From Indonesia to Myanmar: A Review of Seismic Images across the Indo-Australian/Sunda Plate Margin: The Anatomy of a Subduction Zone in Space & Time*

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Abstract

From published and unpublished sources, eleven seismic images have been compiled across the Indo-Australian/Sunda Plate margin from Sumatra, where a subduction margin is generally recognized, through the Andaman Islands (India), to Myanmar where the nature of margin is subject to debate. Integrating the seismic images, earthquake data, GPS velocities, volcanic K-Ar ages with available models and worldwide analogues gives the following insights into the Indo-Australian/Sunda plate margin in space and time.

Present day:

- Plate margin shows transition(s) from subduction to transform from south to north
- Central Andaman Basin is a trench-linked strike-slip fault pull-apart basin
- Recent volcanism seen at Barren Is, Narcondam Is and in Central Myanmar could perhaps be transform margin/slab tear related.

In the Past:

- Plate margin was wholly subduction to +/- 25Ma (?)
- Subduction may have ceased in North Andaman-Irrawaddy region +/- 25Ma and in North Myanmar +/- 13.5Ma
- Alcock and Sewell Rises may represent Early Miocene episode of trench-linked strike-slip fault pull-apart sea floor spreading (Curray, 2005)

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Thanks to:

PGS
A Clearer Image

Spectrum

TOTAL

DGH
DIRECTORATE GENERAL OF HYDROCARBONS
(Ministry of Petroleum & Natural Gas, Government of India)

For allowing me to show unpublished seismic images.

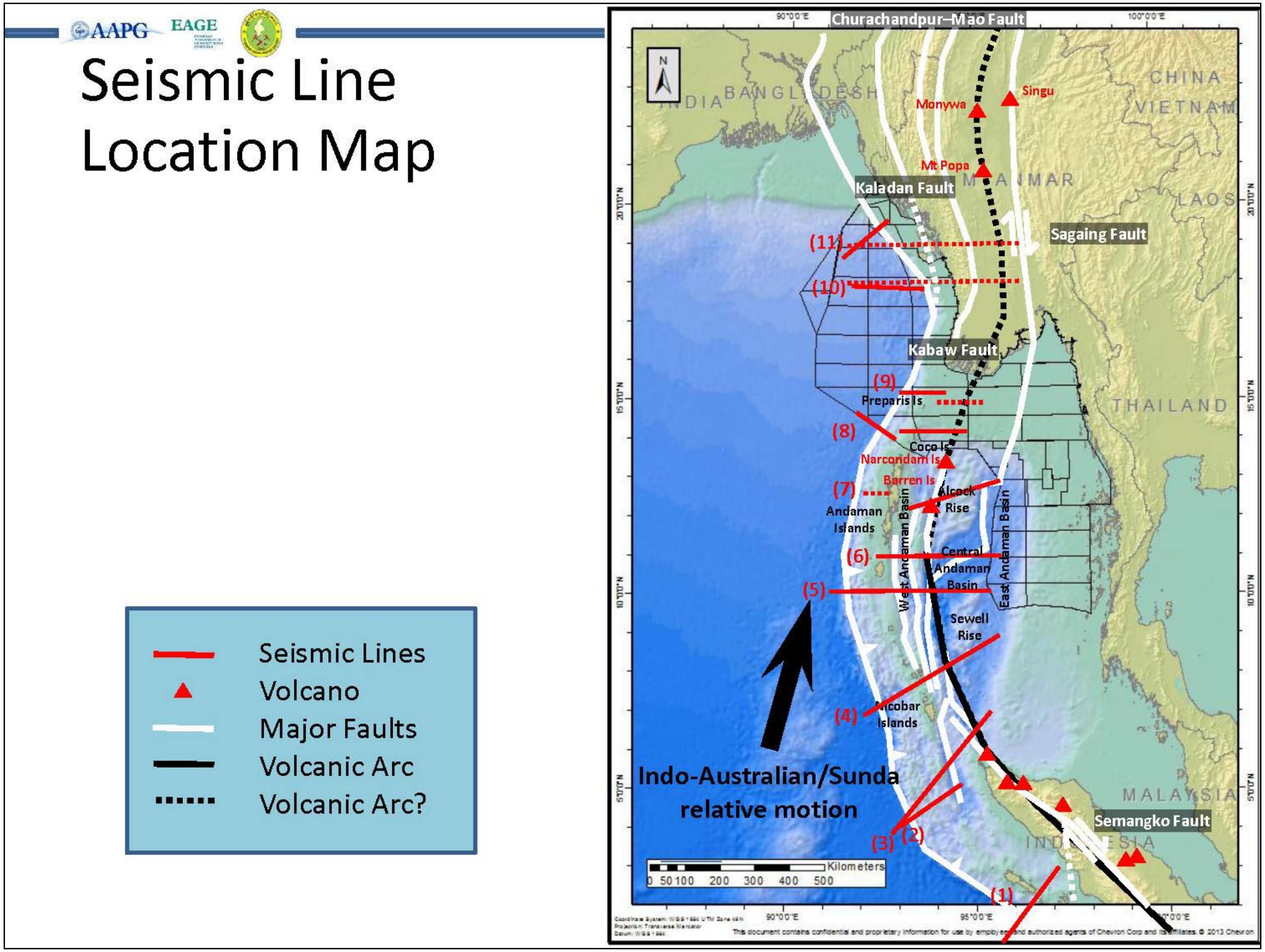
Acknowledgement to:

Chevron

Where I started my literature search.

From Indonesia to Myanmar: A Review of Seismic Images Across the Indo-Australian/Sunda Plate Margin: The Anatomy of a Subduction Zone in Space & Time

- Observations:
  - Seismic lines (x11)
  - Earthquakes & GPS velocities
  - Faults & spreading
  - Volcanic rock K-Ar ages
- Models & Global Analogues
- Integration & Insights



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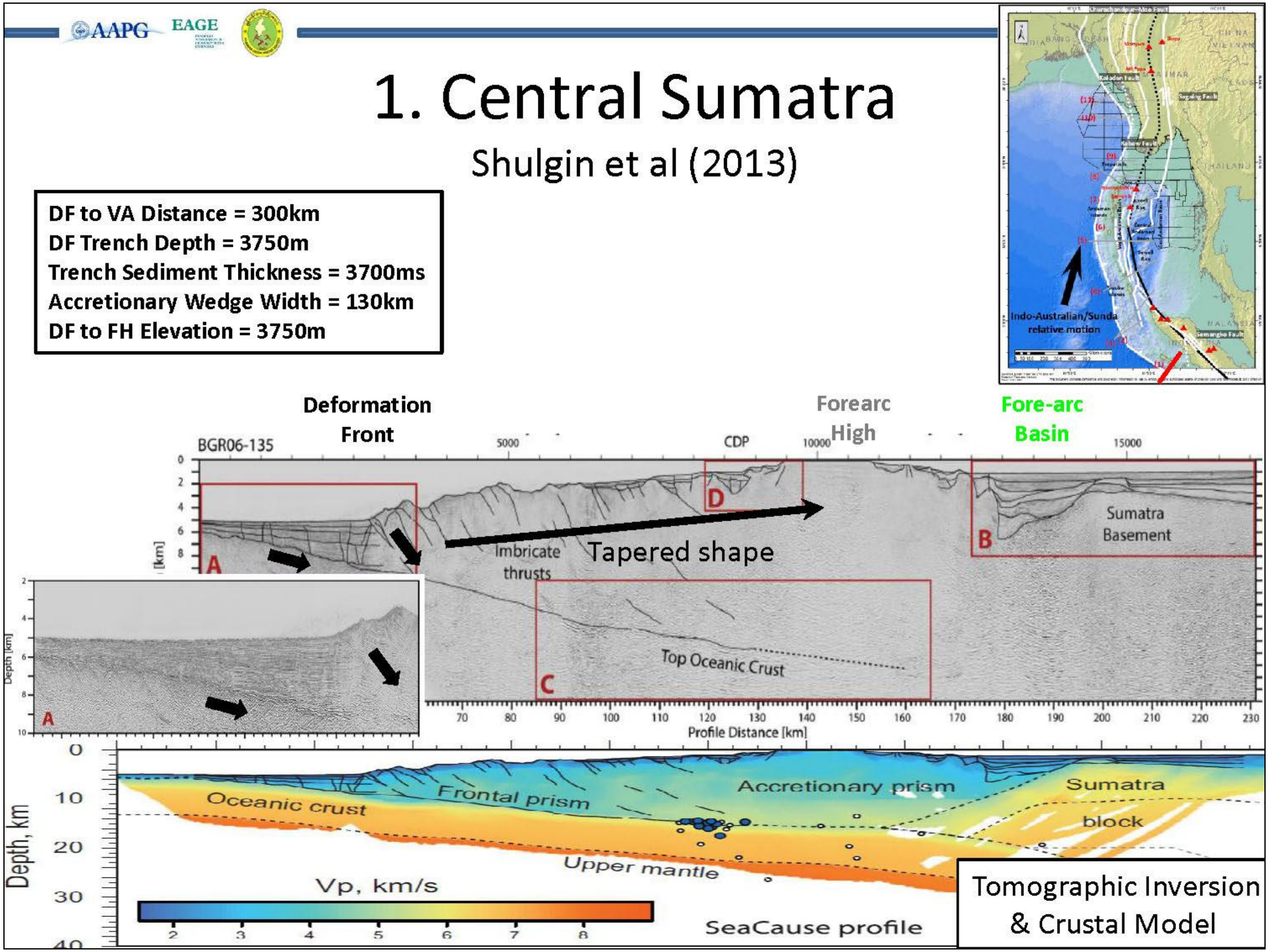
Seismic Line Location Map

▬ Seismic Lines
▲ Volcano
▬ Major Faults
▬ Volcanic Arc
▪▪▪▪▪▪ Volcanic Arc?

Seismic line location map with volcanoes, major faults (including deformation front) and volcanic arc annotated. Of particular note are the Sagaing and Semangko dextral strike slip faults that appear to be connected via Central Andaman Basin that it is thought has seen sea floor spreading since the Pliocene oblique to the deformation front. The black arrow shows the Indo-Australian/Sunda plate relative motion.

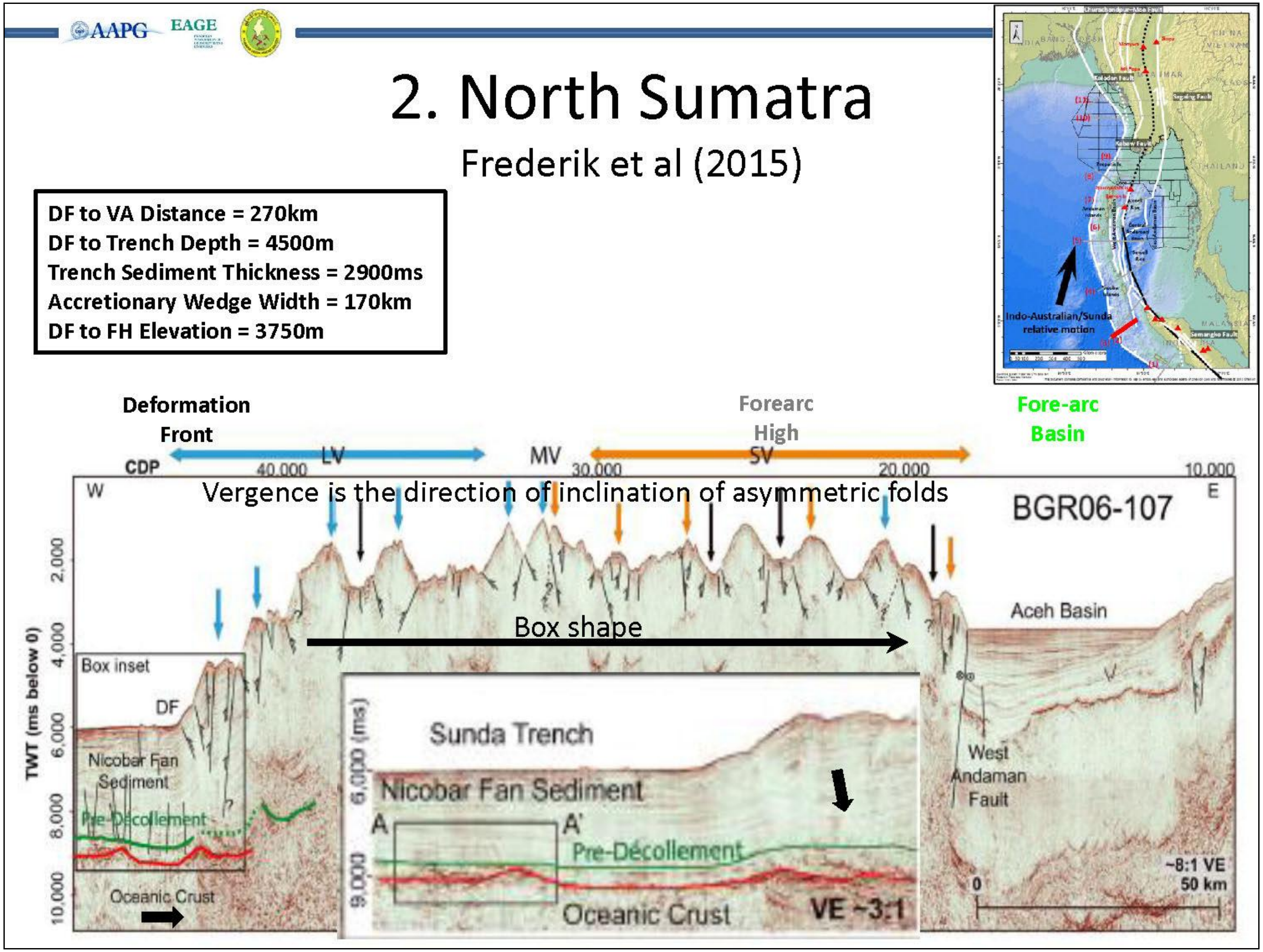


1. Central Sumatra

Shulgin et al (2013)

DF to VA Distance = 300km
DF Trench Depth = 3750m
Trench Sediment Thickness = 3700ms
Accretionary Wedge Width = 130km
DF to FH Elevation = 3750m

Introduces qualitative features (tectonic features, arrows) and quantitative parameters (tectonic features and box). Subduction margin with top oceanic crust weakly imaged on seismic.



2. North Sumatra

Frederik et al (2015)

DF to VA Distance = 270km
DF to Trench Depth = 4500m
Trench Sediment Thickness = 2900ms
Accretionary Wedge Width = 170km
DF to FH Elevation = 3750m

Vergence is the direction of inclination of asymmetric folds

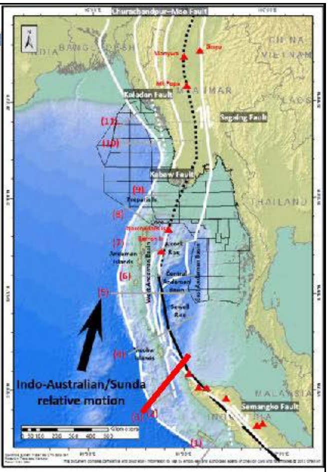
Box shape

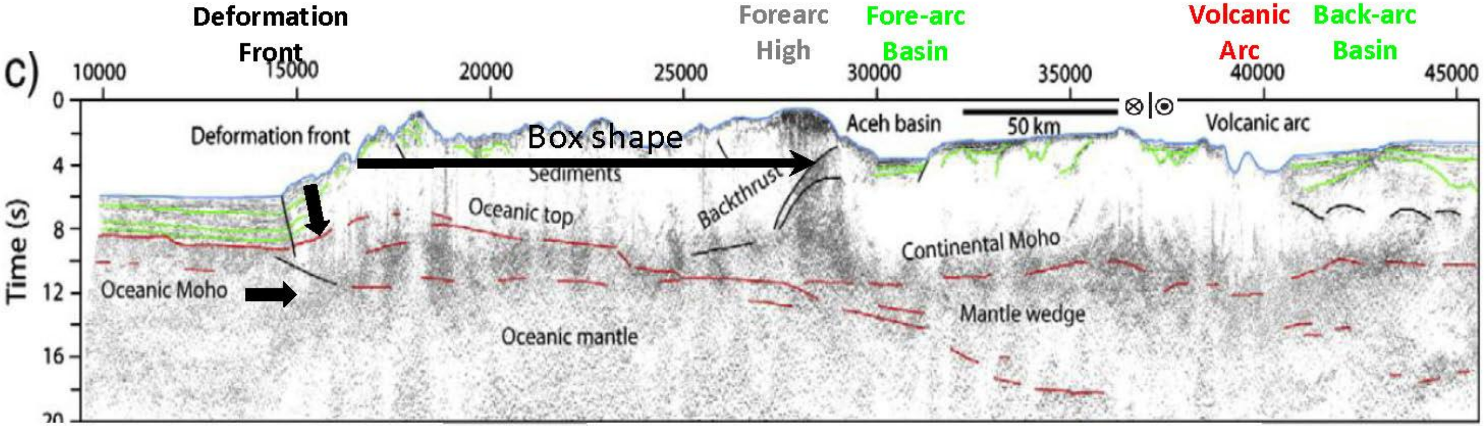
Introduces observation of landward vergence (LV) and seaward vergence (SV). Subduction margin with top oceanic crust weakly imaged on seismic.

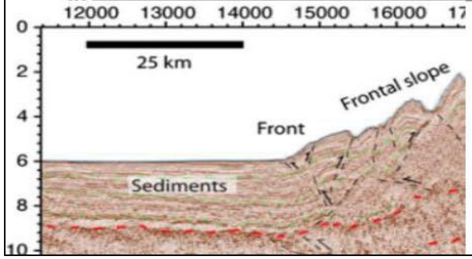
3. Nicobar – N Sumatra

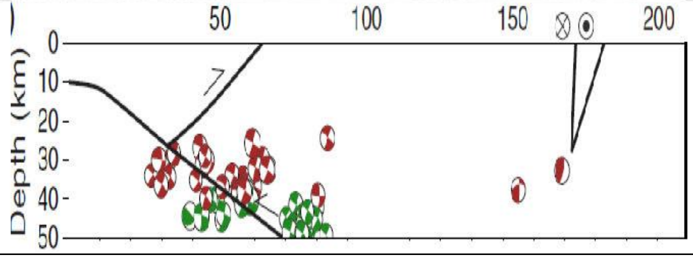
Singh et al (2012)

DF to VA Distance = 280km (corrected to orthogonal from 310km)
DF Trench Depth = 4500m
Trench Sediment Thickness = 3100ms
Accretionary Wedge Width = 190km
DF to FH Elevation = 4125m





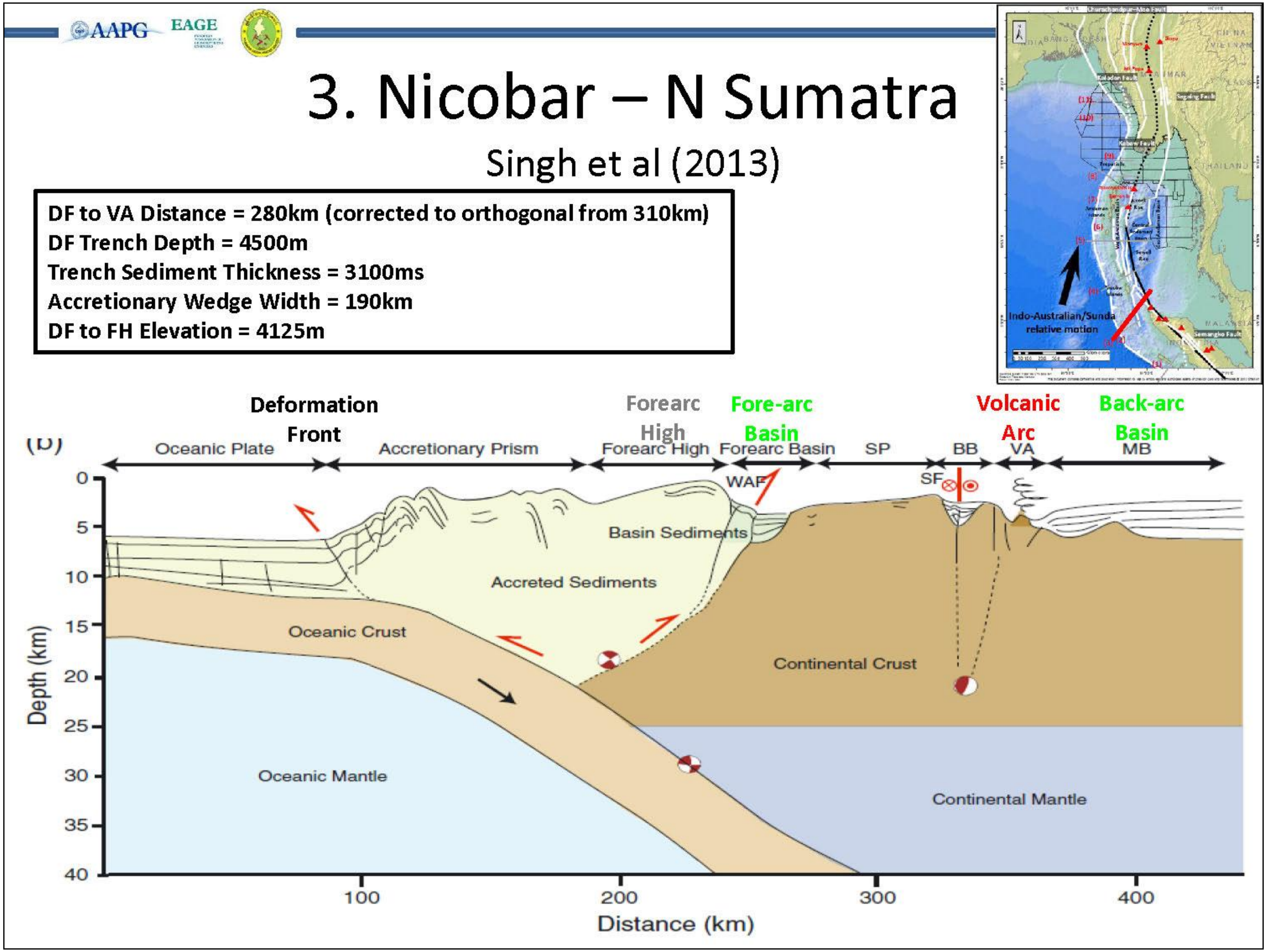




Earthquake Hypocentres

Singh et al (2013)

Subduction margin with top oceanic crust weakly imaged on seismic but supported by earthquake hypocentres.

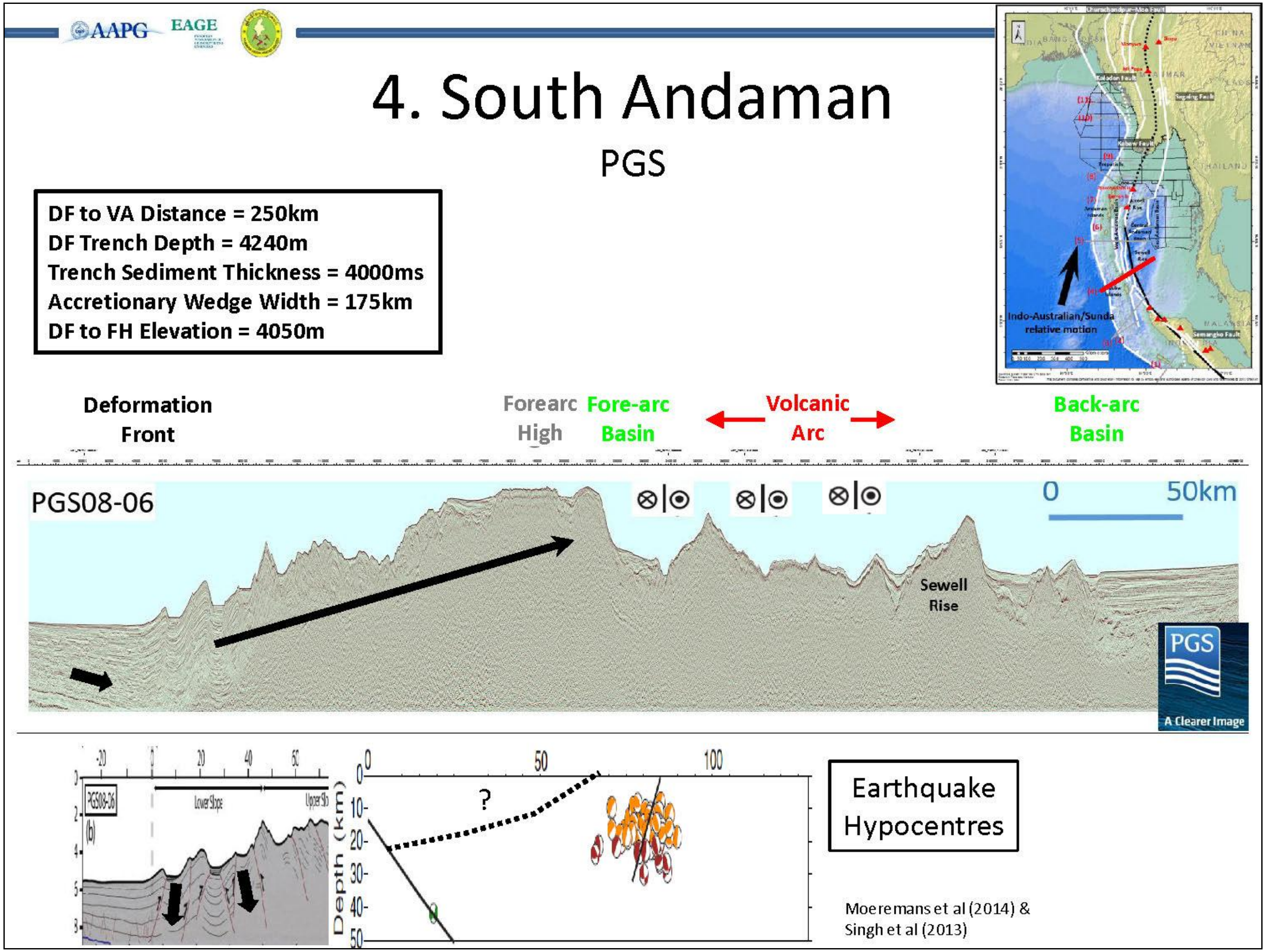


3. Nicobar – N Sumatra

Singh et al (2013)

DF to VA Distance = 280km (corrected to orthogonal from 310km)
DF Trench Depth = 4500m
Trench Sediment Thickness = 3100ms
Accretionary Wedge Width = 190km
DF to FH Elevation = 4125m

Singh et al, 2013, line three model illustrates the subduction margin interpretation.



4. South Andaman

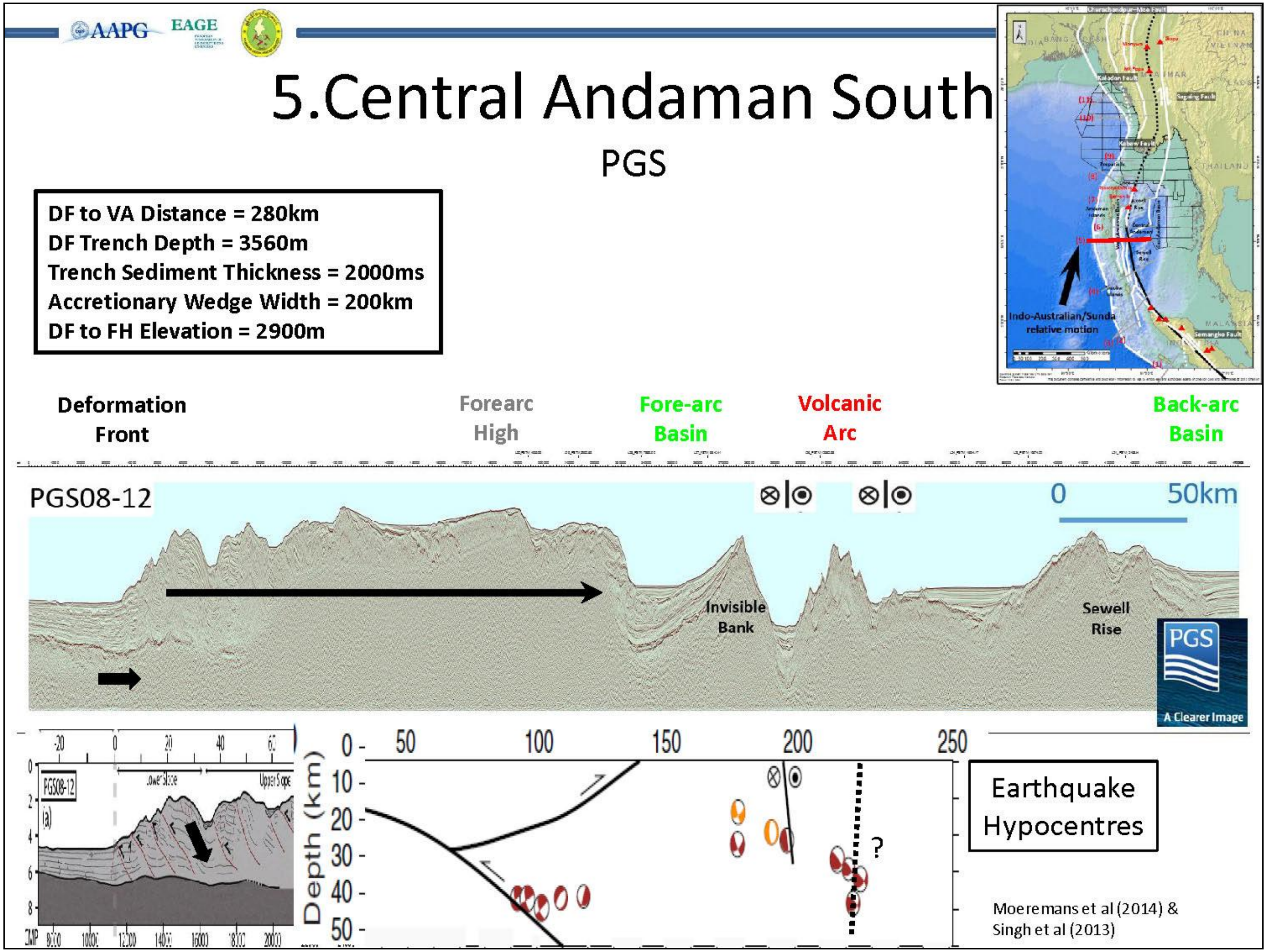
PGS

DF to VA Distance = 250km
DF Trench Depth = 4240m
Trench Sediment Thickness = 4000ms
Accretionary Wedge Width = 175km
DF to FH Elevation = 4050m

Earthquake Hypocentres

Moeremans et al (2014) &
Singh et al (2013)

This line shows a series of strike slip faults and the Sewell Rise high plus LV folds. South Andaman is thought to be a subduction margin but seismic record length insufficient to image top oceanic crust and most of earthquakes related to a strike slip fault.



5.Central Andaman South

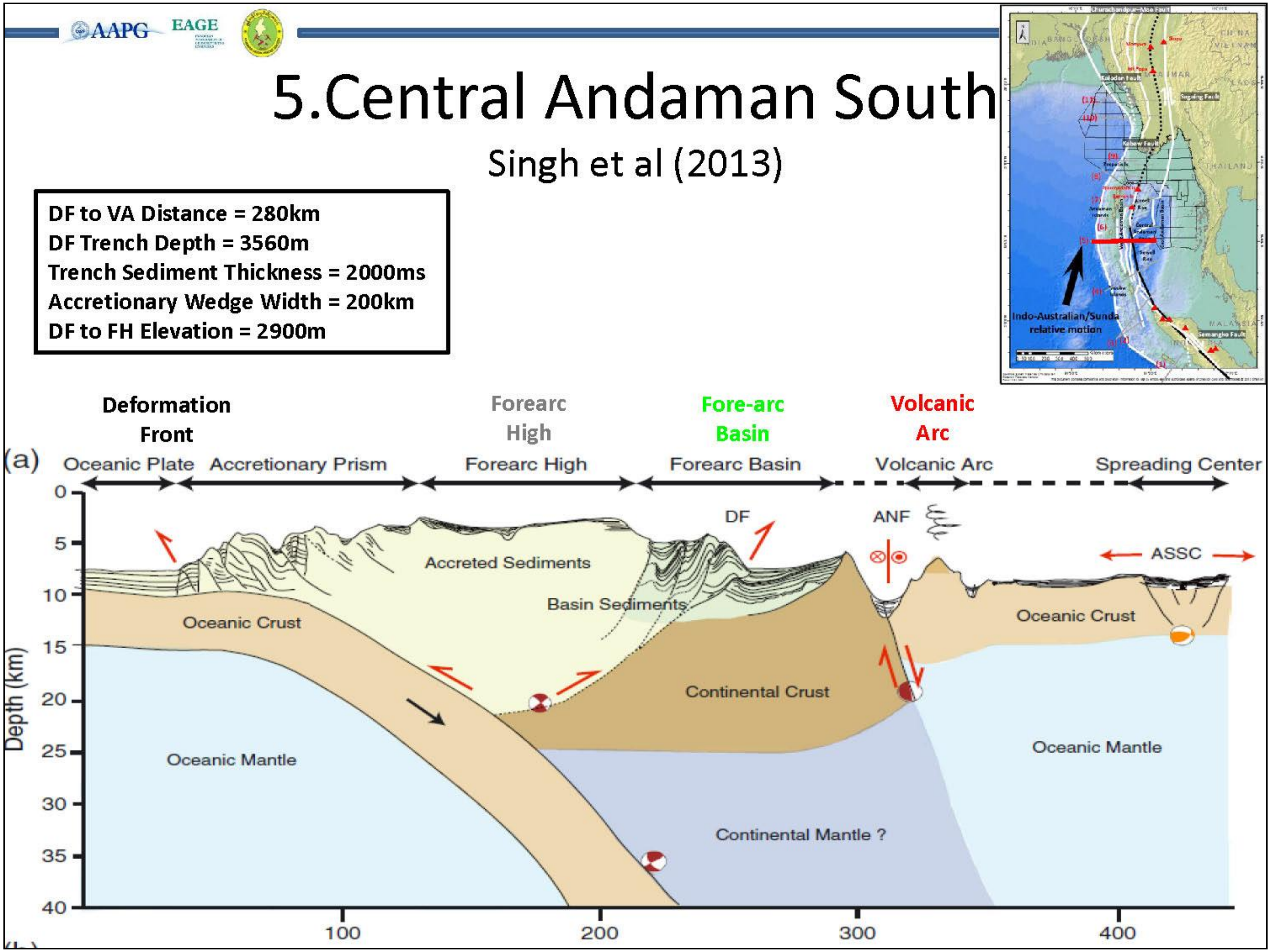
PGS

DF to VA Distance = 280km
DF Trench Depth = 3560m
Trench Sediment Thickness = 2000ms
Accretionary Wedge Width = 200km
DF to FH Elevation = 2900m

Earthquake Hypocentres

Moeremans et al (2014) & Singh et al (2013)

Central Andaman South line exhibits different attitude of Indian plate and shape of accretionary prism to South Andaman line but still thought to be a subduction margin. Note the Sewell Rise high feature with thin sedimentary cover.

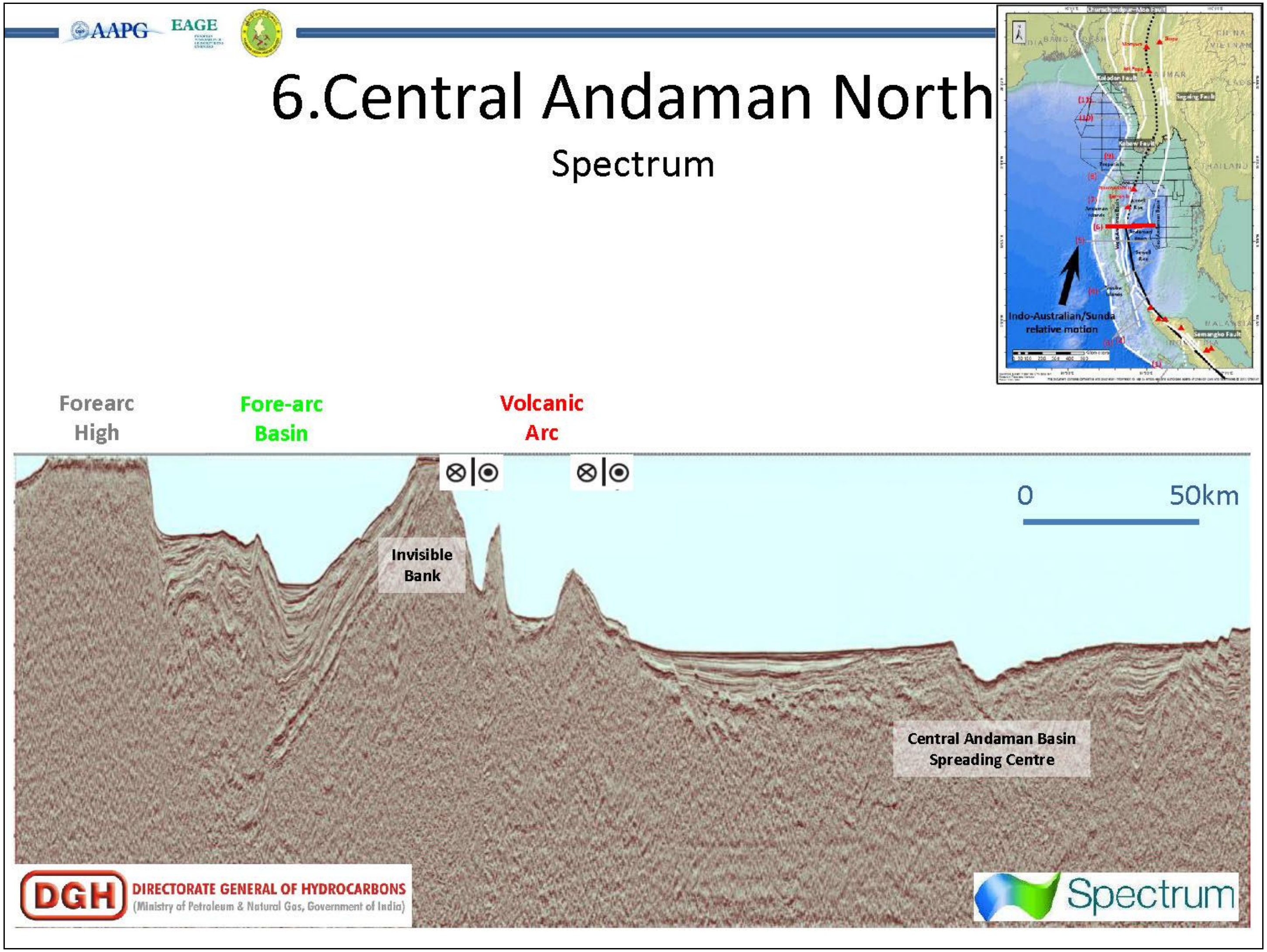


5.Central Andaman South

Singh et al (2013)

DF to VA Distance = 280km
DF Trench Depth = 3560m
Trench Sediment Thickness = 2000ms
Accretionary Wedge Width = 200km
DF to FH Elevation = 2900m

Singh at al., 2015, line 5 model illustrates the subduction margin interpretation. Note the oceanic crust of the Central Andaman Basin, which is perhaps better illustrated in the next slide.



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6.Central Andaman North

Spectrum

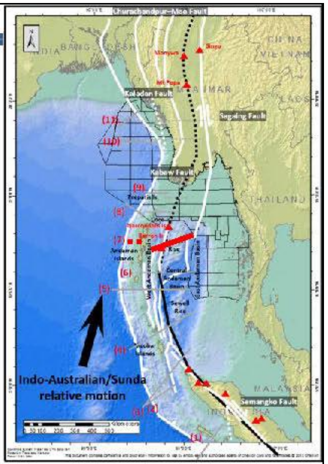
DGH DIRECTORATE GENERAL OF HYDROCARBONS (Ministry of Petroleum & Natural Gas, Government of India)

Spectrum

Line 6 goes obliquely across the Central Andaman Basin spreading centre. A seismic line to the west was unavailable so quantitative parameters are not shown.

7. North Andaman

Roy (1992) & Spectrum



DF to VA Distance = 210km
DF Trench Depth = 3375m
Trench Sediment Thickness = 4000ms
Accretionary Wedge Width = 175km
DF to FH Elevation = 3375m

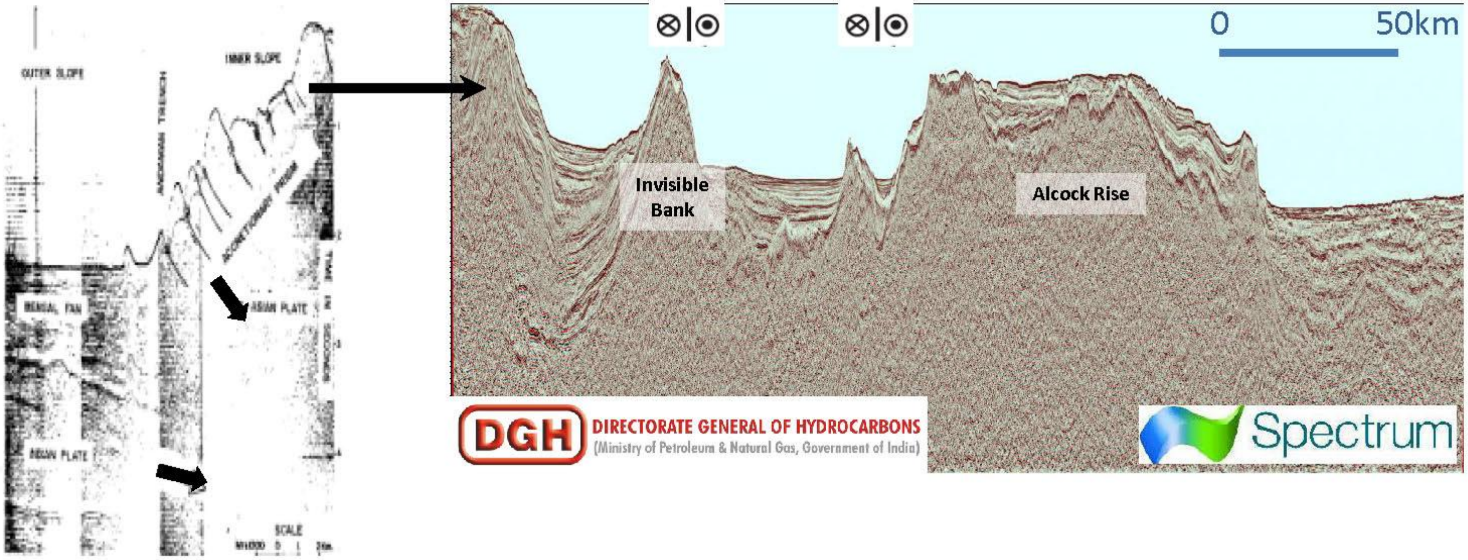
Deformation Front

Forearc High

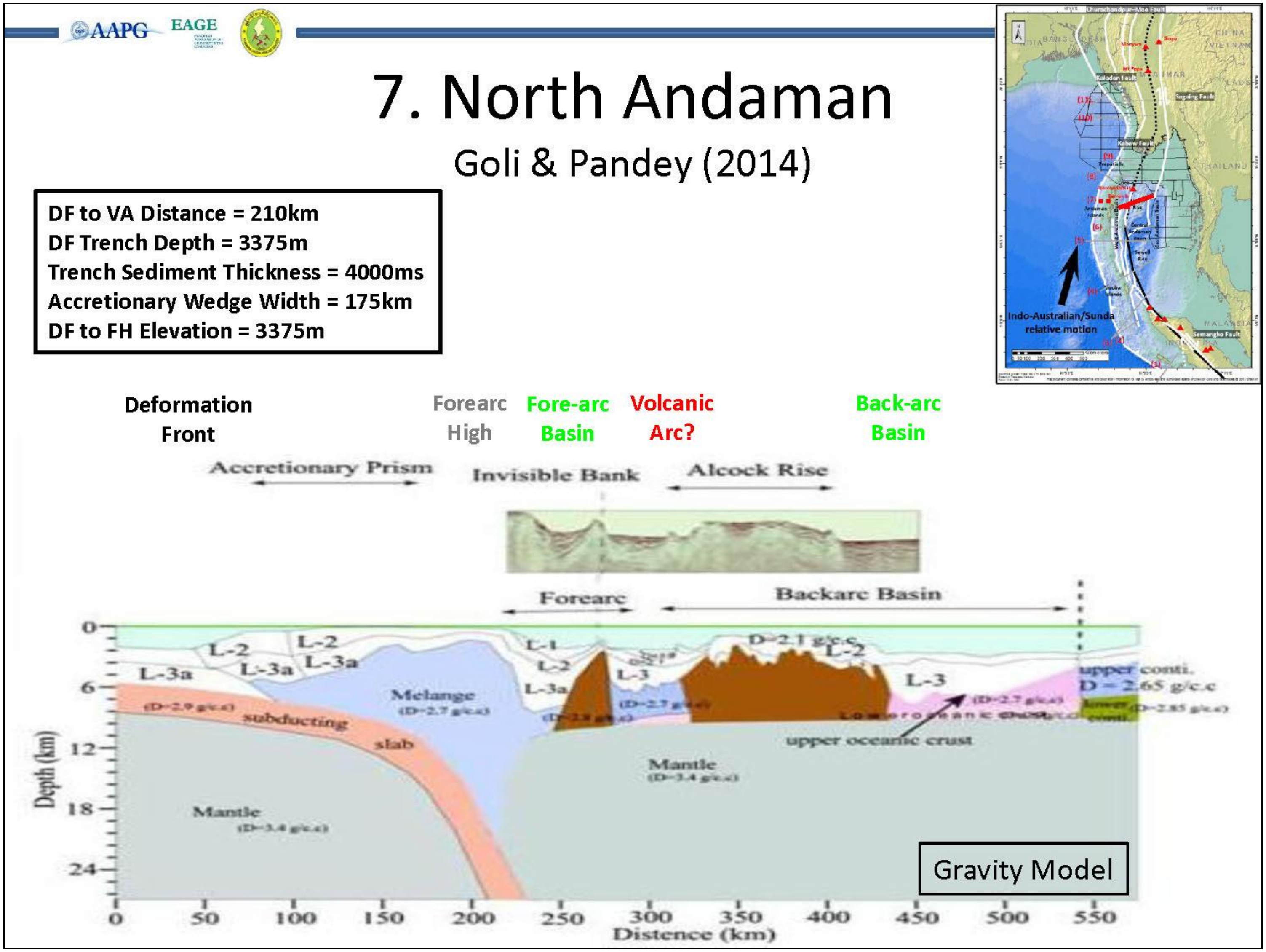
Fore-arc Basin

Volcanic Arc? (Near Barren Is)

Back-arc Basin



Line 7 is a composite line. Note the form of the Alcock Rise high, which is similar to that of the Sewell Rise.

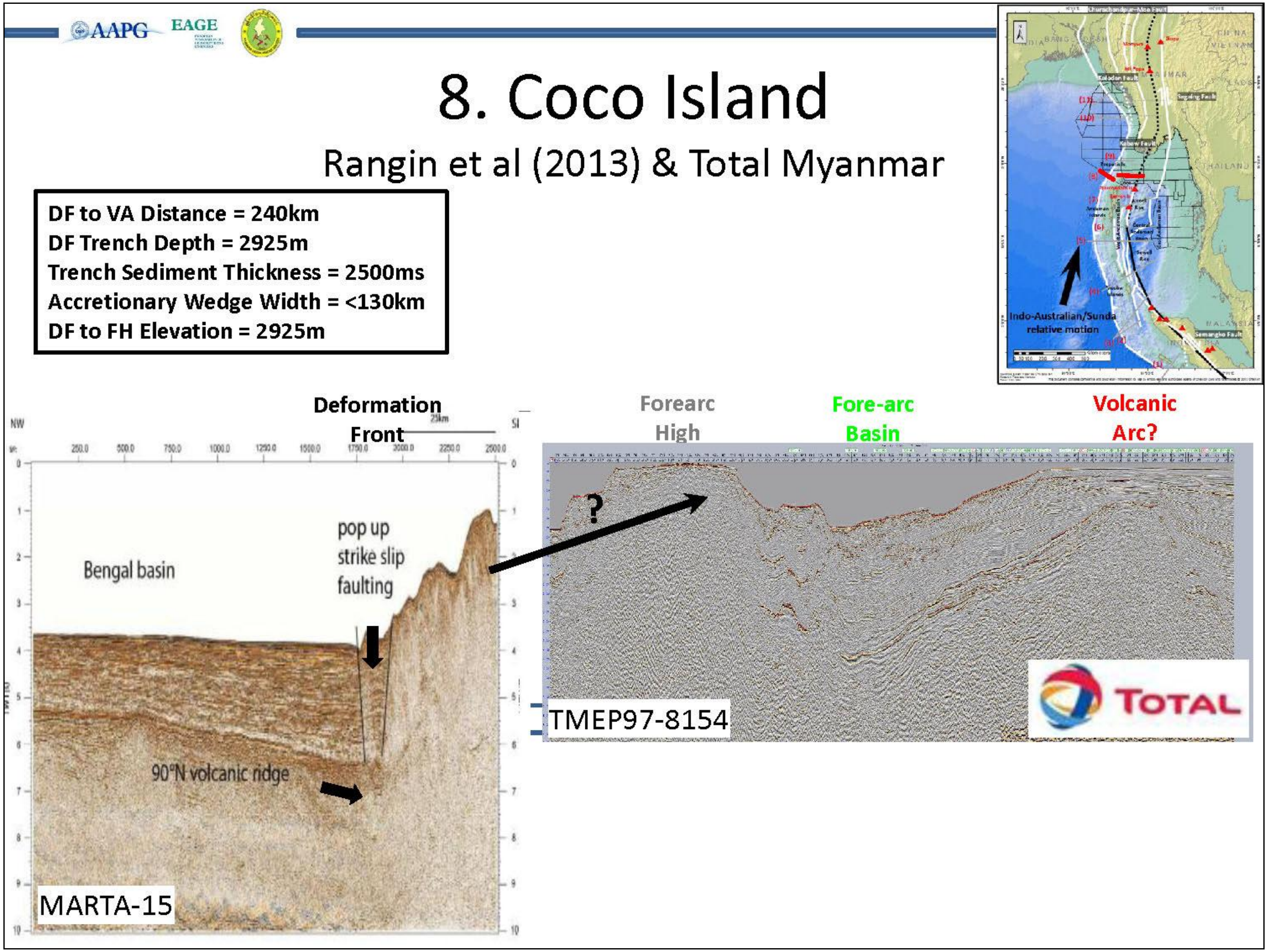


7. North Andaman

Goli & Pandey (2014)

DF to VA Distance = 210km
DF Trench Depth = 3375m
Trench Sediment Thickness = 4000ms
Accretionary Wedge Width = 175km
DF to FH Elevation = 3375m

Goli and Pandey's (2014) gravity model along a line of section including the eastern segment of line 7 shows a subduction margin perhaps with a more steeply subducting slab plus the Alcock Rise, which is modelled as relatively high-density igneous rock.

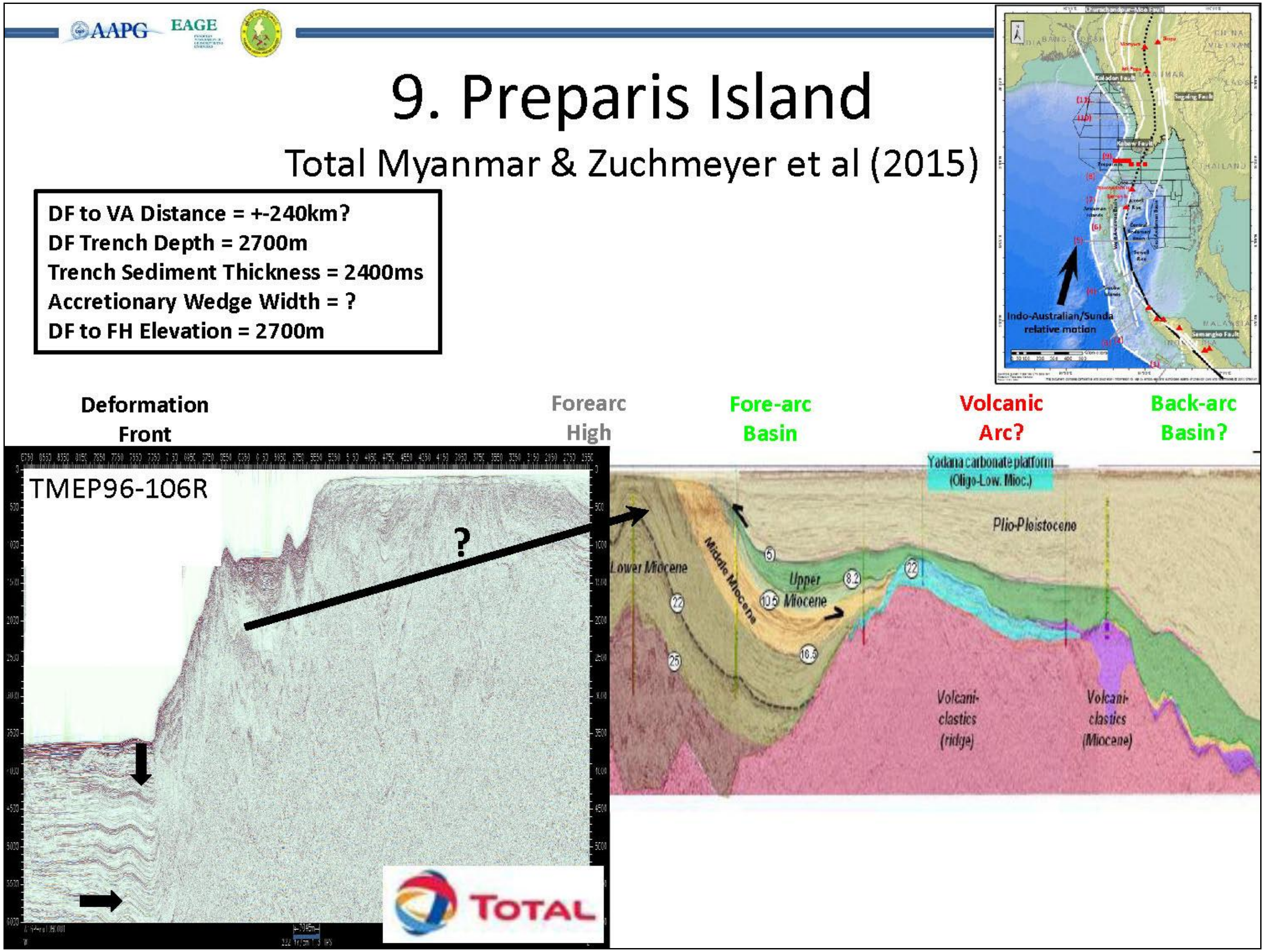


8. Coco Island

Rangin et al (2013) & Total Myanmar

DF to VA Distance = 240km
DF Trench Depth = 2925m
Trench Sediment Thickness = 2500ms
Accretionary Wedge Width = <130km
DF to FH Elevation = 2925m

Line 8 is a composite line. Similar tectonic features are identified perhaps including a paleo volcanic arc high. Transition to transform margin?

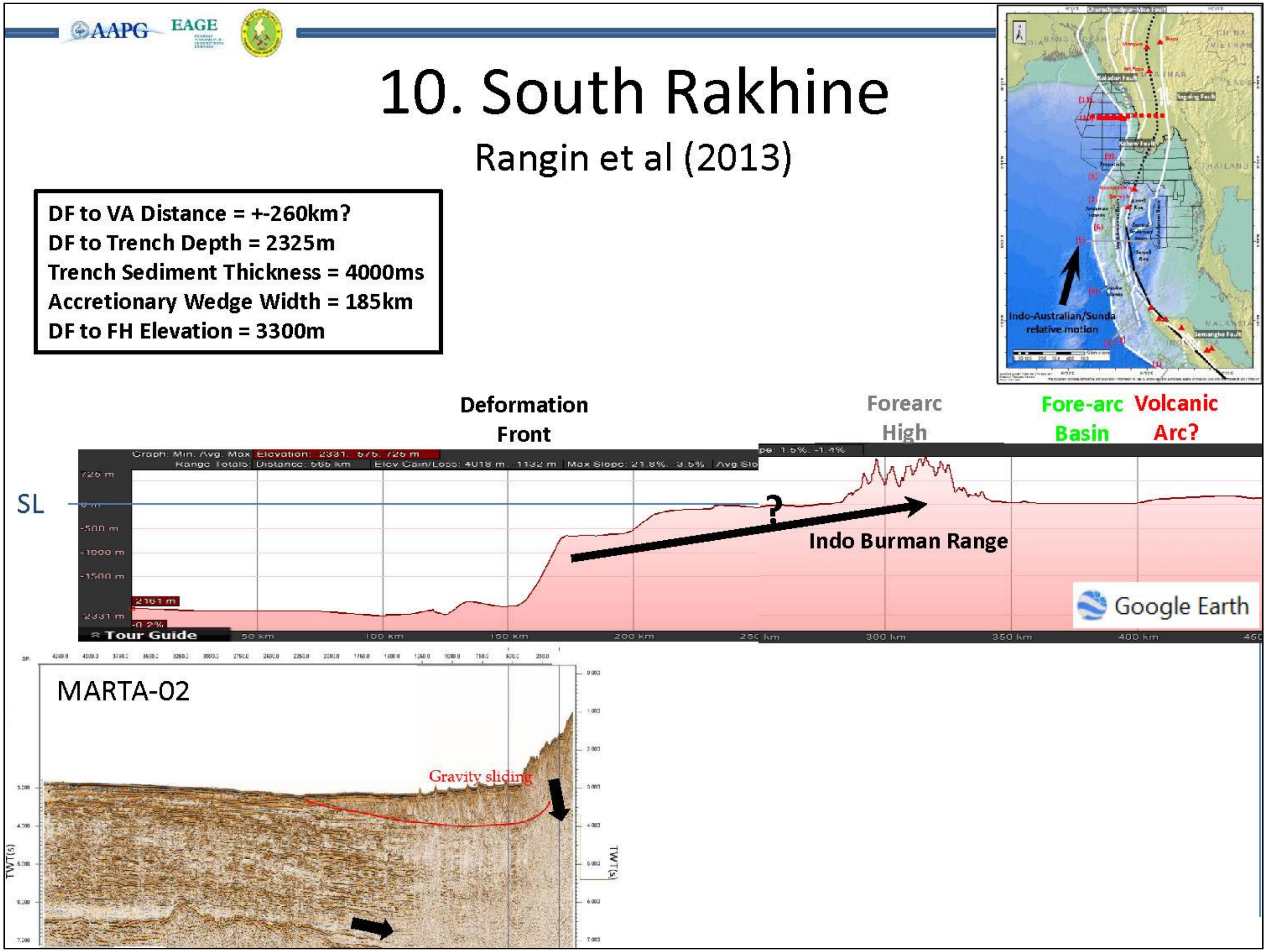


9. Preparis Island

Total Myanmar & Zuchmeyer et al (2015)

DF to VA Distance = +-240km?
DF Trench Depth = 2700m
Trench Sediment Thickness = 2400ms
Accretionary Wedge Width = ?
DF to FH Elevation = 2700m

Line 9 is another composite. Note in the fore-arc basin uplift starting approximately 10Ma ago and extensive erosion both in the fore-arc and the accretionary prism. Note also the identification of the Yadana High as a possible paleo volcanic arc high. Transition to transform margin?

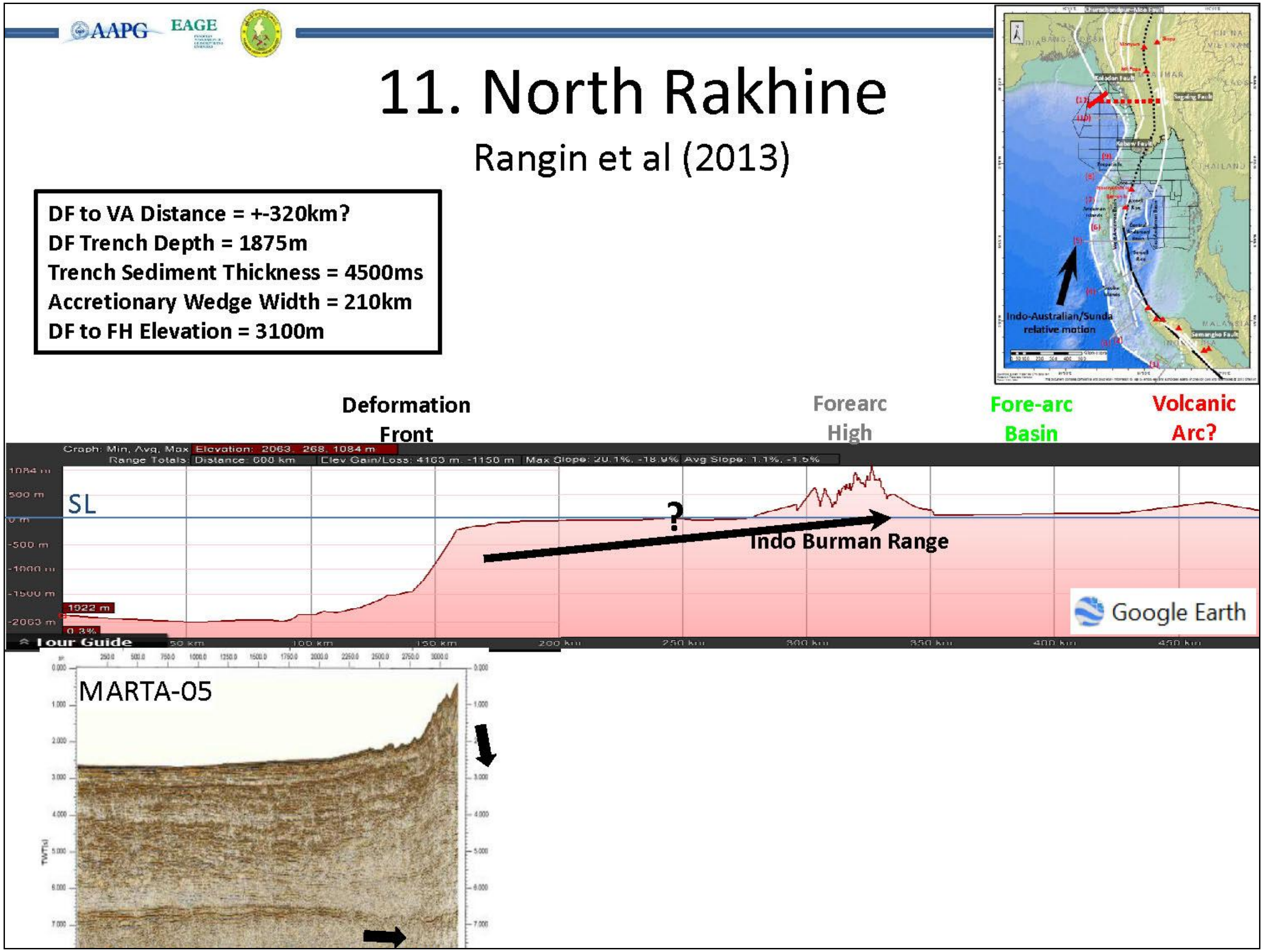


10. South Rakhine

Rangin et al (2013)

DF to VA Distance = +-260km?
DF to Trench Depth = 2325m
Trench Sediment Thickness = 4000ms
Accretionary Wedge Width = 185km
DF to FH Elevation = 3300m

Line 10 only has partial seismic coverage so is illustrated via a Google Earth elevation profile. The Forearc High is identified with the Indo-Burman Range, which of course is above sea level. The Volcanic Arc as identified is on trend with Mt Popa. Transform margin?

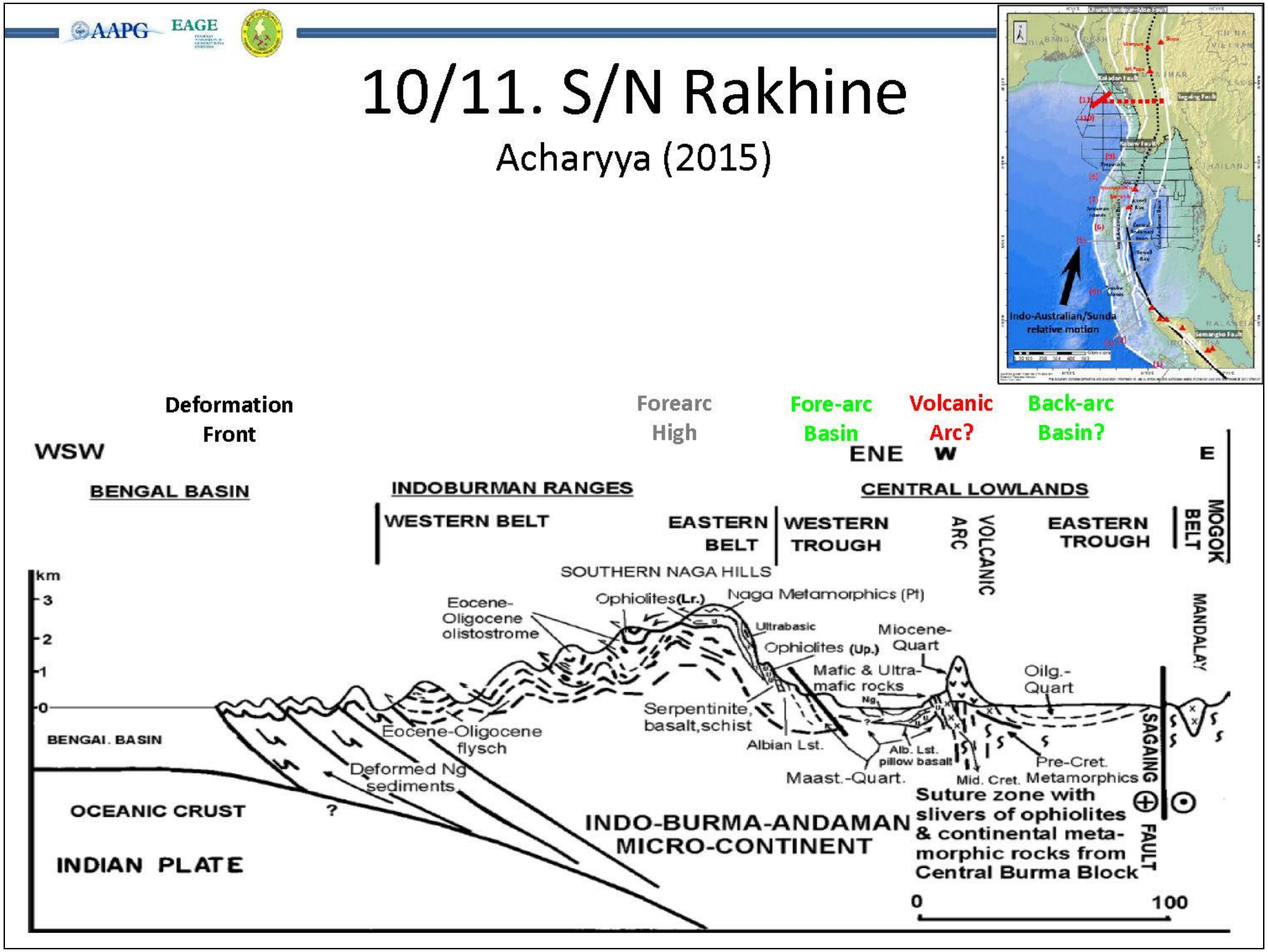


11. North Rakhine

Rangin et al (2013)

DF to VA Distance = +-320km?
DF Trench Depth = 1875m
Trench Sediment Thickness = 4500ms
Accretionary Wedge Width = 210km
DF to FH Elevation = 3100m

Line 12 only has partial seismic coverage so is illustrated via a Google Earth elevation profile. The Forearc High is identified with the Indo-Burman Range, which of course is above sea level. The Volcanic Arc as identified is on trend with Mt Popa. Transform margin?



10/11. S/N Rakhine

Acharyya (2015)

Acharyya's (2015) schematic composite cross-section illustrates the model applicable to South and North Rakhine (and North Myanmar). Note that a subducting Indian Plate is shown but is question marked and a Volcanic Arc with Miocene and Quaternary volcanics is identified.

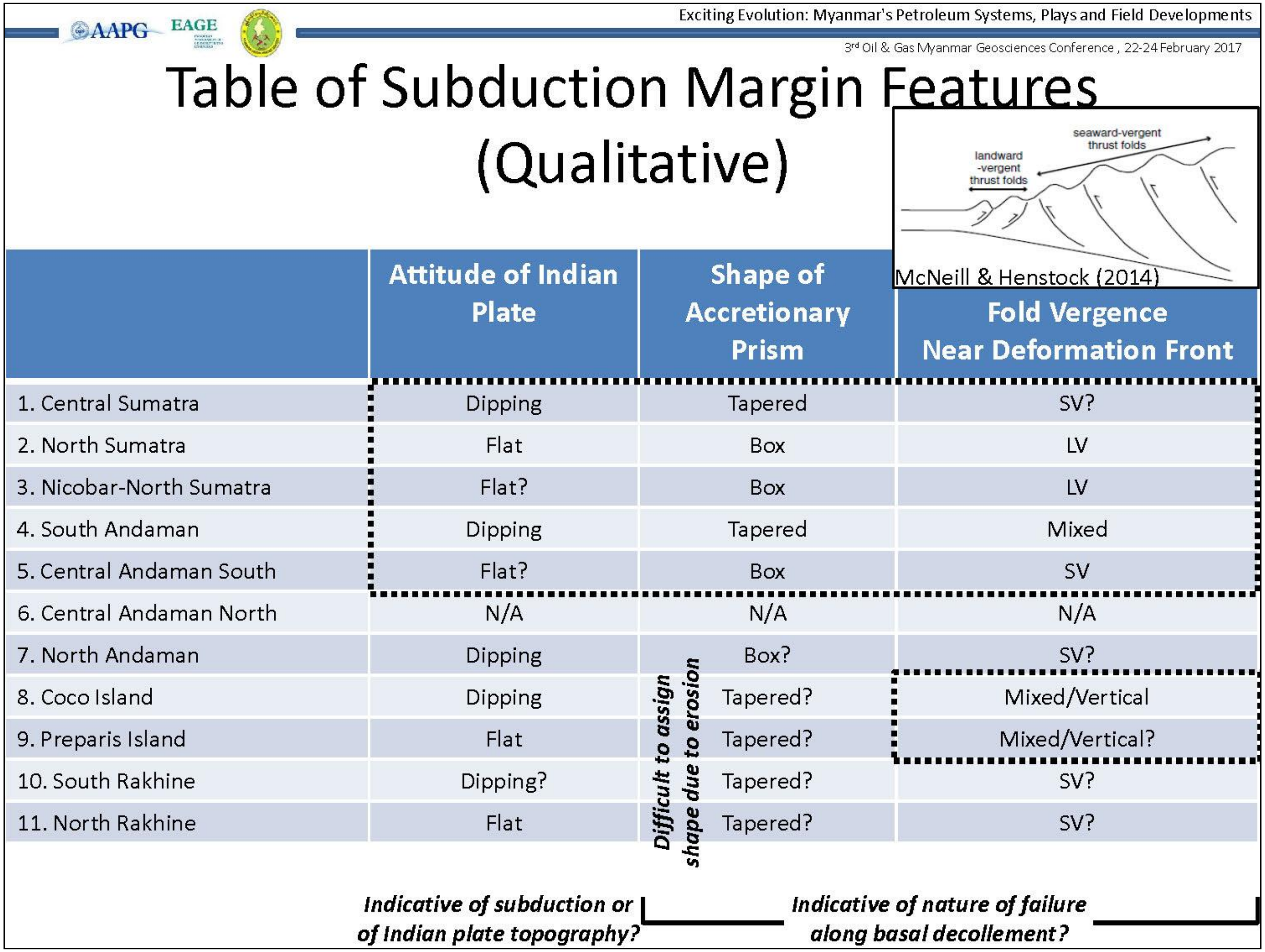


Table of Subduction Margin Features (Qualitative)

McNeill & Henstock (2014)

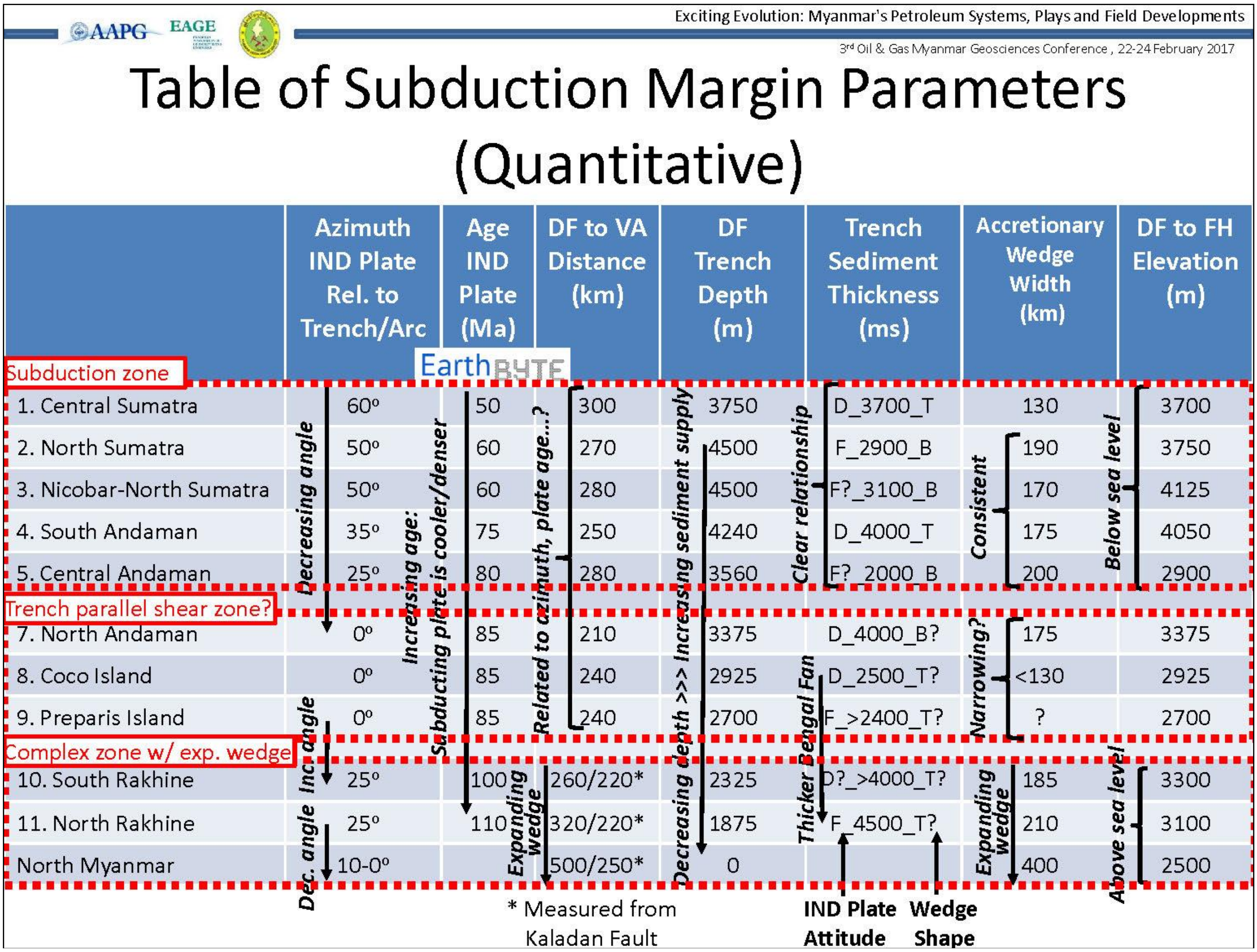
	Attitude of Indian Plate	Shape of Accretionary Prism	Fold Vergence Near Deformation Front
1. Central Sumatra	Dipping	Tapered	SV?
2. North Sumatra	Flat	Box	LV
3. Nicobar-North Sumatra	Flat?	Box	LV
4. South Andaman	Dipping	Tapered	Mixed
5. Central Andaman South	Flat?	Box	SV
6. Central Andaman North	N/A	N/A	N/A
7. North Andaman	Dipping	Box?	SV?
8. Coco Island	Dipping	Tapered?	Mixed/Vertical
9. Preparis Island	Flat	Tapered?	Mixed/Vertical?
10. South Rakhine	Dipping?	Tapered?	SV?
11. North Rakhine	Flat	Tapered?	SV?

Difficult to assign shape due to erosion

Indicative of subduction or of Indian plate topography?

Indicative of nature of failure along basal decollement?

Table of qualitative subduction margin features show some consistency for lines 1-5. Where the attitude of the Indian Plate is dipping the accretionary prism is tapered, where it is more flat the prism is box shaped. It is not clear whether attitude of the Indian Plate is indicative of the subduction process or is simply indicative of the Indian Plate topography/ridges.



Exciting Evolution: Myanmar's Petroleum Systems, Plays and Field Developments

3^{rd} Oil & Gas Myanmar Geosciences Conference , 22-24 February 2017

Table of Subduction Margin Parameters (Quantitative)

	Azimuth IND Plate Rel. to Trench/Arc	Age IND Plate (Ma)	DF to VA Distance (km)	DF Trench Depth (m)	Trench Sediment Thickness (ms)	Accretionary Wedge Width (km)	DF to FH Elevation (m)
Subduction zone							
1. Central Sumatra	60°	50	300	3750	D_3700_T	130	3700
2. North Sumatra	50°	60	270	4500	F_2900_B	190	3750
3. Nicobar-North Sumatra	50°	60	280	4500	F?_3100_B	170	4125
4. South Andaman	35°	75	250	4240	D_4000_T	175	4050
5. Central Andaman	25°	80	280	3560	F?_2000_B	200	2900
Trench parallel shear zone?							
7. North Andaman	0°	85	210	3375	D_4000_B?	175	3375
8. Coco Island	0°	85	240	2925	D_2500_T?	<130	2925
9. Preparis Island	0°	85	240	2700	F_>2400_T?	?	2700
Complex zone w/ exp. wedge							
10. South Rakhine	25°	100	260/220*	2325	D?_>4000_T?	185	3300
11. North Rakhine	25°	110	320/220*	1875	F_4500_T?	210	3100
North Myanmar	10-0°		500/250*	0		400	2500

* Measured from Kaladan Fault

Table of quantitative subduction margin parameters shows:

(i) Azimuth of Indian Plate relative to trench/arc starting at 60 deg for line 1 and reducing to +-0 deg for lines 7-9, thereafter increasing and then decreasing.

(ii) Age of Indian Plate increasing form 50Ma in the south to 110Ma in the north. There has been some suggestion in the literature that older oceanic crust being cooler and denser could lead to steeper subducting slab and a reduced DF to VA distance.

(iii) DF to VA distance does indeed exhibit a general decreasing trend from Sumatra to North Andaman but with numerous variables, no firm conclusion should be drawn. In the Rakhine, the accretionary wedge expands due to increased sediment supply post-Shillong Plateau uplift in the Pliocene. The pre-Pliocene DF was probably along the line of the Kaladan fault and if this point of reference is used then DF to VA remains constant.

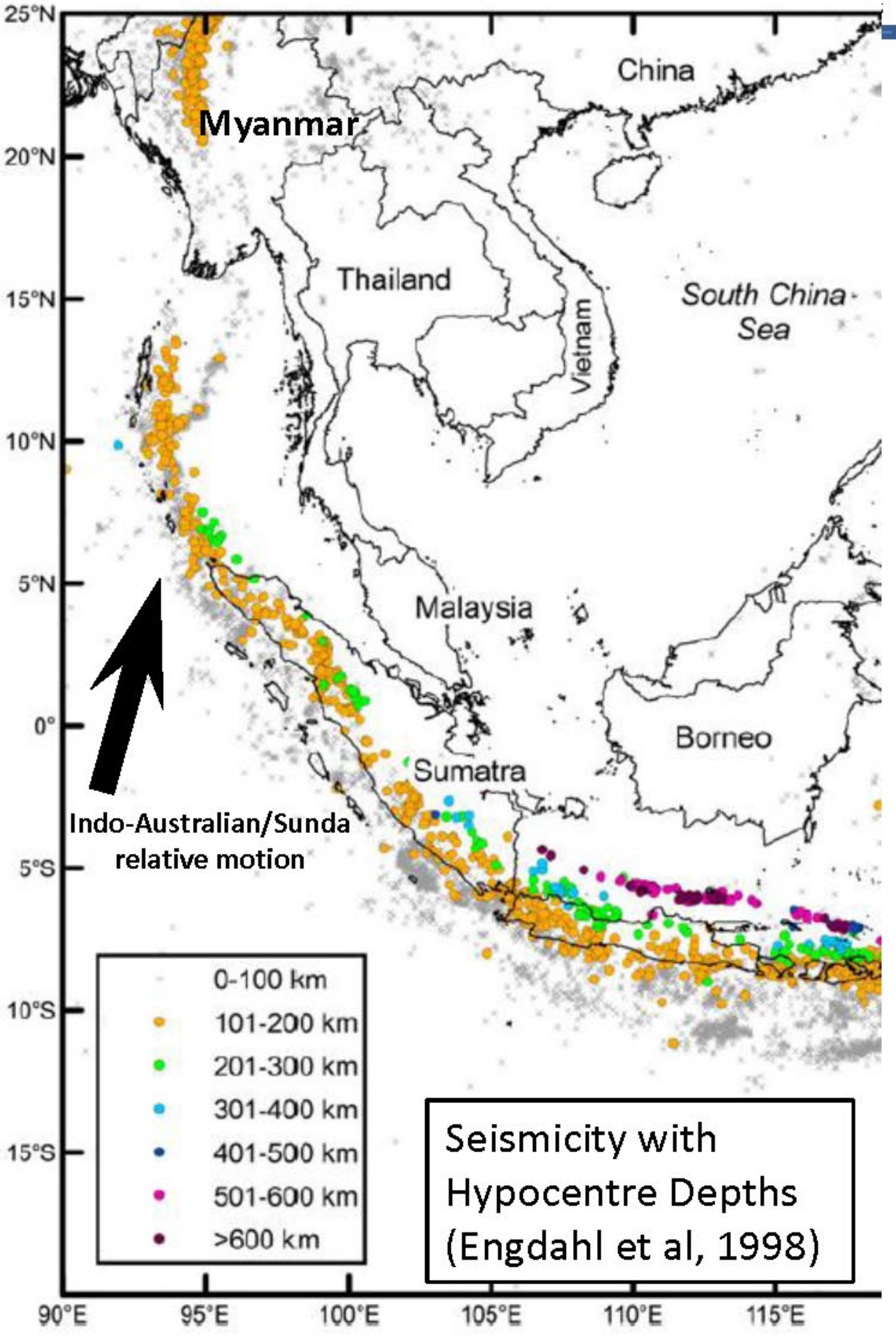
(iv) DF trench depth generally decreases from south to north reflecting increasing Bengal Fan sediment input.

(v) For lines 1-5 trench sediment thickness, though variable, seems to have a clear relationship to Indian Plate attitude/wedge shape. Trench sediment thickness is greater with dipping plate attitude and tapered wedge shape and less with flat plate attitude and box wedge shape.

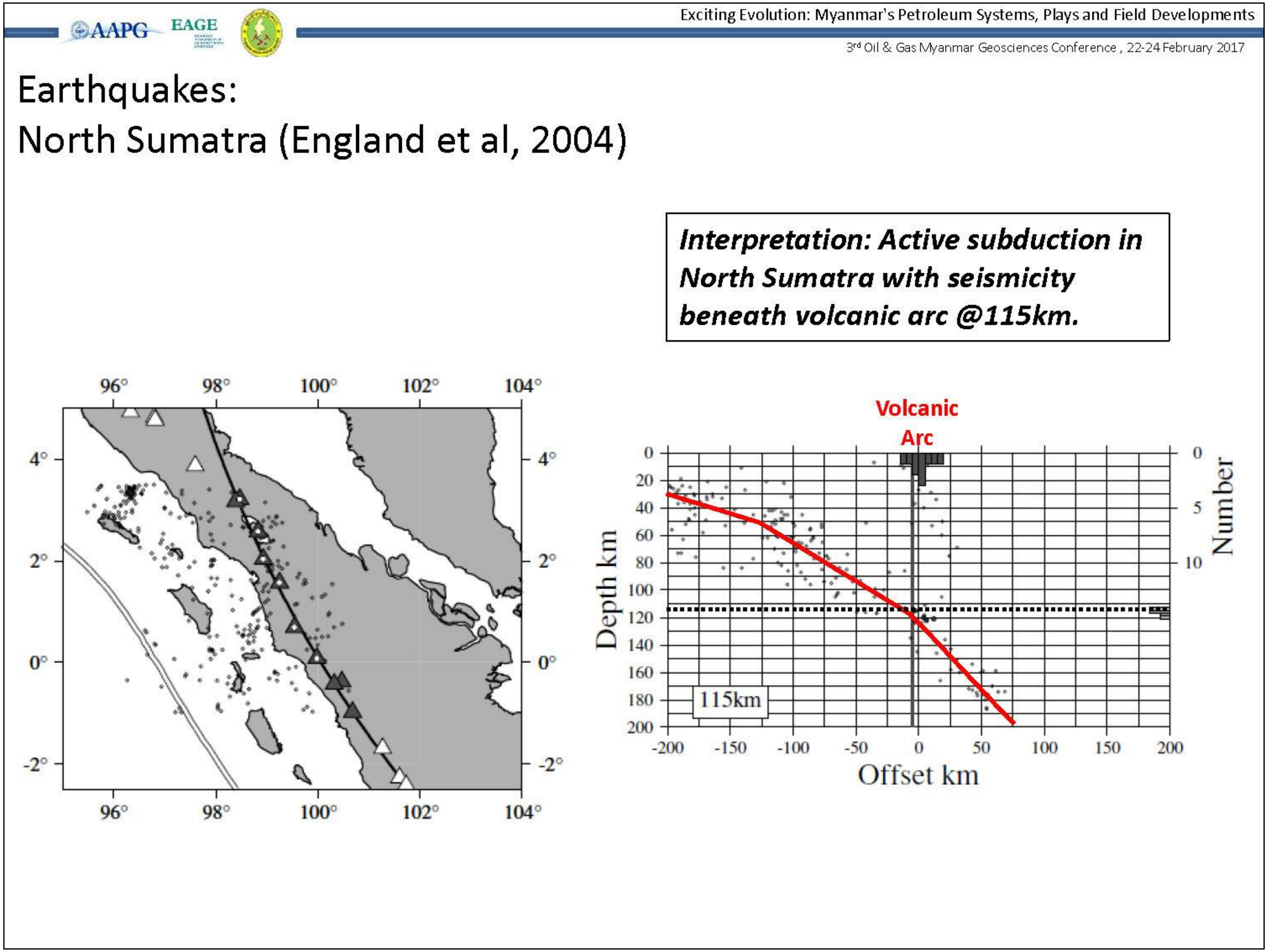
From the two tabulations of seismic features/parameters, three zones have been identified: (1) Subduction zone; (2) Trench parallel shear zone and (3) Complex zone with expanding wedge. To understand more about this plate margin additional data needs to be considered.

Earthquakes: Indonesia to Myanmar (Hall & Spakman, 2015)

Observations: Deepest seismicity >600km in the south (Java) where subduction is orthogonal. Further to the north seismicity is shallower and more localised as subduction becomes more oblique. Sparse seismicity in the North Andaman-Irrawaddy region is 0-100km where plate motion is +-parallel to plate boundary. In North Myanmar seismicity is in a broader arcuate belt 0-200km.



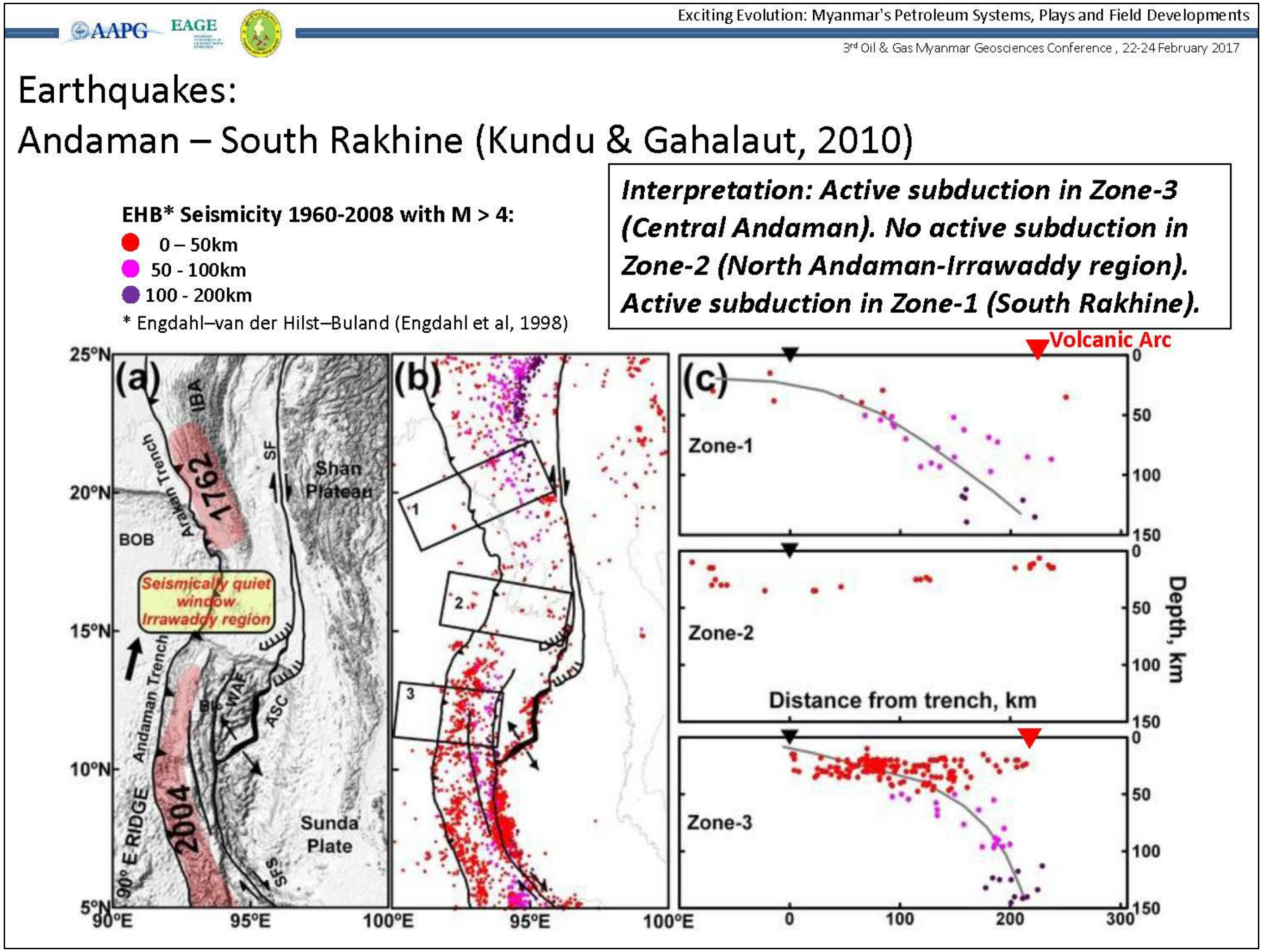
Seismicity with Hypocentre Depths (Engdahl et al, 1998)



Earthquakes:
North Sumatra (England et al, 2004)

Interpretation: Active subduction in North Sumatra with seismicity beneath volcanic arc @115km.

Earthquakes cross-section North Sumatra shows active subduction with seismicity beneath volcanic arc at 115km.



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Earthquakes:
Andaman – South Rakhine (Kundu & Gahalaut, 2010)

Interpretation: Active subduction in Zone-3 (Central Andaman). No active subduction in Zone-2 (North Andaman-Irrawaddy region). Active subduction in Zone-1 (South Rakhine).

EHB* Seismicity 1960-2008 with M > 4:

- ● 0 – 50km
- ● 50 - 100km
- ● 100 - 200km

* Engdahl–van der Hilst–Buland (Engdahl et al, 1998)

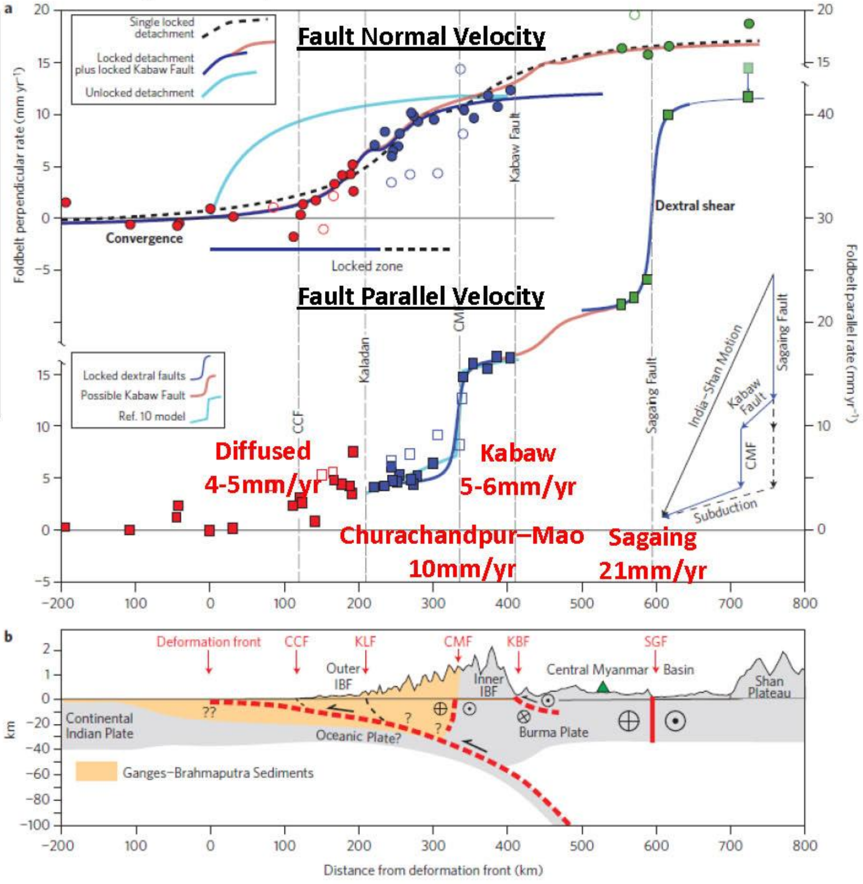
Kundu and Gahalaut (2010) presented earthquakes cross-sections, which were interpreted to show active subduction in the Central Andaman zone, no active subduction in the North Andaman-Irrawaddy zone and active subduction in the South Rakhine zone. Note for the Central Andaman zone higher seismicity and more steeply subducting slab and for South Rakhine zone lower seismicity and more gently subducting slab.

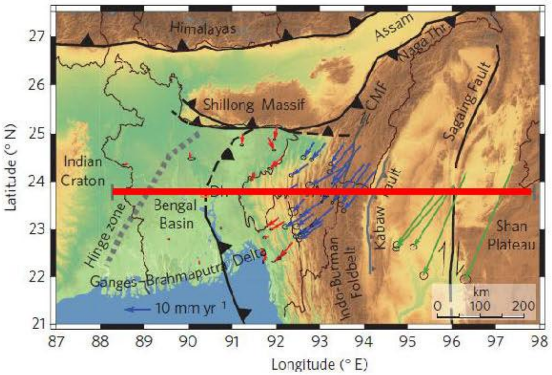
GPS Velocities:
North Myanmar 24°N (Steckler et al, 2016)

Interpretation: India–Sunda relative plate motion partitioned between fault normal and fault parallel:

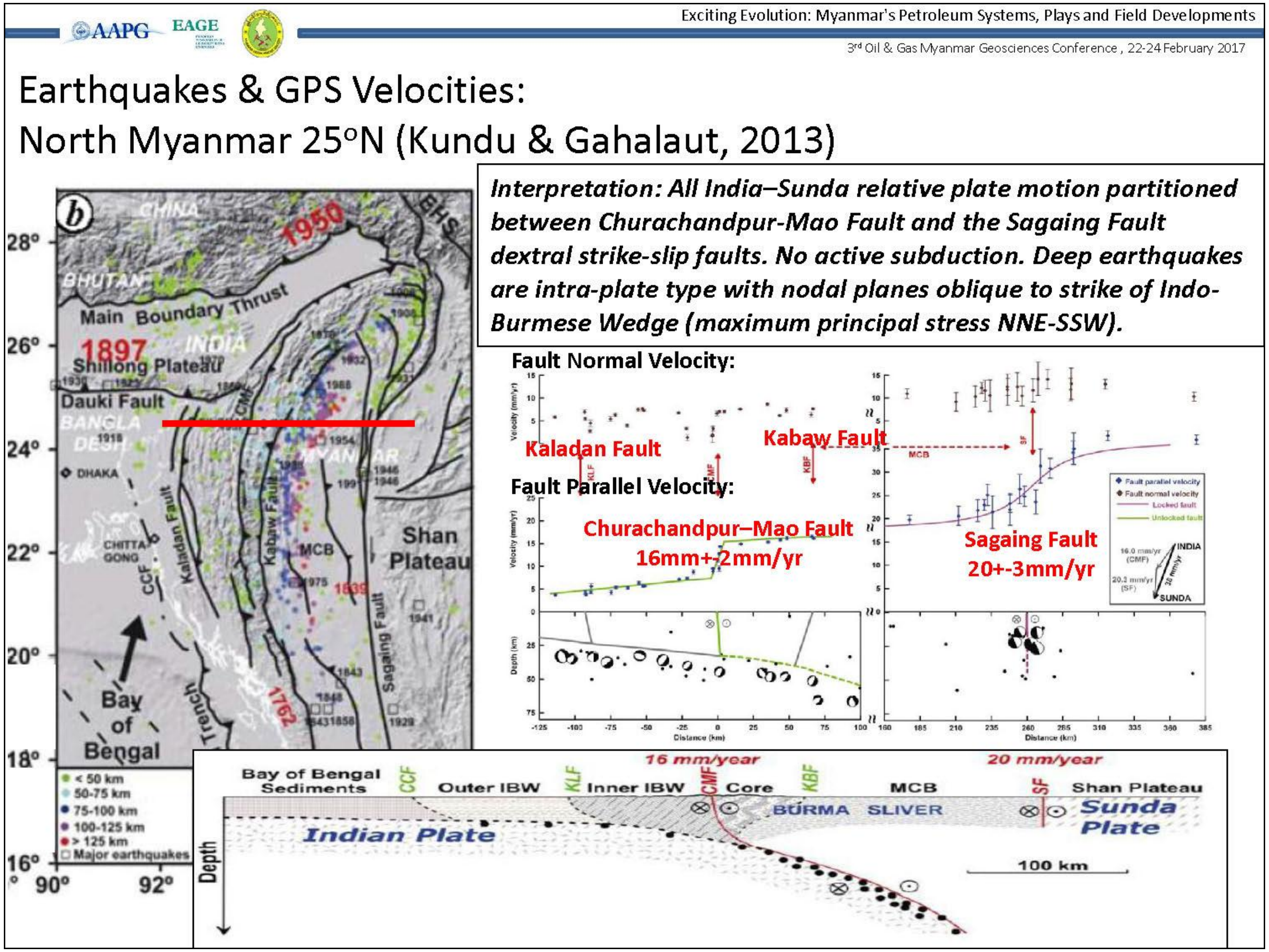
- ***13–17mm/yr fault normal plate convergence***
- ***41mm/yr fault parallel dextral strike slip***

Active subduction.





Steckler et al (2016) used GPS velocities in North Myanmar at approx. 24 deg north to show India-Sunda relative plate motion partitioned between fault normal and fault parallel (13-17mm/yr fault normal plate convergence, 41mm/yr fault parallel dextral strike slip). Although the predominant motion is fault parallel, the fault normal motion indicated there is active subduction.



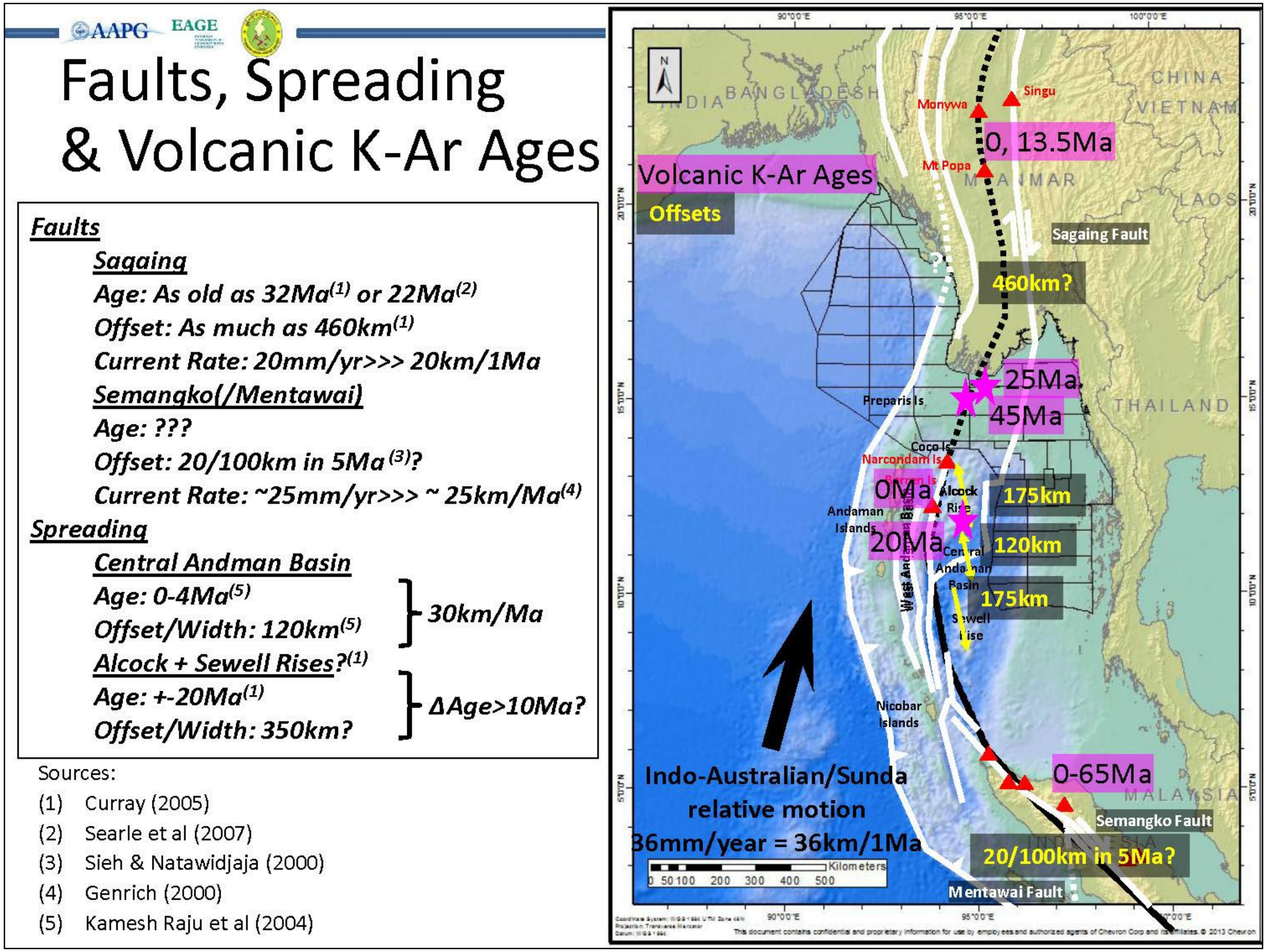
Earthquakes & GPS Velocities:
North Myanmar 25°N (Kundu & Gahalaut, 2013)

Interpretation: All India–Sunda relative plate motion partitioned between Churachandpur-Mao Fault and the Sagaing Fault dextral strike-slip faults. No active subduction. Deep earthquakes are intra-plate type with nodal planes oblique to strike of Indo-Burmese Wedge (maximum principal stress NNE-SSW).

Fault Normal Velocity:

Fault Parallel Velocity:

Kundu and Gahalaut (2013) also used GPS velocities in North Myanmar at approx. 25 deg north to show all India–Sunda relative plate motion partitioned between the Churachandpur-Mao Fault and the Sagaing Fault dextral strike-slip faults. The interpretation of no active subduction was supported by the interpretation of deep earthquake as intra-plate type with nodal planes oblique to strike of Indo-Burmese Wedge (maximum principal stress NNE-SSW). Note how C-M dextral strike-slip fault is extended at depth along what could be interpreted as a subducting slab.



Faults, Spreading & Volcanic K-Ar Ages

Faults

Sagaing

Age: As old as 32Ma(1) or 22Ma(2)

Offset: As much as 460km(1)

Current Rate: 20mm/yr>>> 20km/1Ma

Semangko(/Mentawai)

Age: ???

Offset: 20/100km in 5Ma(3)?

Current Rate: ~25mm/yr>>> ~ 25km/Ma(4)

Spreading

Central Andman Basin

Age: 0-4Ma(5)

Offset/Width: 120km(5)

} *30km/Ma*

Alcock + Sewell Rises?(1)

Age: +-20Ma(1)

Offset/Width: 350km?

} *ΔAge>10Ma?*

Sources:

(1) Curray (2005)

(2) Searle et al (2007)

(3) Sieh & Natawidjaja (2000)

(4) Genrich (2000)

(5) Kamesh Raju et al (2004)

Summary map of fault, spreading and volcanic K-Ar ages: State offsets and then go through faults and spreading box comments. It appears that there could have been 80-120km of movement along the whole Sagaing-Semangko system with corresponding sea floor spreading in the Central Andaman basin in the last 4Ma. The question arises of how much fault movement took place before this and was there corresponding sea floor spreading? In the last 4Ma a significant proportion of the Indo-Australian/Sunda plate relative motion has been along the Sagaing-Semangko system.

Faults, Spreading & Volcanic K-Ar Ages

Volcanic K-Ar Ages

- ***Sumatra***
  - *Long lived volcanism but discrete periods some more active than others*
- ***Alcock Rise***
  - *East of volcanic arc. Oceanic basalt(3)?*
- ***North Andaman***
  - *Recent volcanism not subduction related?*
- ***Irrawaddy***
  - *Paleo volcanic arc indicating that subduction ceased 25Ma ago?*
- ***North Myanmar***
  - *Paleo volcanic arc indicating that subduction ceased 13.5Ma ago with recent volcanism not subduction related(4)?*

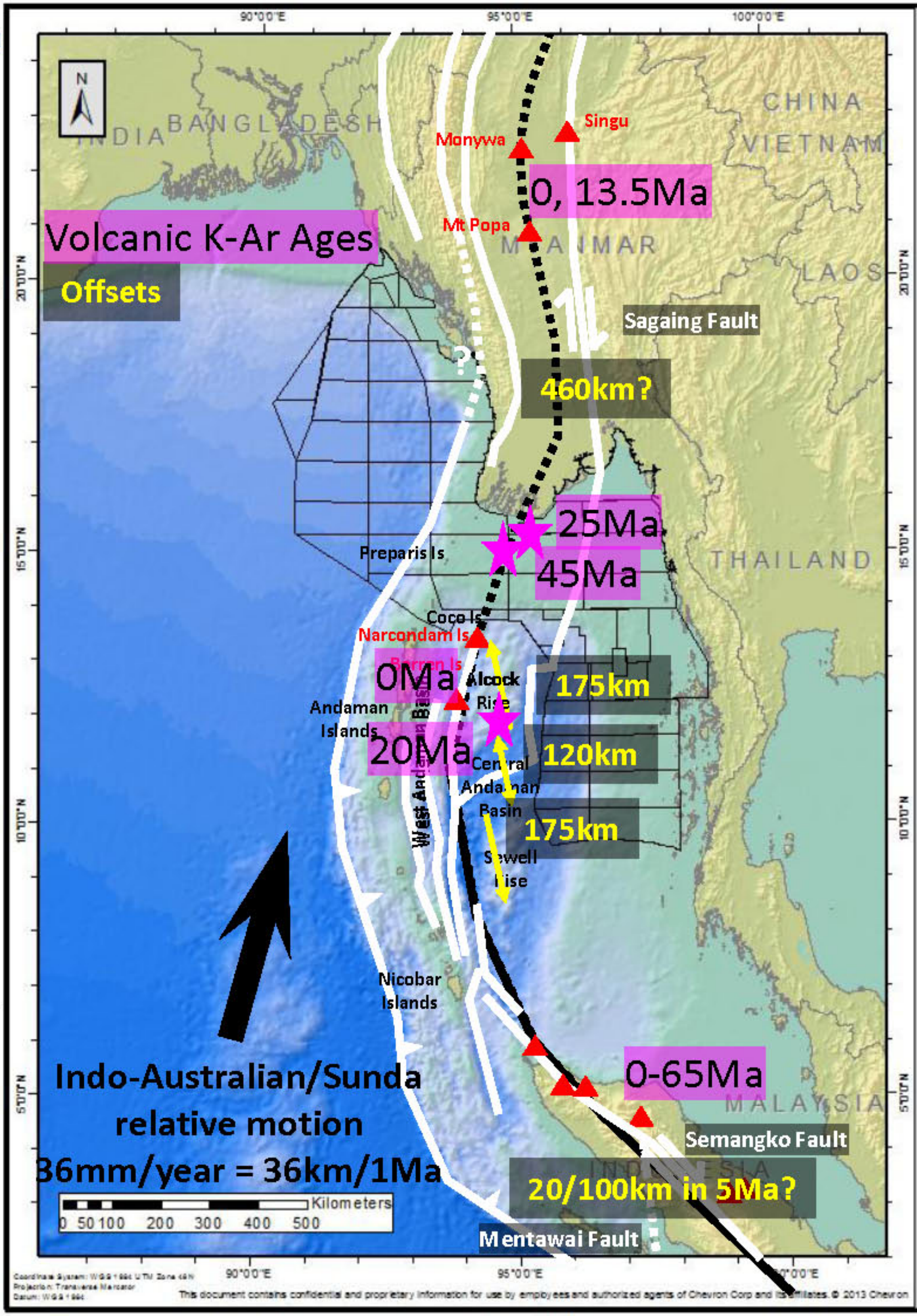
Sources of K-Ar ages:

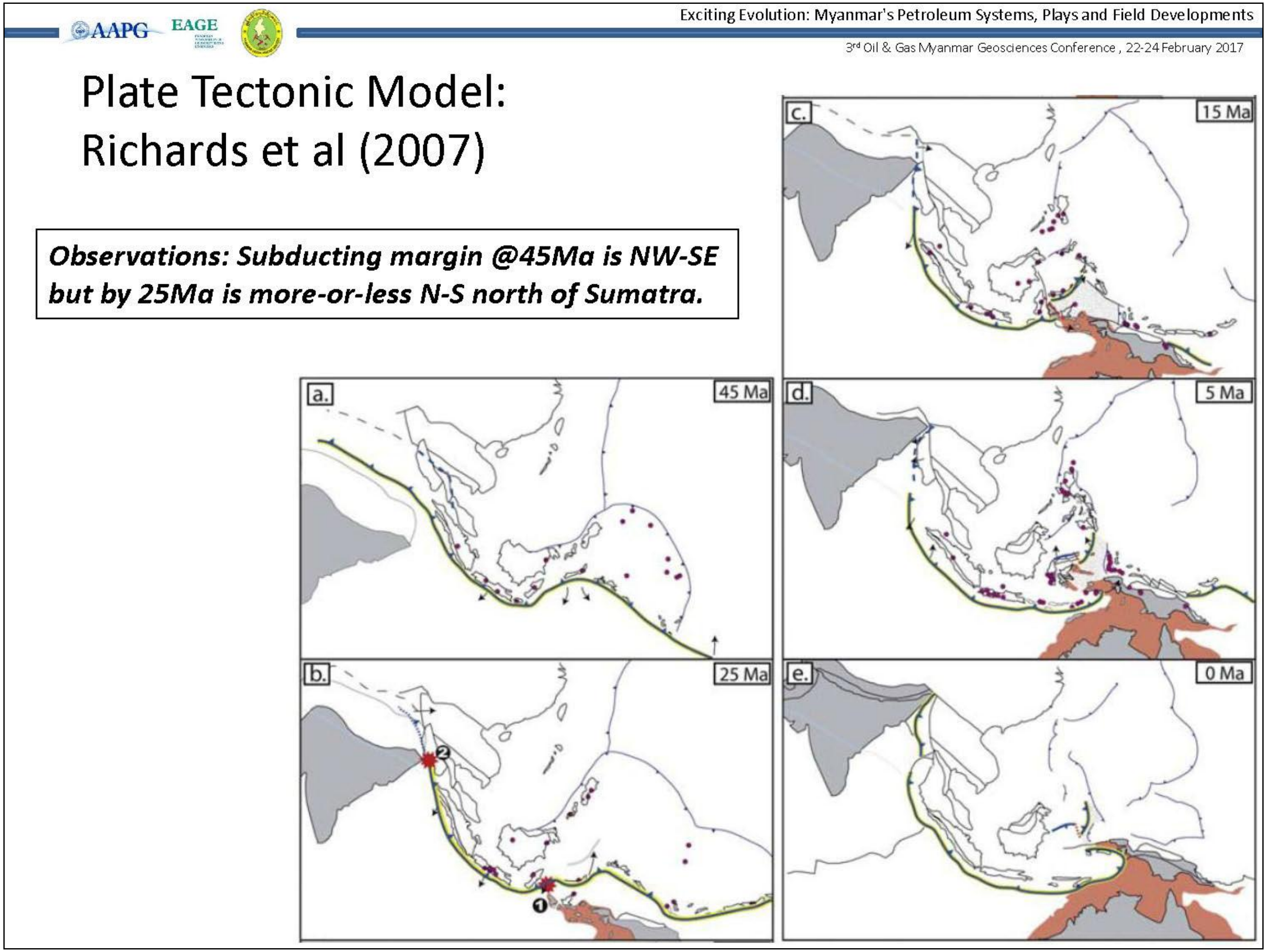
(1) Sumatra - Crow (2005)

(2) Irrawaddy - Total Myanmar

(3) Alcock Rise - Curray (2005)

(4) North Myanmar - Lee et al (2016)





Exciting Evolution: Myanmar's Petroleum Systems, Plays and Field Developments

3rd Oil & Gas Myanmar Geosciences Conference , 22-24 February 2017

Plate Tectonic Model: Richards et al (2007)

Observations: Subducting margin @45Ma is NW-SE but by 25Ma is more-or-less N-S north of Sumatra.

Plate tectonic models, including Richard's et al (2007) illustrated, show that specifically north of Andaman region there has been a change of orientation from oblique to parallel of the Indian Plate relative to the subducting margin.

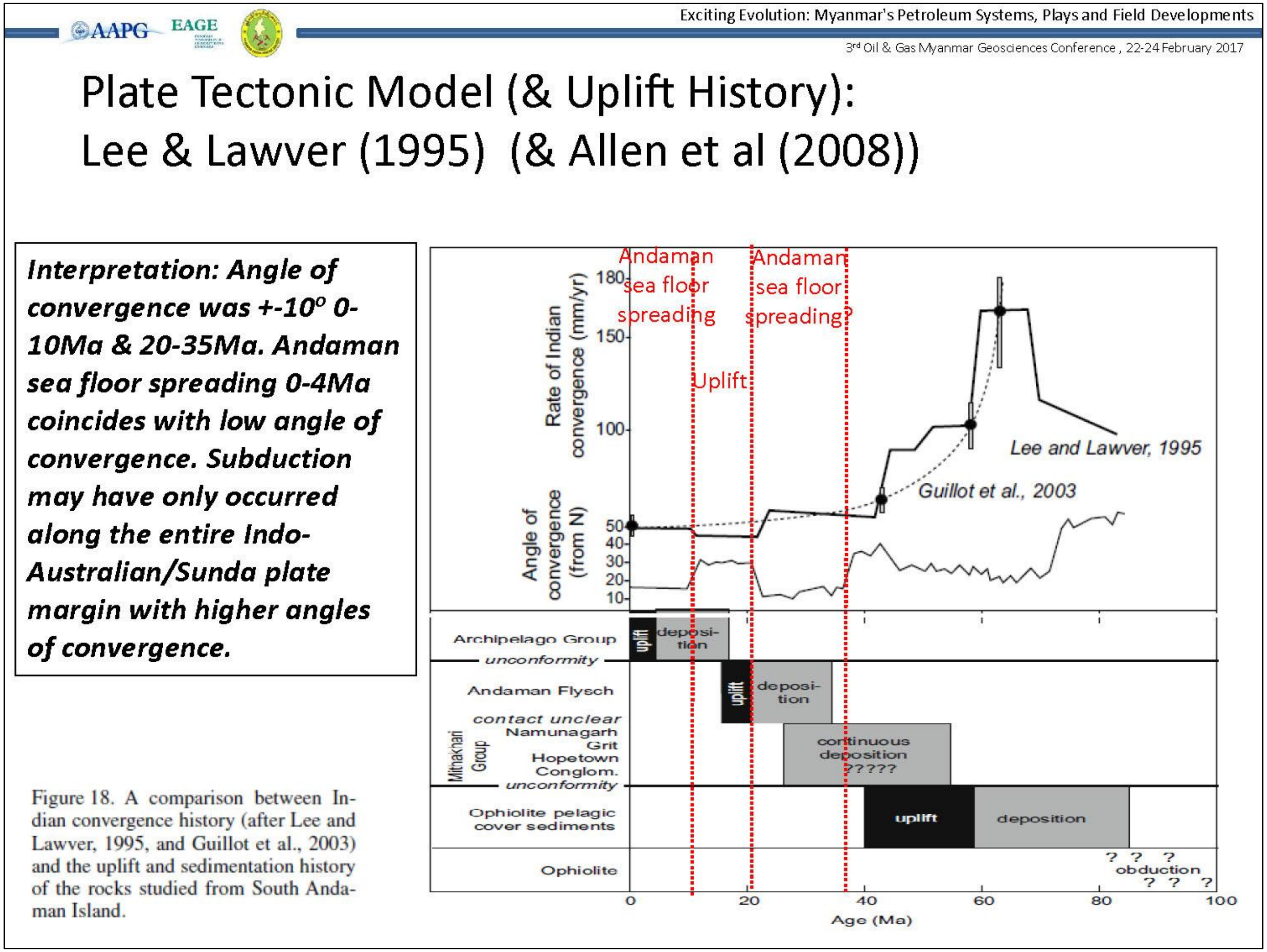


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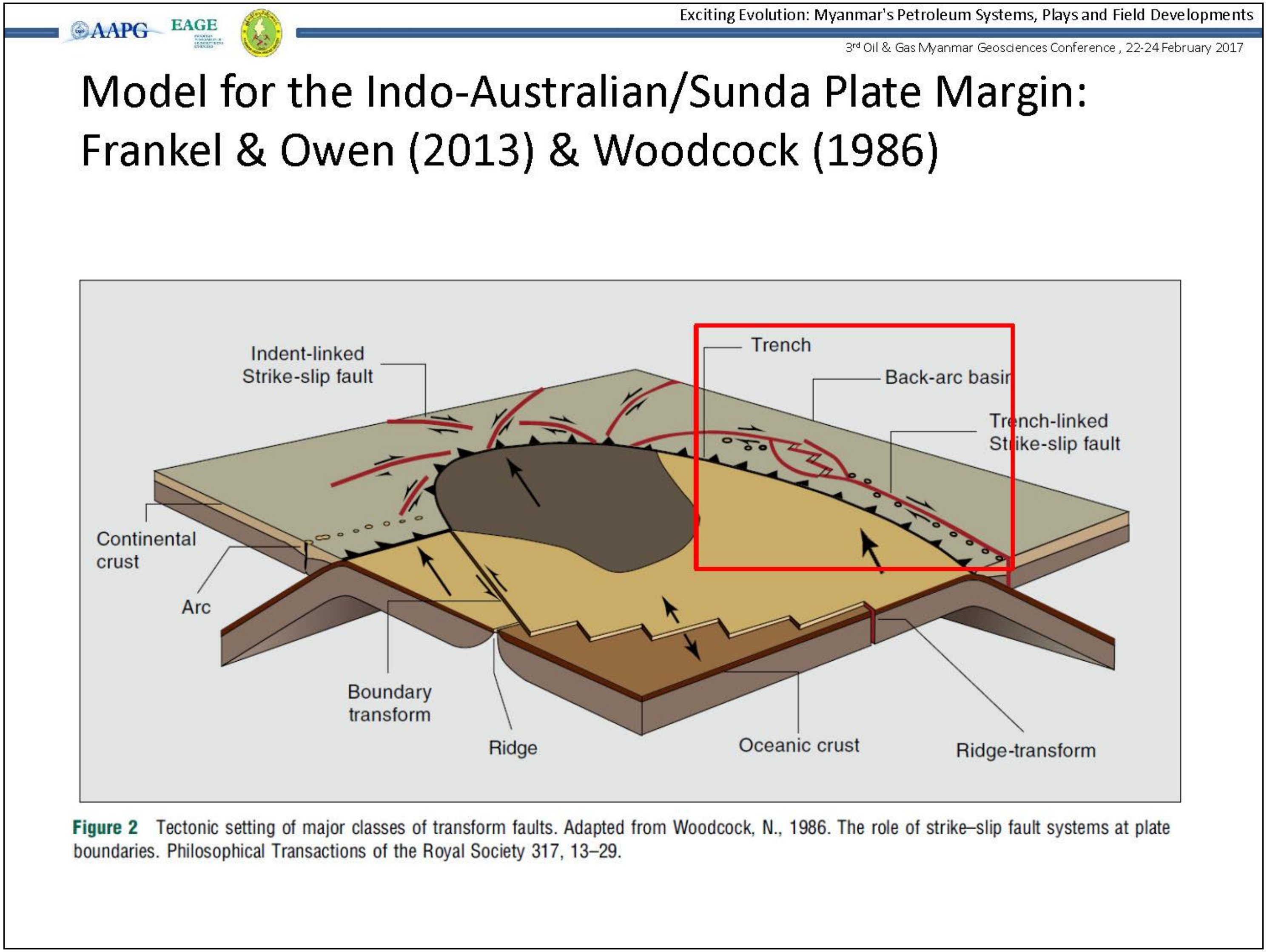
Plate Tectonic Model (& Uplift History): Lee & Lawver (1995) (& Allen et al (2008))

Interpretation: Angle of convergence was +-10° 0-10Ma & 20-35Ma. Andaman sea floor spreading 0-4Ma coincides with low angle of convergence. Subduction may have only occurred along the entire Indo-Australian/Sunda plate margin with higher angles of convergence.

Figure 18. A comparison between Indian convergence history (after Lee and Lawver, 1995, and Guillot et al., 2003) and the uplift and sedimentation history of the rocks studied from South Andaman Island.

Lee and Lawver's (1995) graph illustrates this quantitatively in more detail. Read through the box. The question arises whether there could have been an early period of sea floor spreading associated with low angles of convergence. Note that Allen at el (2008) identified periods of uplift from rock studied from South Andaman Is. Except for recently, periods of uplift are associated with higher angles of convergence and perhaps active subduction.



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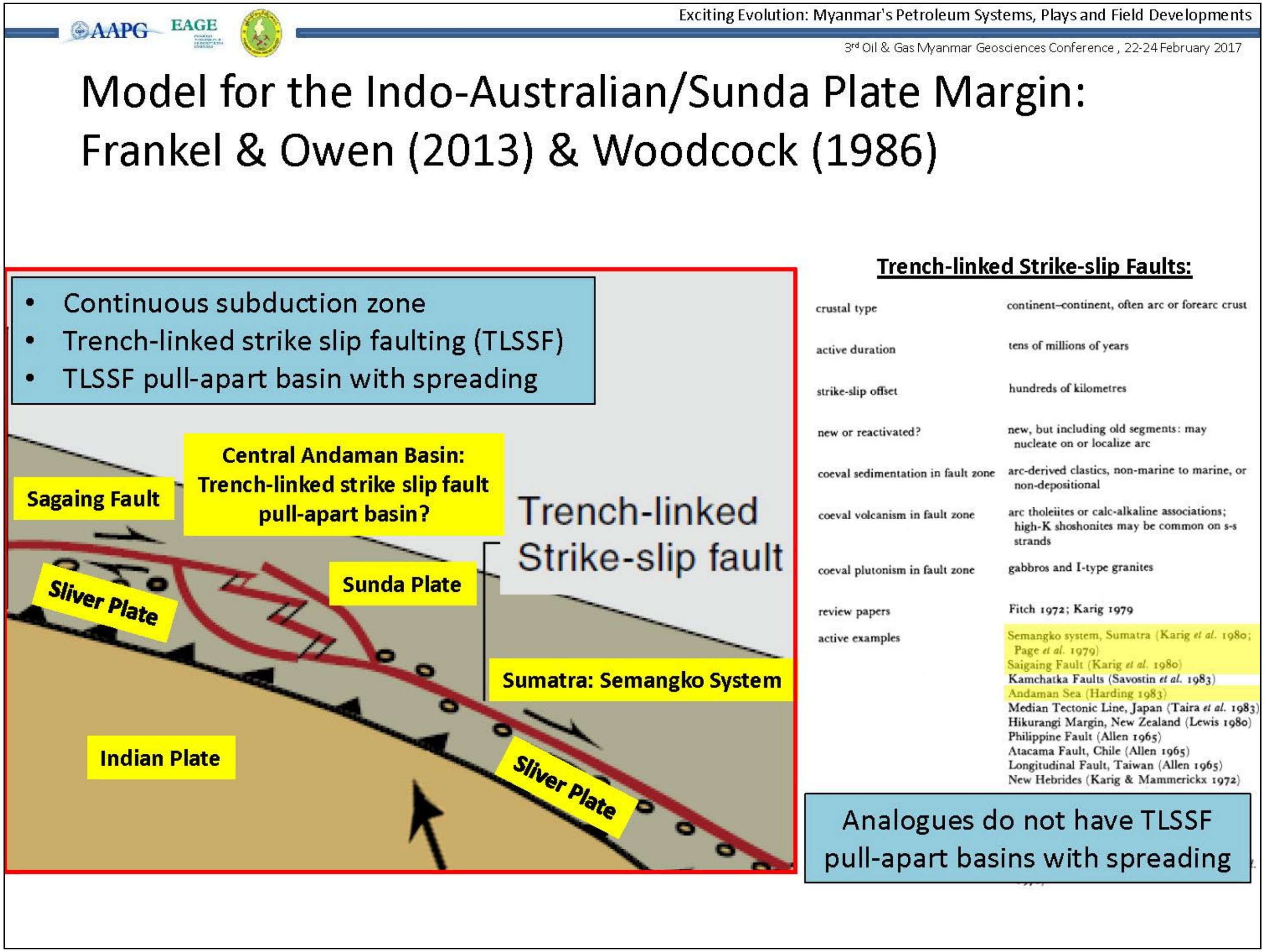
Model for the Indo-Australian/Sunda Plate Margin: Frankel & Owen (2013) & Woodcock (1986)

Figure 2 Tectonic setting of major classes of transform faults. Adapted from Woodcock, N., 1986. The role of strike–slip fault systems at plate boundaries. Philosophical Transactions of the Royal Society 317, 13–29.

One model for the Indo-Australian/Sunda plate margin comes from Woodcock's (1986) tectonic setting of major classes of transform faults. AOI is highlighted in the red box.



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Model for the Indo-Australian/Sunda Plate Margin: Frankel & Owen (2013) & Woodcock (1986)

- Continuous subduction zone
- Trench-linked strike slip faulting (TLSSF)
- TLSSF pull-apart basin with spreading

Trench-linked Strike-slip Faults:

crustal type	continent–continent, often arc or forearc crust
active duration	tens of millions of years
strike-slip offset	hundreds of kilometres
new or reactivated?	new, but including old segments: may nucleate on or localize arc
coeval sedimentation in fault zone	arc-derived clastics, non-marine to marine, or non-depositional
coeval volcanism in fault zone	arc tholeiites or calc-alkaline associations; high-K shoshonites may be common on s-s strands
coeval plutonism in fault zone	gabbros and I-type granites
review papers	Fitch 1972; Karig 1979
active examples	Semangko system, Sumatra (Karig *et al.* 1980; Page *et al.* 1979) Saigaing Fault (Karig *et al.* 1980) Kamchatka Faults (Savostin *et al.* 1983) Andaman Sea (Harding 1983) Median Tectonic Line, Japan (Taira *et al.* 1983) Hikurangi Margin, New Zealand (Lewis 1980) Philippine Fault (Allen 1965) Atacama Fault, Chile (Allen 1965) Longitudinal Fault, Taiwan (Allen 1965) New Hebrides (Karig & Mammerickx 1972)

Analogues do not have TLSSF pull-apart basins with spreading

Zoom of red box identifies key features in the context of Indo-Australian/Sunda plate margin. Central Andaman Basin is trench-linked strike slip fault pull-apart basin. Note blue box comments. Woodcock's (1986) examples include Semangko, Sagaing and Andaman Sea separately and none of the other examples involves a pull-apart basin with spreading.

Subduction to Strike-Slip Transitions: Bilich et al (2001)

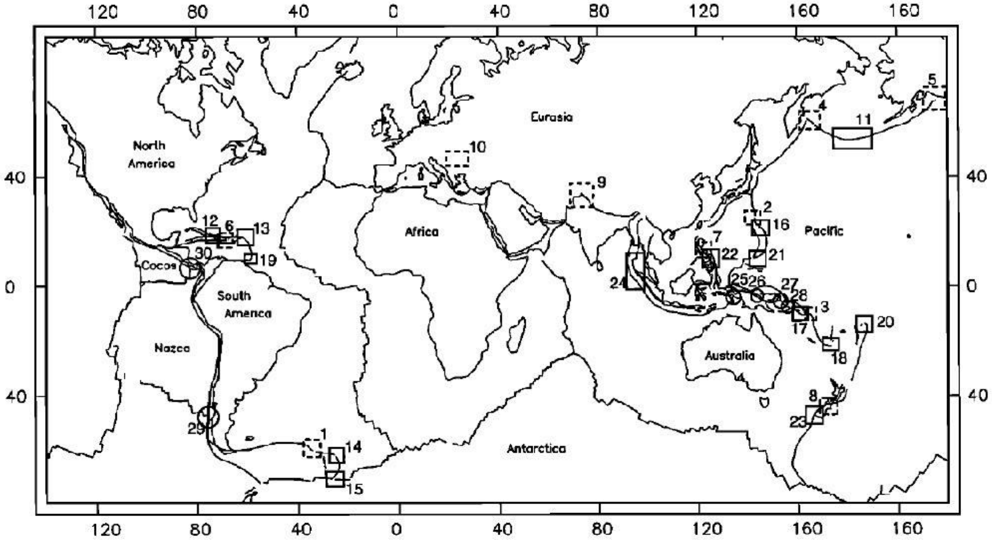


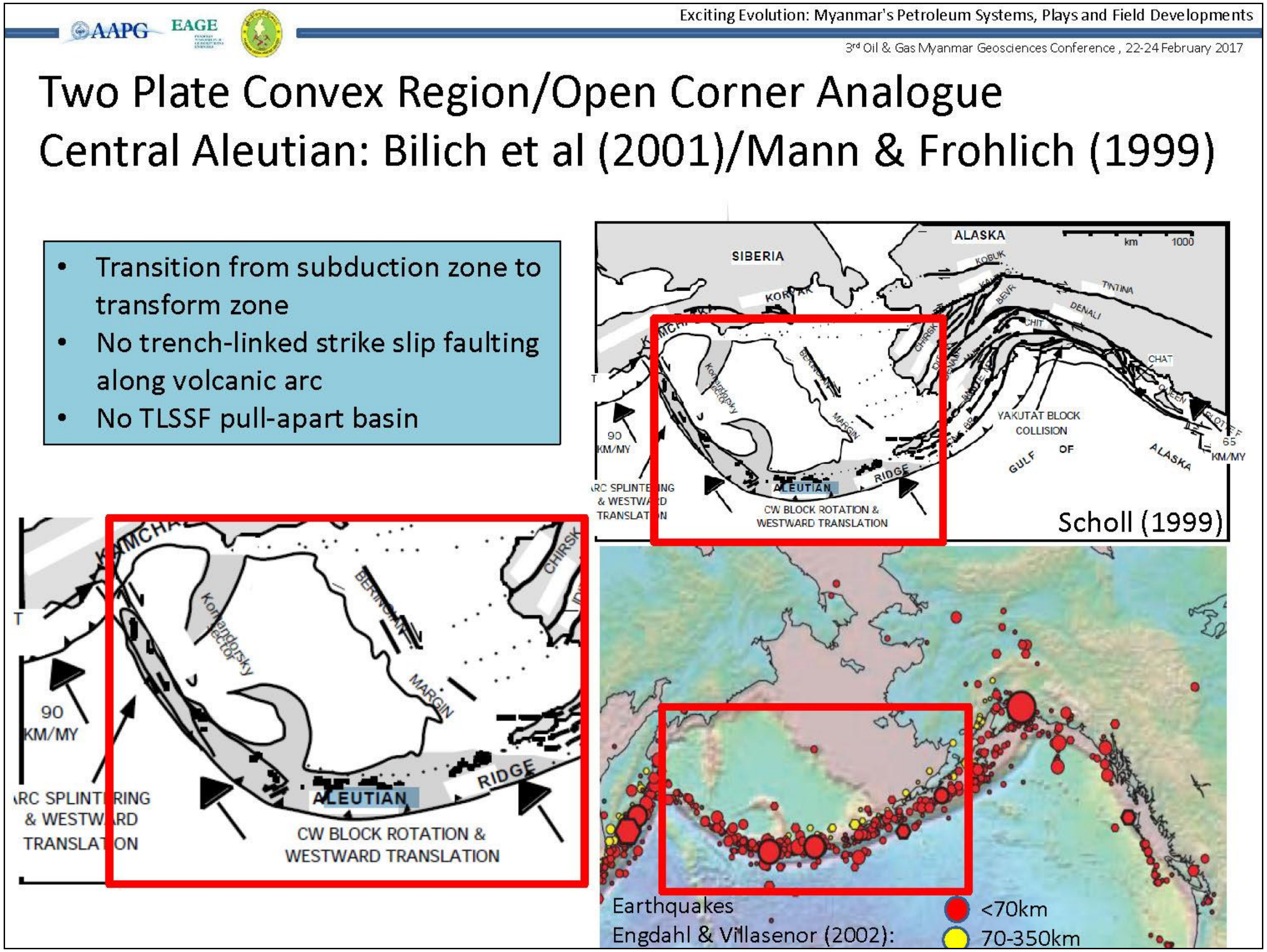
Figure 1. Locations of the 30 subduction-to-strike-slip transition regions, numbered as in Table 1. Regions 1-24 are two-plate transition regions; solid boxes indicate convex trench geometry, while dashed boxes indicate concave trench geometry. Regions 25-30 are triple junctions, indicated by circles. Note that convex and concave transition regions often occur in close geographic proximity.

Region	Plates[a]	Region Name
Two-Plate Concave Regions:		
1	sa-sc	south Georgia
2	pc-ph	Itu Trench
3	au-pc	Santa Cruz-New Hebrides
4	na-pc	Kamchatka
5	na-pc	southwestern Alaska
6	ca-na	Northern Domincan Republic
7	eu-ph	Luzon
8	au-pc	Hikurangi
9	eu-in	western Himalayas
10	af-eu	southern Carpathians
Two-Plate Convex Regions:		
11	na-pc	Central Aleutians
12	ca-na	north Haiti
13	ca-na	Lesser Antilles
14	sa-sc	north Scotia
15	sa-an	South Scotia[d]
16	pc-ph	north Mariana
17	au-pc	south Soloman Islands
18	au-pc	south Vanuatu
19	ca-sa	Trinidad-northern South America[d]
20	au-pc	Samoa Islands-Tonga
21	pc-ph	Guam
22	eu-ph	Mindanao
23	au-pc	southern New Zealand
24	au-eu	Sumatra
Triple Junction Regions:		
25	eu-au-pc	Banda
26	au-nb-sb	New Guinea
27	sb-ss-pc	New Britain
28	ss-pc-au	Woodlark
29	na-an-sa	southern South America
30	ca-nz-na	Cocos-Panama

---

[a] Plate labels are as follows: ph, Philippines; ca, Caribbean, au, Australian; pc, Pacific, eu, Eurasian; af, African; na, North America; sa, South America; an, Antarctic; in, Indian; nb, North Bismark; sb, South Bismark; ss, Solomon Sea; sc, Scotia; and nz, Nazca

Another model for the Indo-Australian/Sunda plate margin comes from Bilich et al's (2001) subduction to strike-slip transitions. Sumatra is listed as a two-plate convex region as are the Central Aleutians, which I would like to compare with Sumatra.



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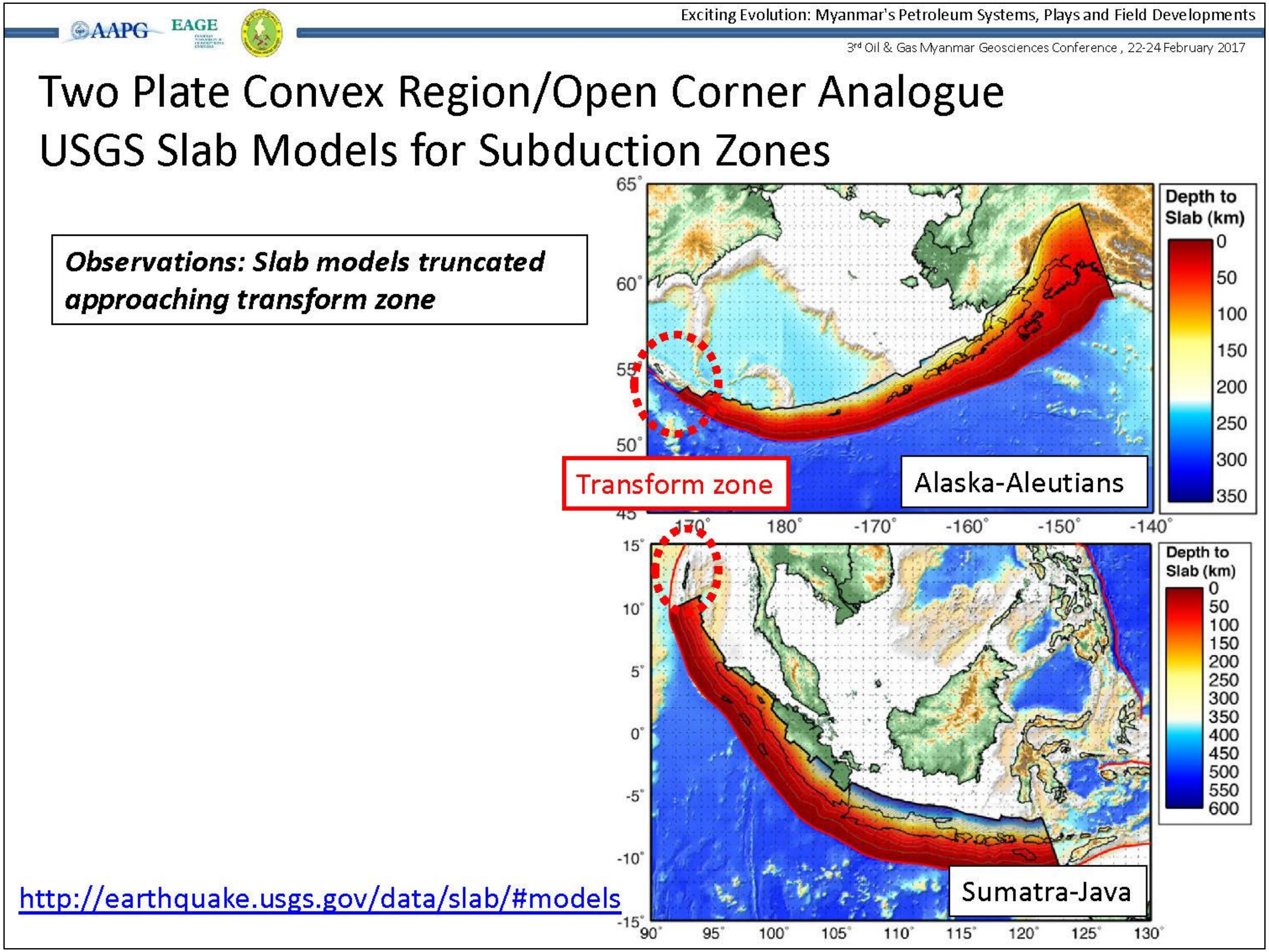
Two Plate Convex Region/Open Corner Analogue Central Aleutian: Bilich et al (2001)/Mann & Frohlich (1999)

- Transition from subduction zone to transform zone
- No trench-linked strike slip faulting along volcanic arc
- No TLSSF pull-apart basin

Scholl (1999)

Earthquakes Engdahl & Villasenor (2002): 🟥 <70km 🟨 70-350km

The Central Aleutians shows a transition from subduction zone to transform zone from east to west as the Pacific Plate motion changes from orthogonal to parallel. No trench-linked strike-slip faulting is identified along the Aleutian Volcanic Arc and there is no pull-apart basin but earthquakes follow the same pattern seen going from Sumatra to the Andaman Is and a sliver plate can be interpreted in strike-slip zone in the west.

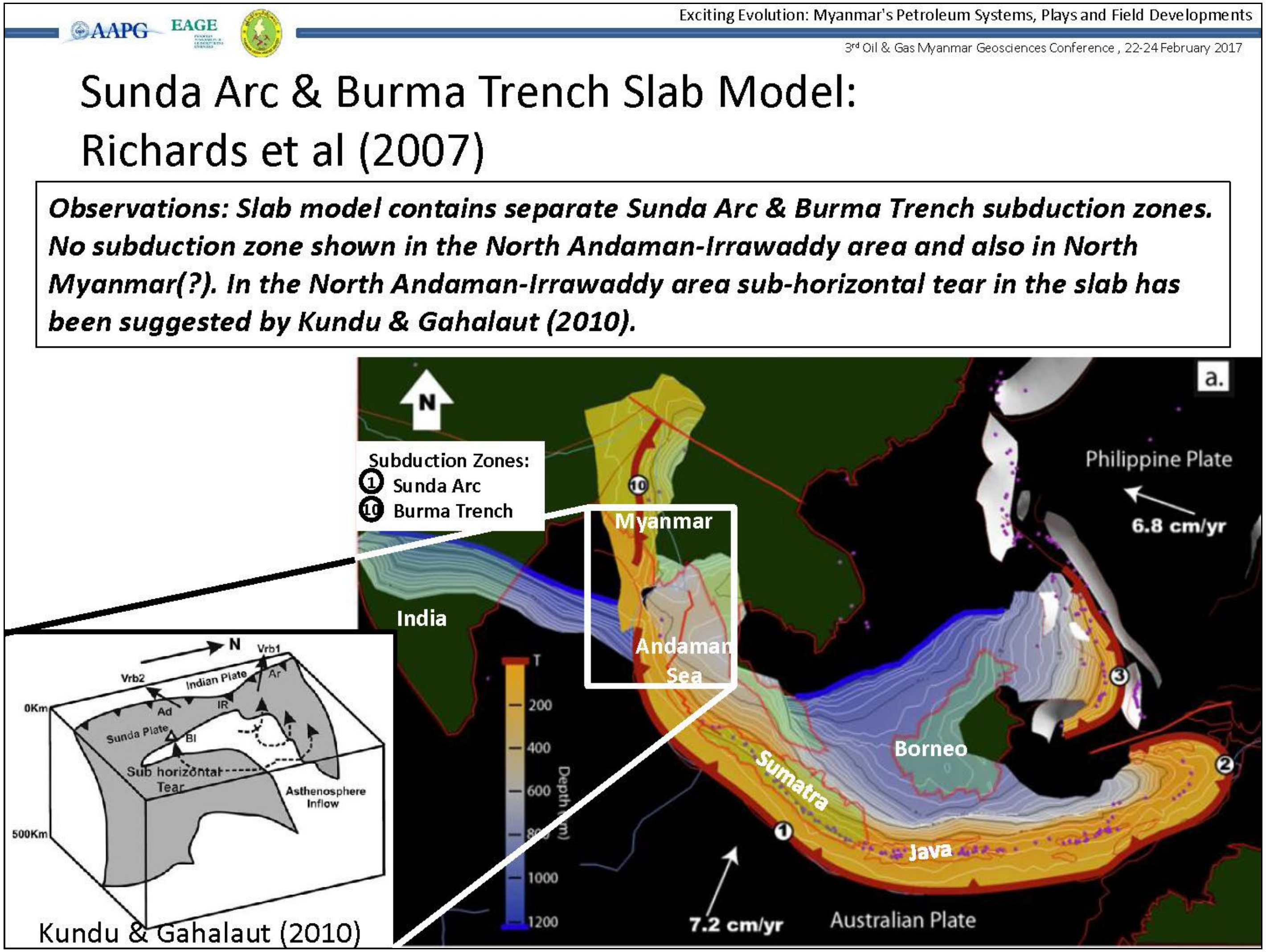


Two Plate Convex Region/Open Corner Analogue
USGS Slab Models for Subduction Zones

Observations: Slab models truncated approaching transform zone

http://earthquake.usgs.gov/data/slab/#models

The USGS slab models for Alaska-Aleutians and Sumatra-Java and similar and they are both truncated approaching the respective transform zones.



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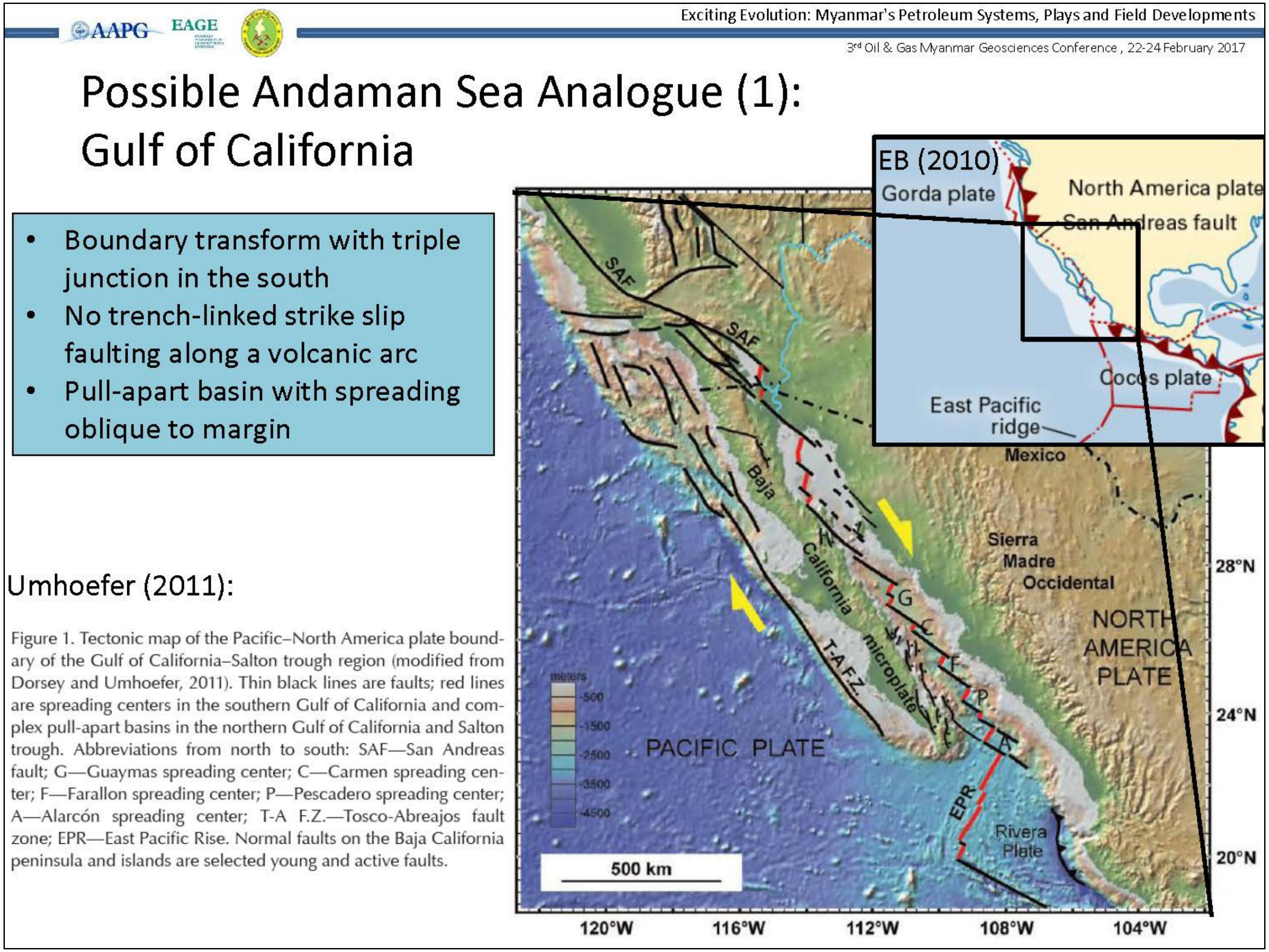
Sunda Arc & Burma Trench Slab Model: Richards et al (2007)

Observations: Slab model contains separate Sunda Arc & Burma Trench subduction zones. No subduction zone shown in the North Andaman-Irrawaddy area and also in North Myanmar(?). In the North Andaman-Irrawaddy area sub-horizontal tear in the slab has been suggested by Kundu & Gahalaut (2010).

Kundu & Gahalaut (2010)

Richards et al (2007) slab model goes further and shows separate Sunda Arc & Burma Trench subduction zones. No subduction zone shown in the North Andaman-Irrawaddy area and perhaps in North Myanmar. In the North Andaman-Irrawaddy area sub-horizontal tear in the slab has been suggested by Kundu and Gahalaut (2010). This may give an idea of what happens to a slab in a subduction to strike-slip transition with time.



Possible Andaman Sea Analogue (1): Gulf of California

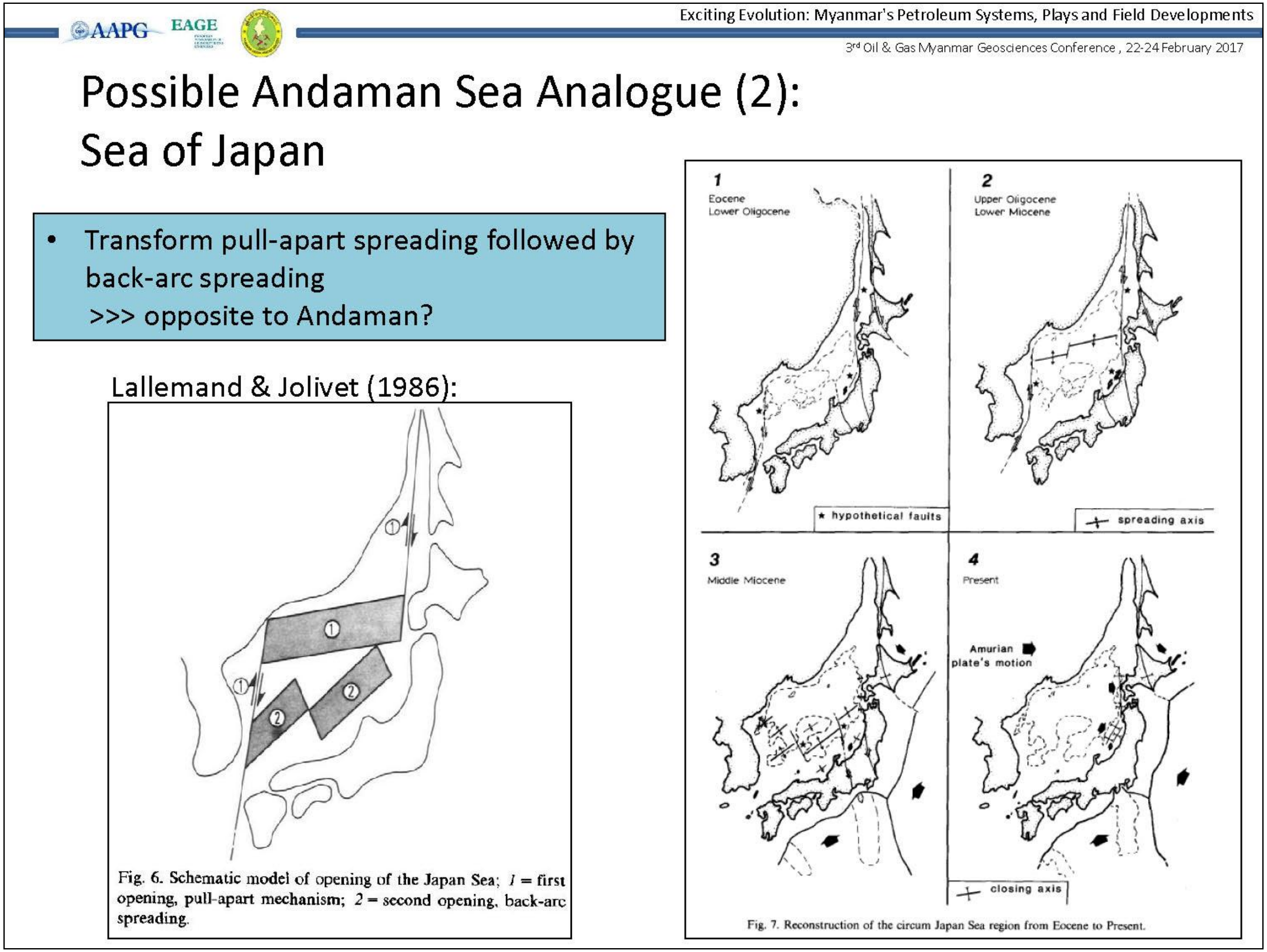
- Boundary transform with triple junction in the south
- No trench-linked strike slip faulting along a volcanic arc
- Pull-apart basin with spreading oblique to margin

Umhoefer (2011):

Figure 1. Tectonic map of the Pacific–North America plate boundary of the Gulf of California–Salton trough region (modified from Dorsey and Umhoefer, 2011). Thin black lines are faults; red lines are spreading centers in the southern Gulf of California and complex pull-apart basins in the northern Gulf of California and Salton trough. Abbreviations from north to south: SAF—San Andreas fault; G—Guaymas spreading center; C—Carmen spreading center; F—Farallon spreading center; P—Pescadero spreading center; A—Alarcón spreading center; T-A F.Z.—Tosco-Abreajos fault zone; EPR—East Pacific Rise. Normal faults on the Baja California peninsula and islands are selected young and active faults.

EB (2010)

In the Gulf of California we see a boundary transform with a subduction zone to the south, however, this is in the context of a triple junction. There is no trench-linked strike slip faulting along a volcanic arc but there is a pull-apart basin with spreading oblique to the margin. Note the identification of the Baja California microplate or sliver plate.



Possible Andaman Sea Analogue (2): Sea of Japan

- Transform pull-apart spreading followed by back-arc spreading
  >>> opposite to Andaman?

Lallemand & Jolivet (1986):

Fig. 6. Schematic model of opening of the Japan Sea; *1* = first opening, pull-apart mechanism; *2* = second opening, back-arc spreading.

Fig. 7. Reconstruction of the circum Japan Sea region from Eocene to Present.

The Sea of Japan has been interpreted as transform pull-apart spreading followed by back-arc spreading which would be the opposite to the Andaman Sea.

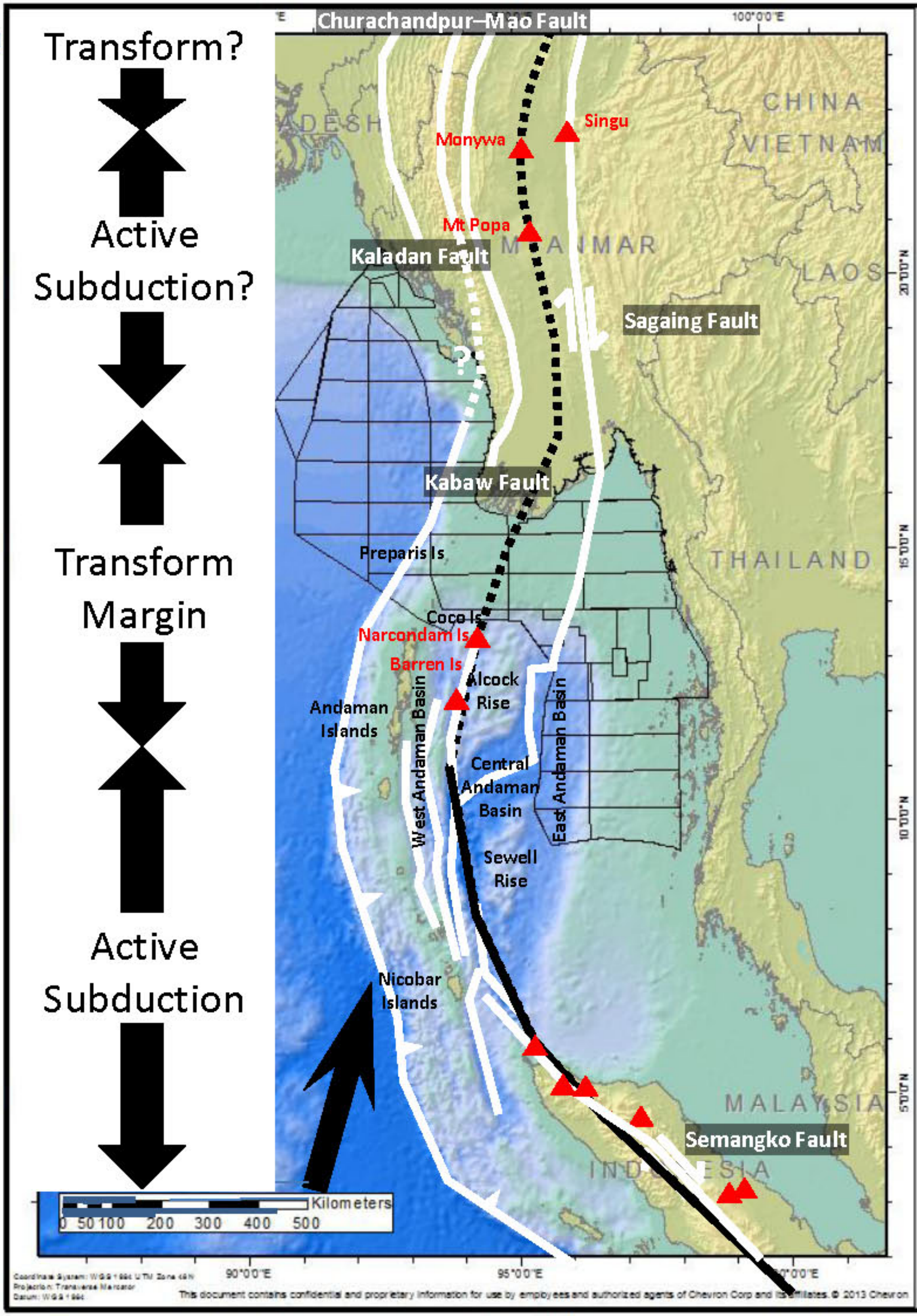
Integration & Insights From Indonesia to Myanmar: The Indo-Australian/Sunda Plate Margin in Space & Time

Present day:

- ***Plate margin shows transition(s) from subduction to transform***
- ***Central Andaman Basin is a trench-linked strike-slip fault pull-apart basin***
- ***Recent volcanism seen at Barren Is, Narcondam Is and in Central Myanmar transform margin/slab tear related?***

In the Past:

- ***Plate margin was wholly subduction to +-25Ma(?)***
- ***Subduction may have ceased in North Andaman-Irrawaddy region +-25Ma and in North Myanmar +-13.5Ma***
- ***Alcock & Sewell Rises may represent Early Miocene episode of trench-linked strike-slip fault pull-apart sea floor spreading (Curray, 2005)***



THANK YOU