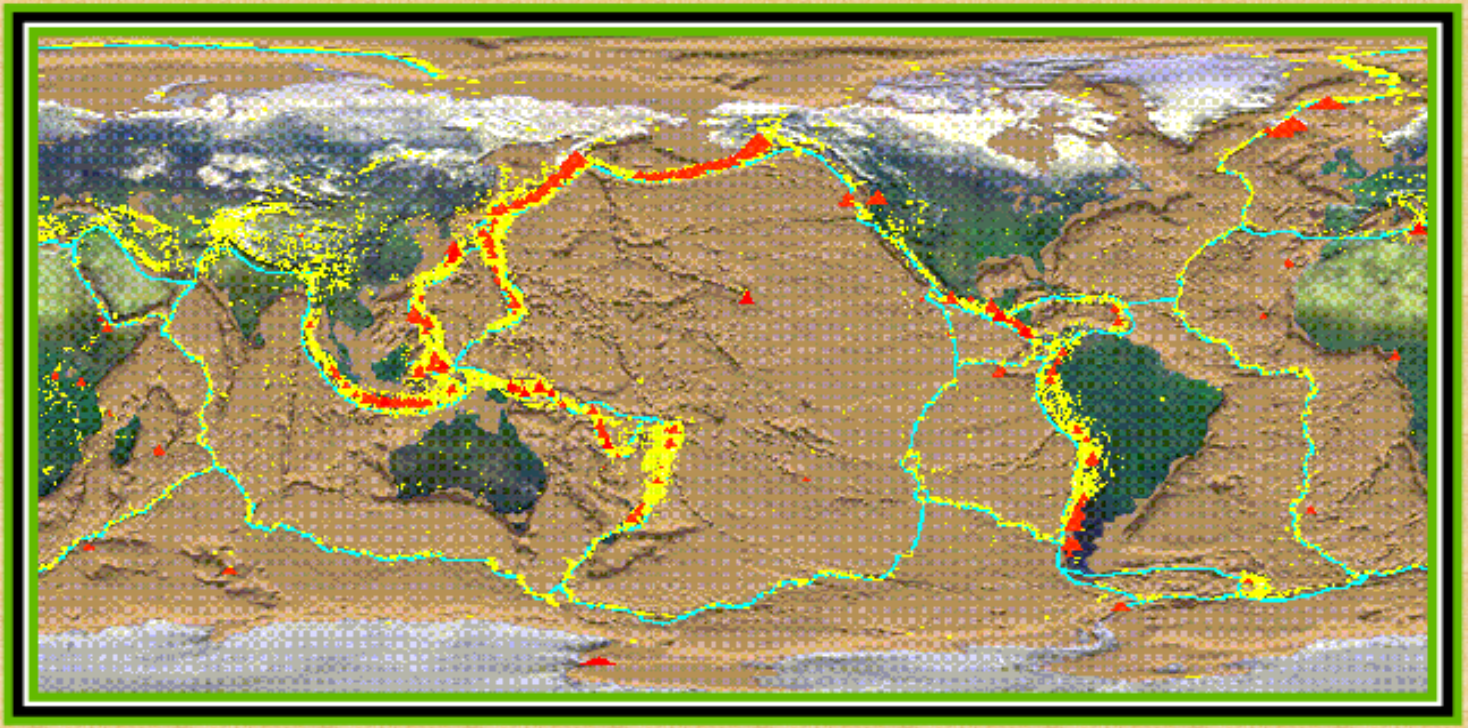
Physical Observations Linked to Rupture areas of Great and Giant EQs and Tsunami Sources

- Subducting Relief
- Sediment Subduction
- Forearc Basins
- Forearc Splay and Reverse Faulting

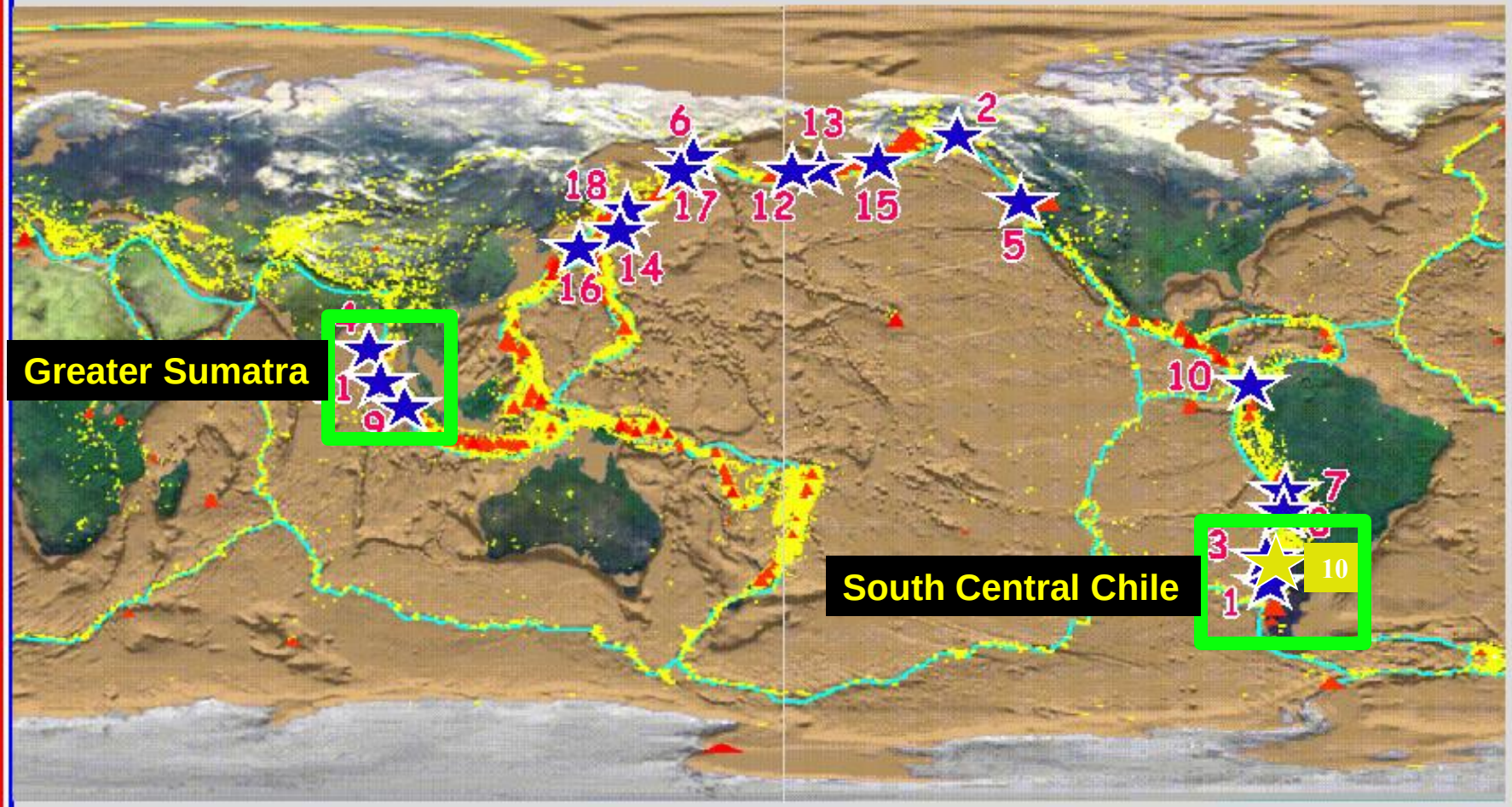


Is the Habitat of High Mw Megathrust EQs Linked to the Rock Fabric and Evolution of a Convergent Margins?

List of GIANT (Mw=/> 8.5) Subduction Zone (Thrust) EQs

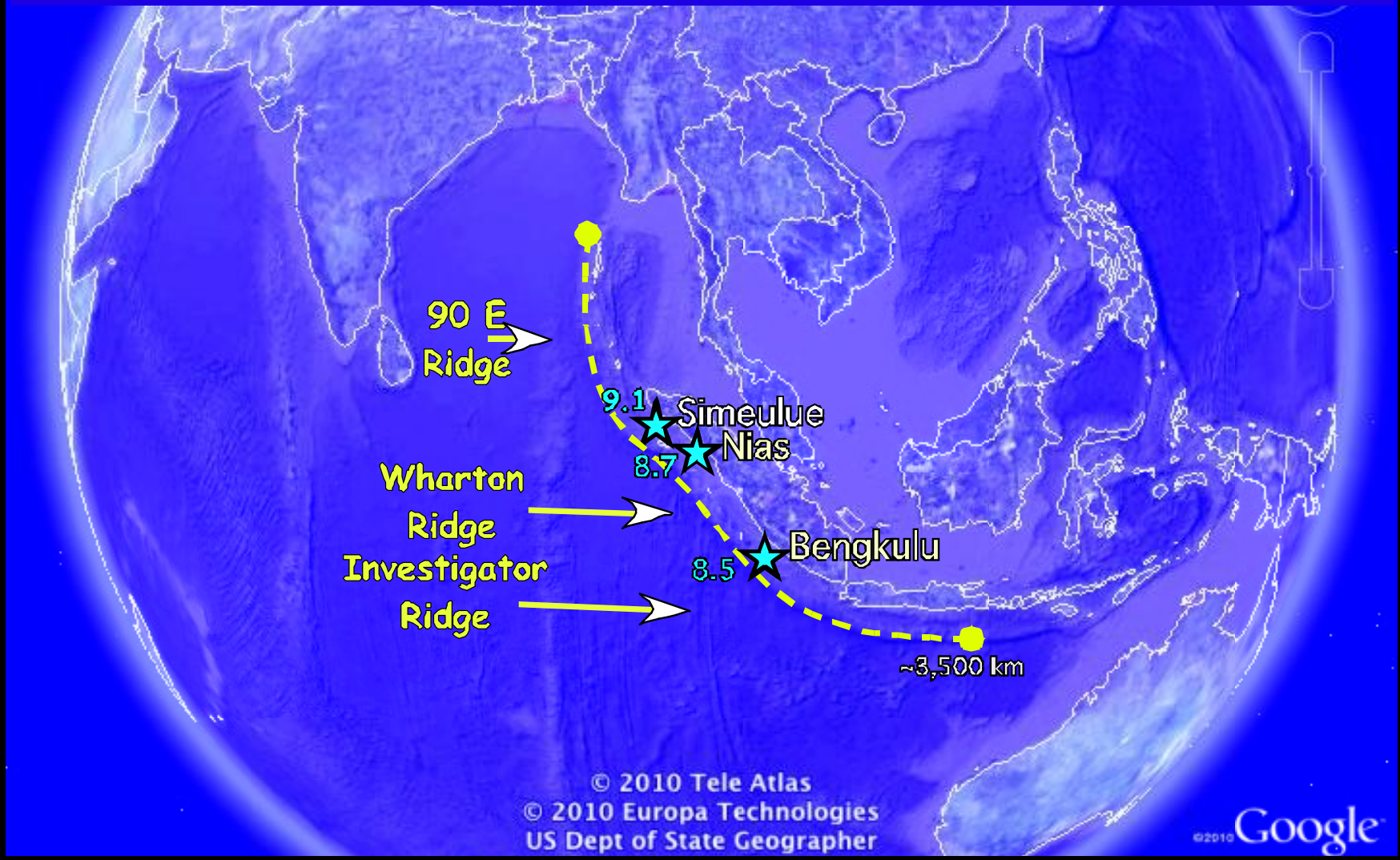
EQ no.	Location	Date	Mw
1	SOUTH CENTRAL CHILE	1960 05 22	9.5
2	SE (PWS) ALASKA	1964 03 28	9.2
3	BANDA ACEH N. SUMATRA	2004 12 26	9.1
4	CASCADIA	Jan 1700	9.0
5	KAMCHATKA	1952 11 04	9.0
6	ARICA. N. CHILE	1868	~9.0
7	N. CHILE	1877 05 09	~9.0
8	SOUTH CENTRAL CHILE	2010 02 27	8.8
9	COLOMBIA	1906 01 31	8.8
10	NIAS, SUMATRA	2005 03 28	8.7
11	RAT IS., ALEUTIAN	1965 02 04	8.7
12	ANDREANOF IS., ALEUTIAN.	1957 03 09	8.7
13	VALPARAISO SC CHILE	1730 07 08	8.7
14	N. HONSHU(SANRIKU), JAPAN	1896 06 15	8.6
15	SW ALASKA PEN. (UNIMAK)	1946 04 01	8.6
16	NANKAI, SW JAPAN	1707 10 04	8.6
17	SOUTH KAMCHATKA	1923 02 03	8.5
18	SOUTH KURILE	1963 10 13	8.5
19	SOUTH SUMATRA	2007 09 12	8.5

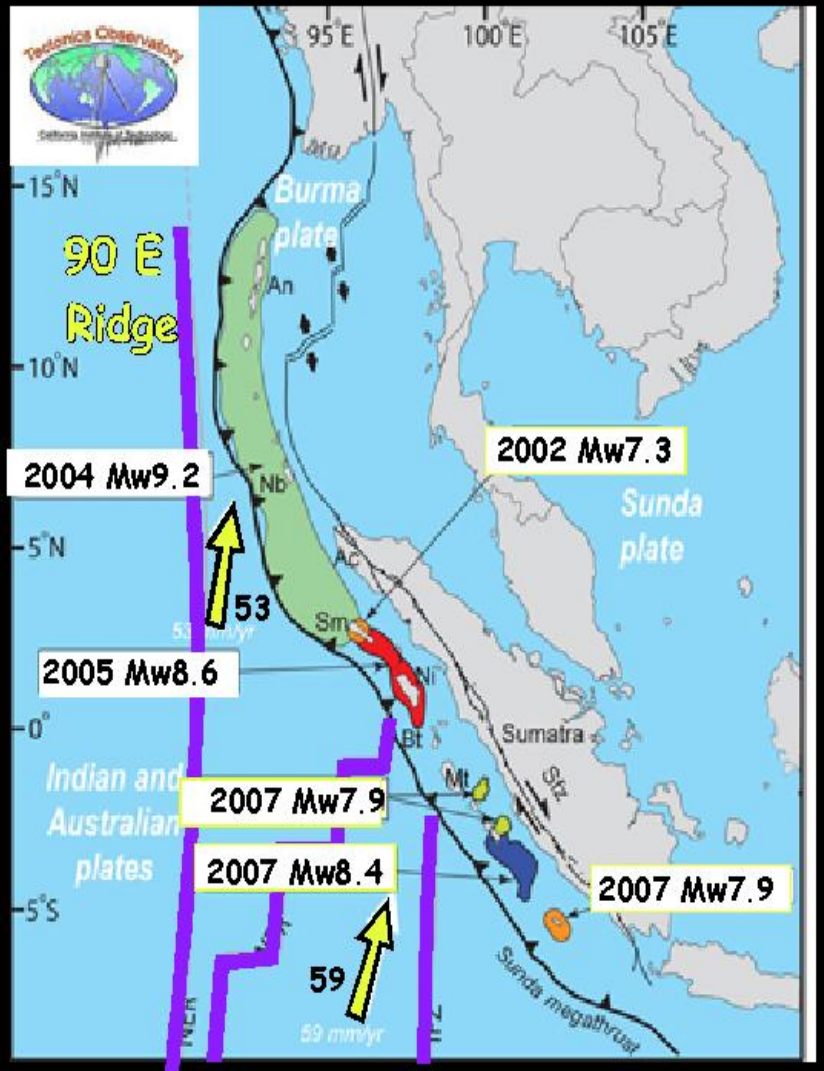
Location of GIANT (Mw=/> 8.5) Subduction Zone (Thrust) EQs,

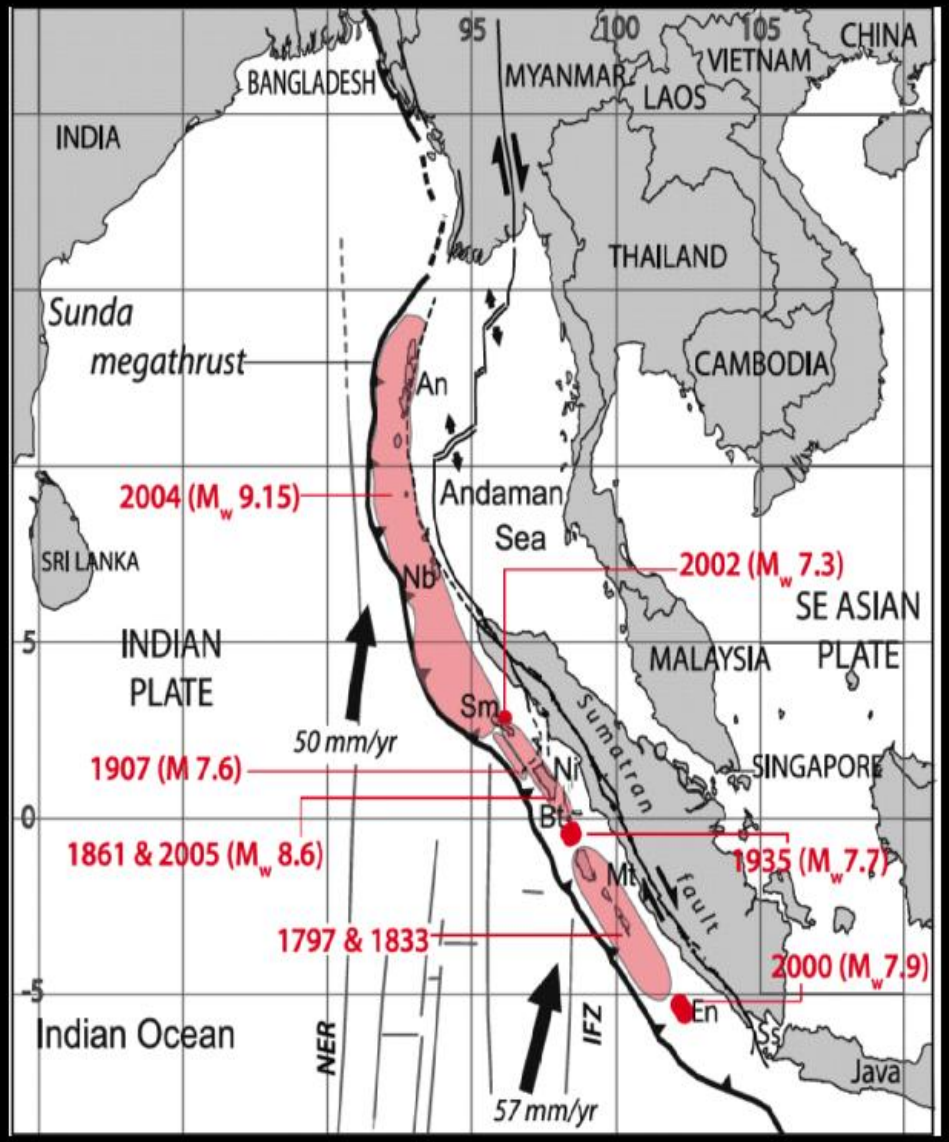


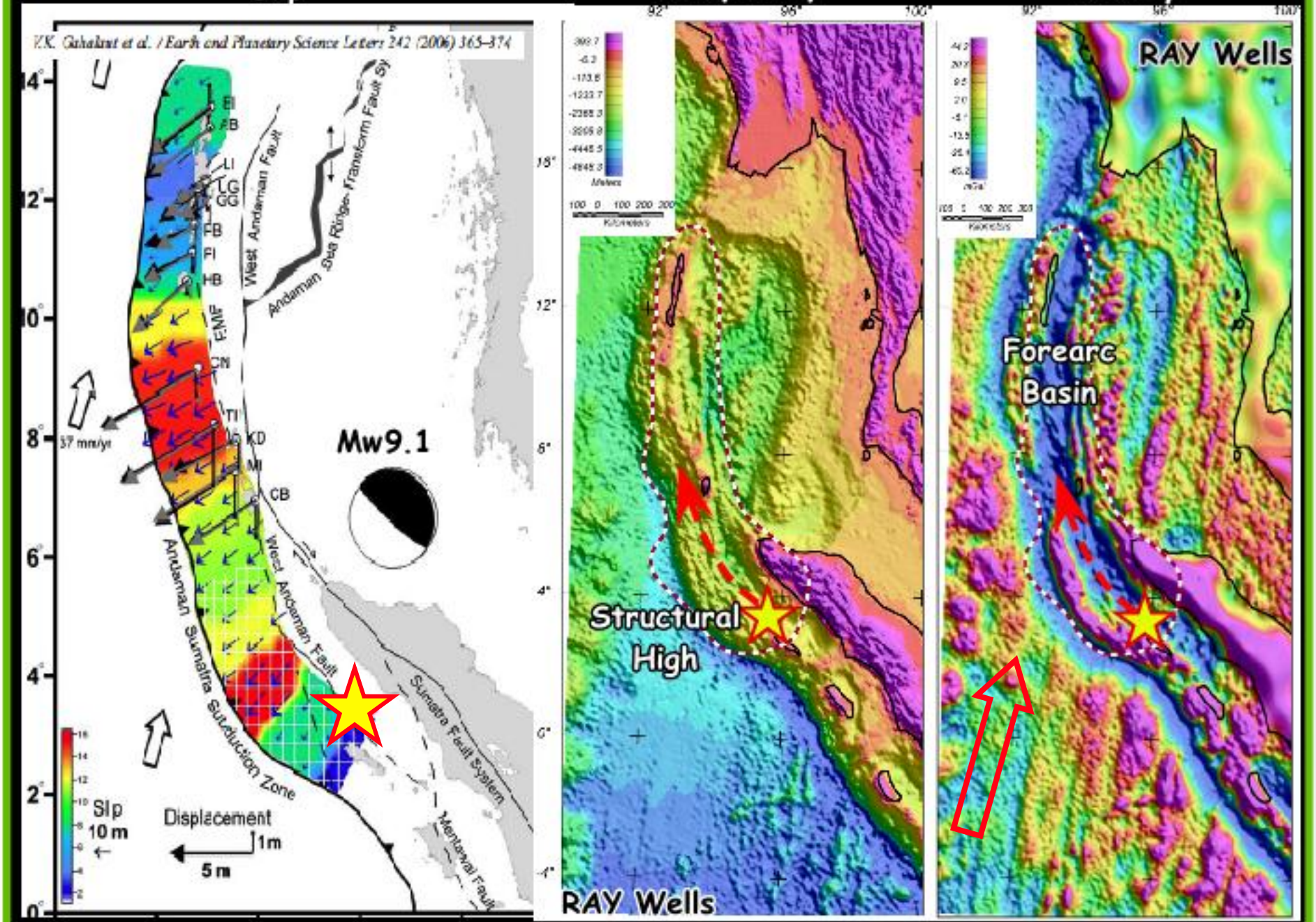
The Greater, Sediment-Flooded Sumatra Subduction Zone

Andaman, Sumatra, & Western Java



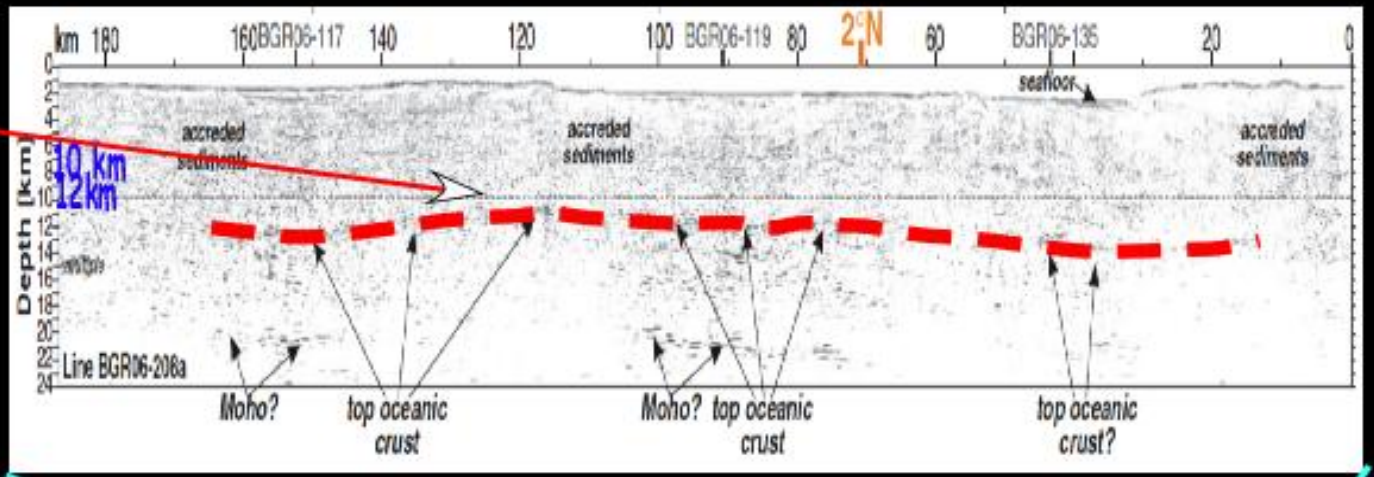

95°E
100°E
105°E
15°N
10°N
5°N
0°
5°S
90 E Ridge
Burma plate
An
Nb
AC
Sm
Ni
Bt
Ml
Sumatra
Sunda plate
Indian and Australian plates
2004 Mw9.2
2002 Mw7.3
2005 Mw8.6
2007 Mw7.9
2007 Mw8.4
2007 Mw7.9
53
59
59 mm/yr
Sunda megathrust
NER
IFZ
Wharton Ridge
Investigator Ridge

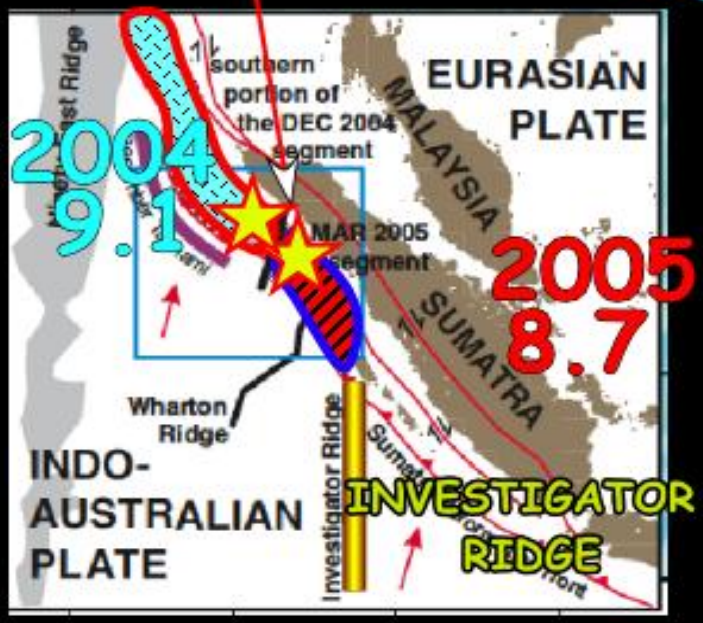

95
100
105
CHINA
BANGLADESH
MYANMAR
VIETNAM
LAOS
INDIA
THAILAND
Sunda megathrust
CAMBODIA
An
2004 (M$_w$ 9.15)
Andaman Sea
SRI LANKA
Nb
2002 (M$_w$ 7.3)
SE ASIAN PLATE
INDIAN PLATE
MALAYSIA
5
50 mm/yr
Sm
Sumatran fault
1907 (M 7.6)
Ni
SINGAPORE
0
Bt
1861 & 2005 (M$_w$ 8.6)
1935 (M$_w$ 7.7)
Mt
1797 & 1833
2000 (M$_w$ 7.9)
-5
En
Indian Ocean
NER
IFZ
57 mm/yr
Java
Investigator Ridge

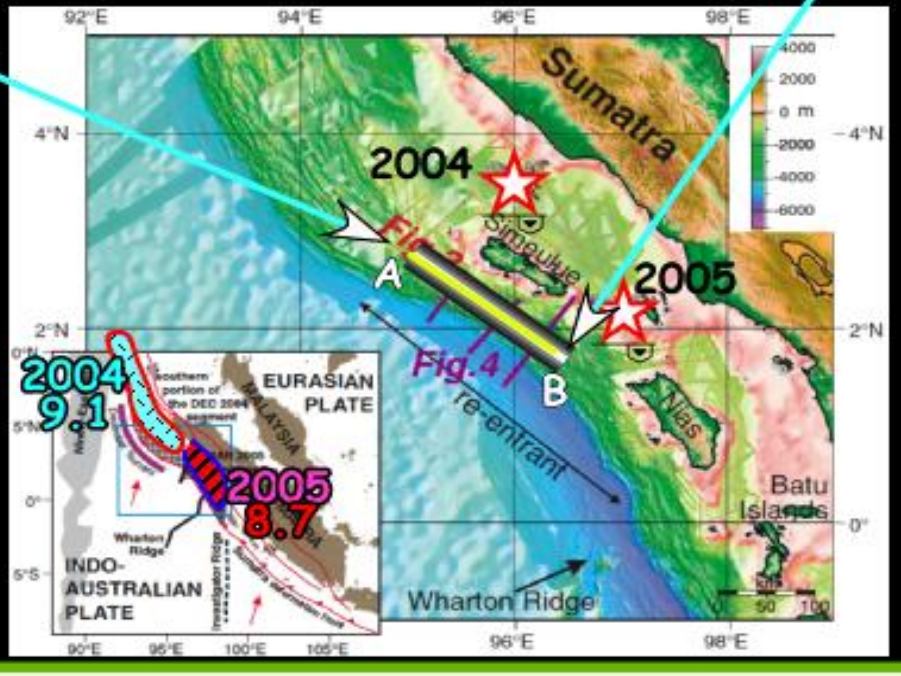

Slip
Bathymetry
Gravity
V.K. Gahalaut et al. / Earth and Planetary Science Letters 242 (2006) 365–374
Mw9.1
37 mm/yr
Andaman Sumatra Subduction Zone
West Andaman Fault
Andaman Sea Ridge- Transform Fault Sy
Sumatra Fault System
Mentawai Fault
Slip
10 m
Displacement
1m
5m
Structural
High
RAY Wells
Forearc
Basin
RAY Wells

FRANKE ET AL., 2008

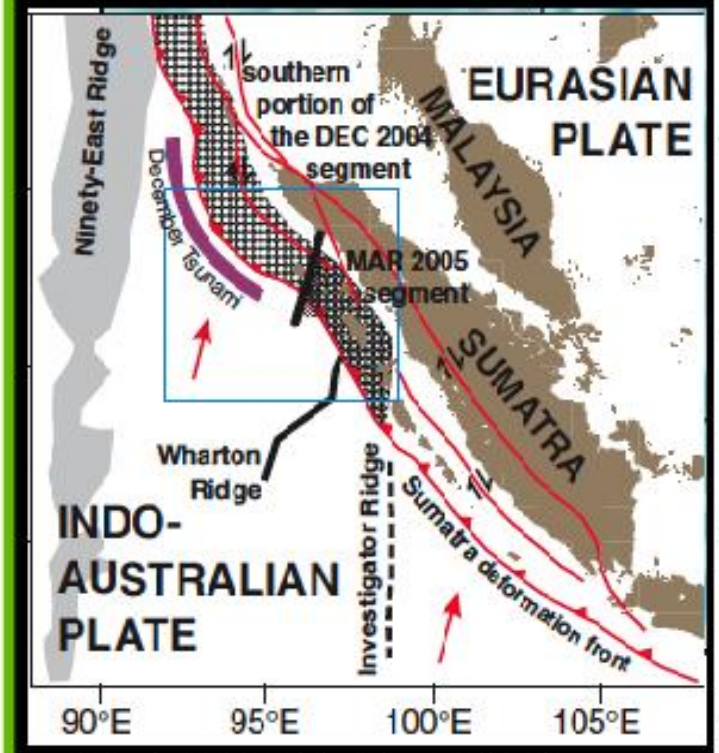
SUBDUCTING RIDGE



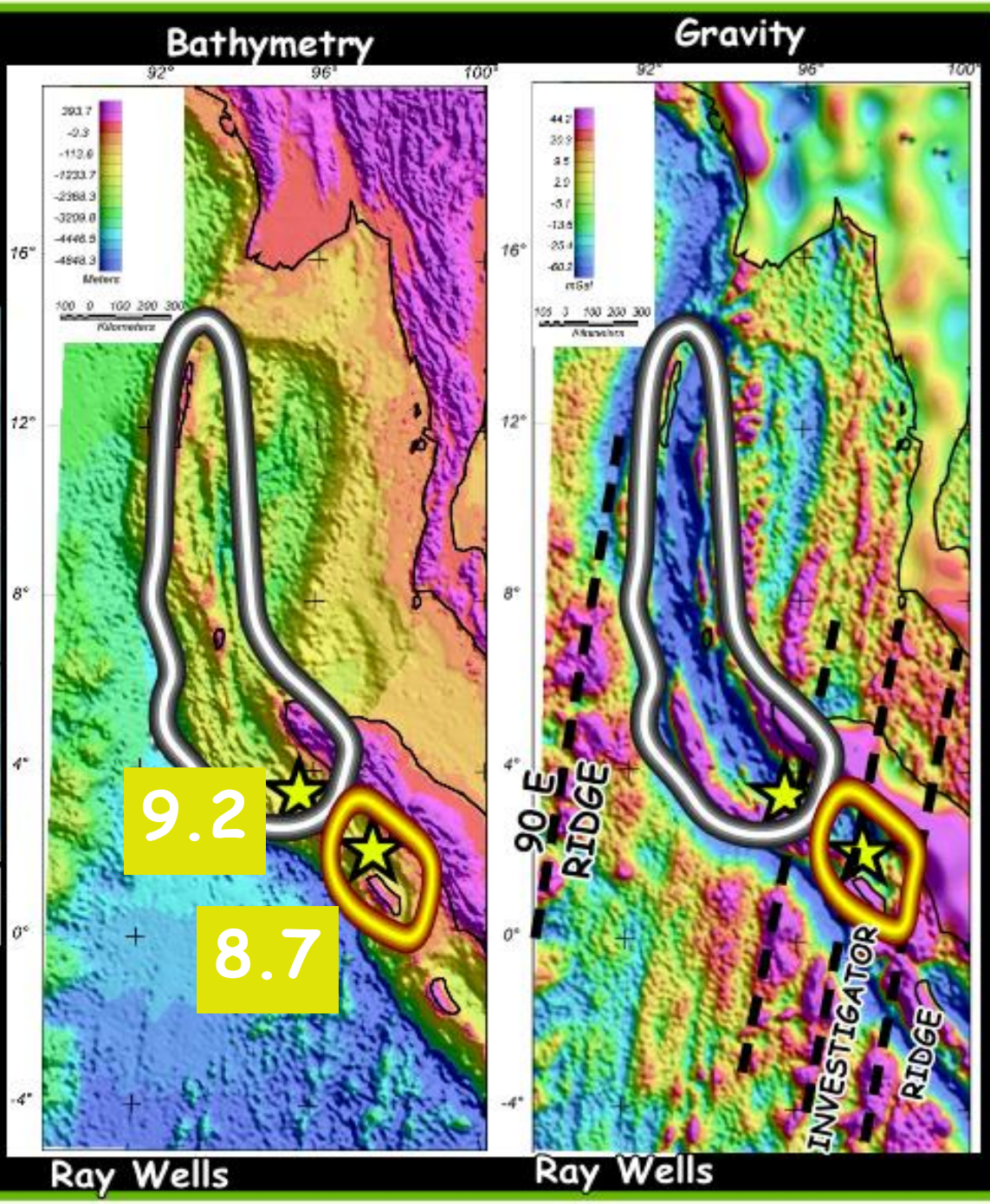




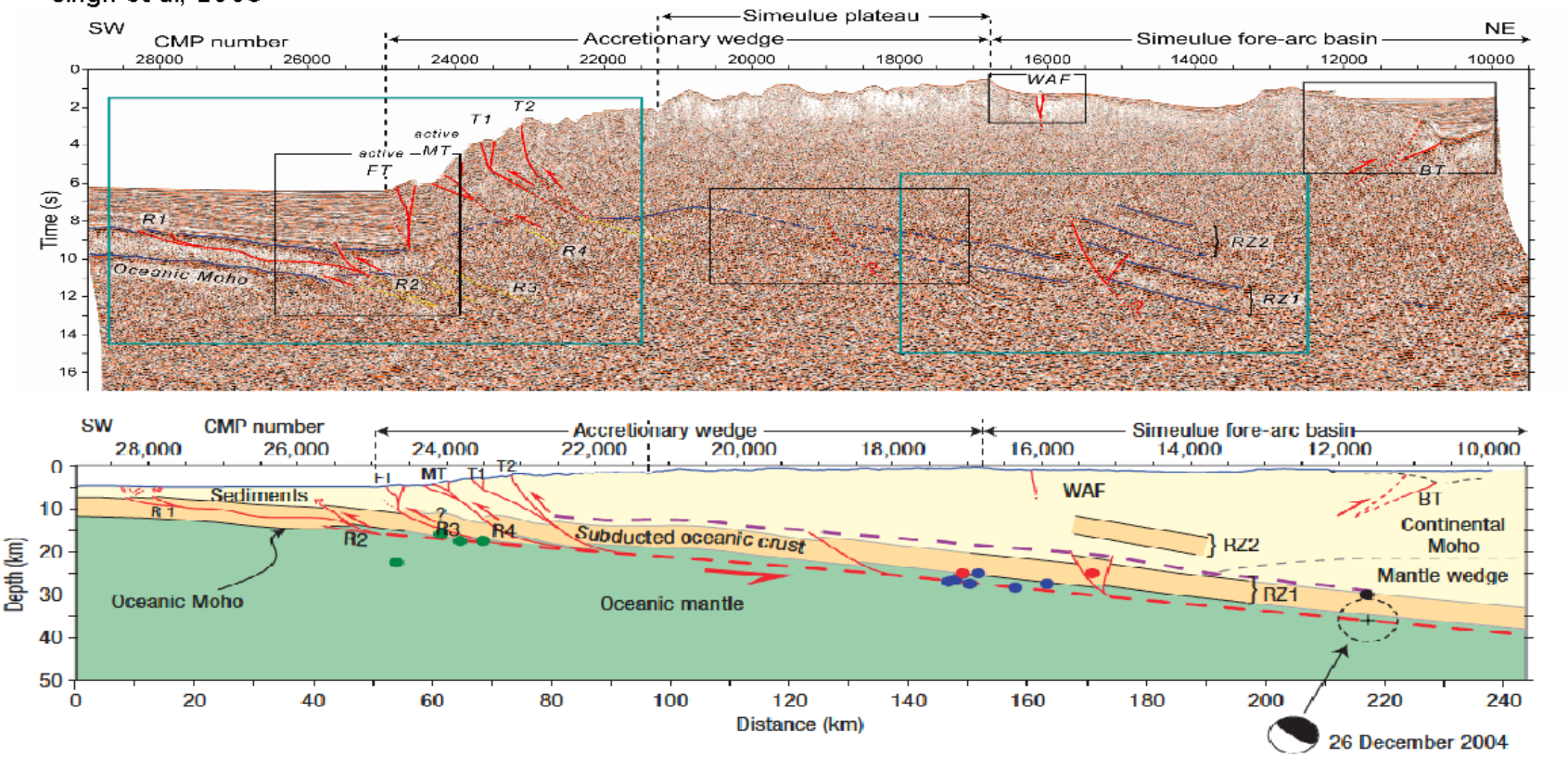
Lateral rupturing starts and ends at subducted ridges



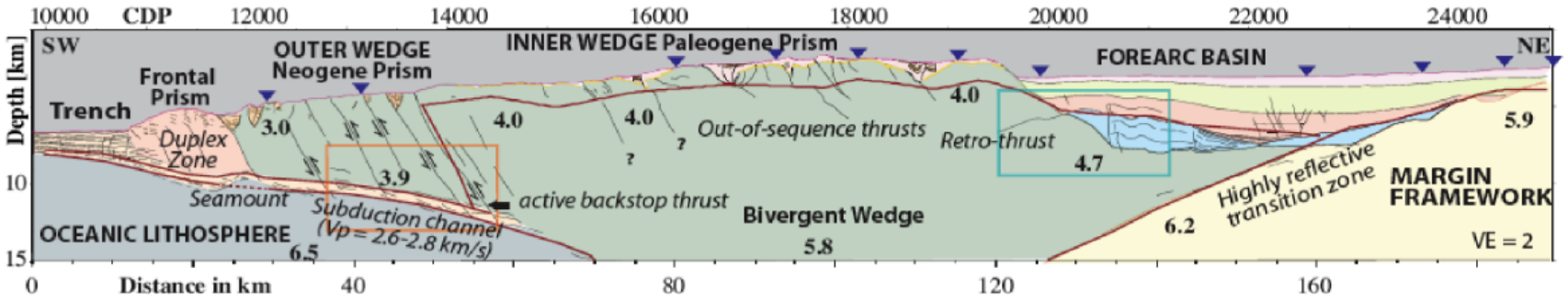
FRANKE ET AL, 2008



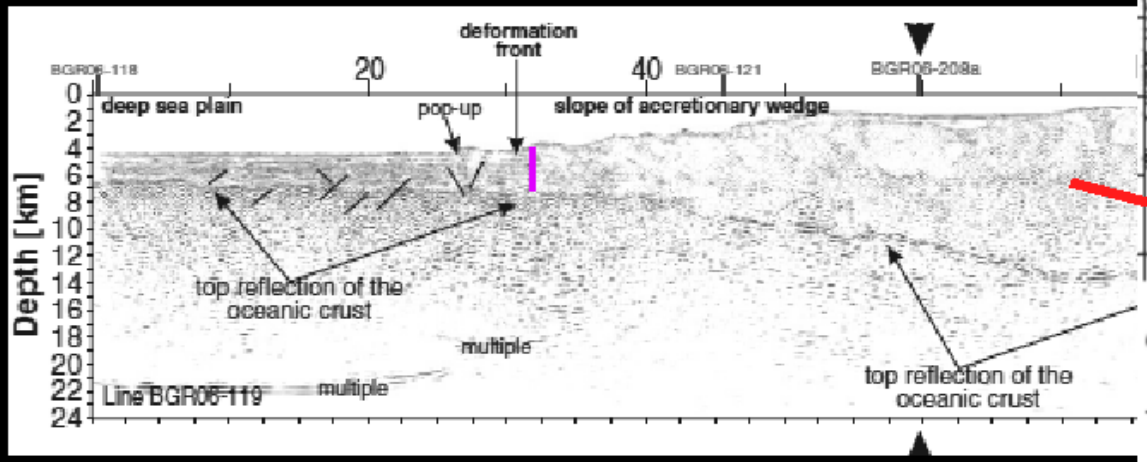
Singh et al, 2008

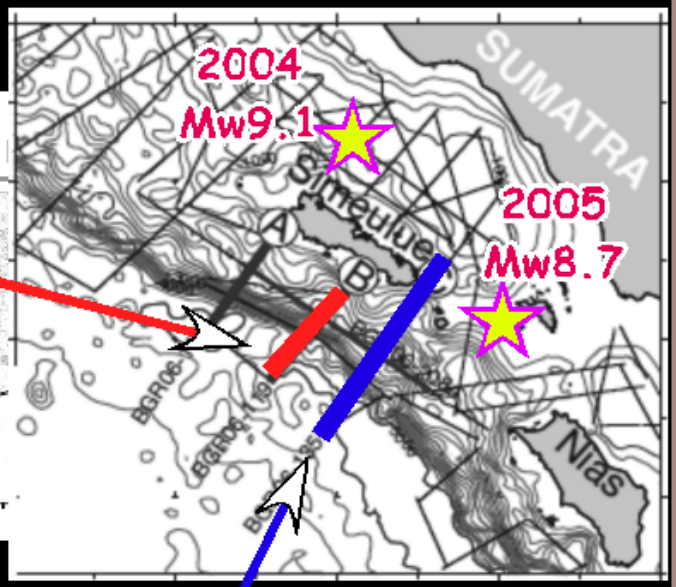


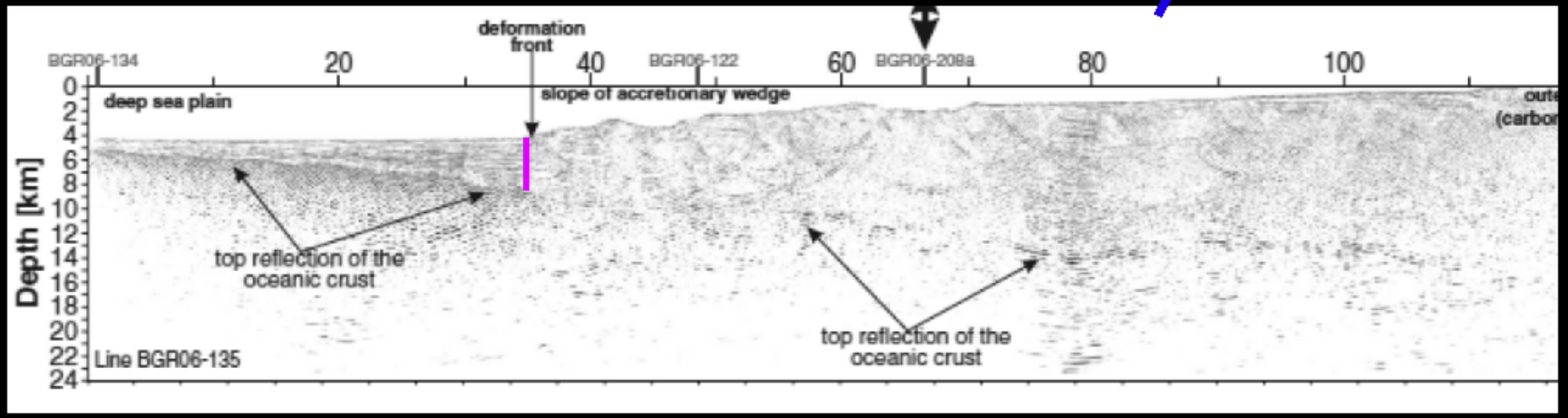
HEIDRUN KOPP ET AL.



Sediment Entering the Subduction Zone is 3-5 km Thick

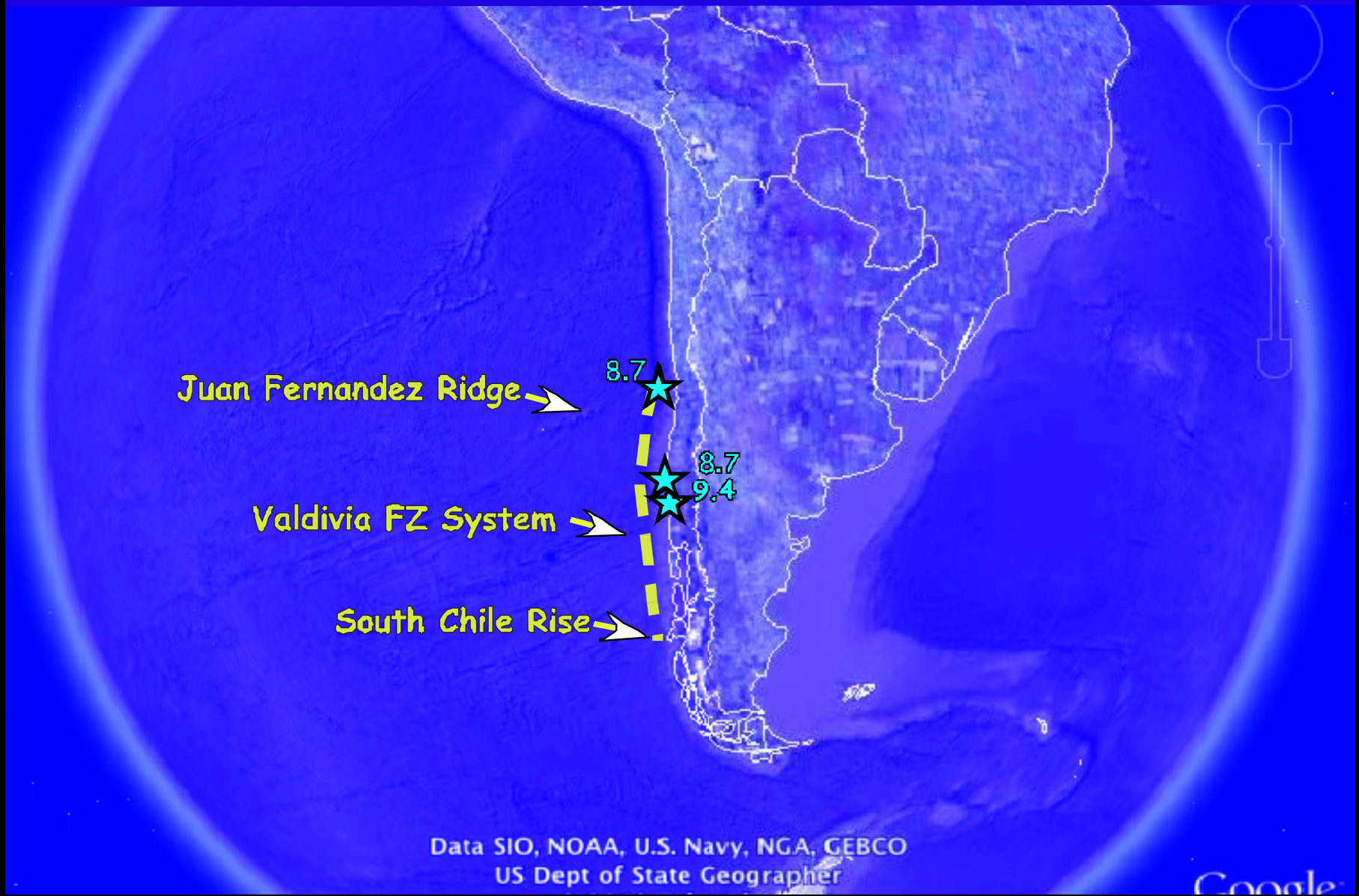


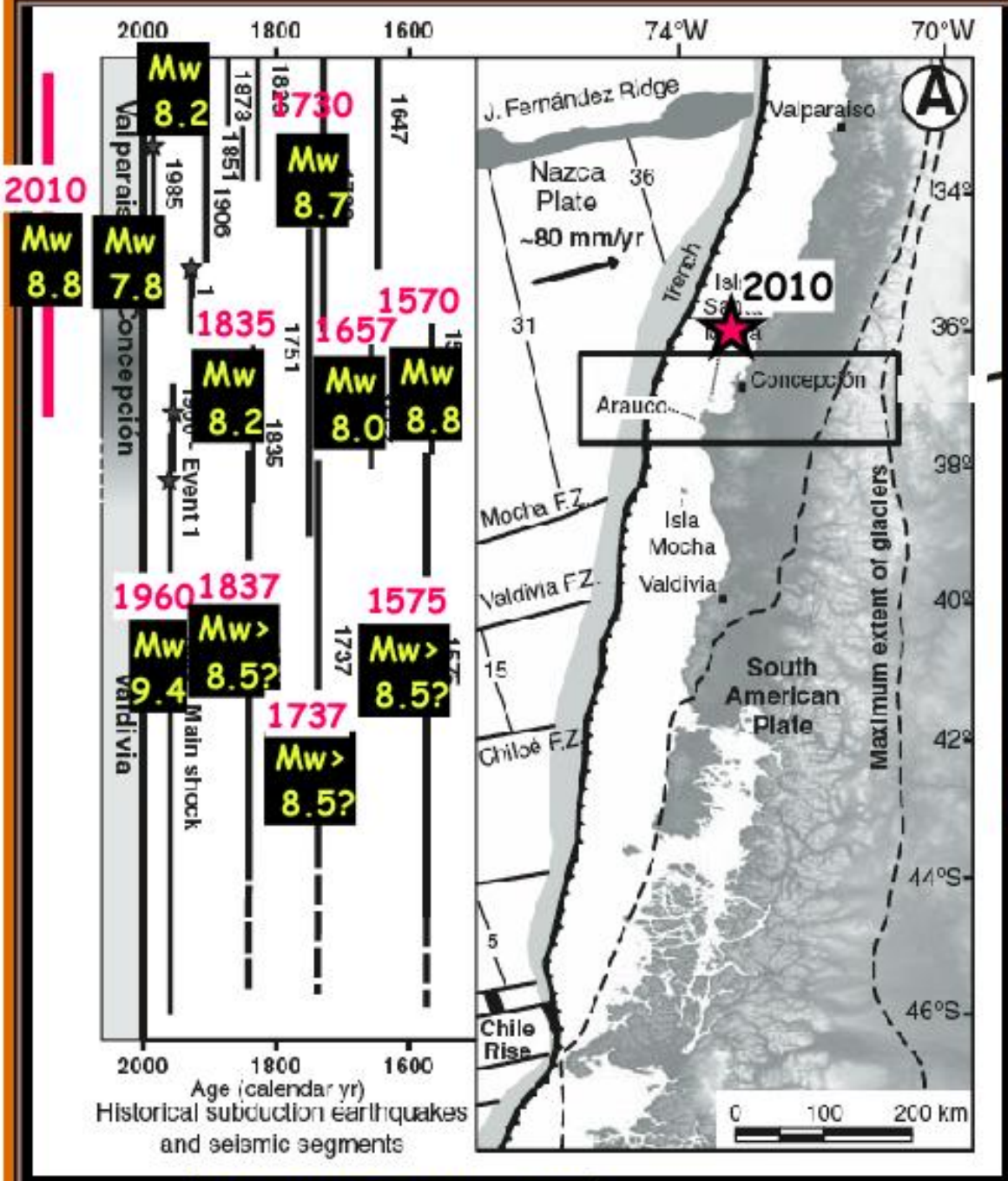


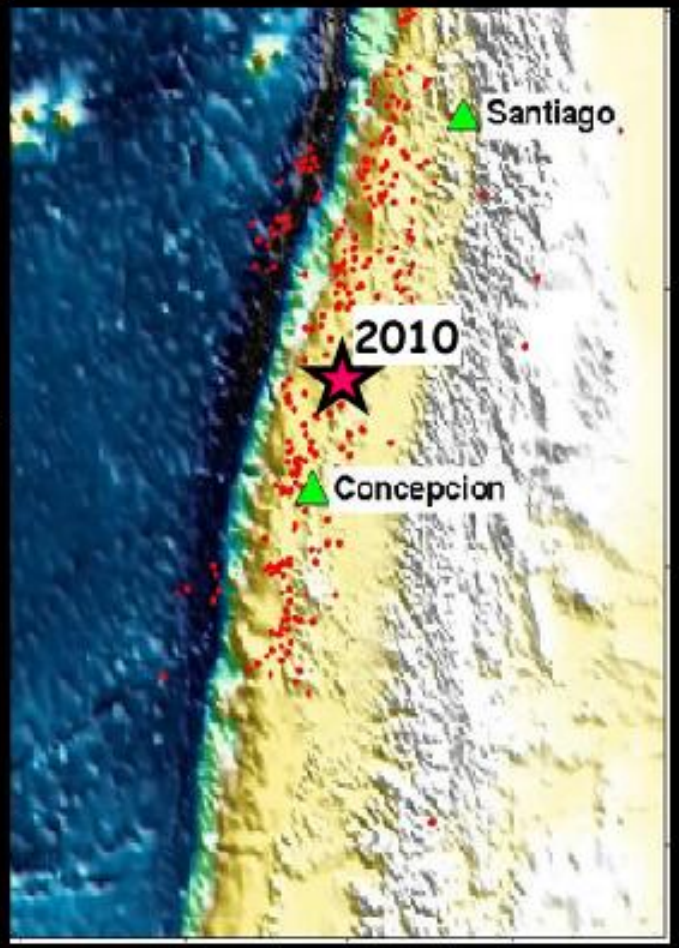


Franke et al., 2008 (EPSL)

Sediment-Flooded South-Central Chile Subduction Zone

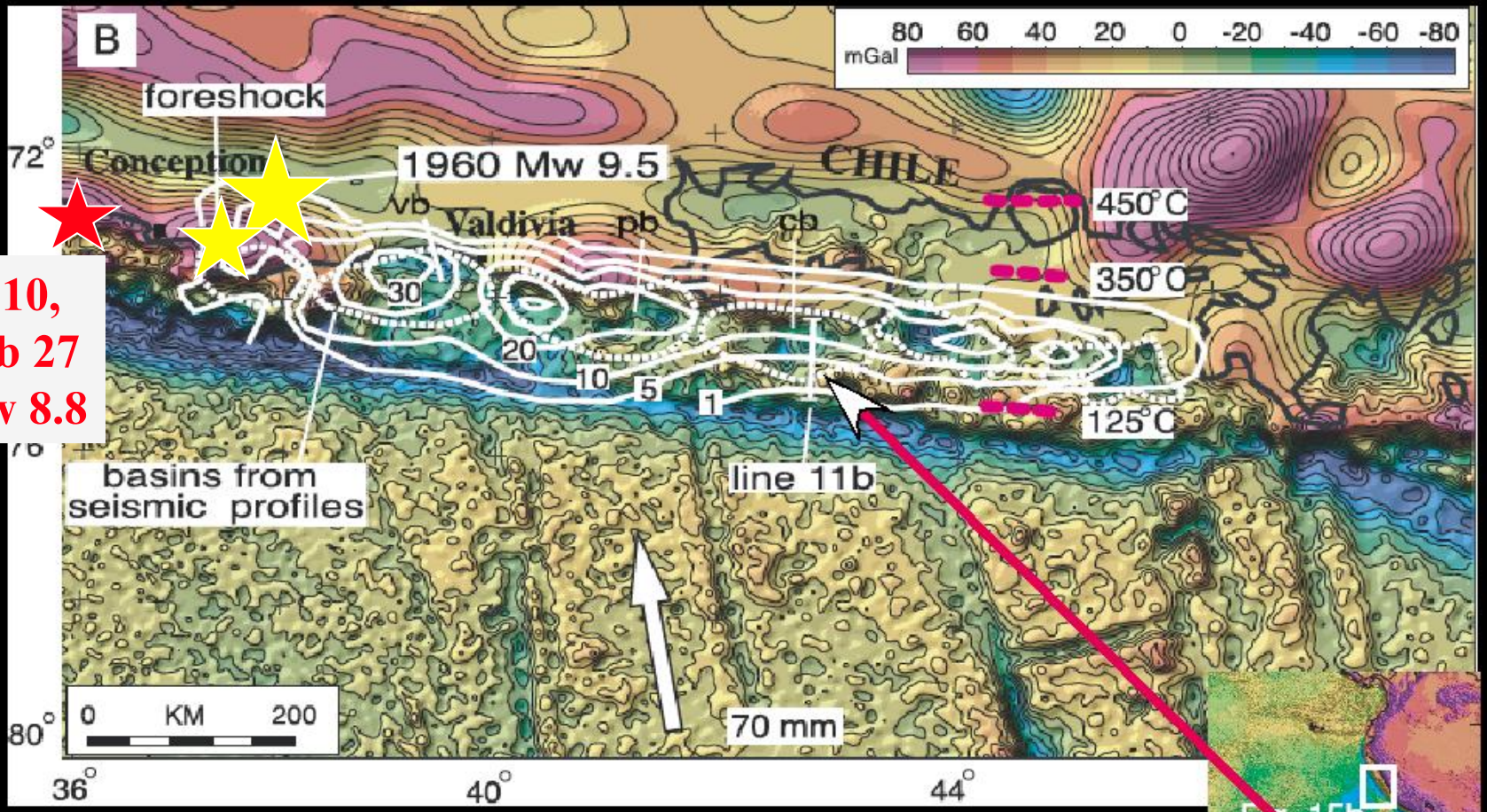






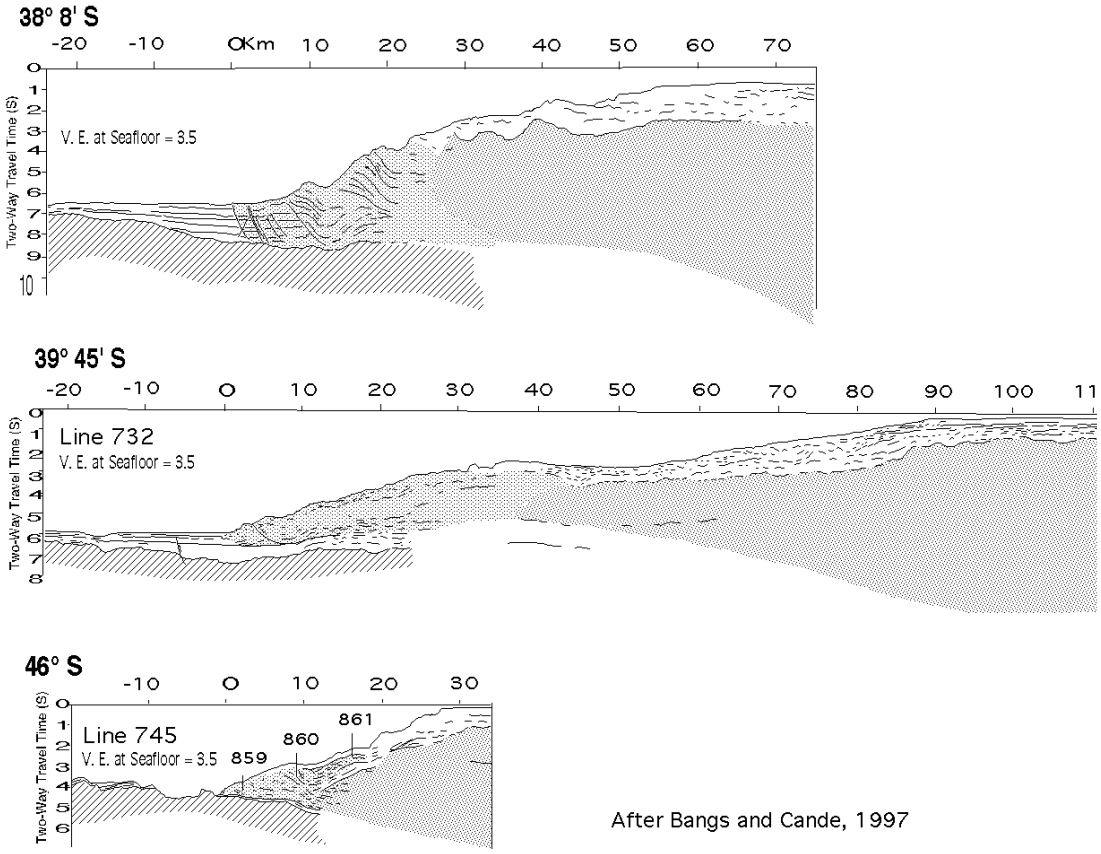
COURTESY OF GEORGE CHOI

MELNICK ET AL., 2006



2010,
Feb 27
Mw 8.8

The Largest (1960, Mw9.5, SC Chile) Instrument-Record Subduction Zone Earthquake Nucleated at the Northern Edge of a Large Forearc Basin Largely Filled with Sediment. Rupture Proceeded Southward and Maximum Interplate slip (20-30 m) Occurred Beneath the Basin Axis



After Bangs and Cande, 1997

Downloaded from gsabulletin.gsapubs.org on June 13, 2010

Scholl et al. (1970)

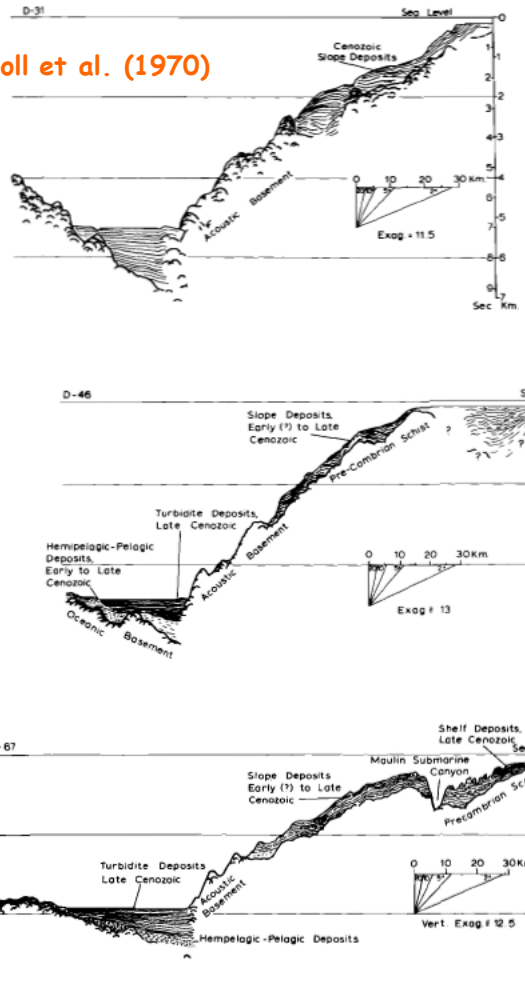


Figure 5. Line drawings, with interpretations, of acoustic reflection profiles. Locations of profiles are shown on Figure 1.

50 km

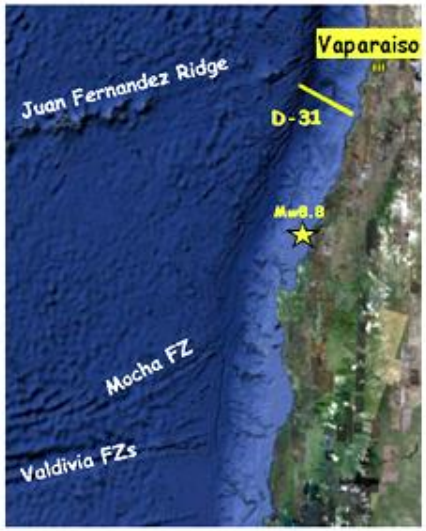
VE = ~10

3 km

4

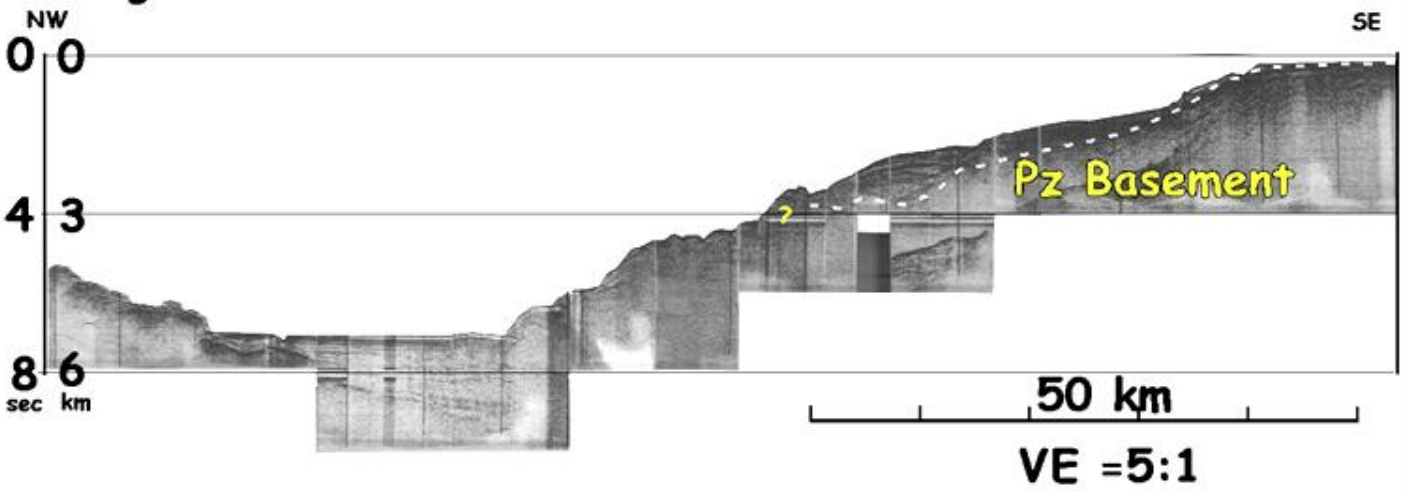
6 km water

8 sec



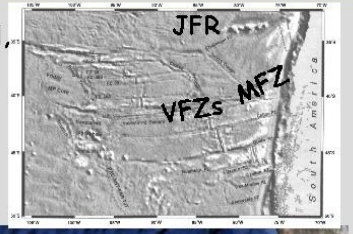
33.5 deg S

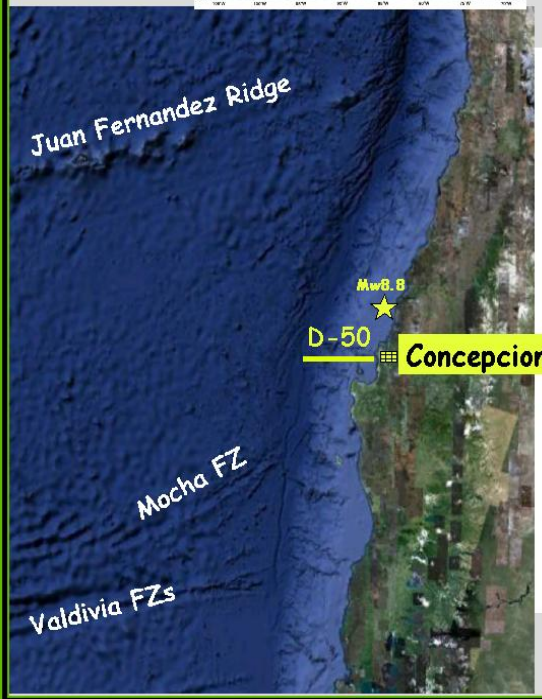
Rio Maipo



R/V Davis, Line D-31, 1967,

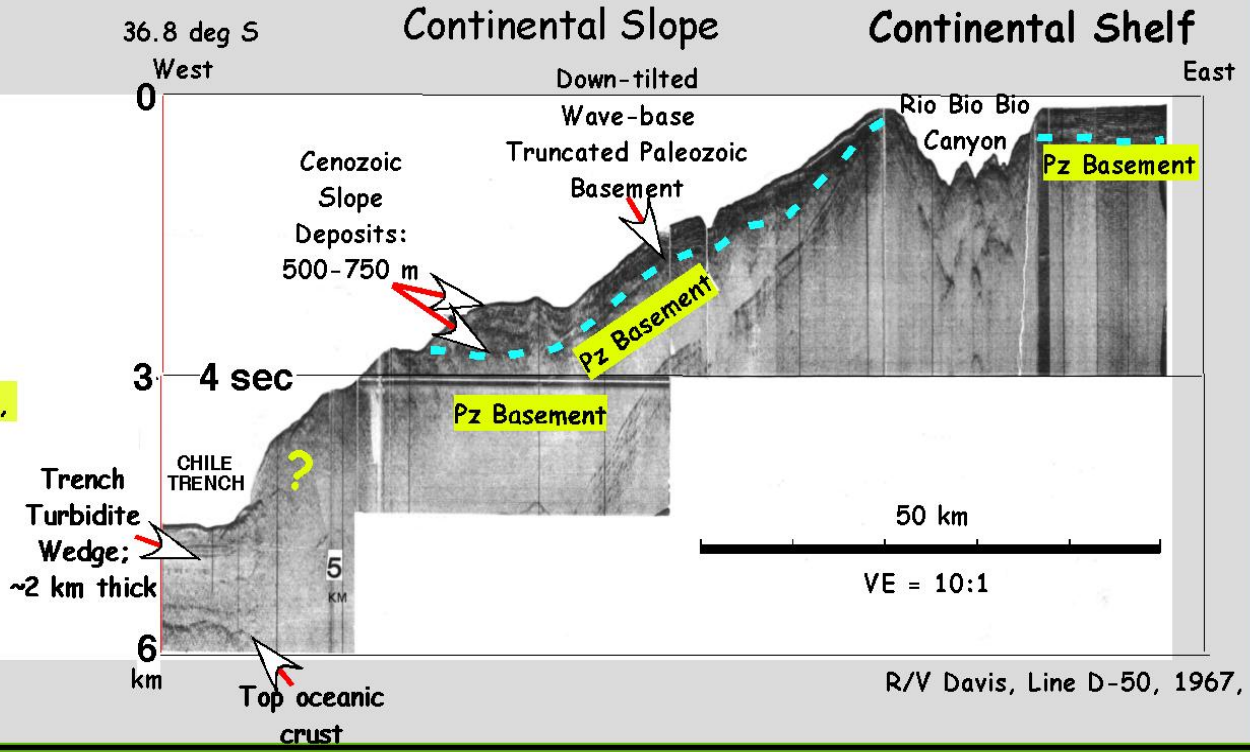
Tebbens et al, 1997 JGR





South-central Chile, Rio Bio Bio

Concepcion



Tebbens et al,
1997 JGR

Concepcion

West

36.8 deg S

Continental Slope

Continental Shelf

East

0

3

4 sec

6

km

Cenozoic
Slope
Deposits:
500-750 m

Down-tilted
Wave-base
Truncated Paleozoic
Basement

Rio Bio Bio
Canyon

Pz Basement

Pz Basement

Pz Basement

CHILE
TRENCH

?

5
KM

Trench
Turbidite
Wedge;
~2 km thick

Top oceanic crust

50 km

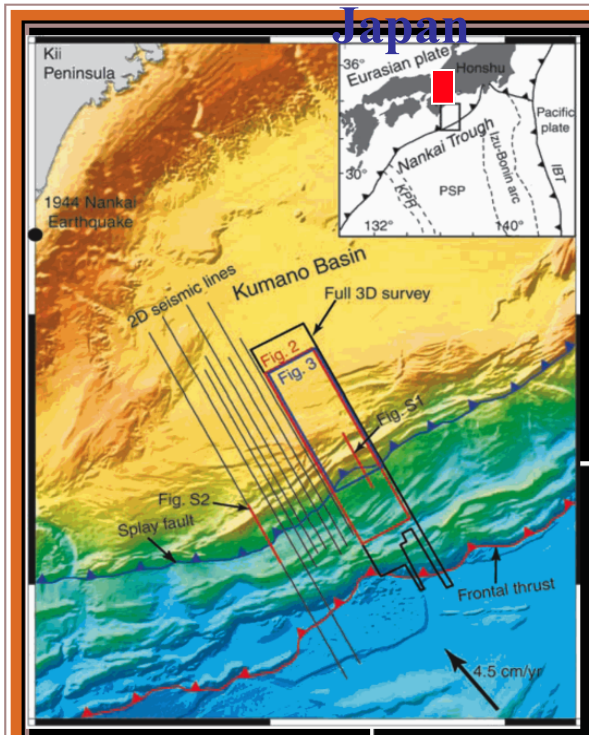
VE = 5:1

R/V Davis, Line D-50, 1967,

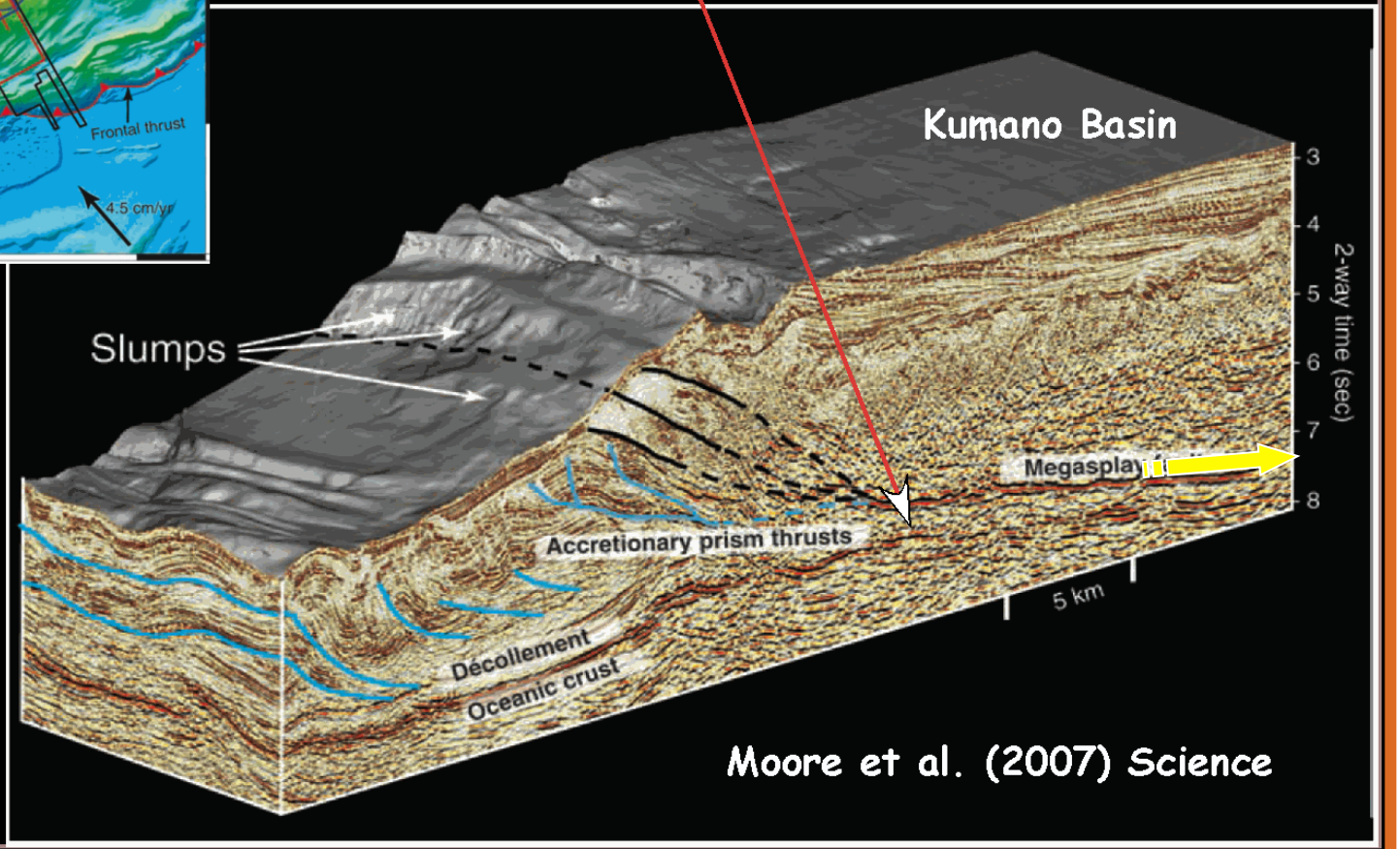
South-central Chile, Rio Bio Bio

The earthquake role of sediment in the subduction channel

Closs and Shreve, 1988a and b (Applied Geophysics, v 128)

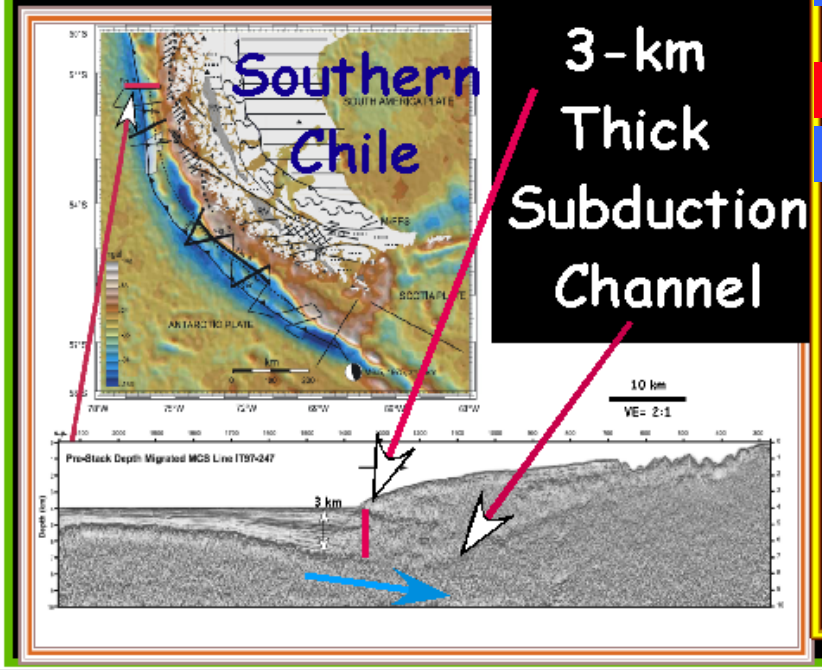


Subduction Channel



Moore et al. (2007) Science

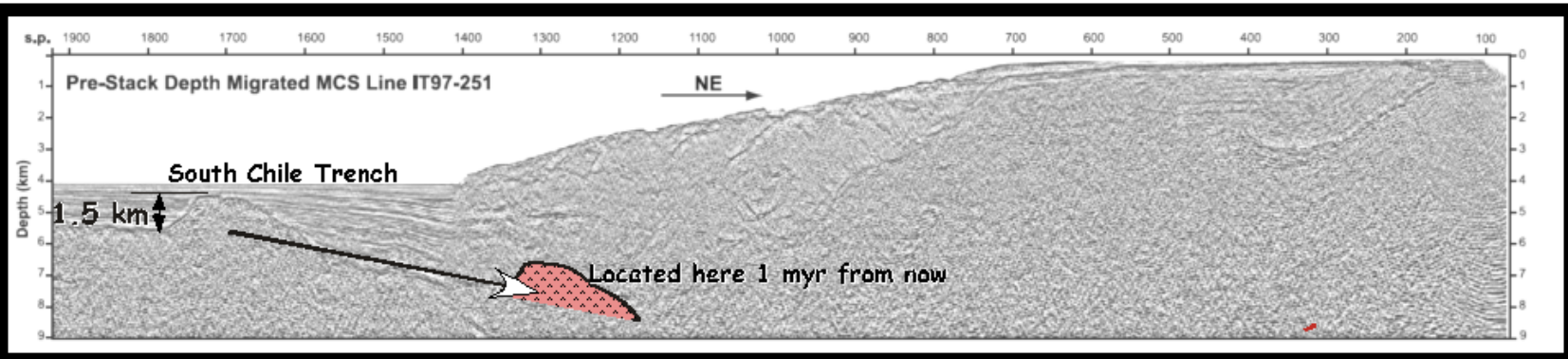
Sediment-Dominated (★) Subduction Zones That Unleashed Giant (Mw=/> 8.5) Megathrust EQs

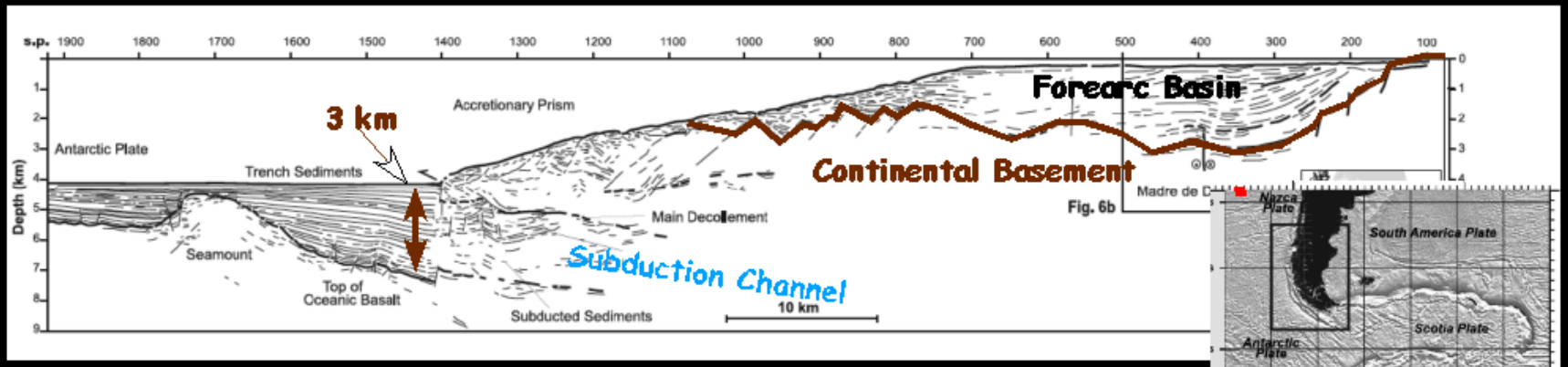


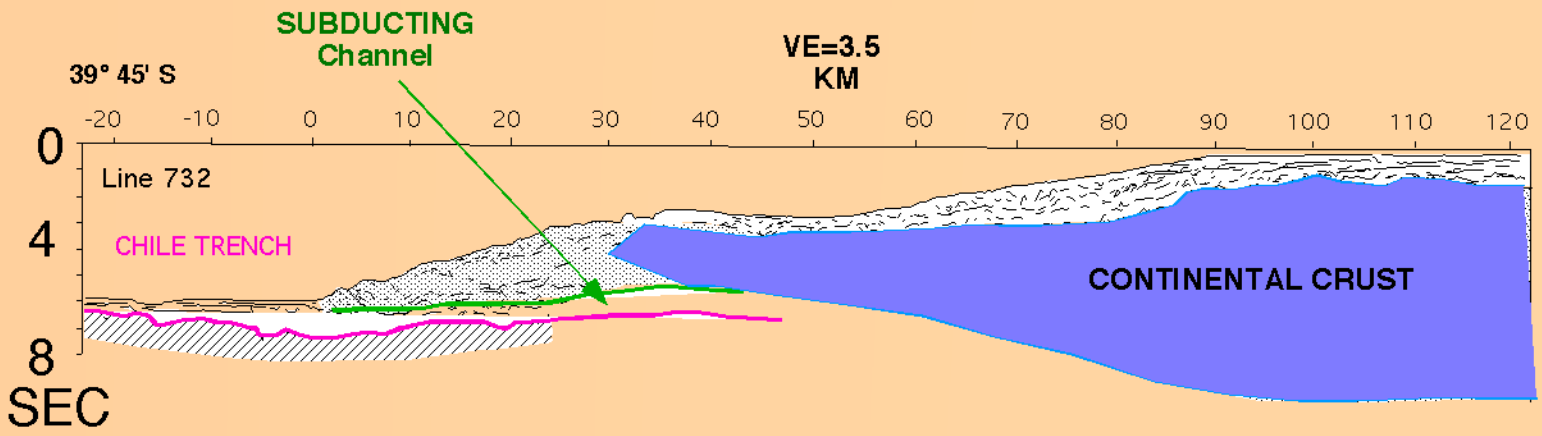
1	SOUTH CENTRAL CHILE ★	1960 05 22	9.5
2	SOUTHEAST ALASKA ★	1964 03 28	9.2
3	CENTRAL CHILE ★	1837 11 07	~9.2
4	BANDA ACEH, N. SUMATRA ★	2004 12 26	9.1
5	CASCADIA ★	Jan 1700	9.0
6	KAMCHATKA	1952 11 04	9.0
7	ARICA, NORTH CHILE	1868	~9.0
8	NORTH CHILE	1877 05 09	~9.0
9	S. C. SUMATRA ★	1883	8.8-8.9
10	COLOMBIA ★	1906 01 31	8.8
11	SOUTH CENTRAL CHILE ★	2010 02 27	8.8
12	NIAS, SUMATRA ★	2005 03 28	8.7
13	RAT IS, ALEUTIAN ★	1965 02 04	8.7
14	ANDREANOF IS, ALEUTIAN ★	1957 03 09	8.7
15	N. HONSHU (SANRIKU), JAPAN	1896 06 15	8.6
16	SW ALASKA PEN. (UNIMAK) ★	1946 04 01	8.6
17	NANKAI, SW JAPAN ★	1707 10 04	8.6
18	SOUTH KAMCHATKA	1923 02 03	8.5
19	SOUTH KURIL	1963 10 13	8.5

Thirty Years Ago Larry Ruff Conjectured that Ingestion of Sediment into the Subduction Channel Separating the Upper and Lower Plates Tectonically "Smooths" the Seismic Interface and Promotes Rupture Continuation that Spawns Giant Megathrust Earthquakes

LARRY J. RUFF, 1989, Do Trench Sediments Affect Great Earthquake Occurrence in Subduction Zones? PAGEOPH, vol. 129, Nos. I/2 (1989)

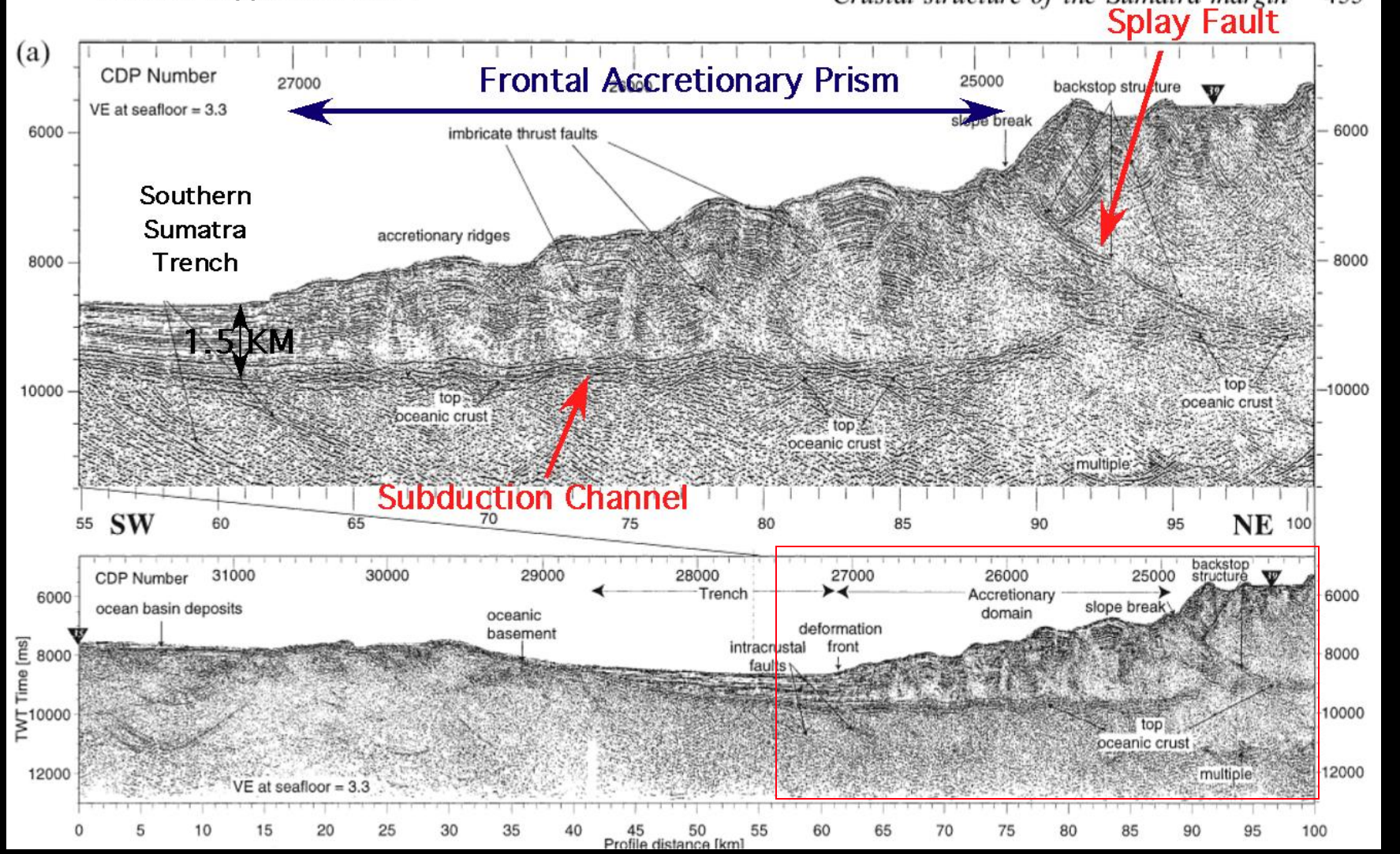


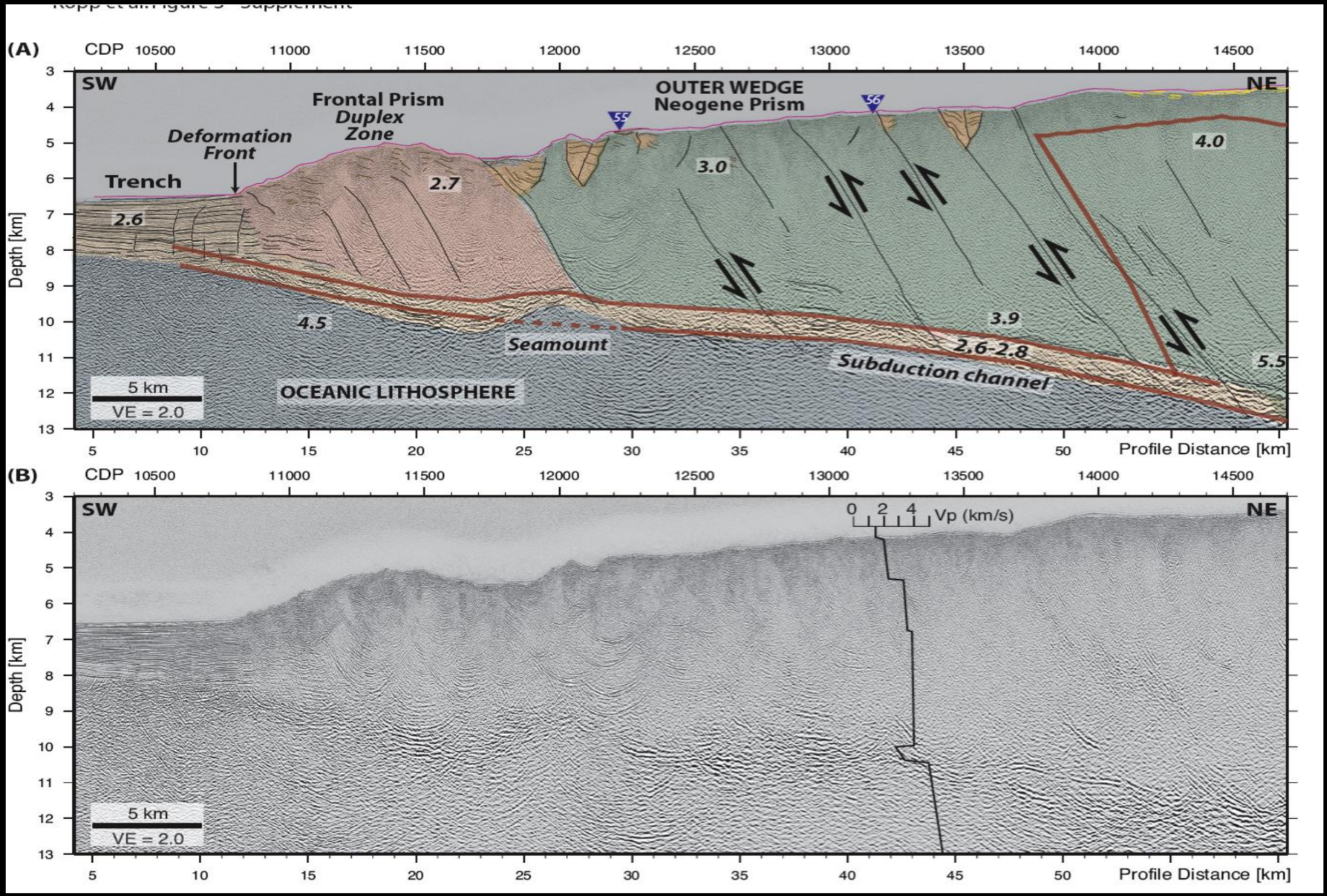




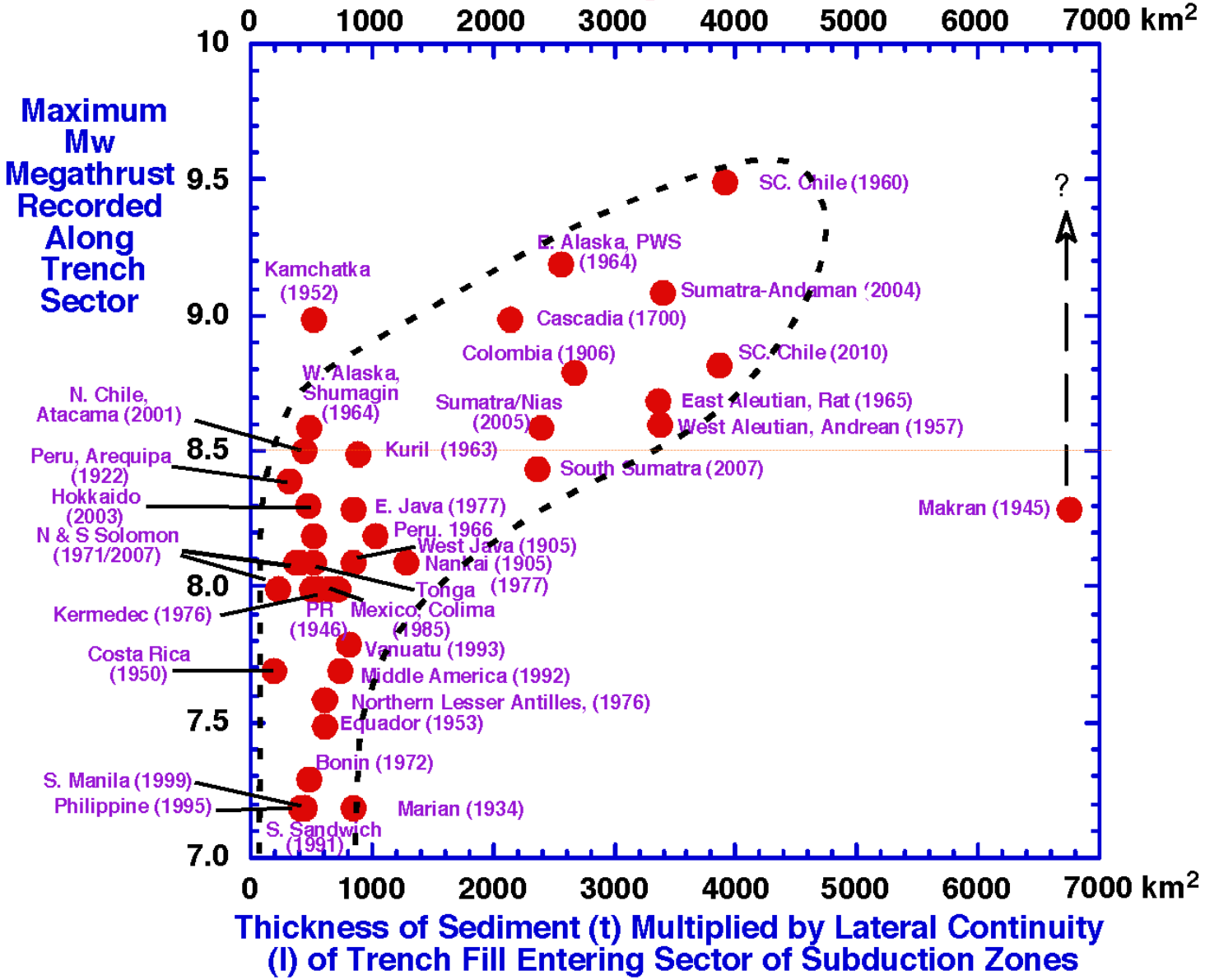
After Bangs and Cande, 1997 (TECTONICS)

Heidrun Kopp et al., 2001




(A)
CDP 10500 11000 11500 12000 12500 13000 13500 14000 14500
SW
NE
Frontal Prism
Duplex
Zone
Deformation
Front
Trench
OUTER WEDGE
Neogene Prism
55
56
2.6
2.7
3.0
4.0
4.5
3.9
Seamount
2.6-2.8
Subduction channel
5.5
OCEANIC LITHOSPHERE
5 km
VE = 2.0
Depth [km]
Profile Distance [km]
(B)
CDP 10500 11000 11500 12000 12500 13000 13500 14000 14500
SW
NE
0 2 4 Vp (km/s)
5 km
VE = 2.0
Depth [km]
Profile Distance [km]

Maximum Subduction Zone EQ Magnitude vs Sediment Entering Subduction Channel



The Evolution of the Rock Fabric of a Convergent Marginis Not Obviously Linked to the Habitats of Great and Giant Megathrust Earthquakes. But the Structure of the Submerged Forearc (i.e., Forearc Basins and Splay Fault Systems) Is.

A Subduction Channel Thickly Charged (> 1-1.5 km) with Subducted Sediment is Strongly Associated with Sectors of Subduction Zones that Repeatedly Rupture in Great and Giant Megathrust Earthquakes