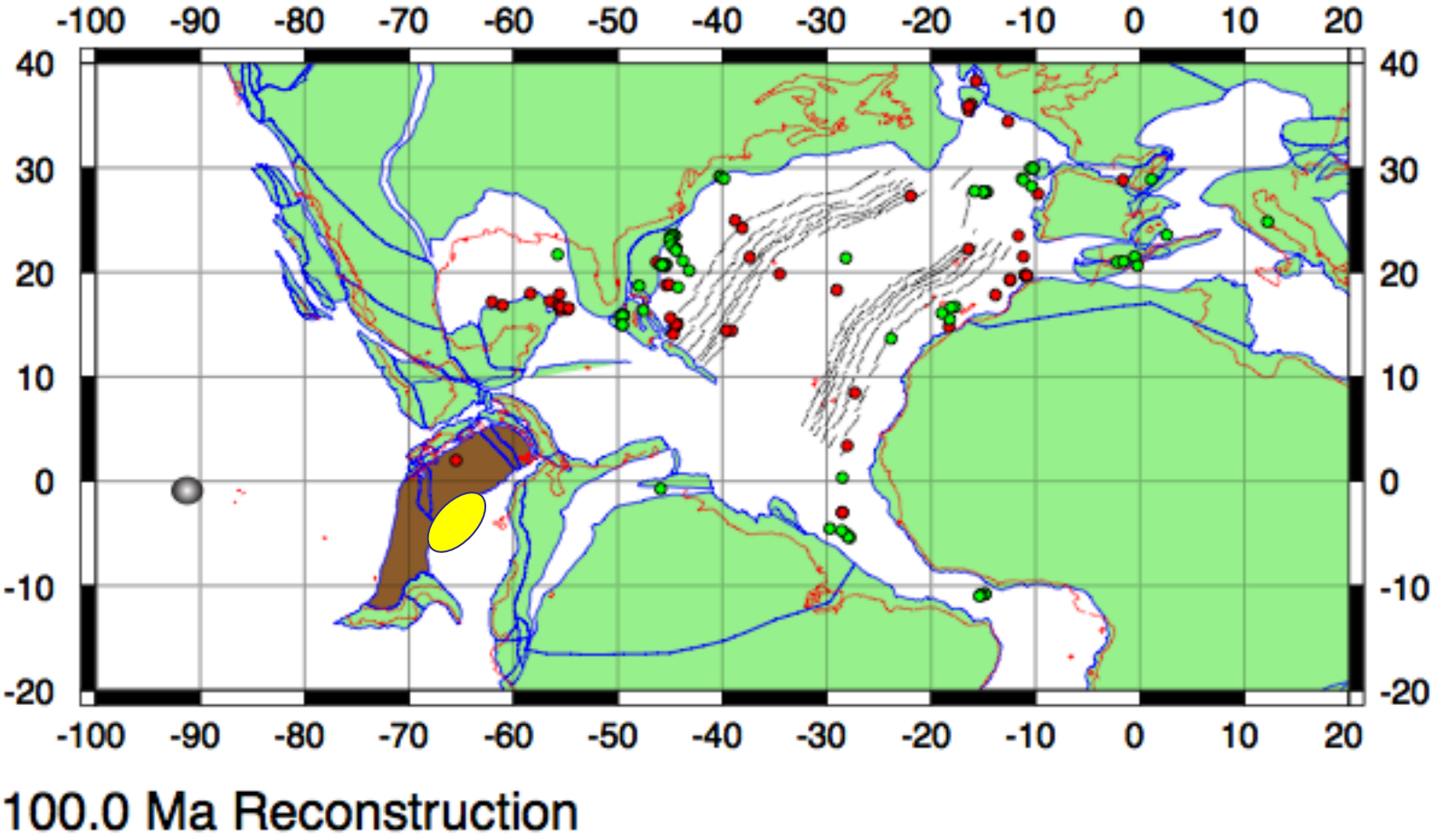
1. How did the Caribbean get where it is
2. ATL and CAR plates in the upper mantle
3. Steep ATL subduction in the east
   - ATL-SA Slab tear
4. Flat-slab CAR subduction in the west
   - Laramide-style uplift of Merida Andes

Hotspot Reference Frame

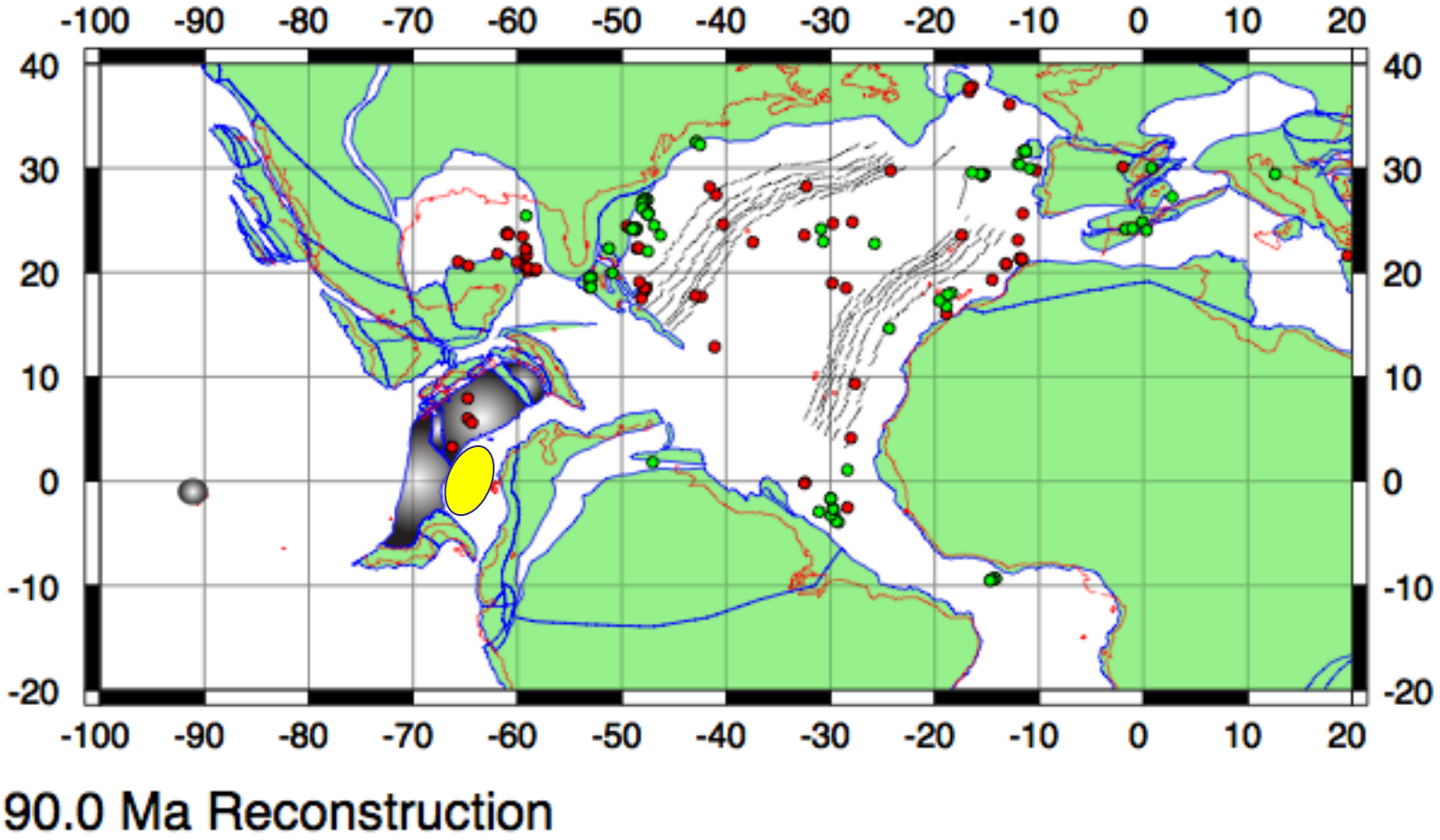


100.0 Ma Reconstruction

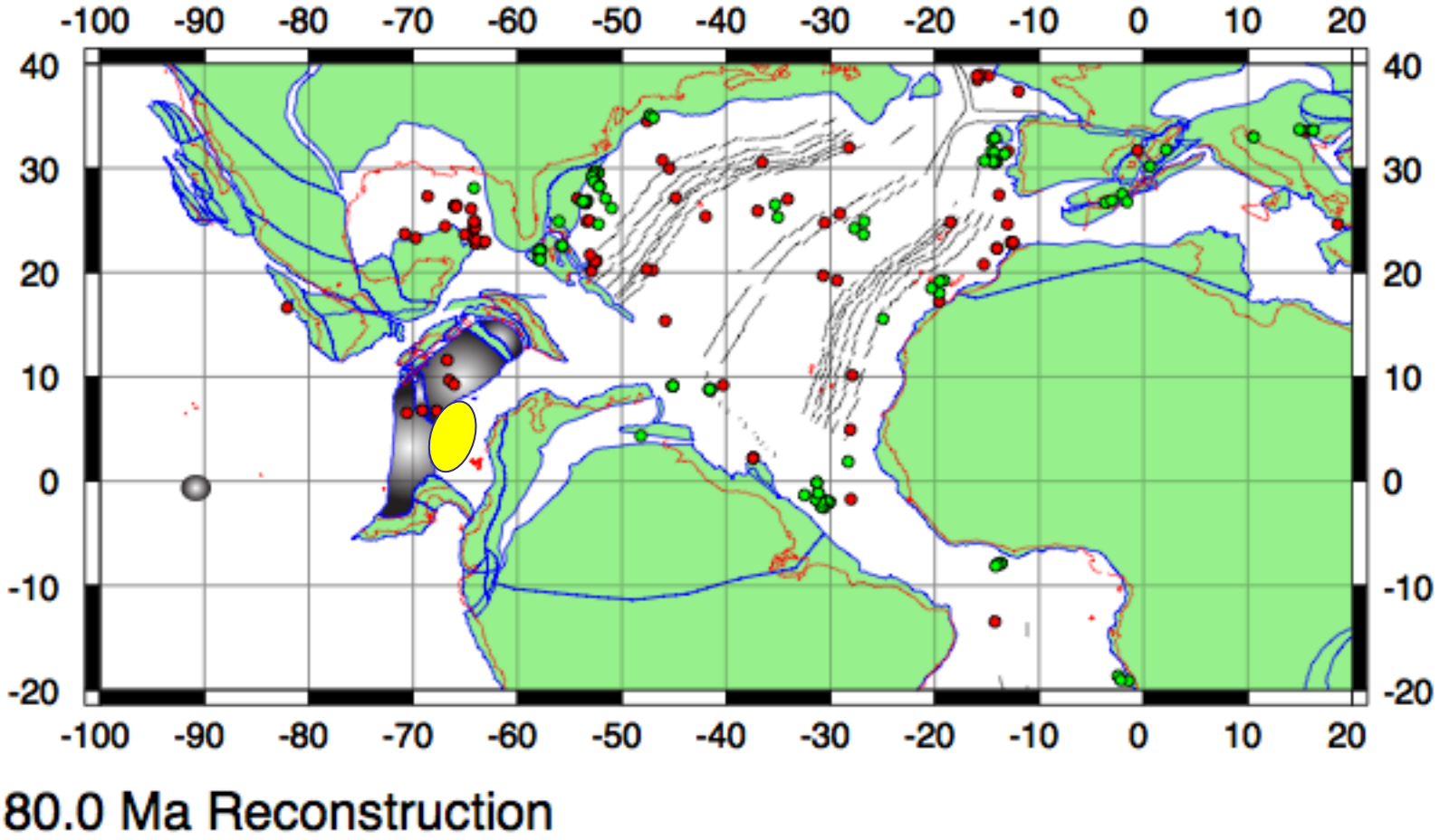
Caribbean Large Igneous Province Forms

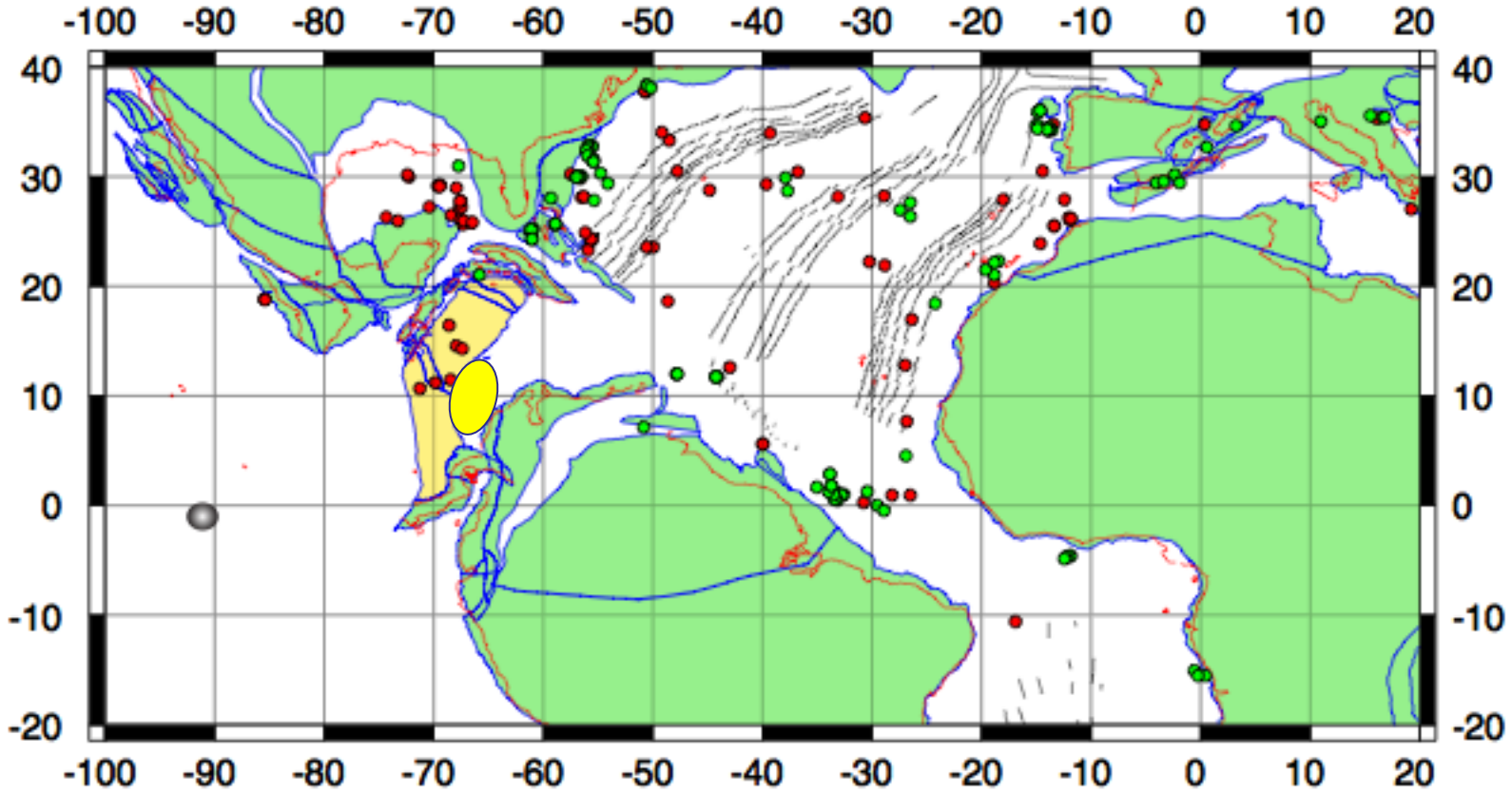


Caribbean Large Igneous Province Forms



Caribbean Large Igneous Province Forms





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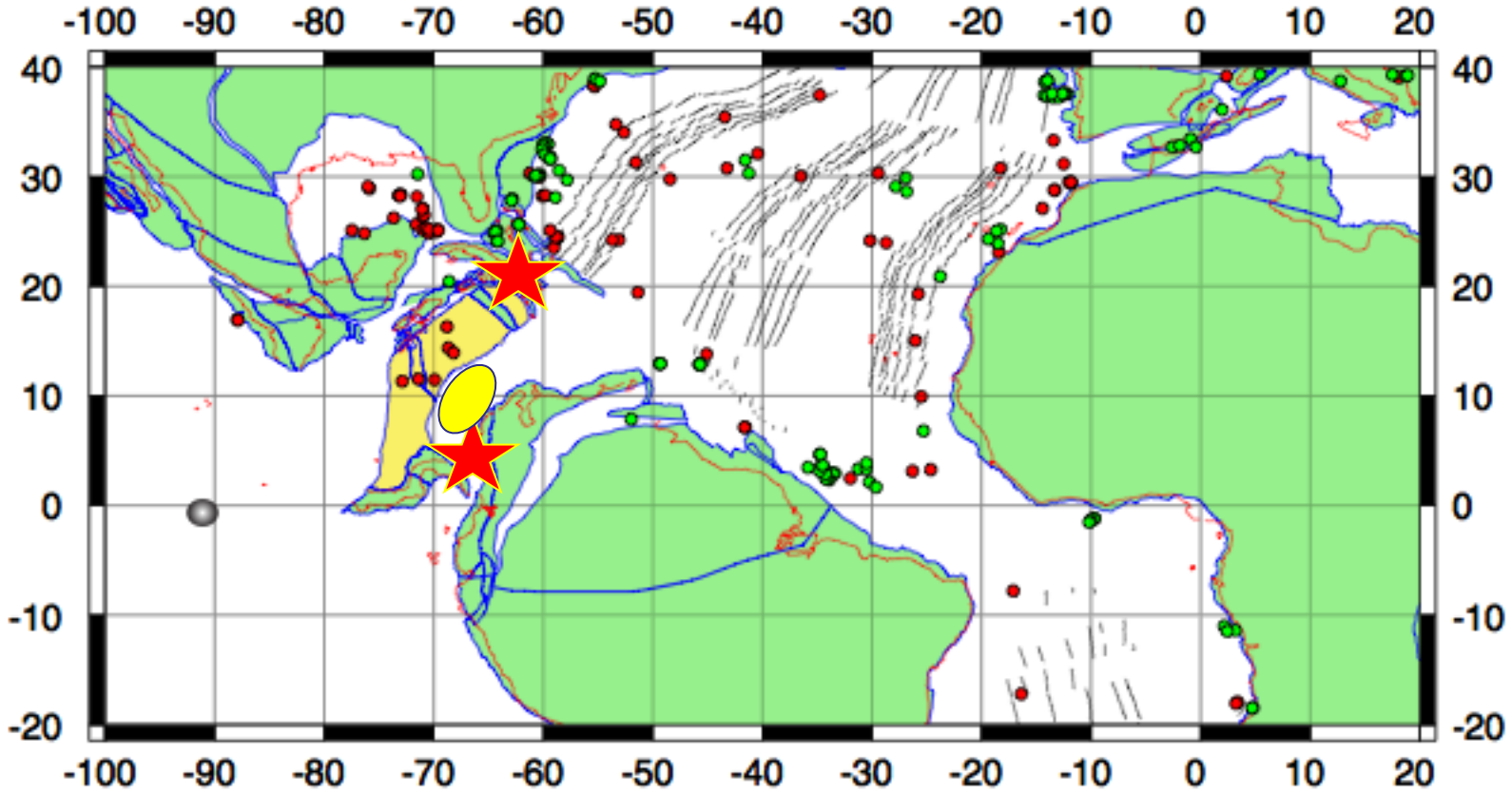

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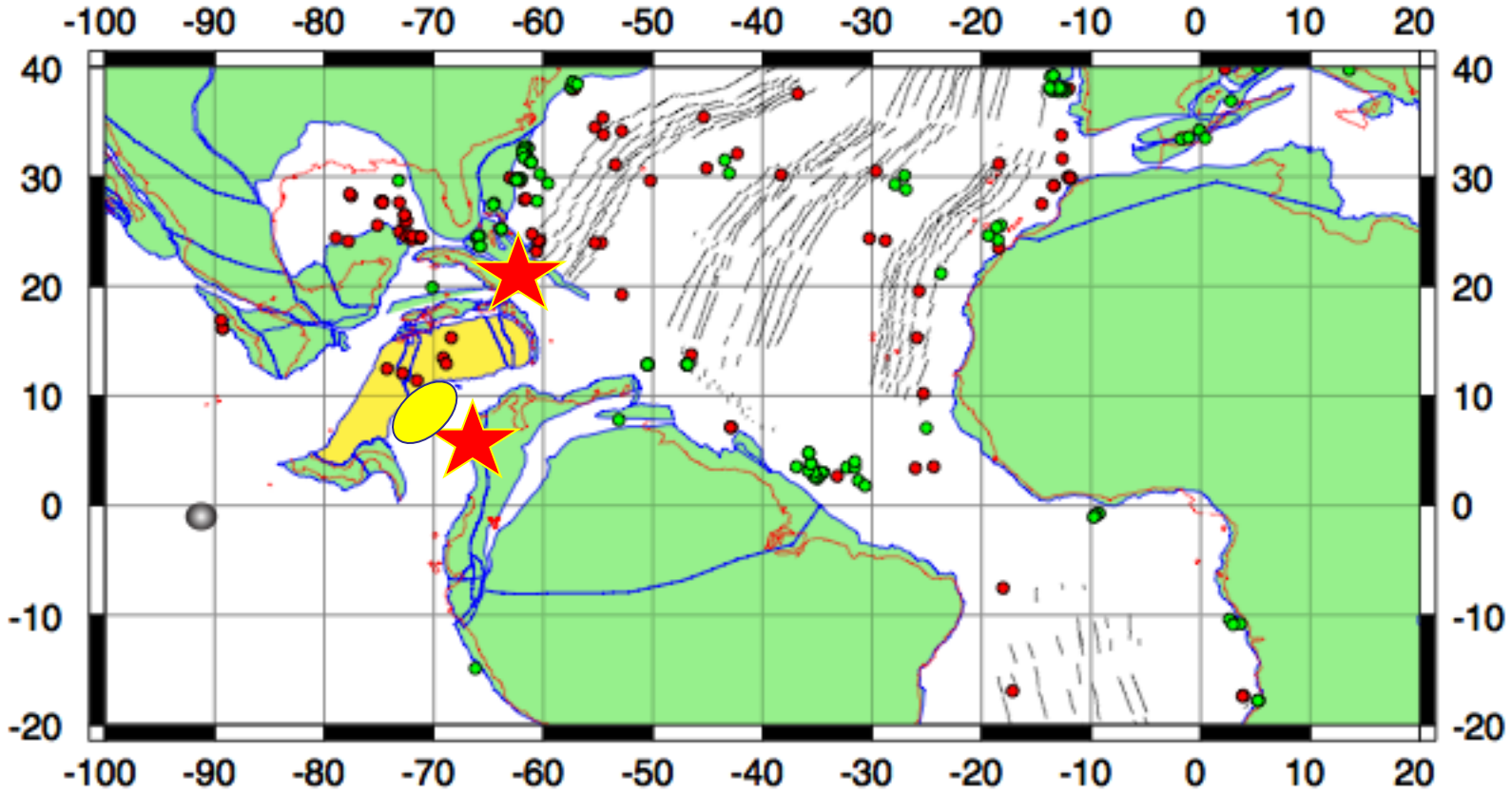

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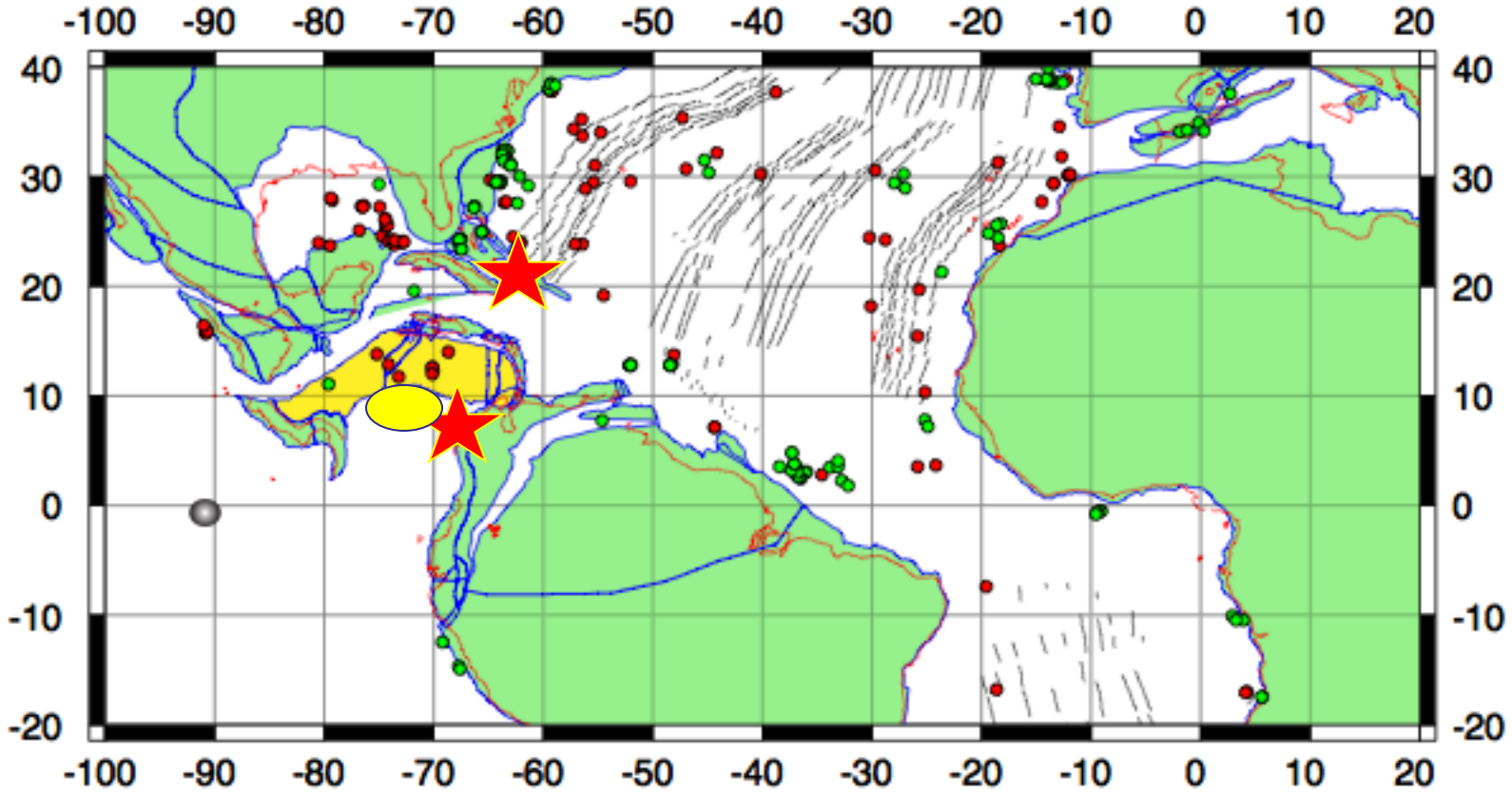

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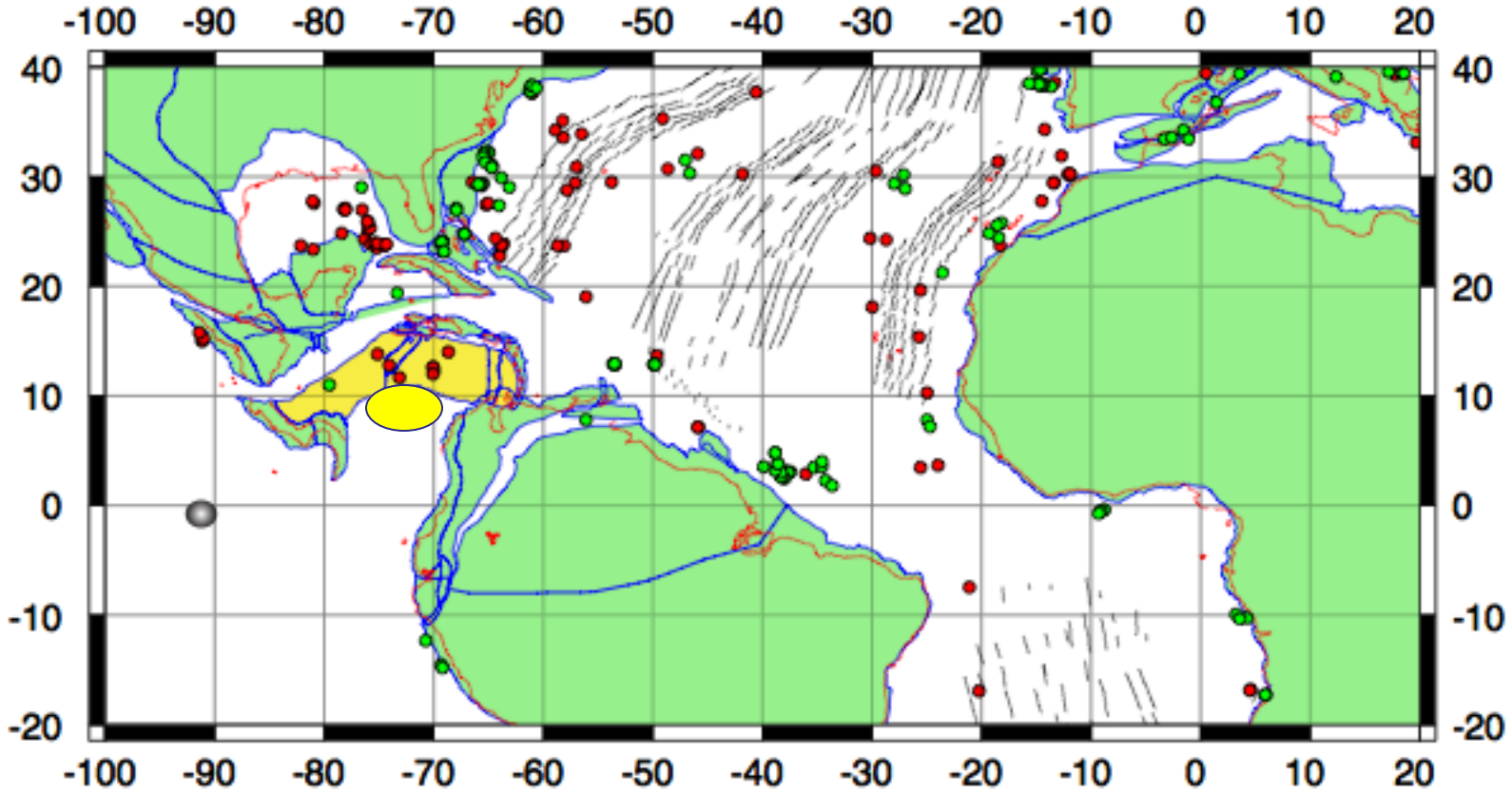

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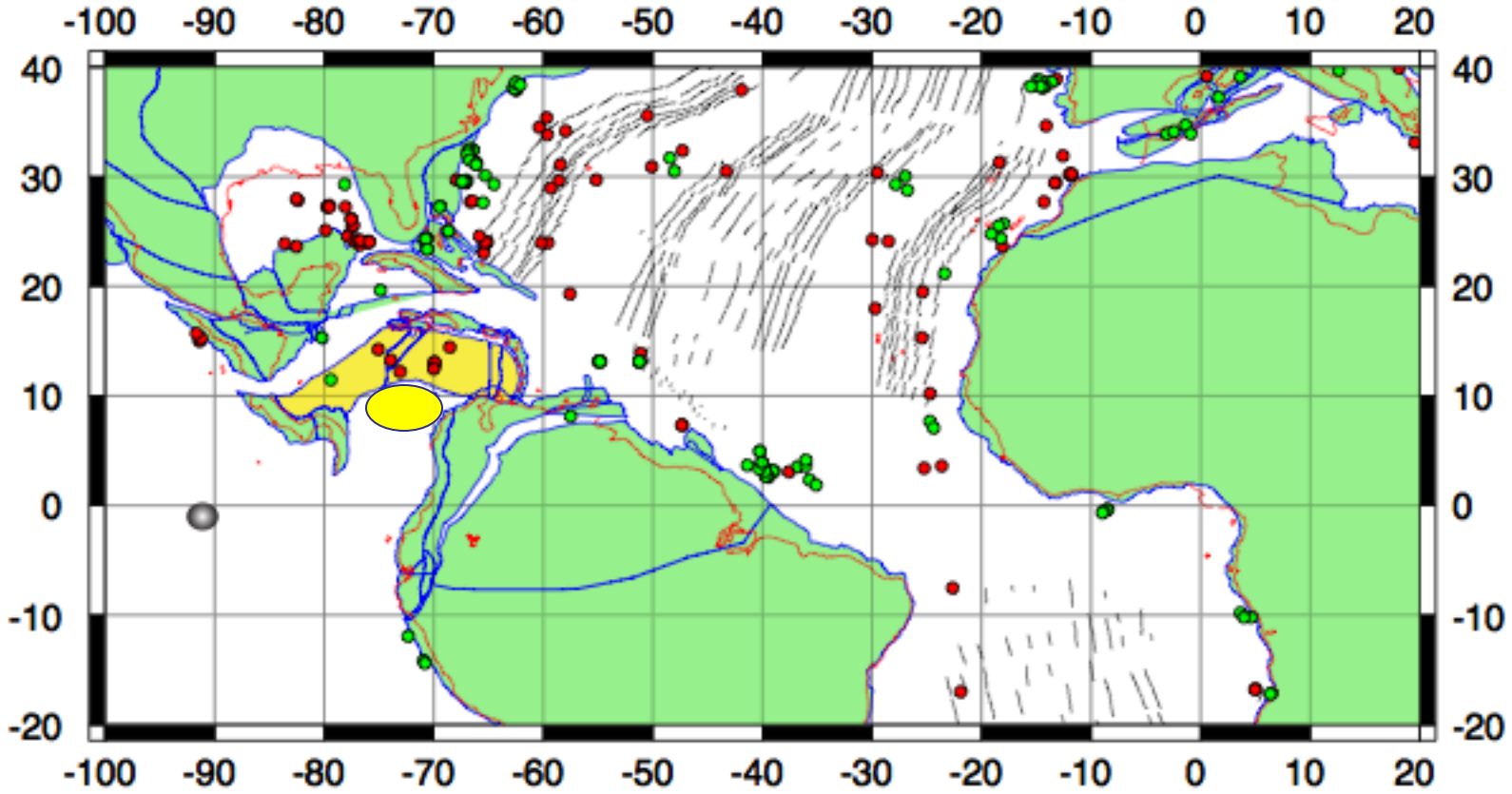

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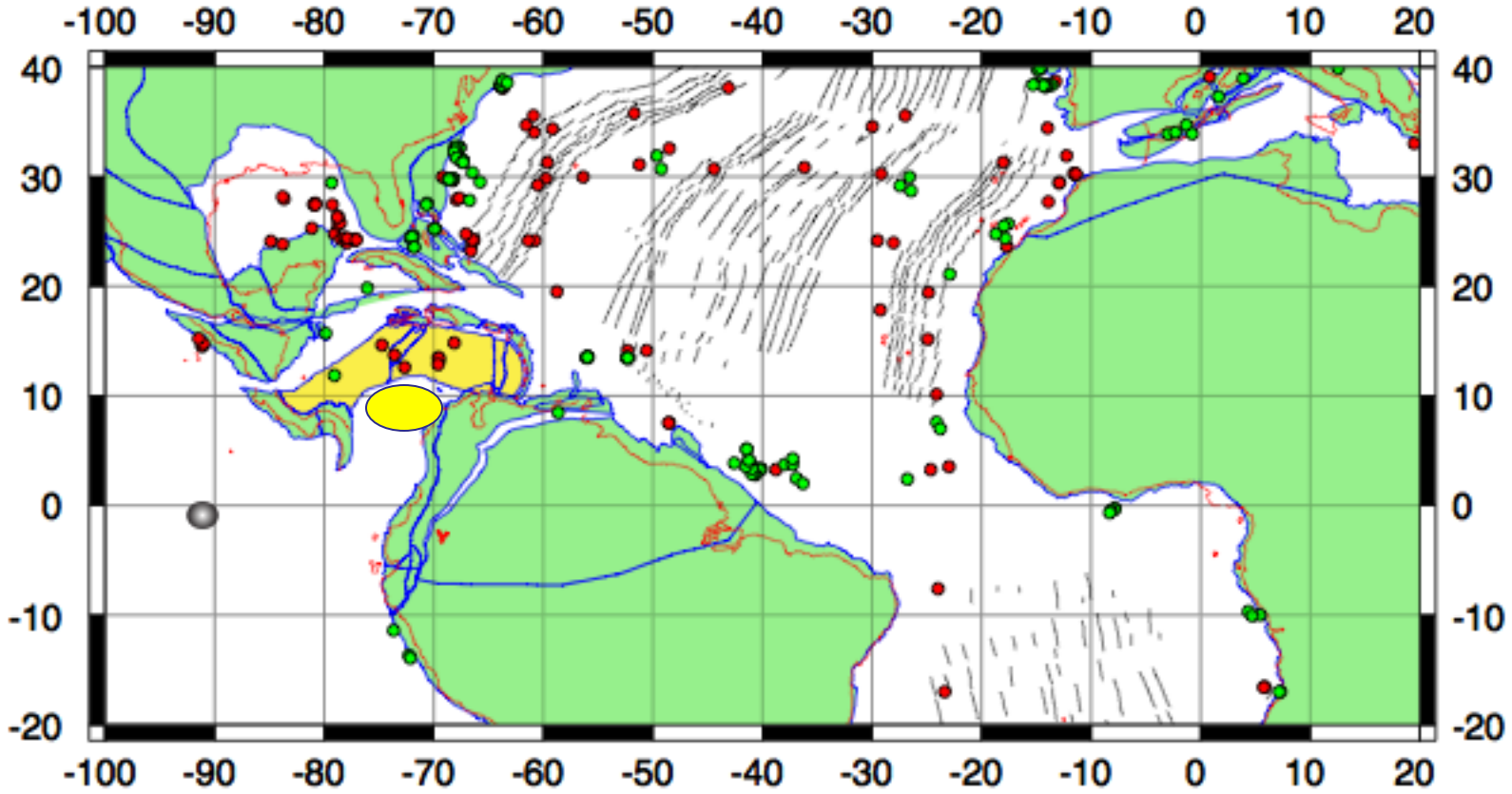

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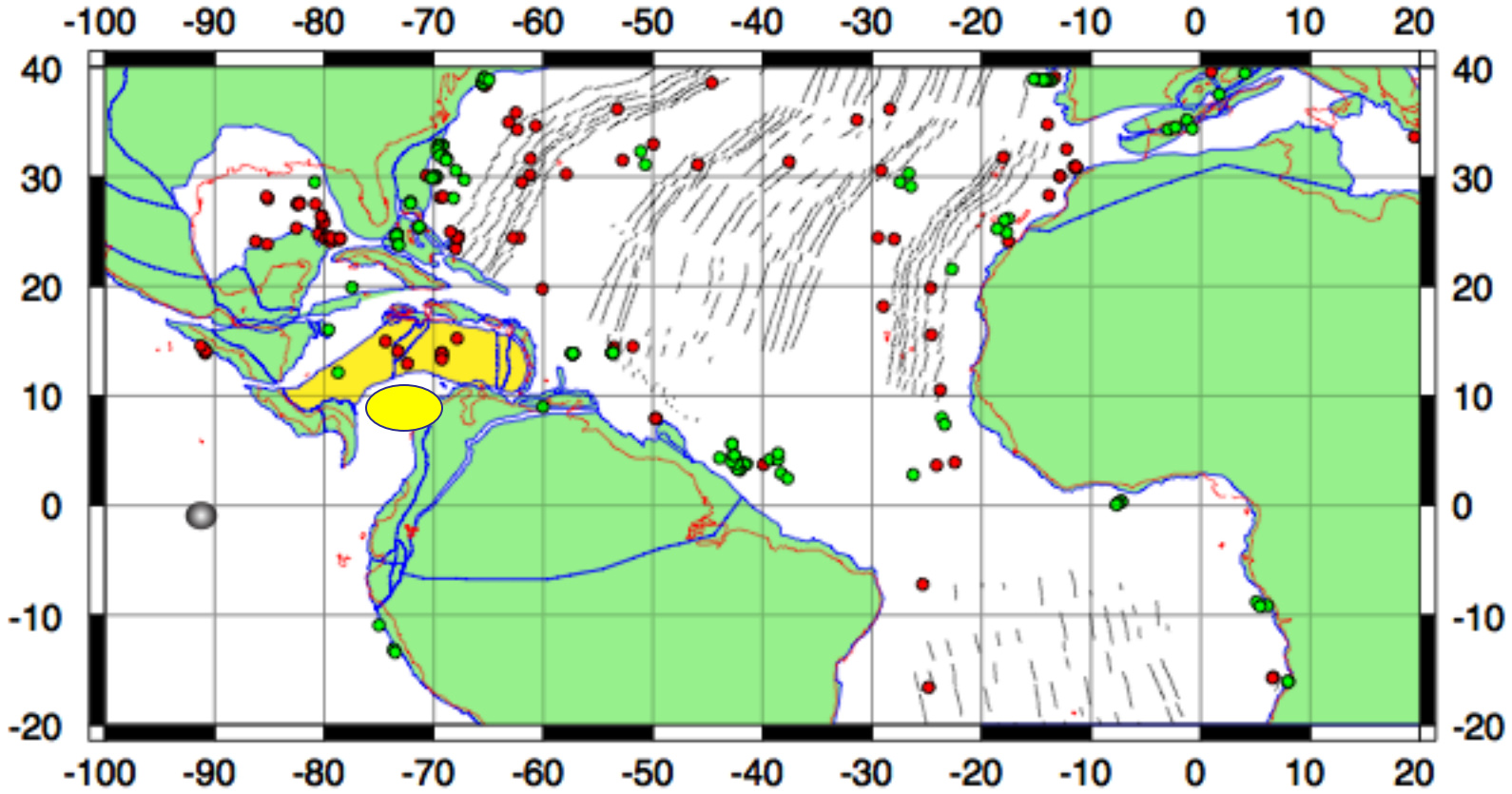

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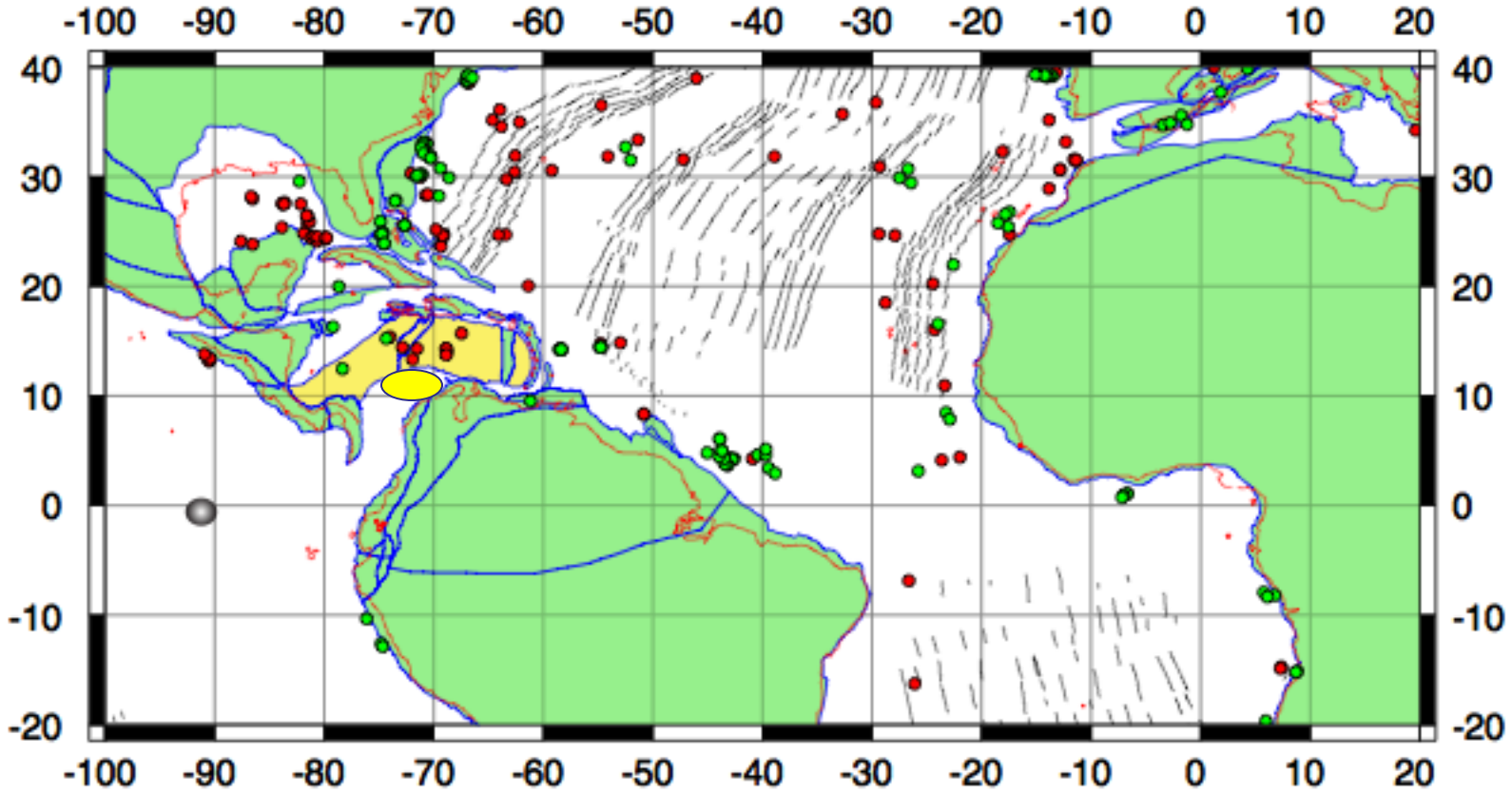

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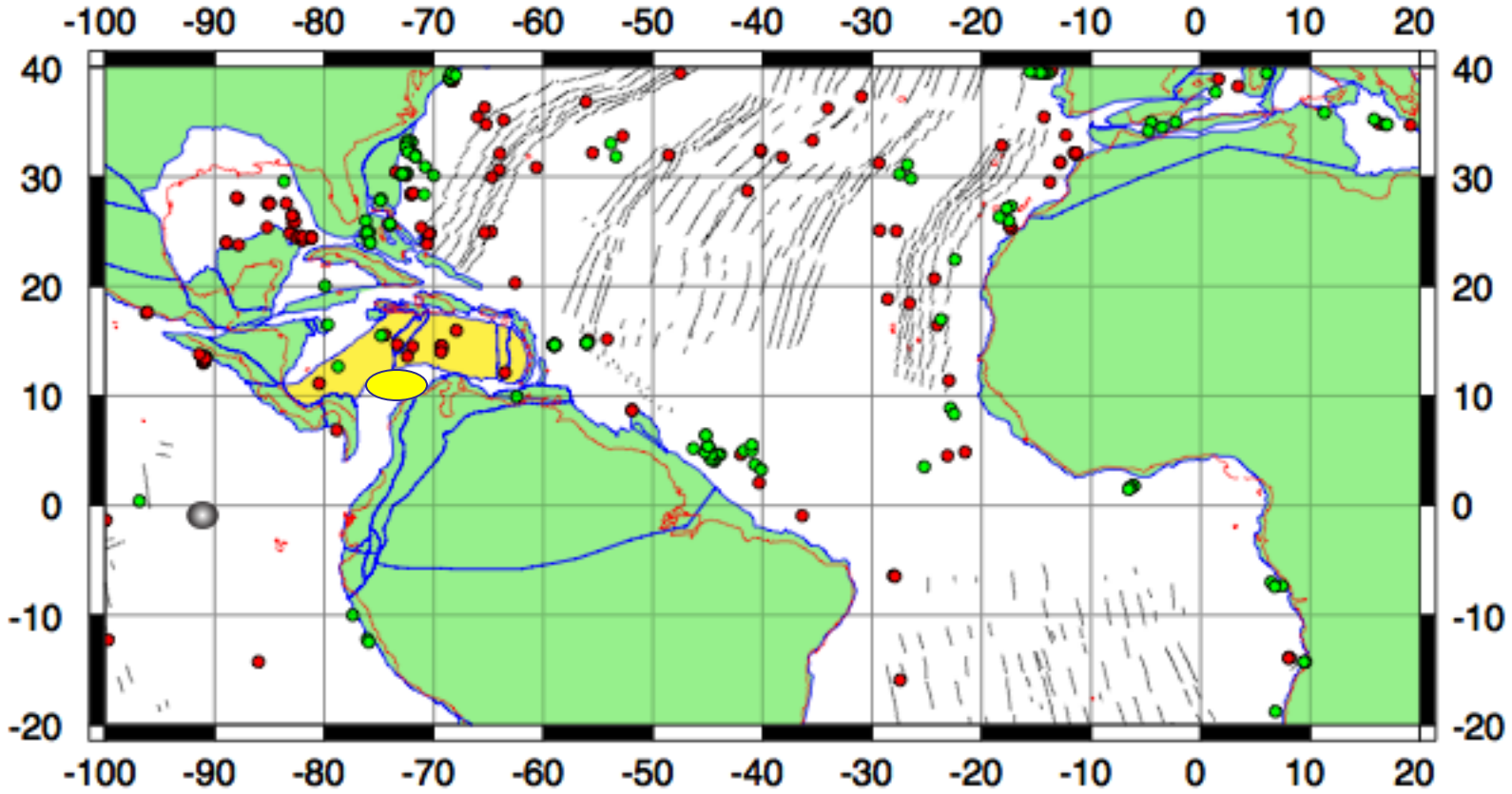

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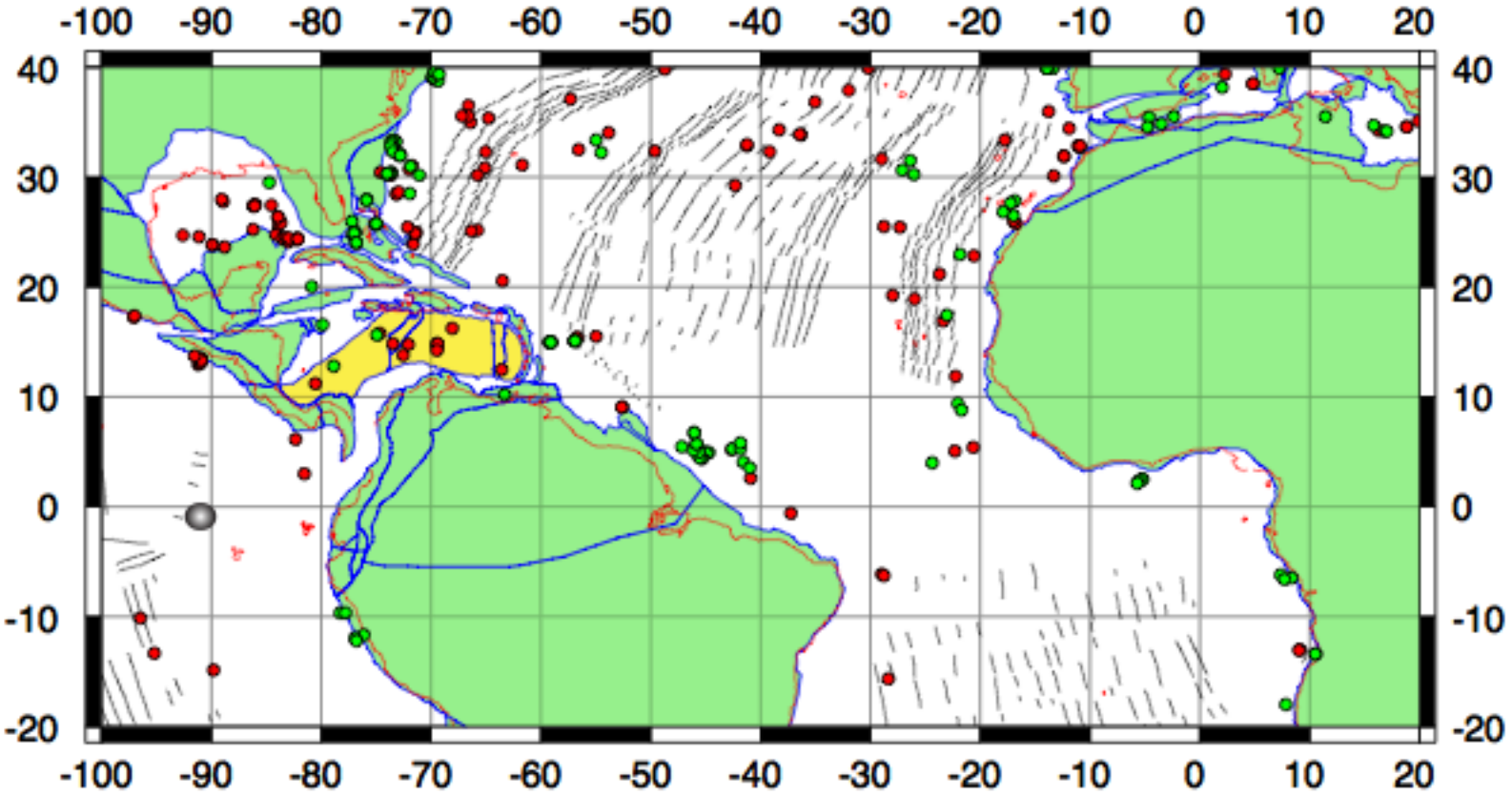

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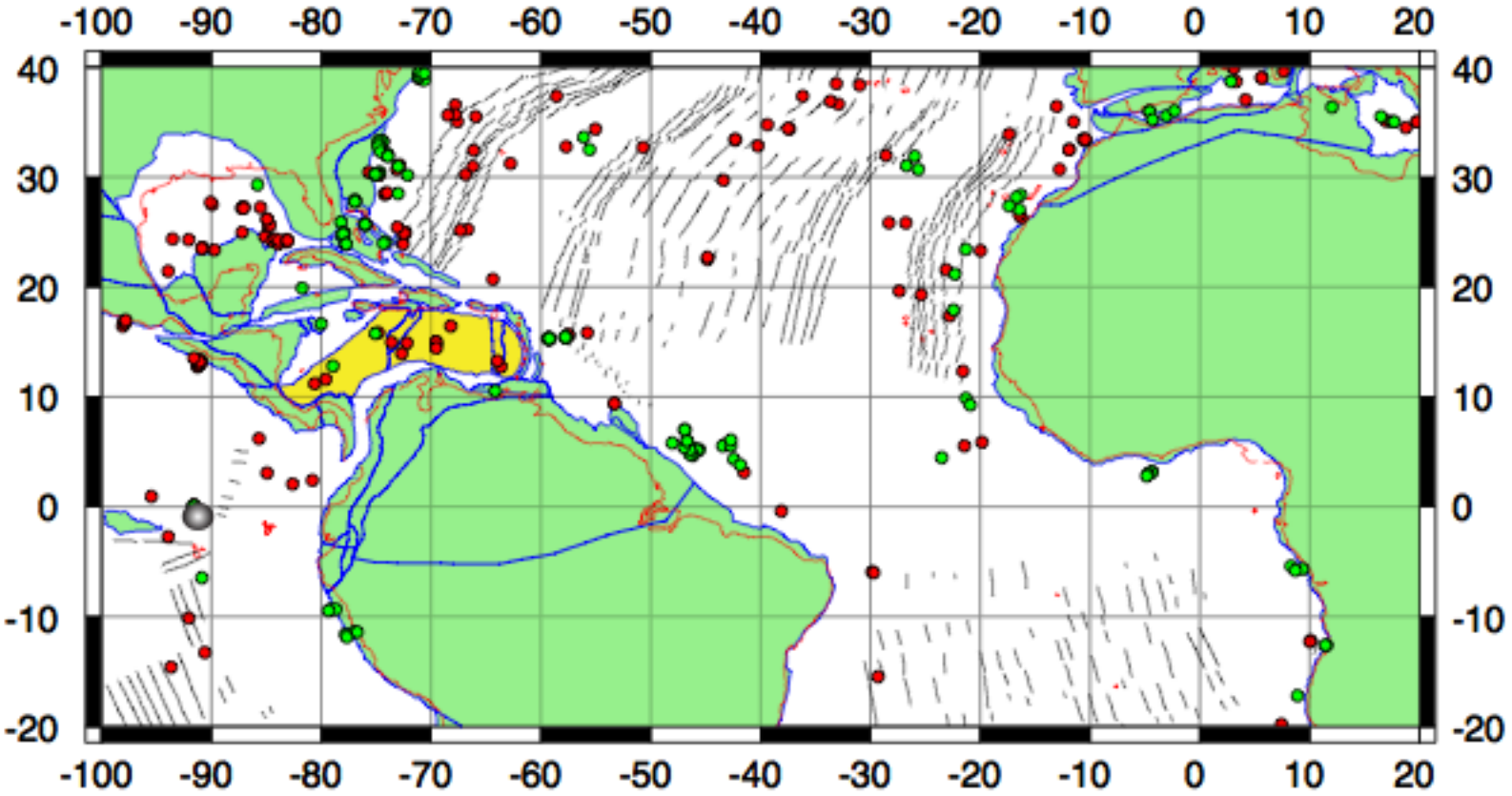

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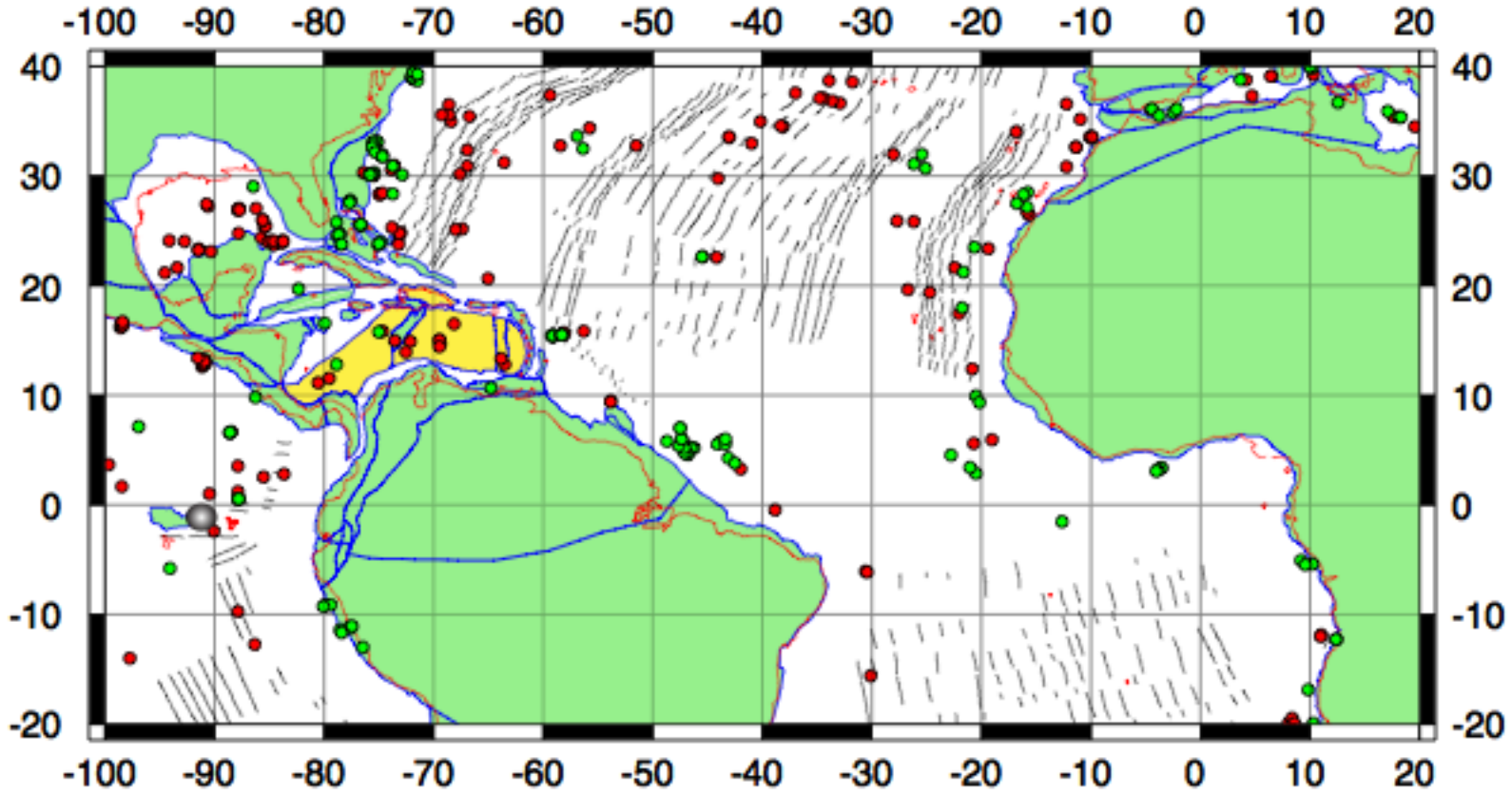

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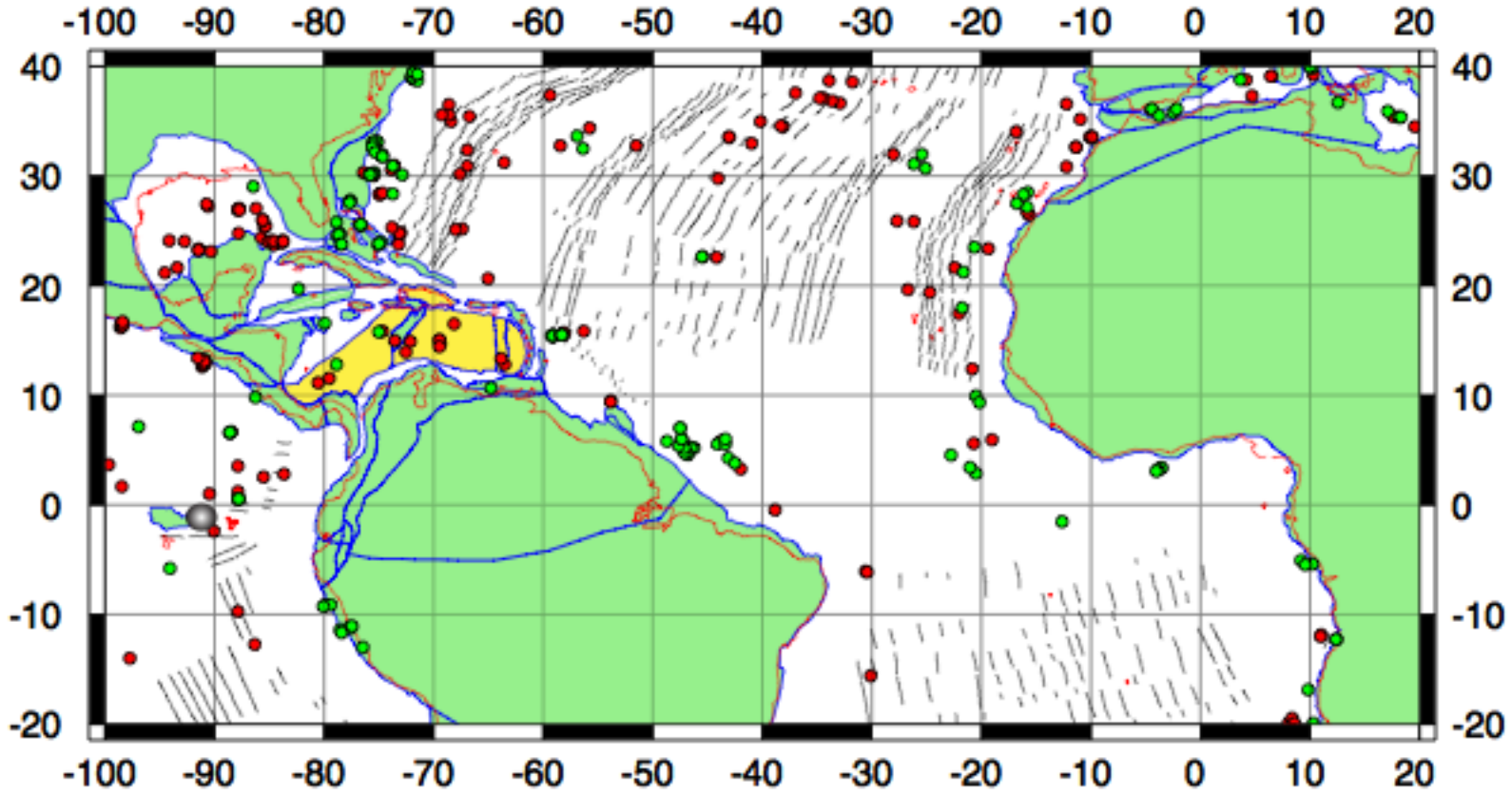
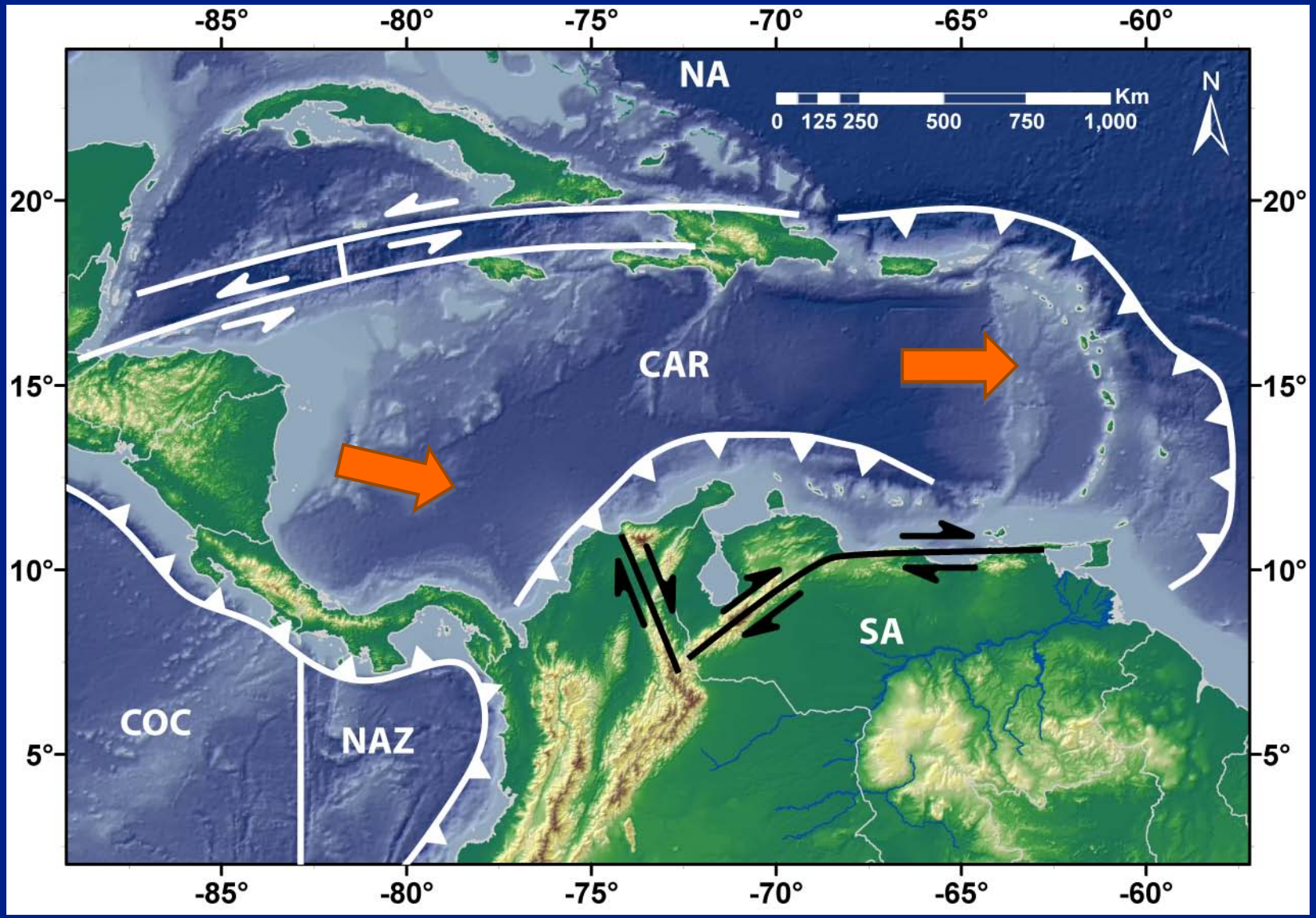
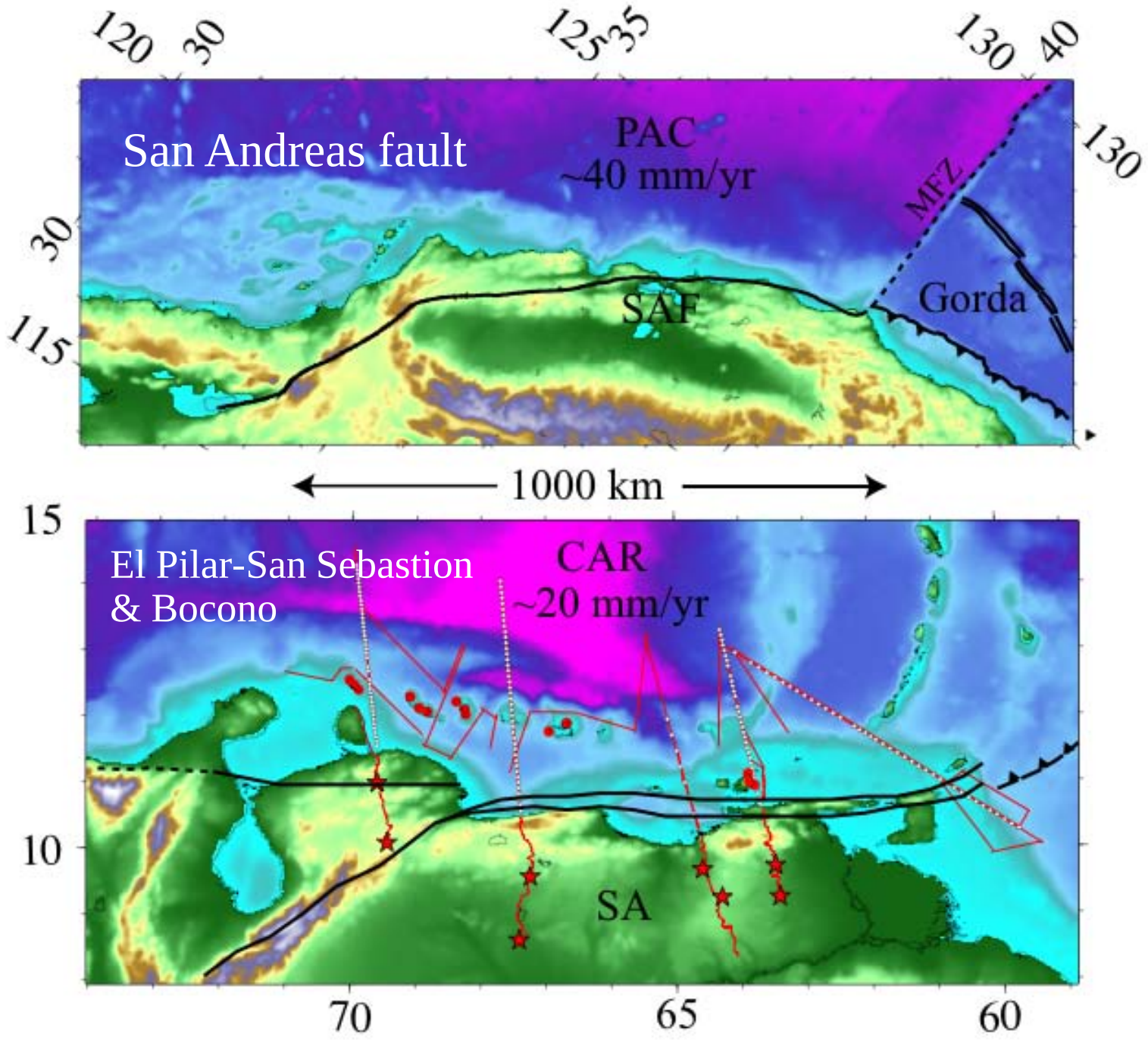


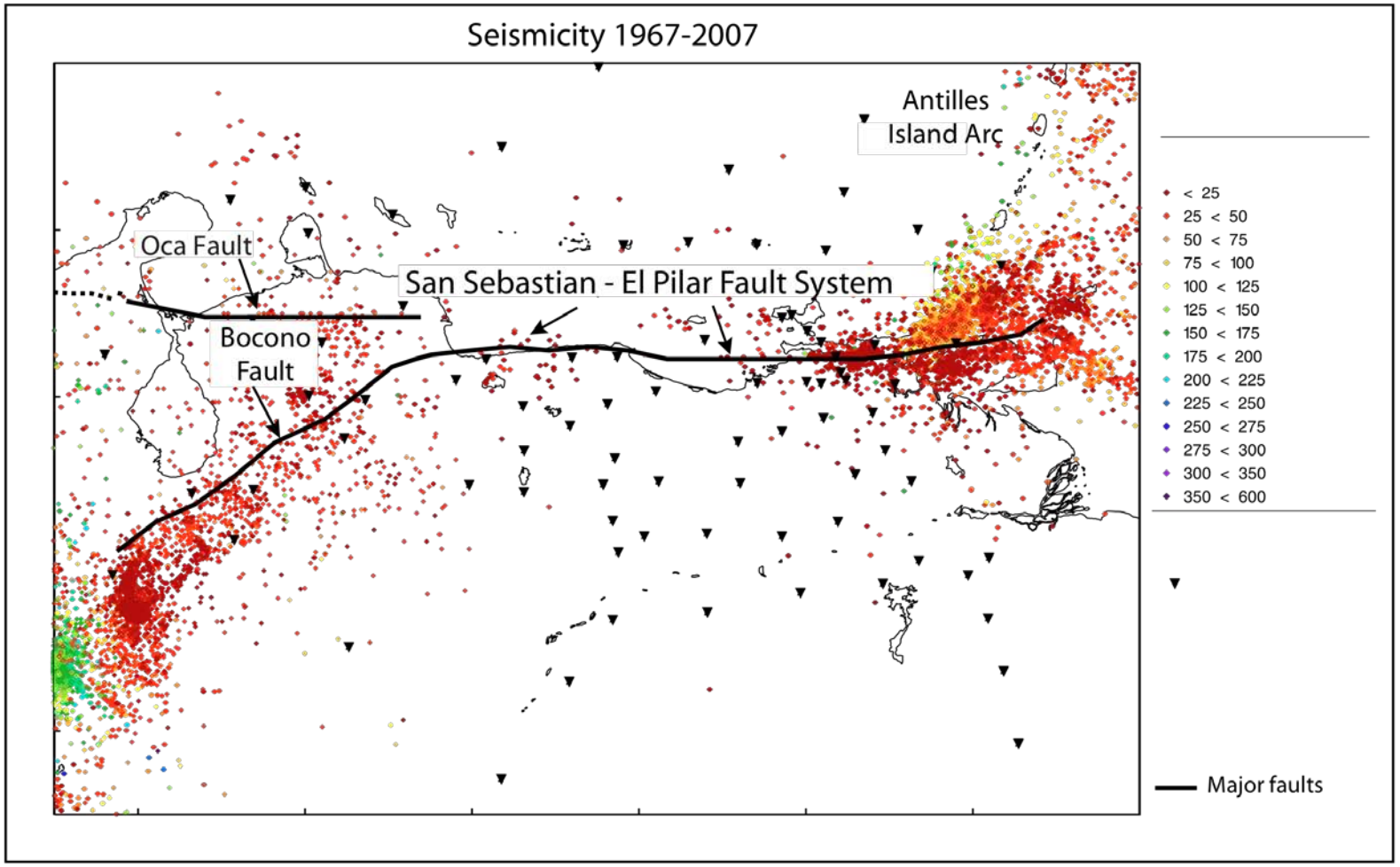
5.0 Ma Reconstruction

Tectonic Setting:

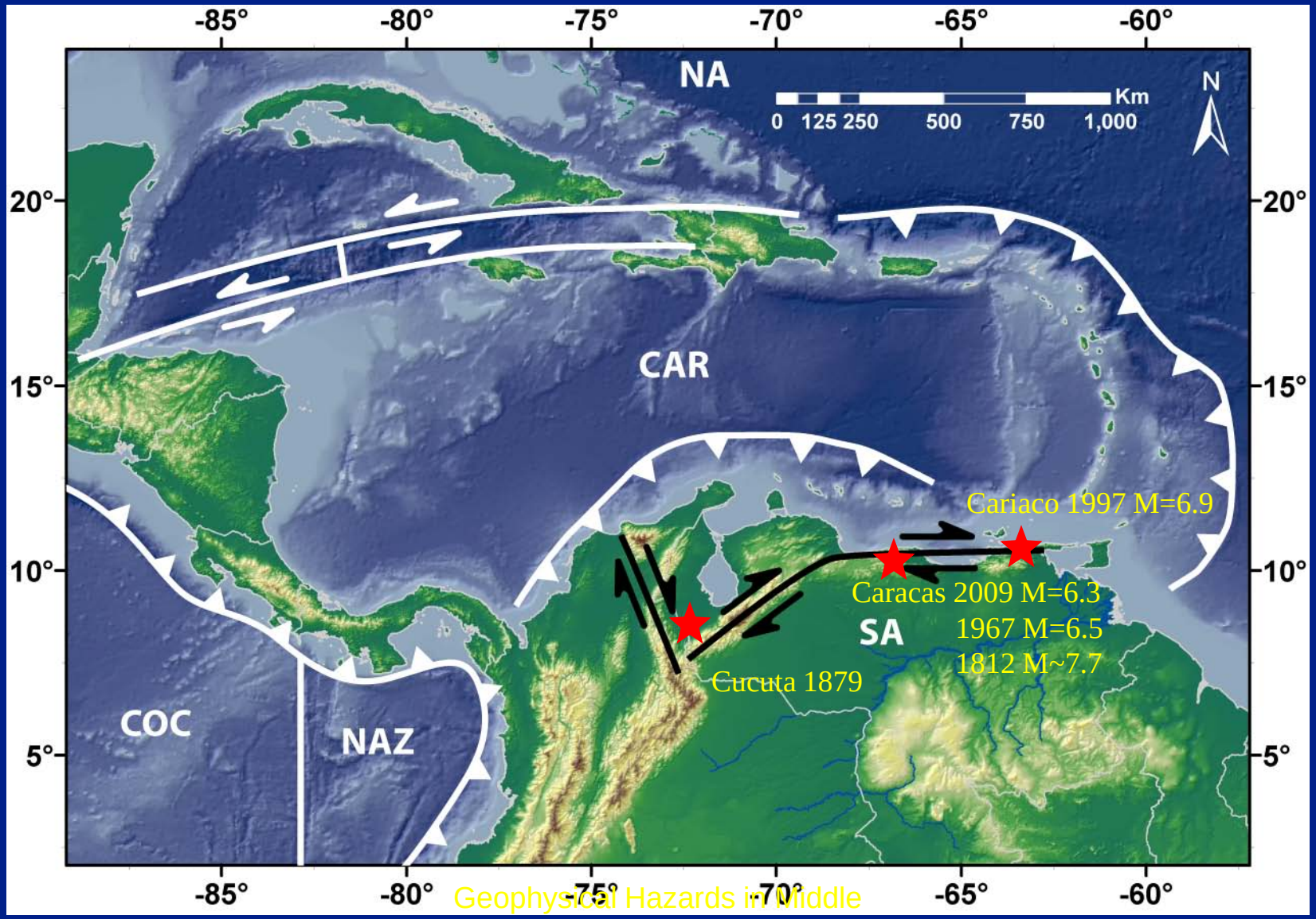


America 2010


120
30
125
35
130
40
San Andreas fault
PAC
~40 mm/yr
MFZ
Gorda
SAF
30
115
130
1000 km
15
El Pilar-San Sebastion
& Bocono
CAR
~20 mm/yr
SA
10
70
65
60


Seismicity 1967-2007
Antilles
Island Arc
Oca Fault
San Sebastian - El Pilar Fault System
Bocono
Fault
< 25
25 < 50
50 < 75
75 < 100
100 < 125
125 < 150
150 < 175
175 < 200
200 < 225
225 < 250
250 < 275
275 < 300
300 < 350
350 < 600
Major faults

Earthquakes:



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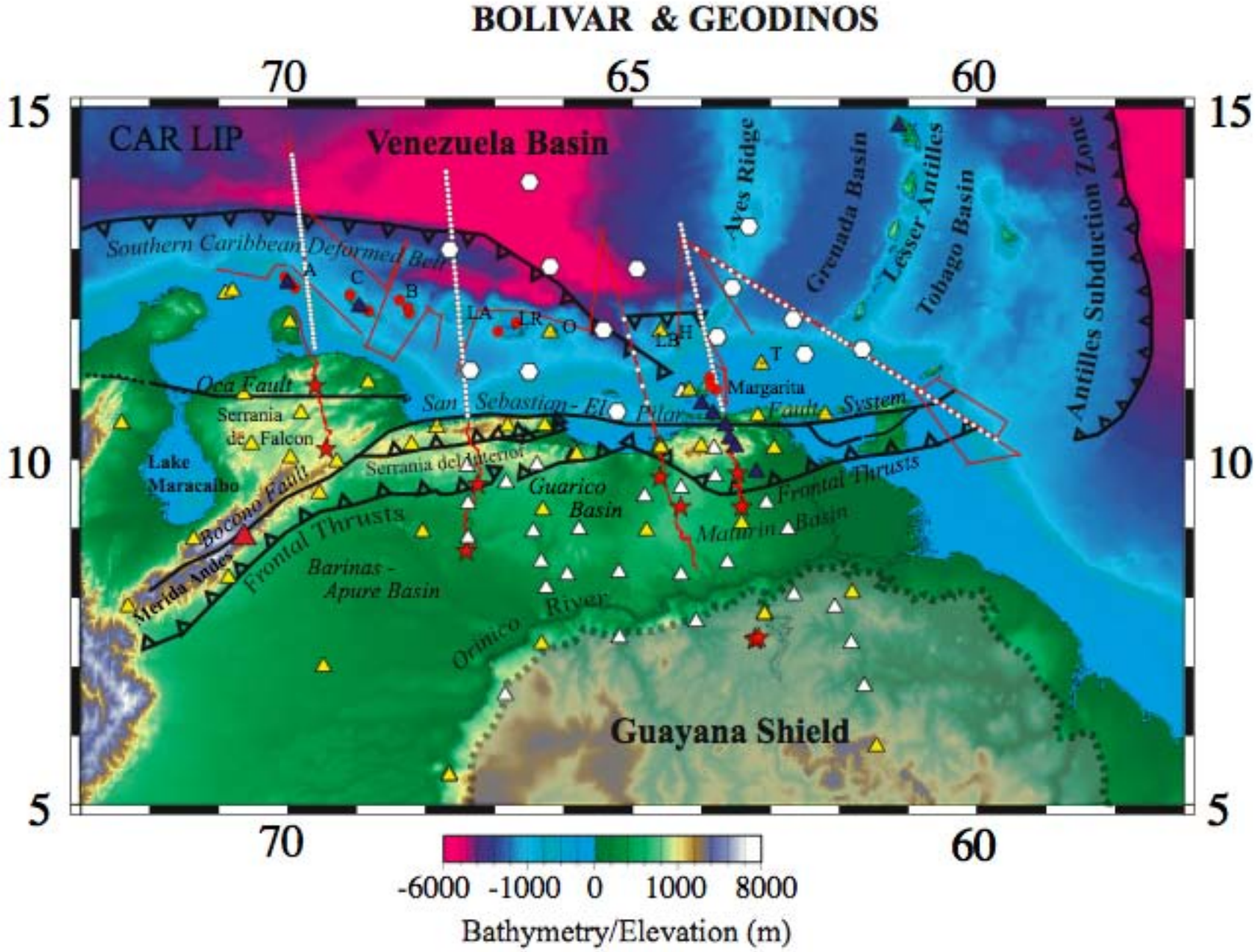
BOLIVAR & GEODINOS
70
65
60
15
10
5
CAR LIP
Venezuela Basin
Aves Ridge
Grenada Basin
Lesser Antilles
Tobago Basin
Antilles Subduction Zone
Southern Caribbean Deformed Belt
A
C
B
LA
LR
O
LB
H
T
Margarita
Oca Fault
San Sebastian - El Pilar Fault System
Serrania de Falcon
Lake Maracaibo
Serrania del Interior
Boconó Fault
Guarico Basin
Frontal Thrusts
Maturin Basin
Merida Andes
Barinas - Apure Basin
Orinoco River
Guayana Shield
-6000
-1000
0
1000
8000
Bathymetry/Elevation (m)

Finite-Frequency Teleseismic P-wave Tomography: Max Bezada's PhD Research

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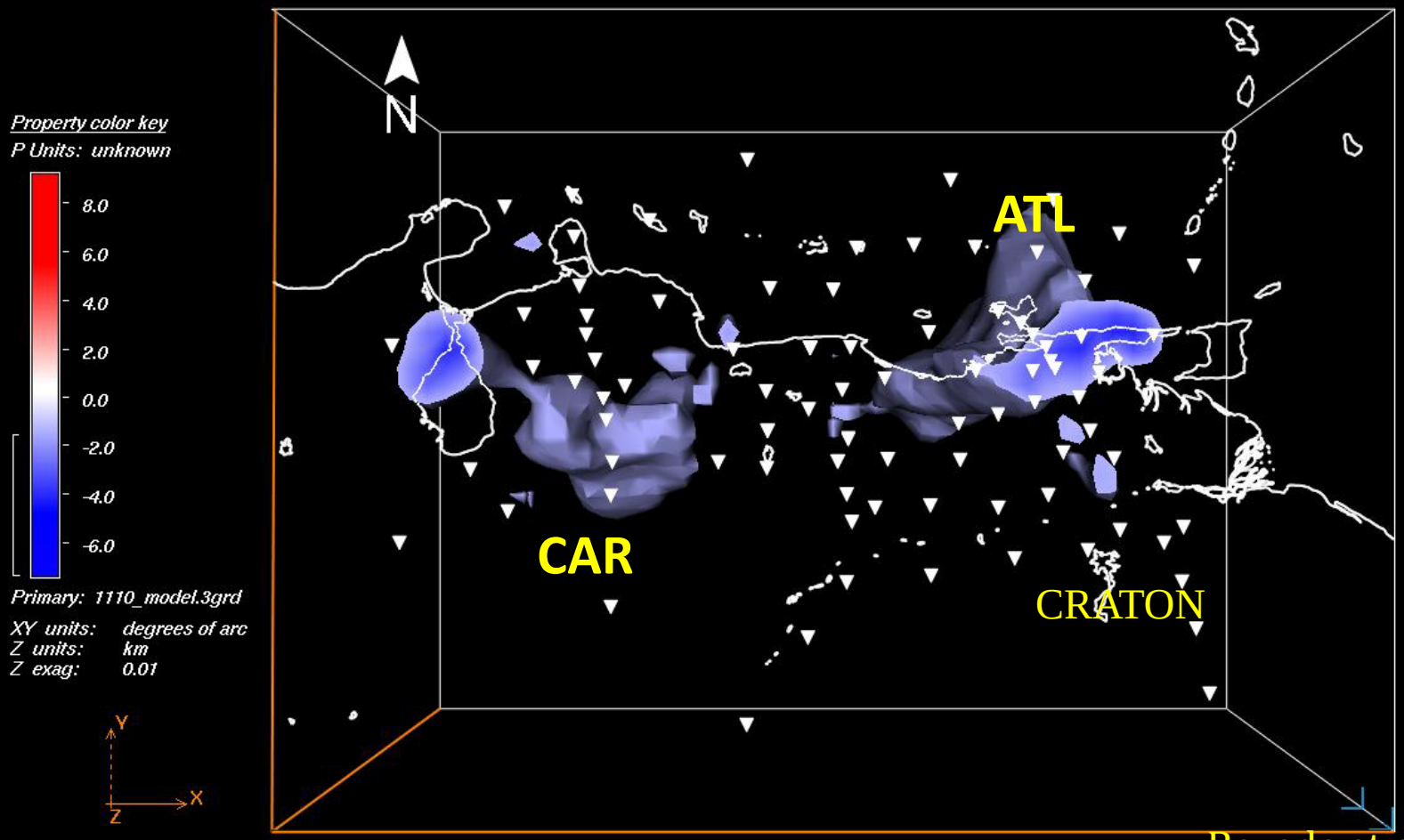
Finite-Frequency P-wave tomography: +1.5%

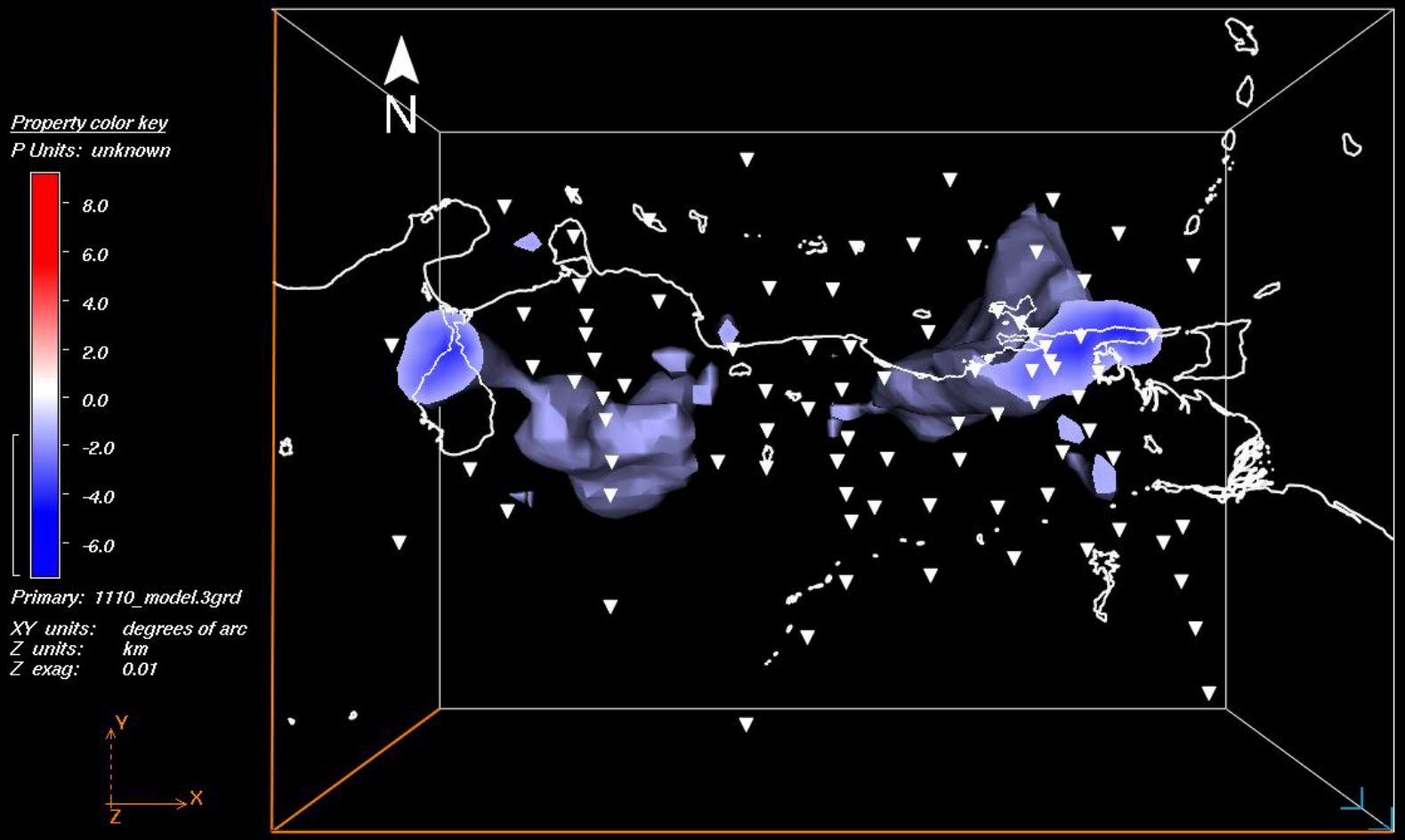
Caribbean in West

Atlantic in East

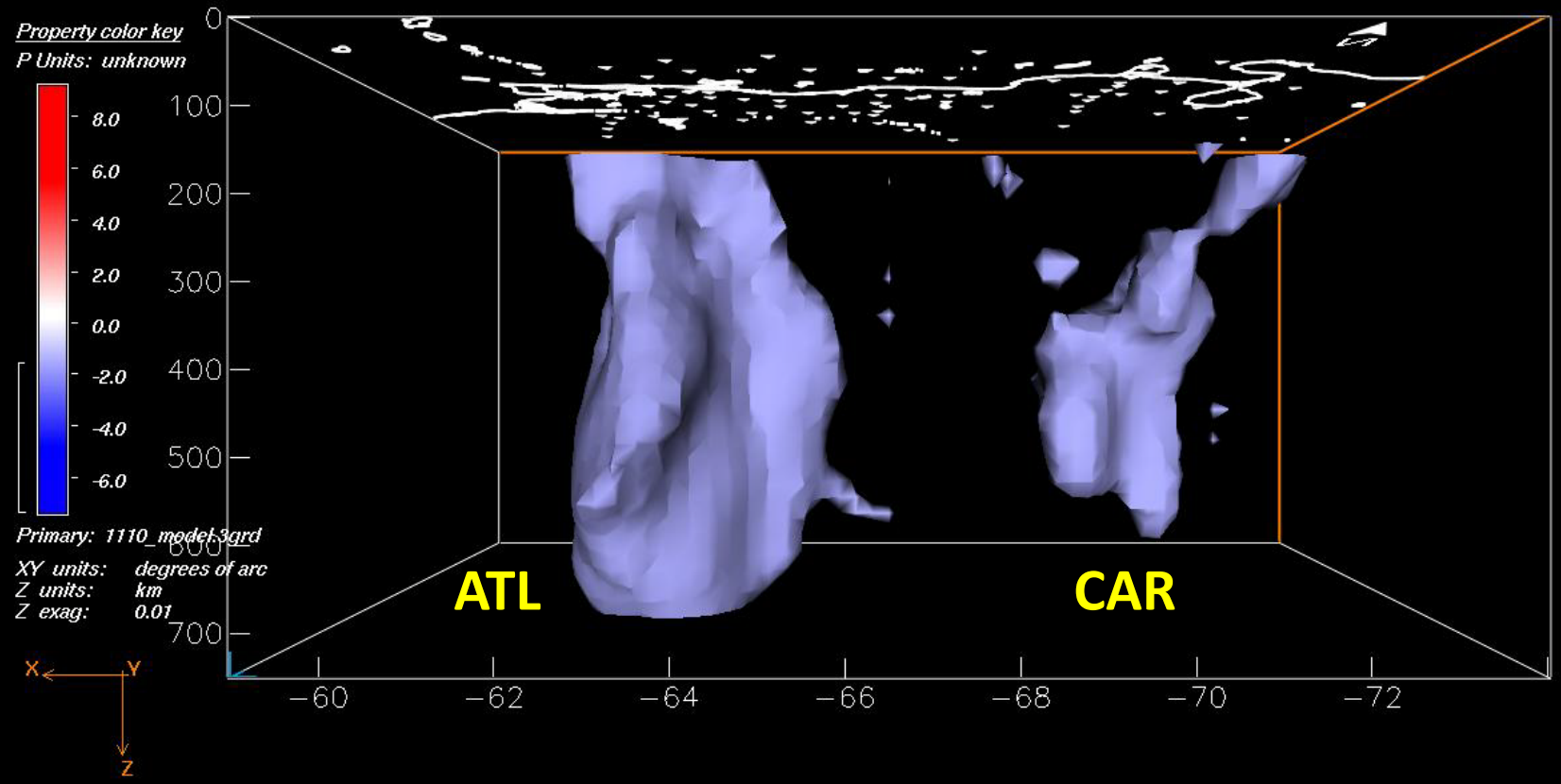


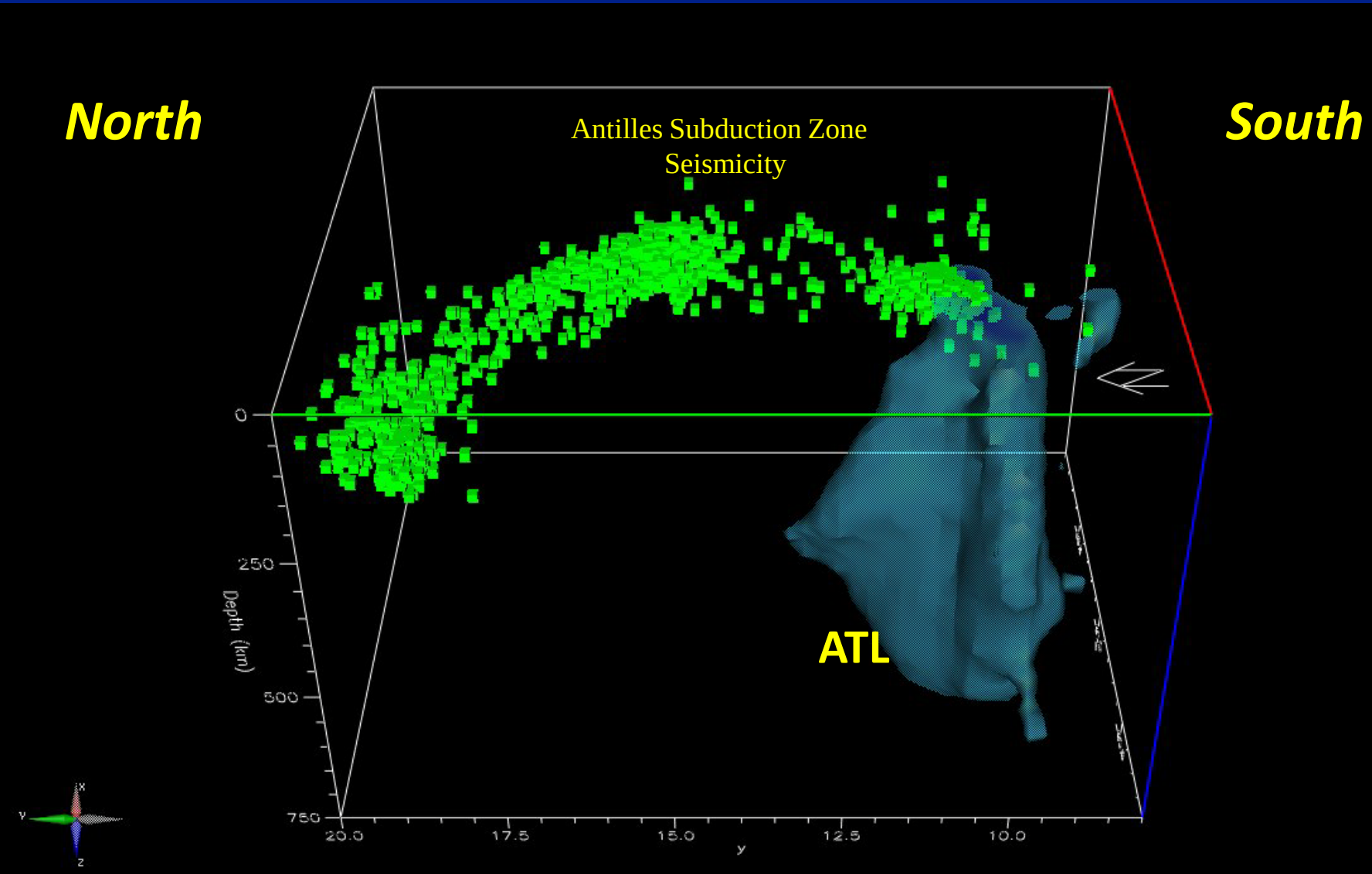
Bezada et al. JGR, 2010

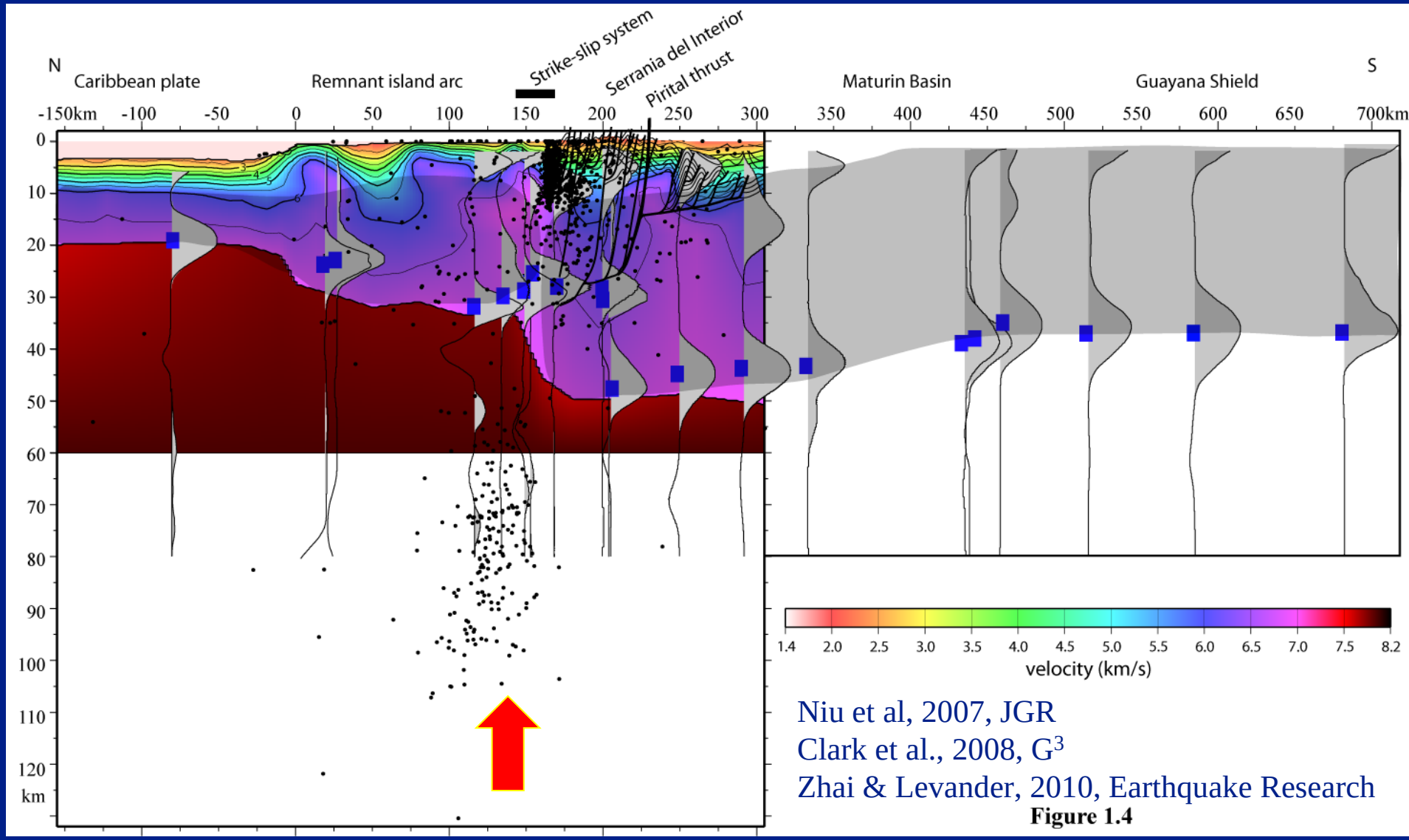
The Slabs in 3D:



The Slabs in 3D:



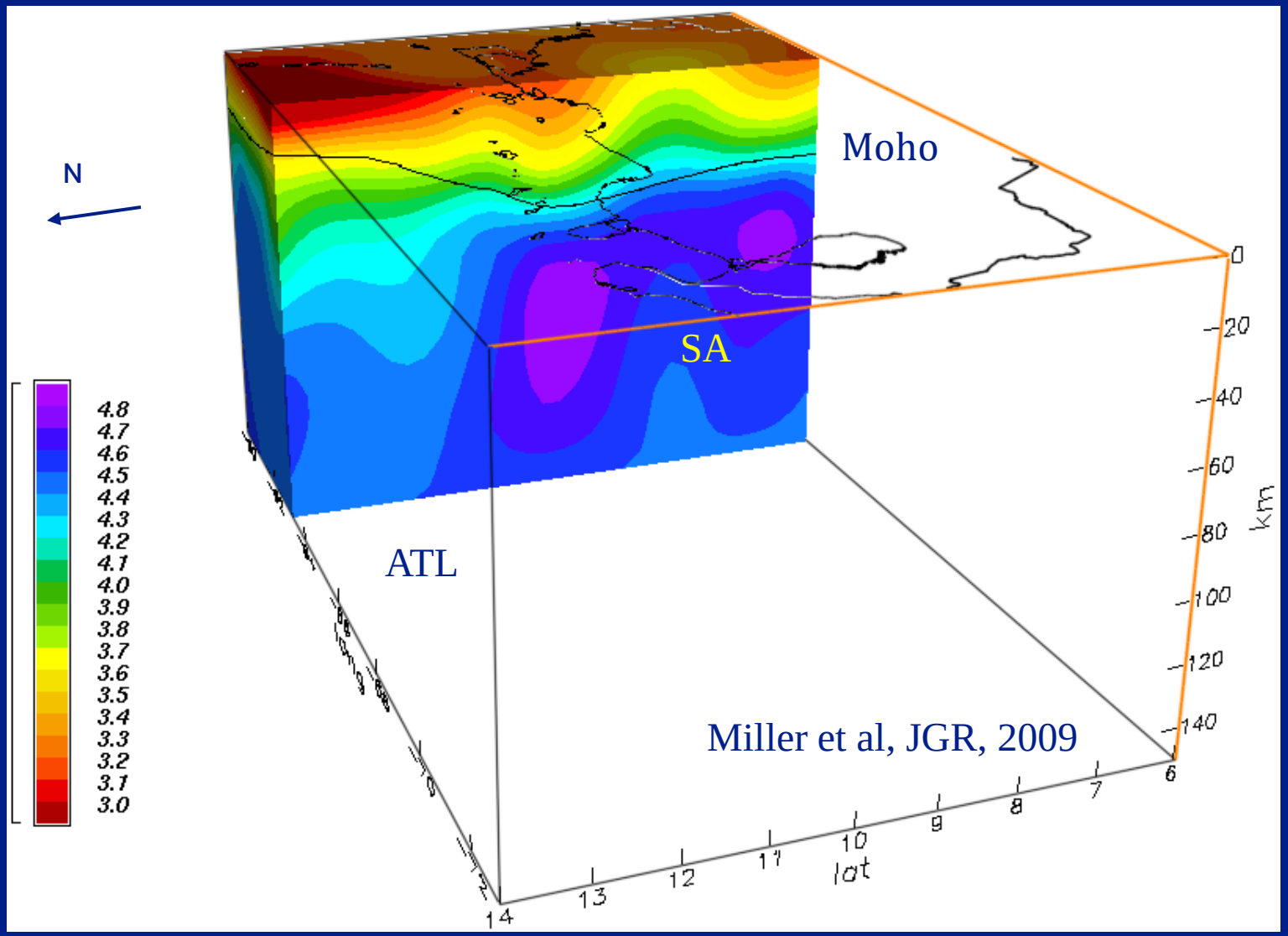

North
South
Antilles Subduction Zone
Seismicity
ATL
0
250
500
750
Depth (km)
20.0
17.5
15.0
12.5
10.0
y
x
y
z



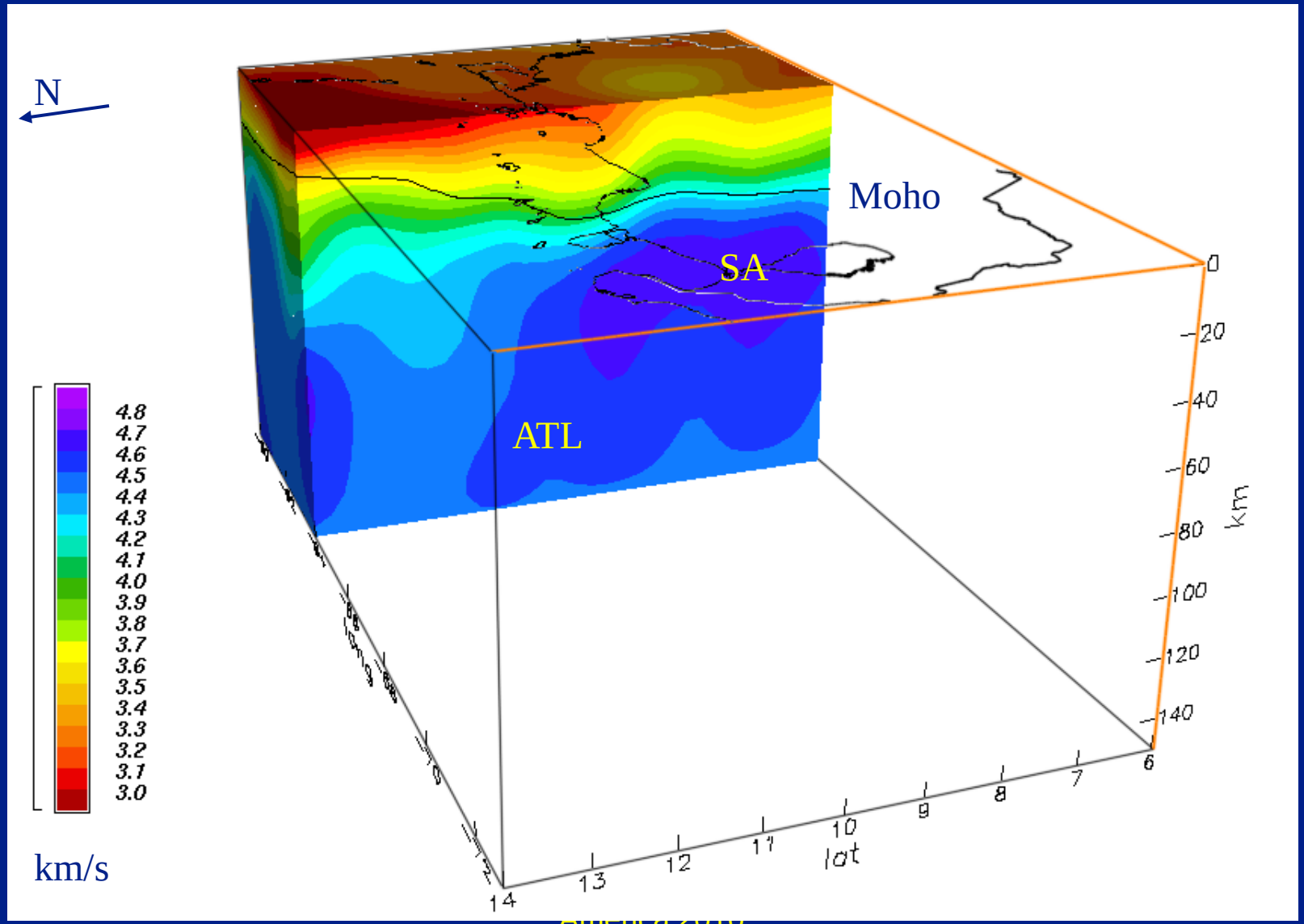
Niu et al, 2007, JGR
Clark et al., 2008, G^3
Zhai & Levander, 2010, Earthquake Research

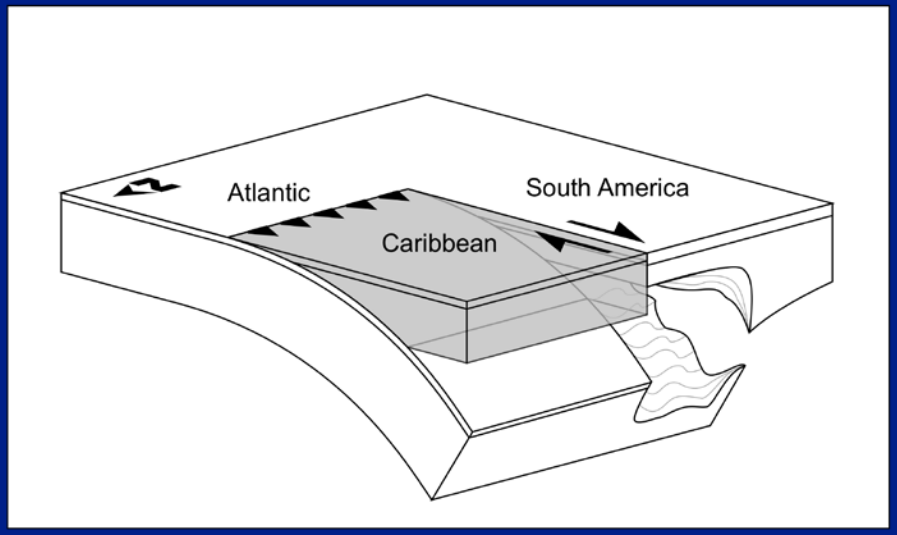
Figure 1.4

63.25W profile - view from west



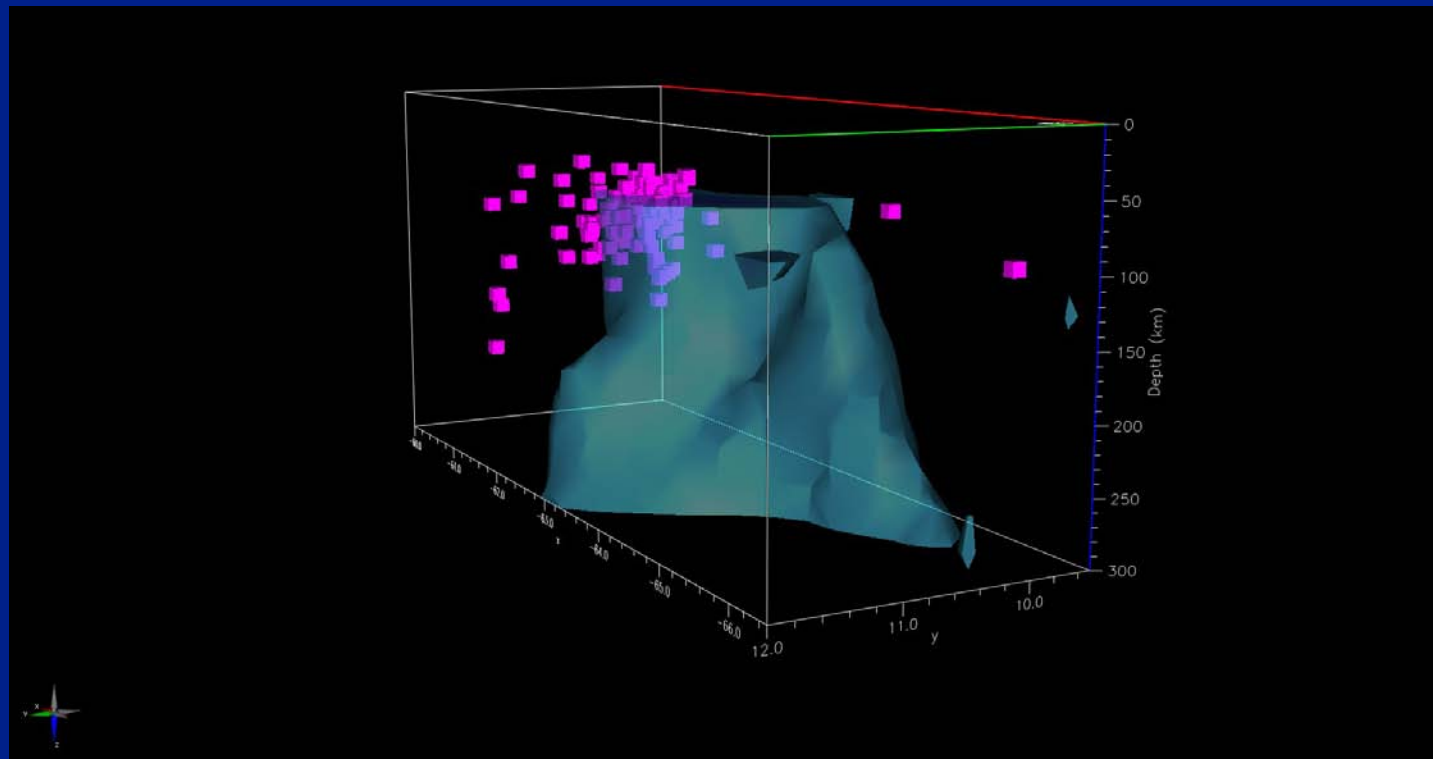
64W profile - view from west

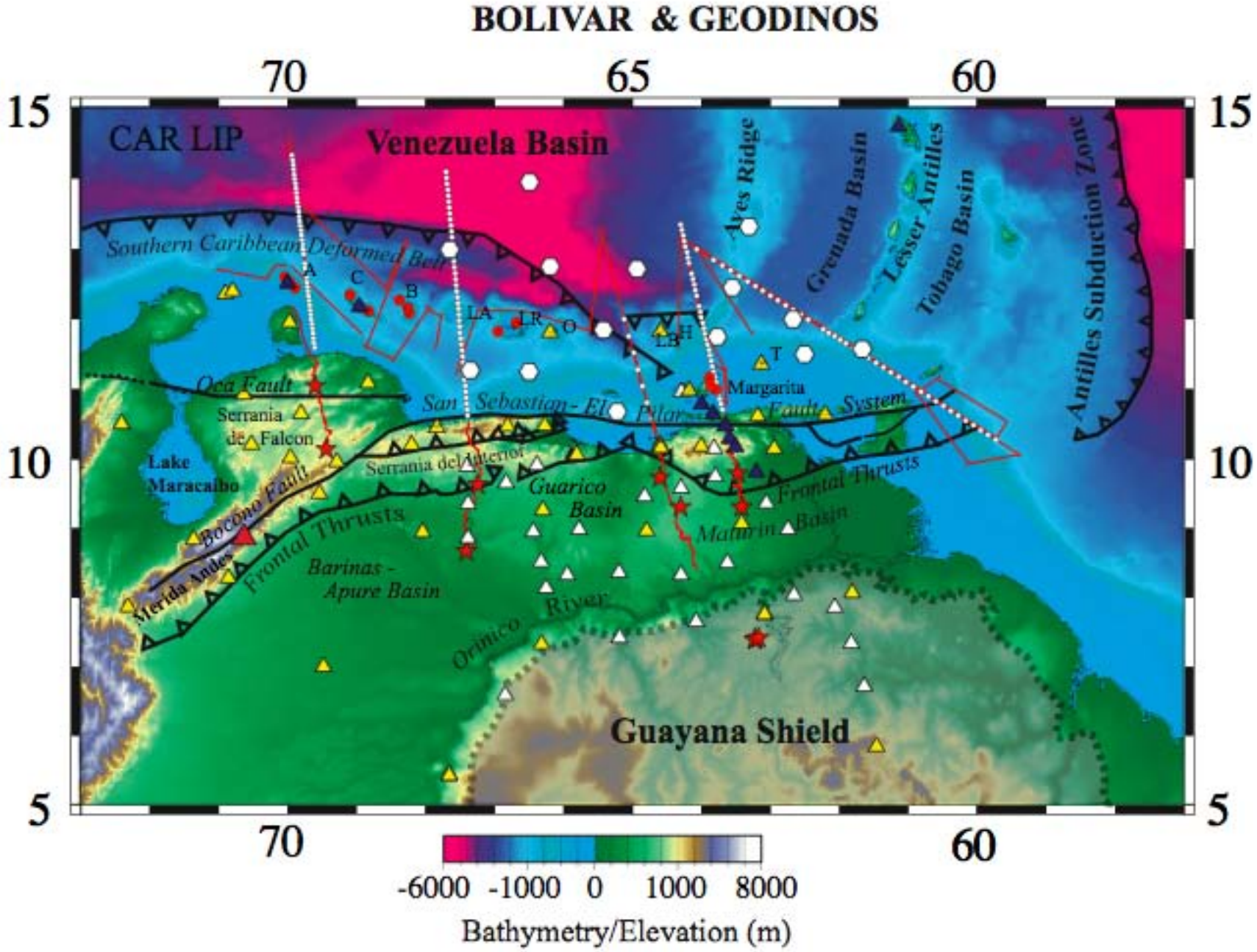




The tear forming between South American and the Atlantic drags off the bottom of the SA lithosphere

This weakens the SA lithosphere

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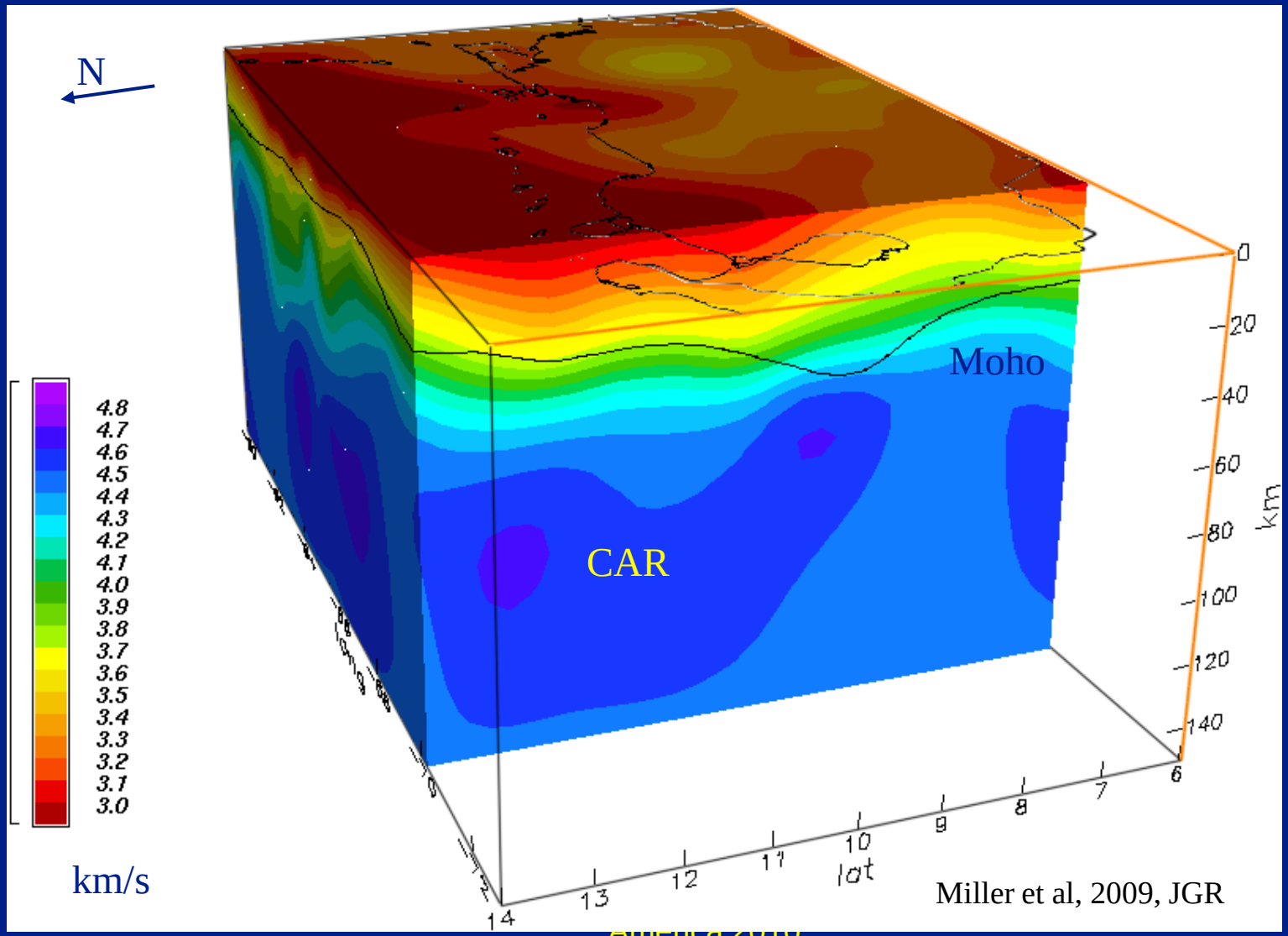
Maturin Basin
Merida Andes
Barinas - Apure Basin
Orinoco River
Guayana Shield
-6000
-1000
0
1000
8000
Bathymetry/Elevation (m)

70.25W profile – Caribbean plate extends as far south as Lake Maracaibo



Miller et al, 2009, JGR

Seismic Refraction Tomography: Maria Guédez Parra's MS Research

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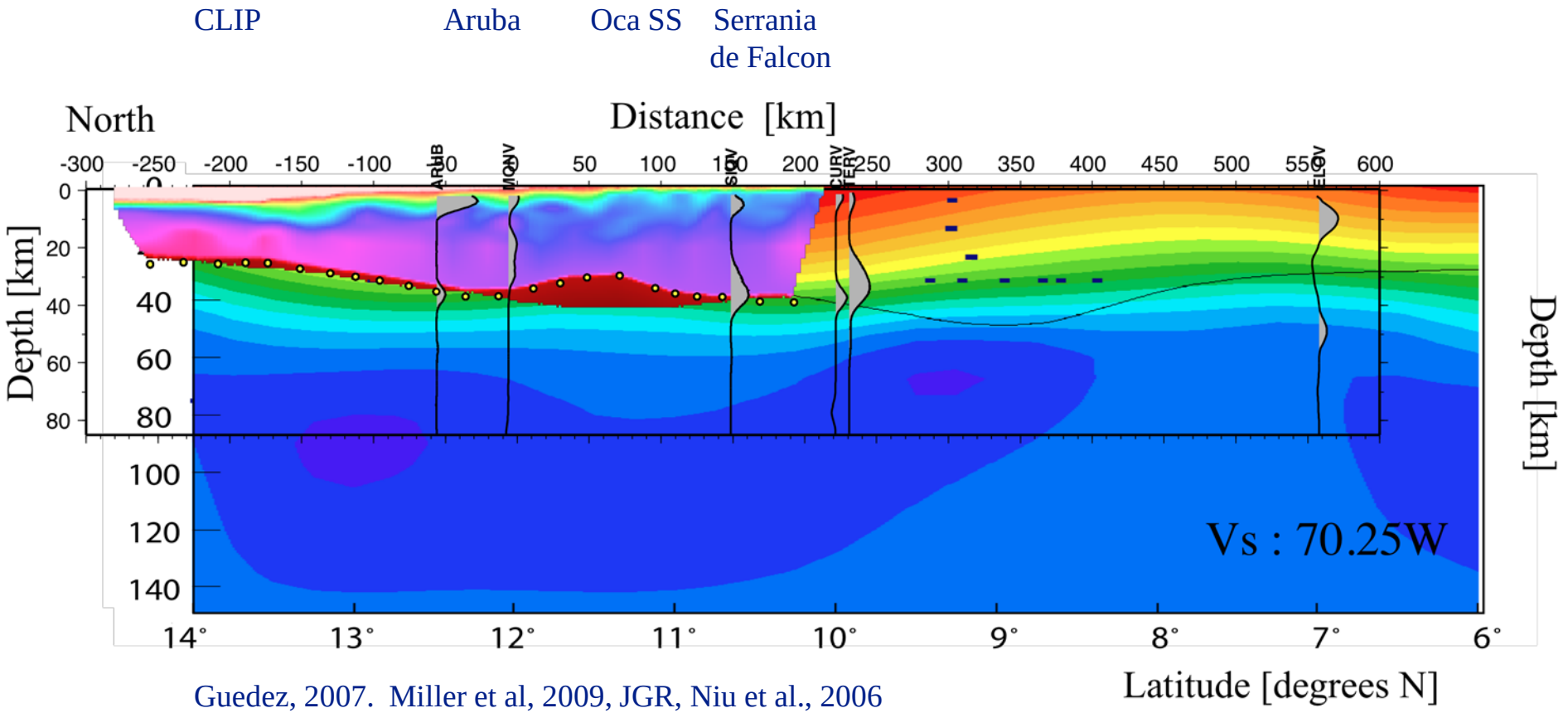
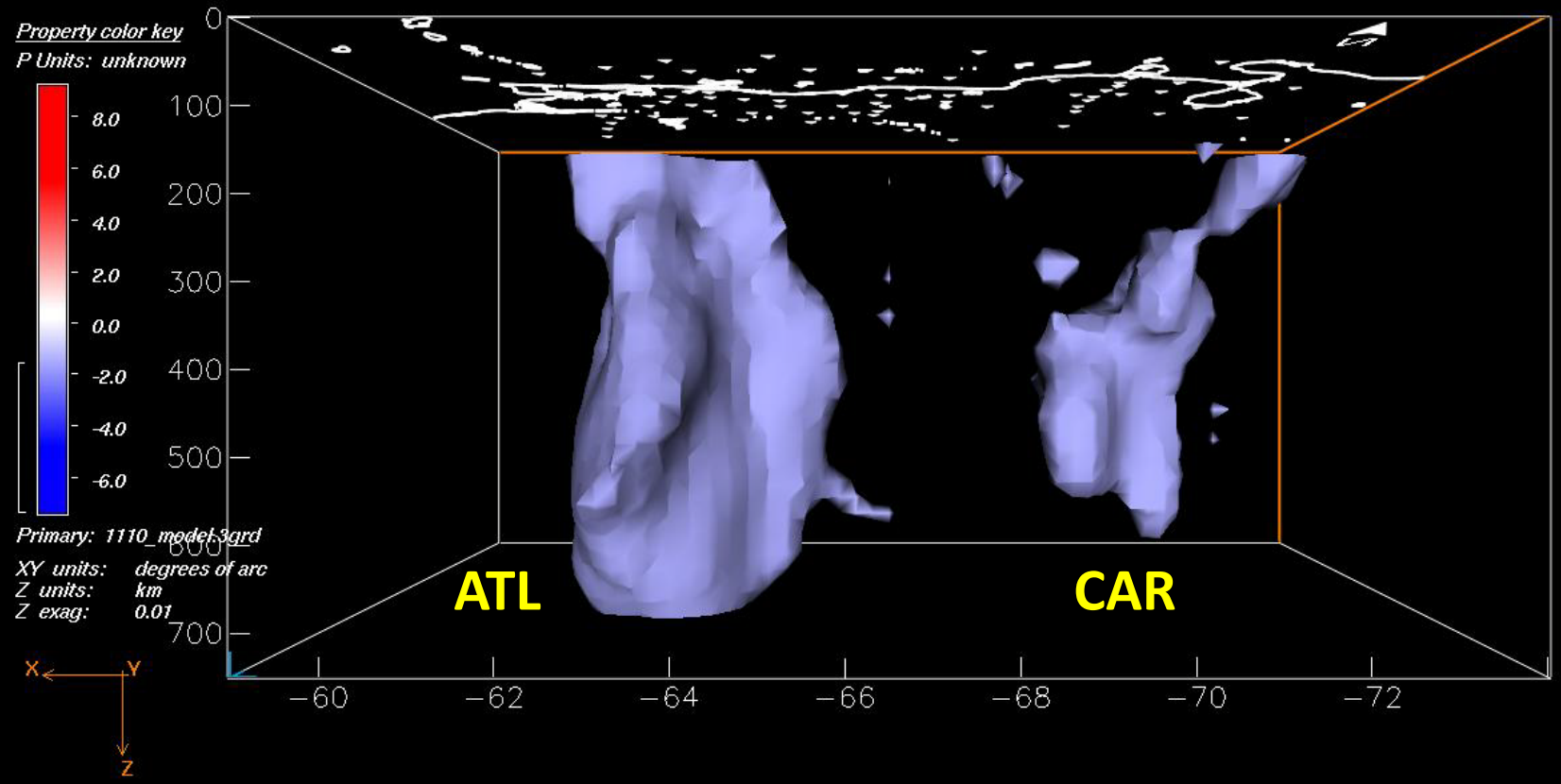
Active Source & Rayleigh wave Tomography and Receiver Functions

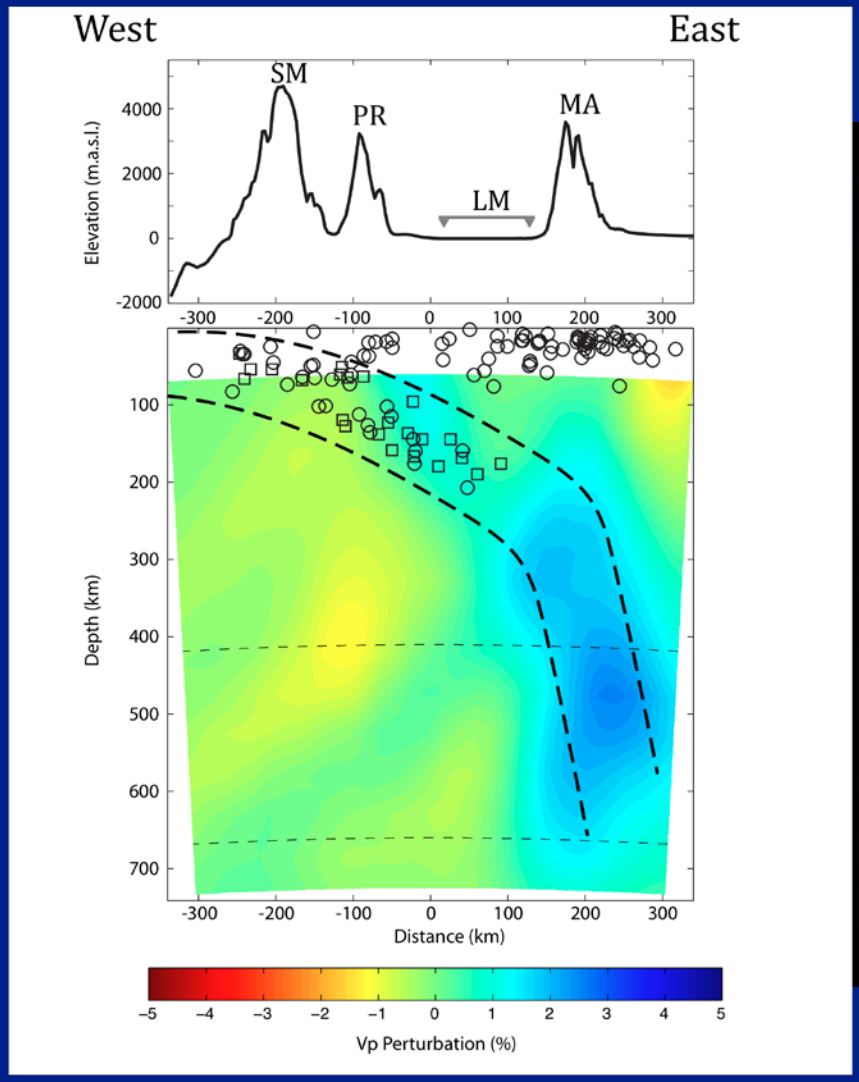


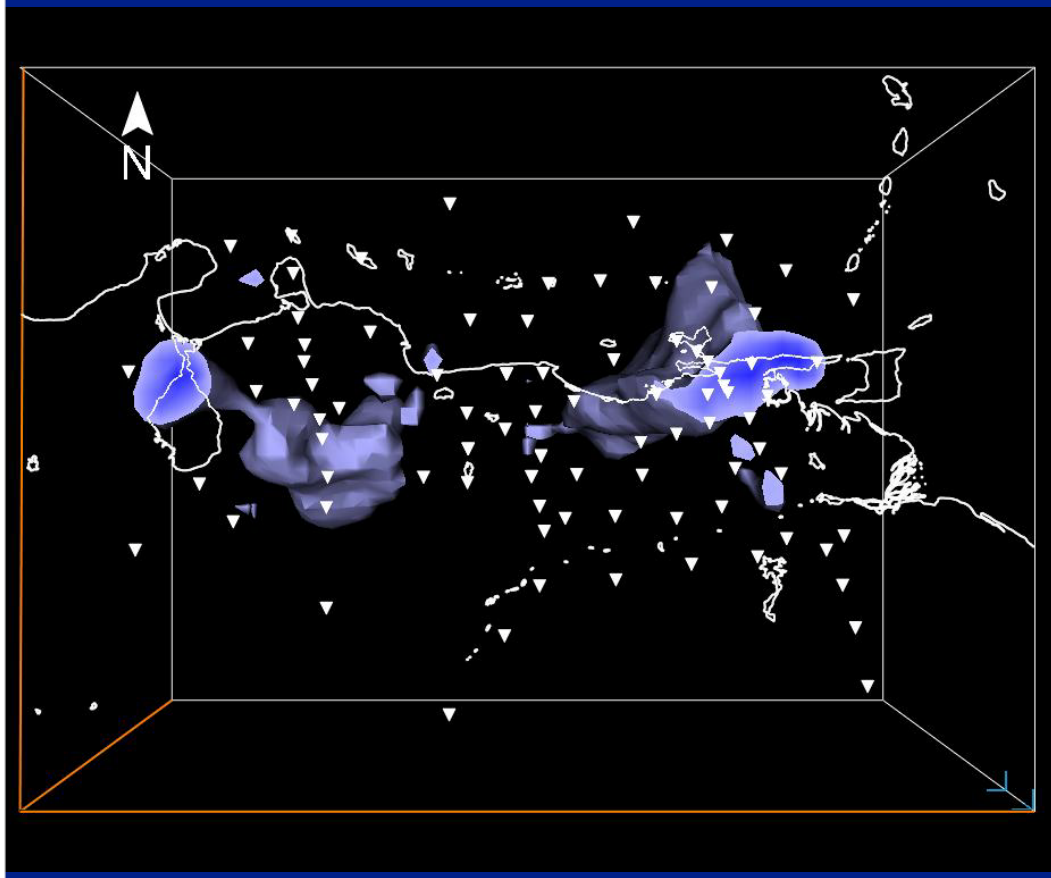
Guedez, 2007. Miller et al, 2009, JGR, Niu et al., 2006

The Slabs in 3D:



Caribbean Plate Flat Slab Subduction





Shear wave Anisotropy and Reciever Functions: Jeniffer Masy's PhD Research

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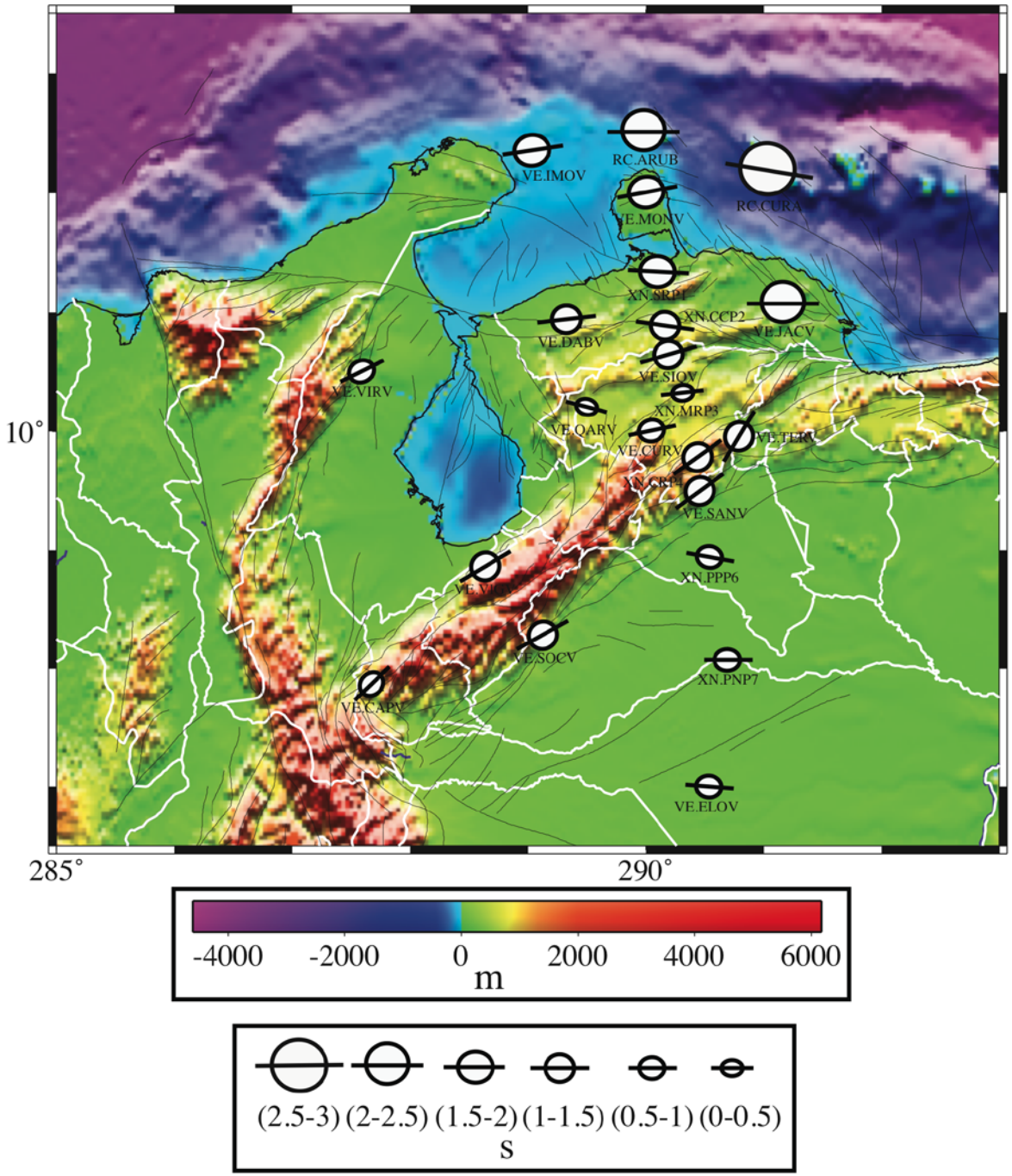


SKS splits

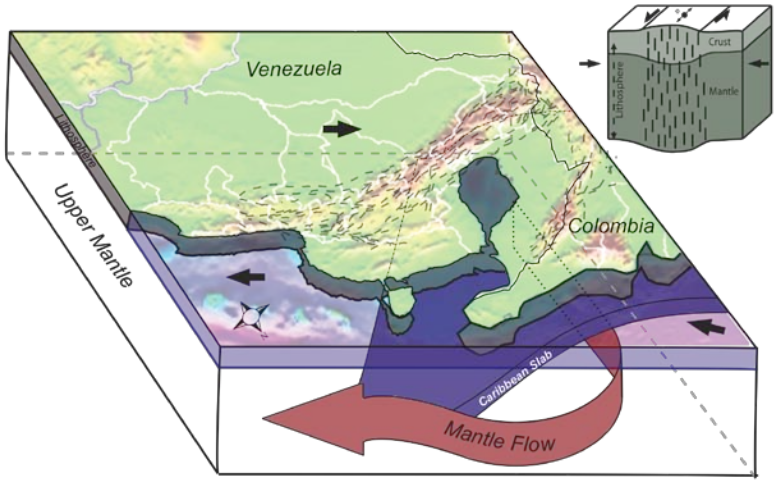
Parallel to

1) Plate boundary
2) Bocono fault
3) Absolute plate motion

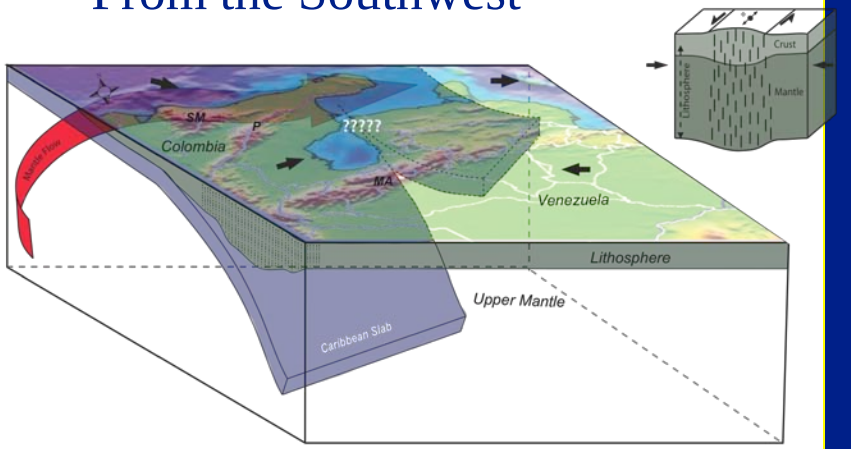
Masy et al., 2009, AGU

Mantle Flow in the West

From the Northeast



From the Southwest



Masy et al, 2009, AGU

Conclusions

1. Subducting ATL and CAR plates dip steeply in opposite directions
2. Both plates tear, weakening the lithosphere as a whole and broadening the zones of seismicity
3. In east subducting ATL tears from SA plate
    1. Initiates strike-slip fault system
    2. Removes SA lithosphere
    3. Influences mountain building and basin development
4. In the west CAR is flat under Columbia and steepens under the Maracaibo block producing Laramide-style uplift of Merida Andes and must tear

Very productive ongoing collaboration w. Venezuela


What is going on here??
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