NORTH SUMATRA – MERGUI BASIN
CROSS BORDER CASE STUDY
EPPM-CCOP

INDONESIAN PROGRESS REVIEW

P1W3 Outcomes & Way Forward

- The case study teams of Indonesia, Malaysia and Thailand have agreed on the following work assignments for the study :

1. Indonesia Team

a. Convert the time structure map to depth
b. Heat flow map, geothermal gradient - inputs to basin modeling
c.To make a 2D basin modeling, with the 2 other countries to provide their data

2. Malaysia

a. Seismic facies map – Thailand to provide their data to Malaysia
b. Chronostratigraphic map

3. Thailand

a. Structural cross-section (using at least 3 lines)

DEPTH MAP of JOINT STUDY AREA

QUALITY and QUANTITY DATA

NO.	SOURCE DATA	LINE NAME
1	INDONESIA	123A
2		123B
3		132_SP6122-101_MV
4		209C
5		210
6		259
7		463-463A
8		506-85_SP714-100_MV
9		NSO69 25
10		NSO69 46
11		NSO80 503
12		NSO81 13
13	THAILAND	DMR95-102
14		DMR95-125
15		DMR95-141
16		DMR95-150
17	MALAYSIA	83MS02
18		83MS09

Tabel 1.1 Seismic data supporting the study

Spacing seismic data is not dense. After loading the seismic data, we have about 15 seismic lines, see Figure 1.1

Note : Almost the available seismic data is migration/stack vectorized

Seismic data consists of some seismic vintage s

Amplitude, continuity and resolution seismic data are moderate quality

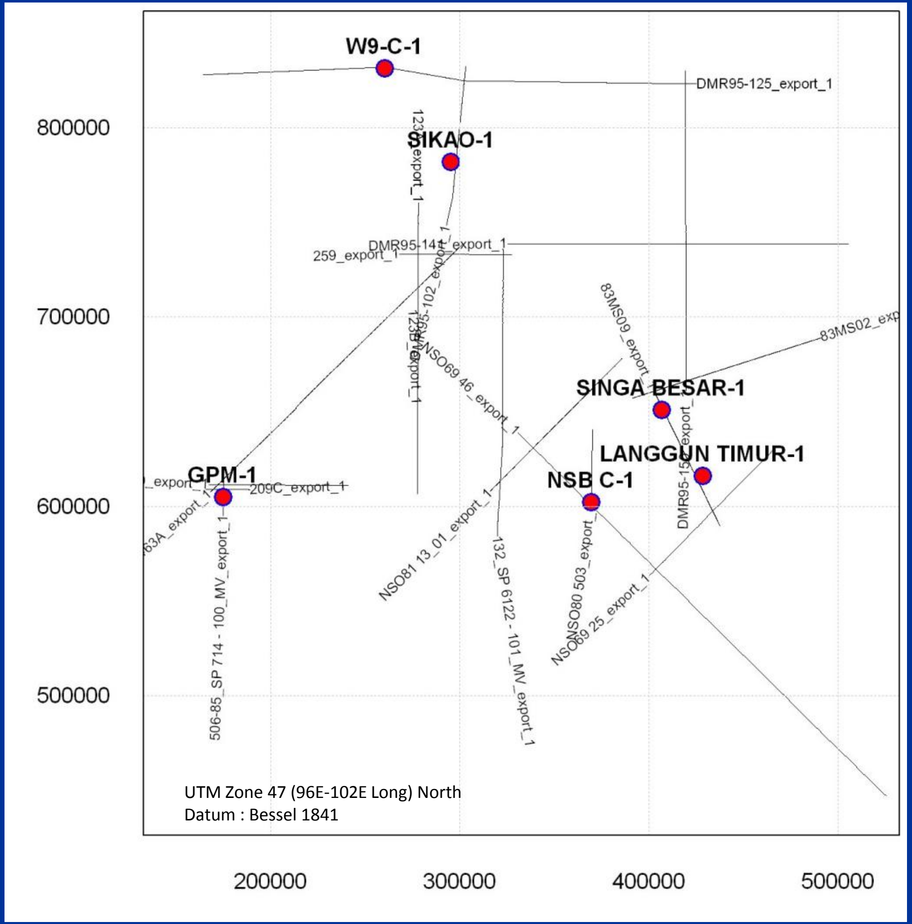


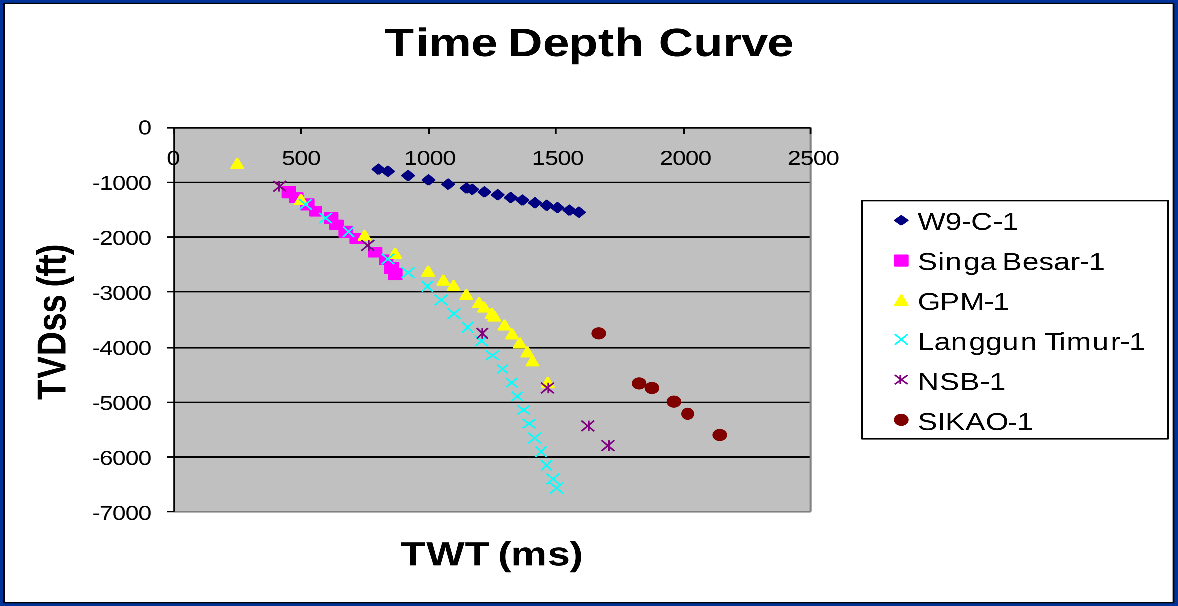
Figure 1.1 BASEMAP OF THE STUDY AREA

Tabel 1.2 The existing well data

No.	Well Name	Lat.	Lon.	TD (ft)	KB (ft)	SOURCE FROM	CHECK-SHOT	LOG DATA
1	GPM-1	5.464906	96.0692	4730.5	42.65	INPEX ACEH LTD	Available	Complete
2	LANGGUN TIMUR-1	5.571326	5.571326	6700	48	SUN OIL	Available	GR log Only
3	NSB C-1	5.44651	97.82547	5900	32	MOBIL OIL INDONESIA INC	Available	Complete, but nothing RHOB log
4	SIKAO-1	7.072194	97.14706	5685	83		Available	Complete
5	SINGA BESAR-1	5.886994	98.15987	2821	51	SUN OIL		GR log Only
6	W9-C-1	7.52	96.83	12219	46		Available	Nothing

All well data are vertical well.

Only two wells have complete log information, but minimum sonic and density log data.



In this study doesn't have any velocity information. Converting time to depth used check-shot information only.

All well data have check-shot data but unfortunately the sampling data is not densely, see Figure 1.1

Figure 1.1

Tabel-1.3

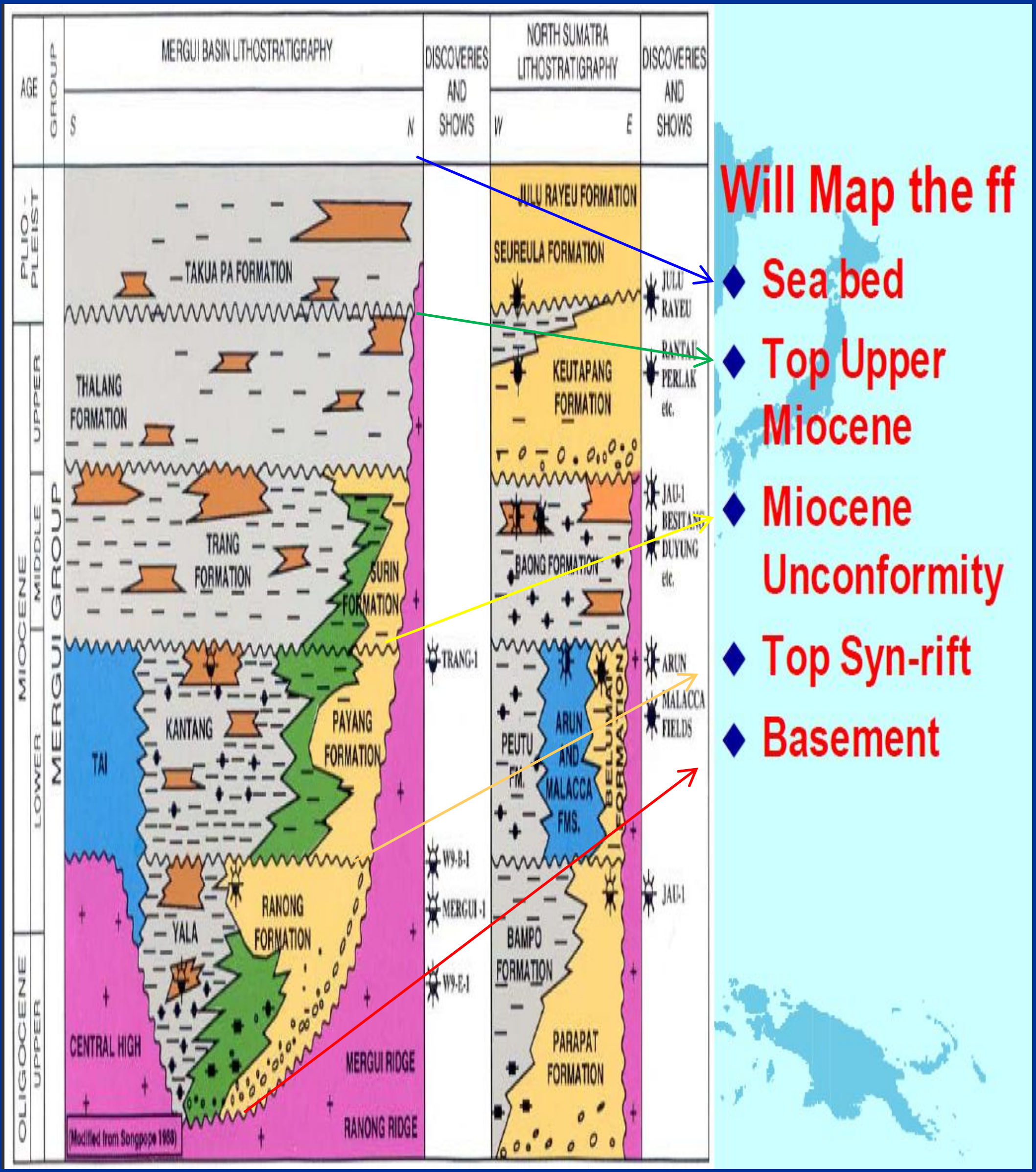
Tabel 3.1 contains well top marker at each well, except W9 C-1 well

Not all well data have complete well top marker.

There are five (5) horizons picked in the study. The interpreted horizons are marked by highlight with blue color.

MARKER	Langgun Timur-1			GPM-1			NSB-1			Singa Besar-1			SIKAO-1		
	Time (ms)	MD (ft)	TVDss (ft)	Time (ms)	MD (ft)	TVDss (ft)	Time (ms)	MD (ft)	TVDss (ft)	Time (ms)	MD (ft)	TVDss (ft)	Time (ms)	MD (ft)	TVDss (ft)
Seabed	155			787			140			148			1324		
Julu Rayeu Top					2673	-2630.4		810	778						
Julu Rayeu Base								2400	2368						
Seurula Top								2460	2428						
Seurula Base								3425	3393						
Top U Mio/Keutapang	803	2353.02	-2305	1106			1205	3550	-3518	746	2216.21	-2165.2	1565		-3679
Keutapang Base								5100	5068						
Mio Unconf/Baong base	1027	3206.36	-3158.4	1455			1625	5220	-5188	habis		habis	1815		-4597
T. Synrift/Bampo	1147	3929.13	-3881.1	1609	3505.58	-3462.9	1783	5758	-5726	habis		habis	1988	4764	-4681
														5010	-4927
Top Karbonat														5226	-5143
Lithic Tuff					4537.4	-4494.8									
Basement	1306	4604.33	-4556.3	1710	4593.18	-4550.5	1945			858	2639.76	-2588.8	2288	5616	-5533

AGREEMENTS

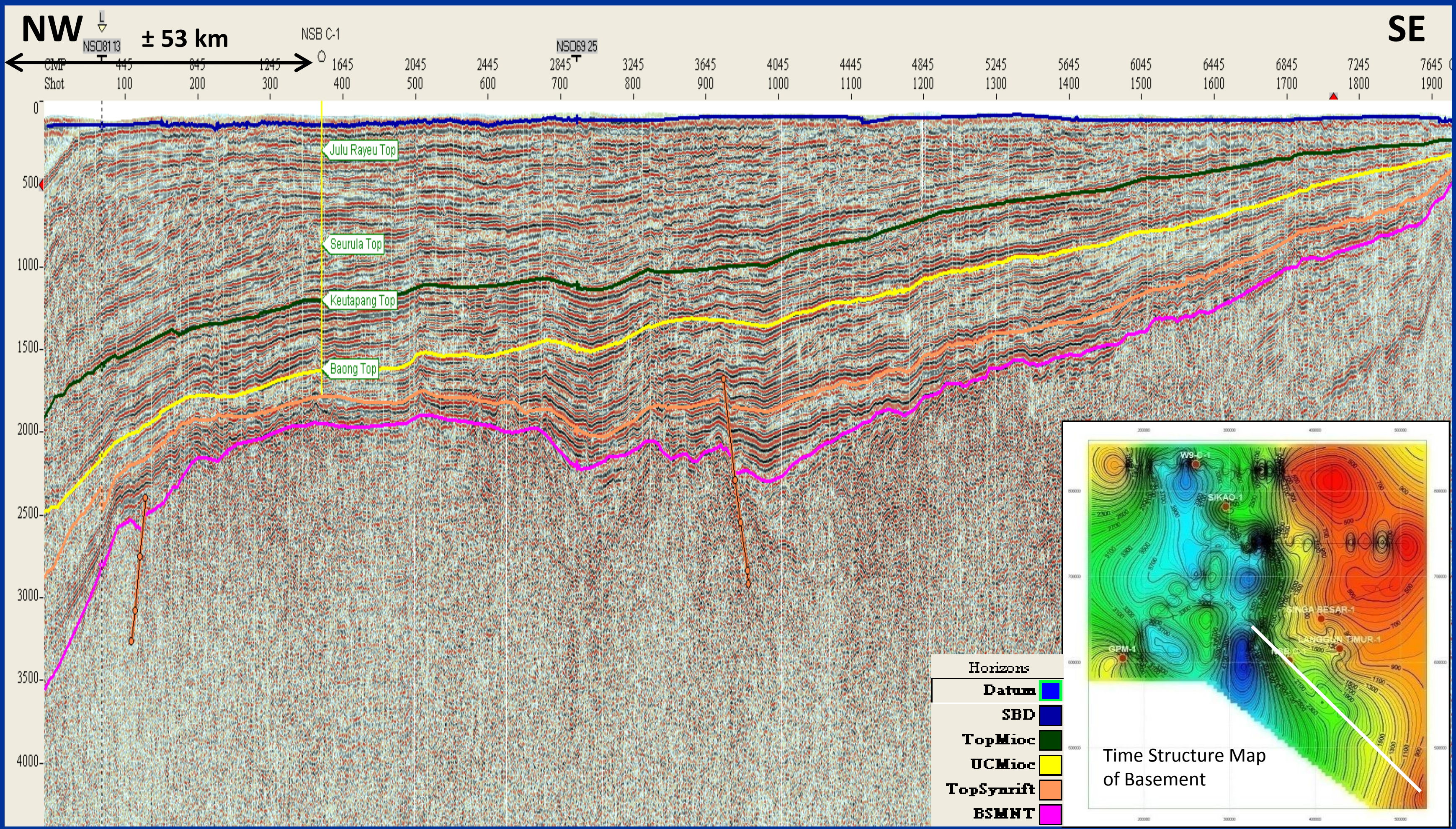


a. Sea bed – blue
b. Top Upper Miocene – Green
c. Miocene Unconformity – Yellow
d. Top Syn-rift – Orange
e. Basement – red/purple

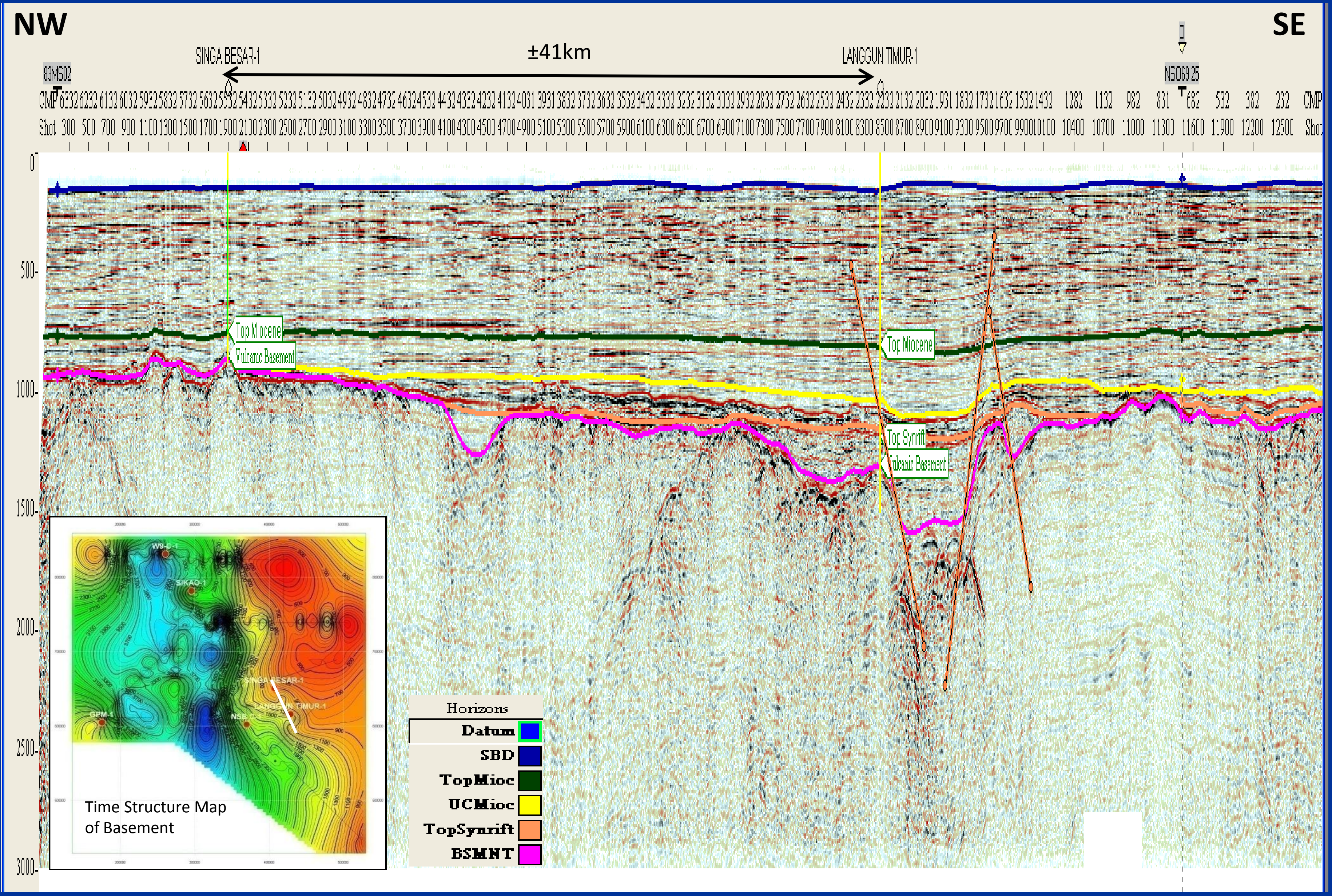
a. Maps – 1: 500,000
b. Seismic sections – 5cm/sec, vertical up to 6 sec.

Synthetic seismogram was not created because the available log data not support and also not complete log data at the interested depth range. Fortunately, in general the check-shot quality is good enough. By using the check-shot, we have good in well tied to seismic. Next, this information will be used to convert time to depth.

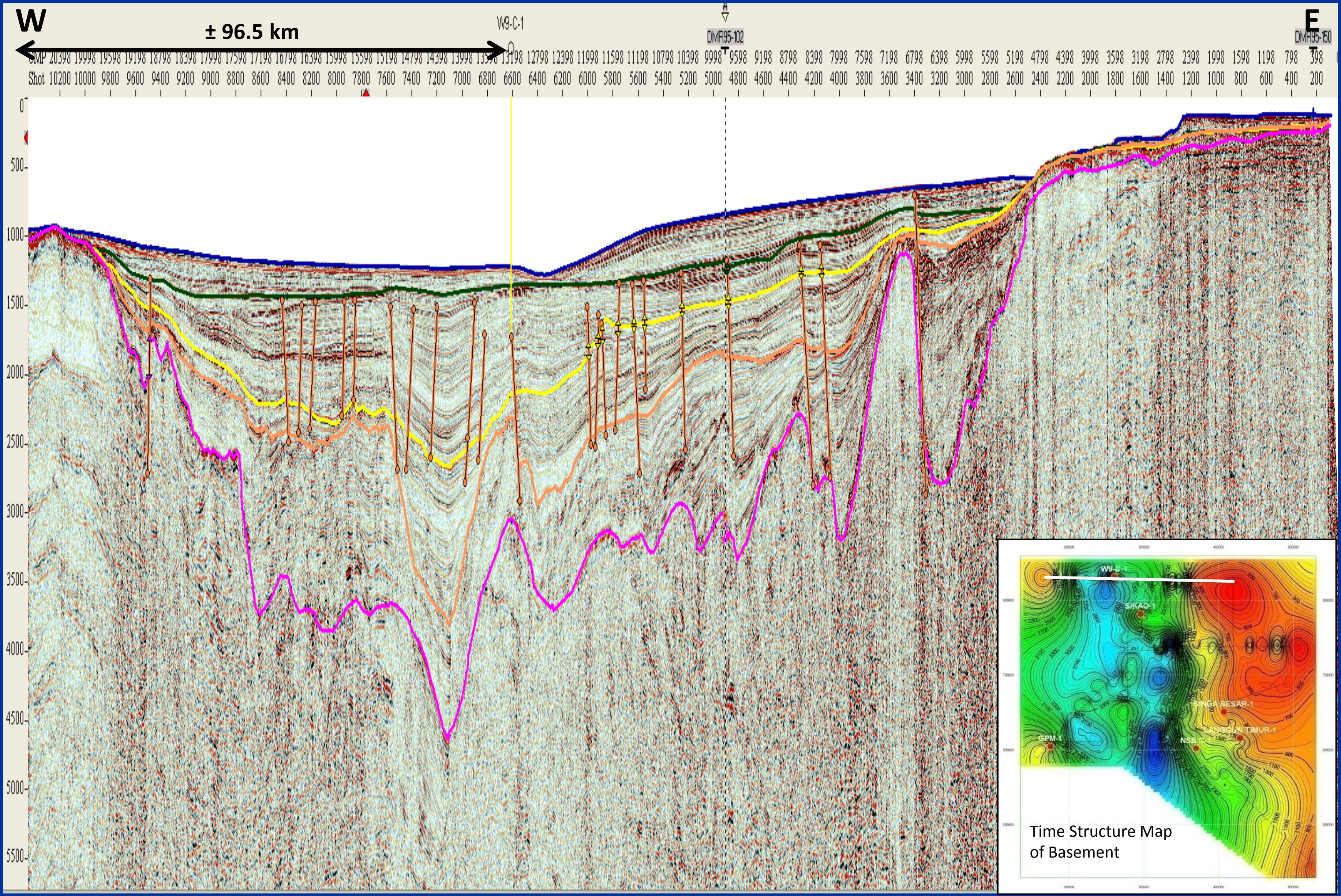
All seismic lines below (un-fault interpretation sections) crossed by or close to well are used as key line for seismic interpretation, actually many faults mainly in basement.



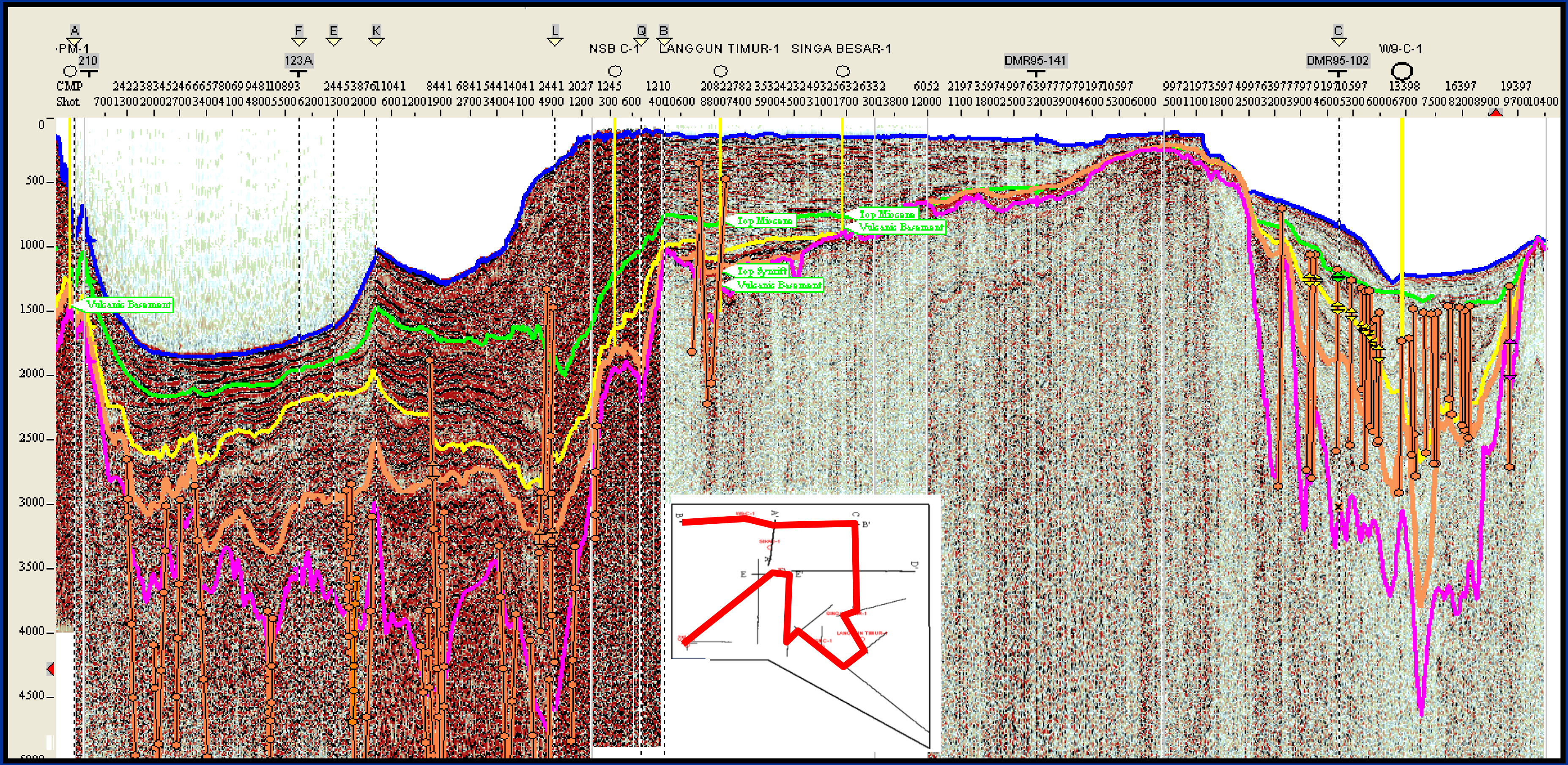
LINE NSO69 46 (INDONESIA)



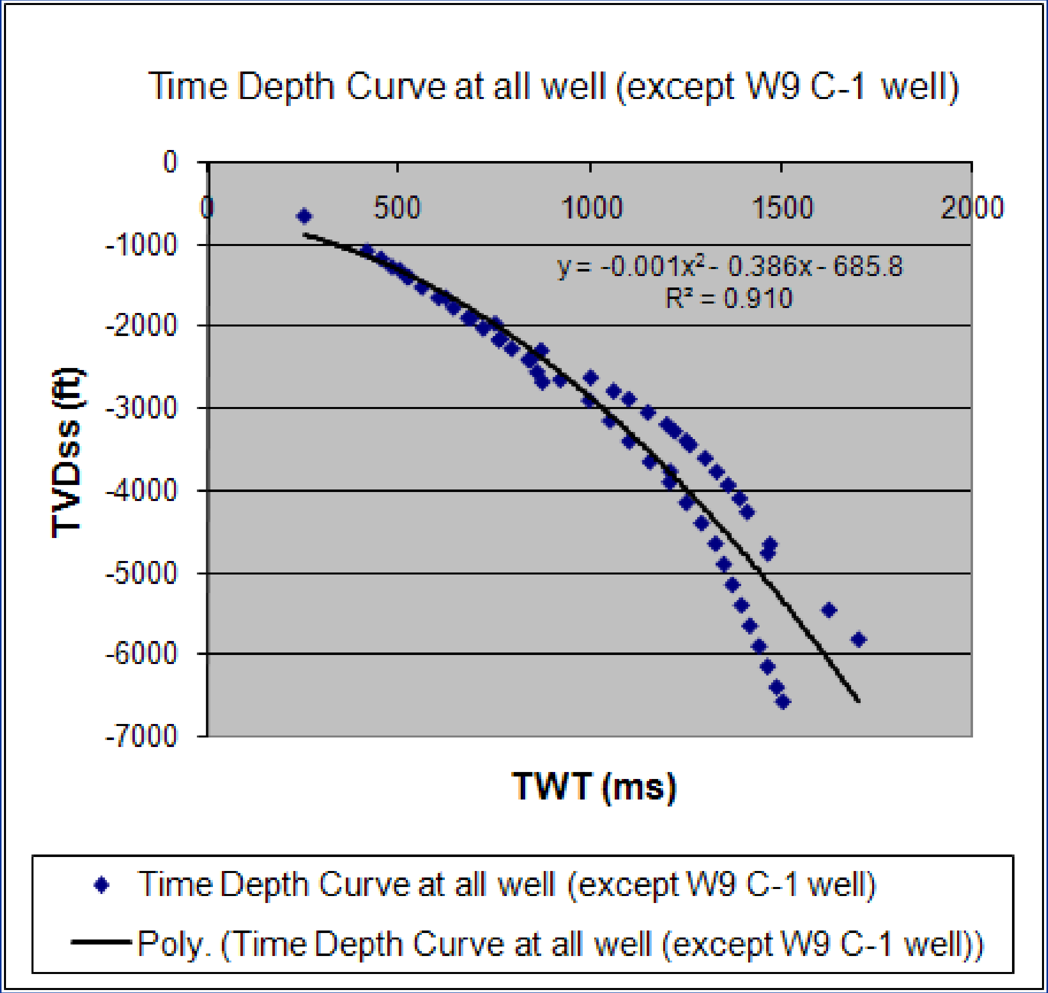
LINE 83MS09 (MALAYSIA)



DMR95-125 (THAILAND)



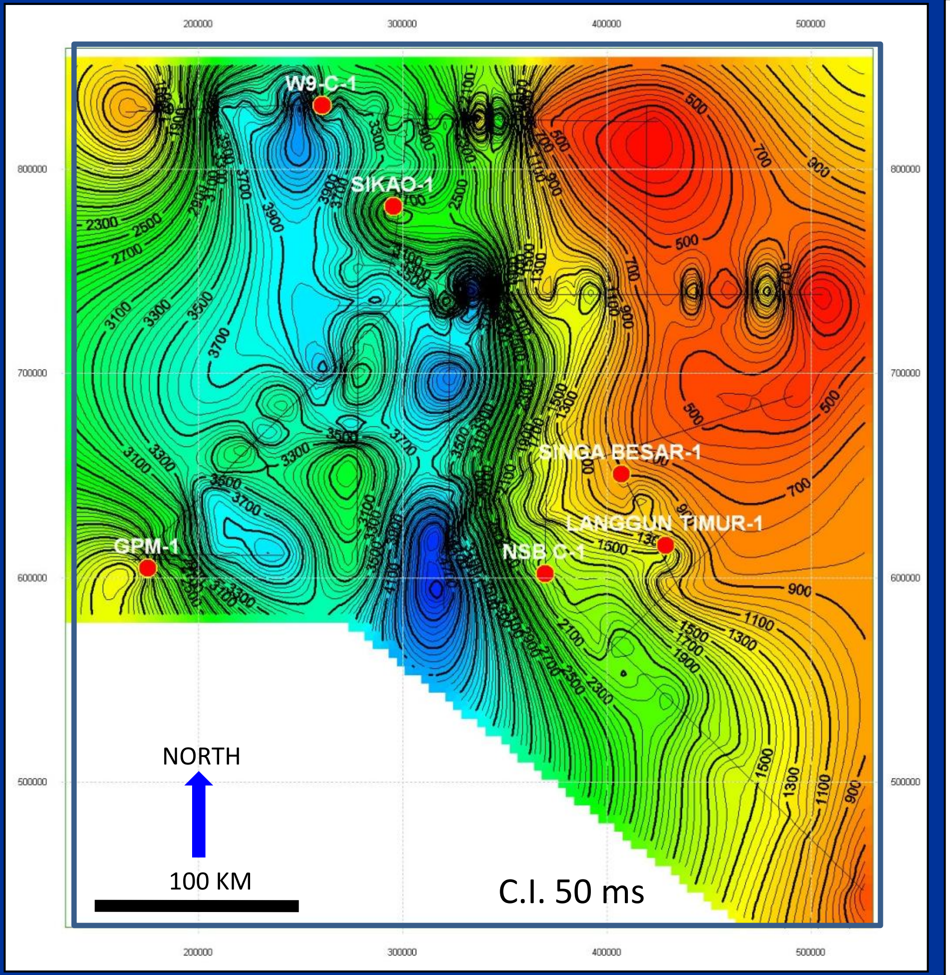
COMPOSITE SEISMIC SECTION)



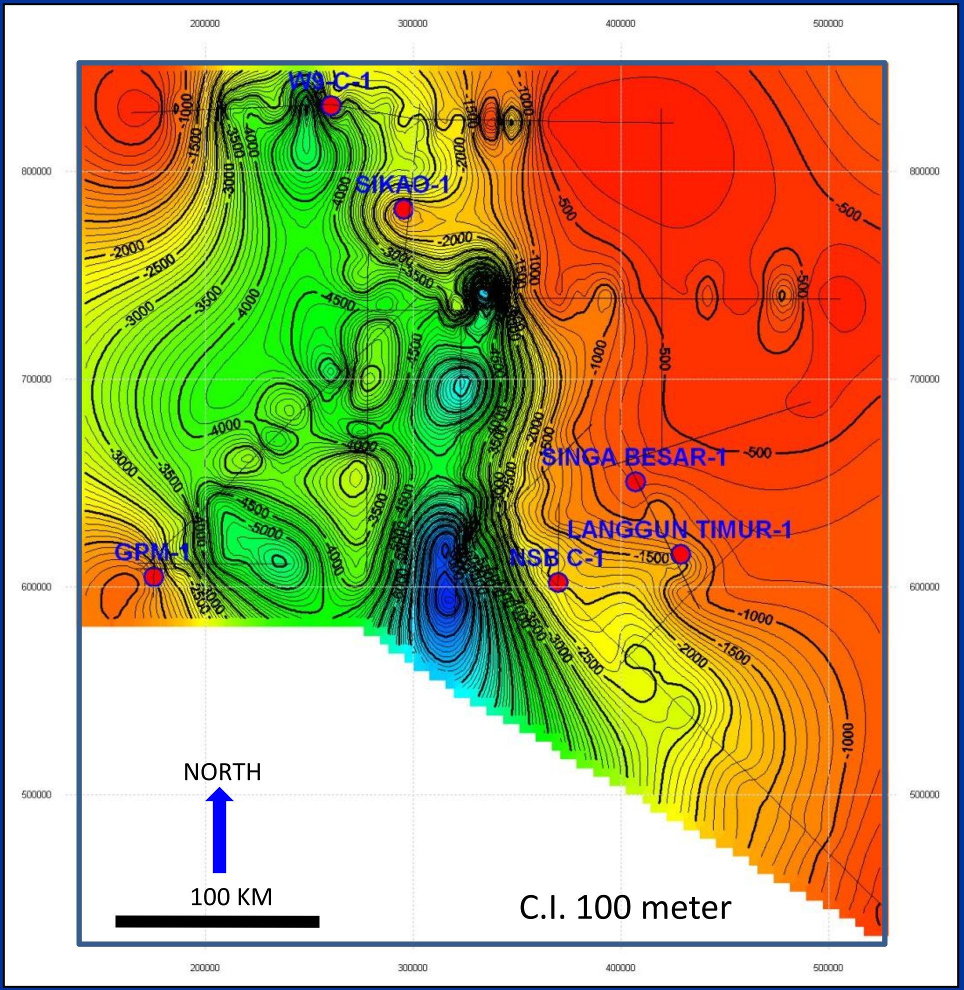
The equation resulted from the time depth curve beside is used to generate initial depth.

Then, initial average velocity can also be calculated.

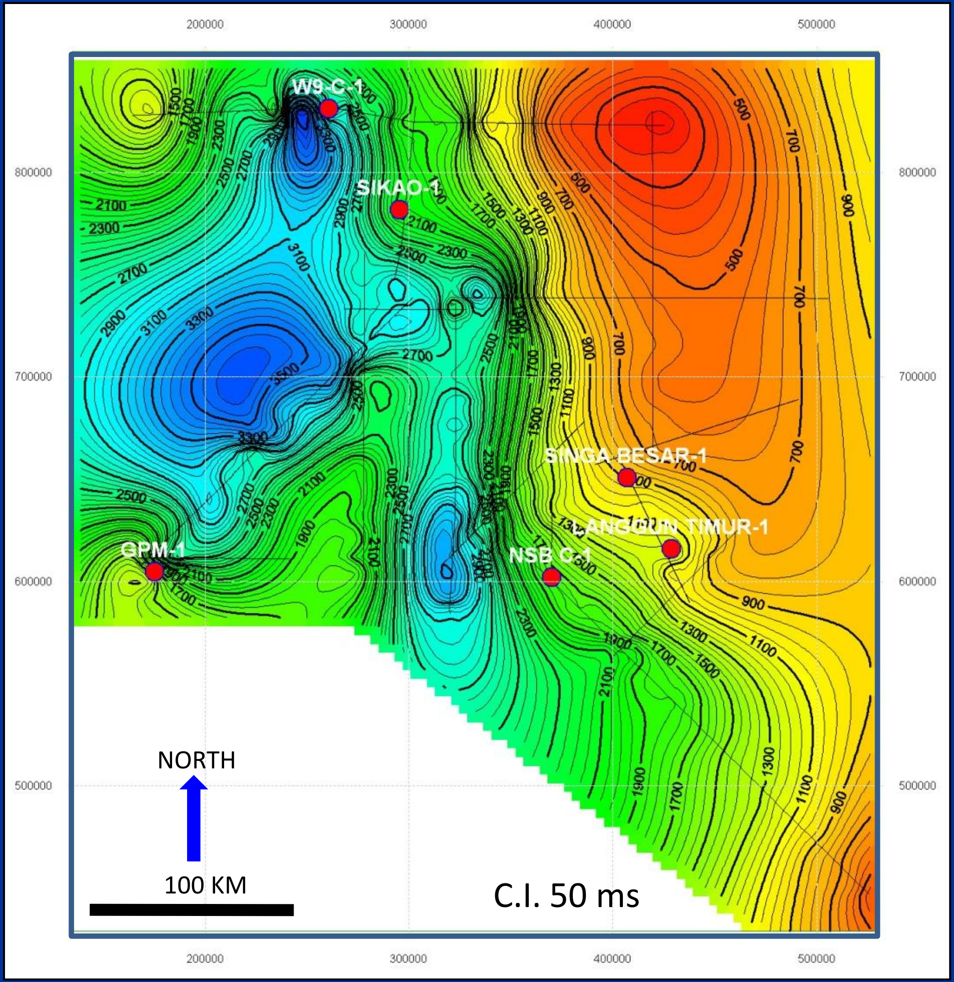
Next step, the initial average velocity is adjusted and calculated until the obtained calculated depth matching with depth value at each well.



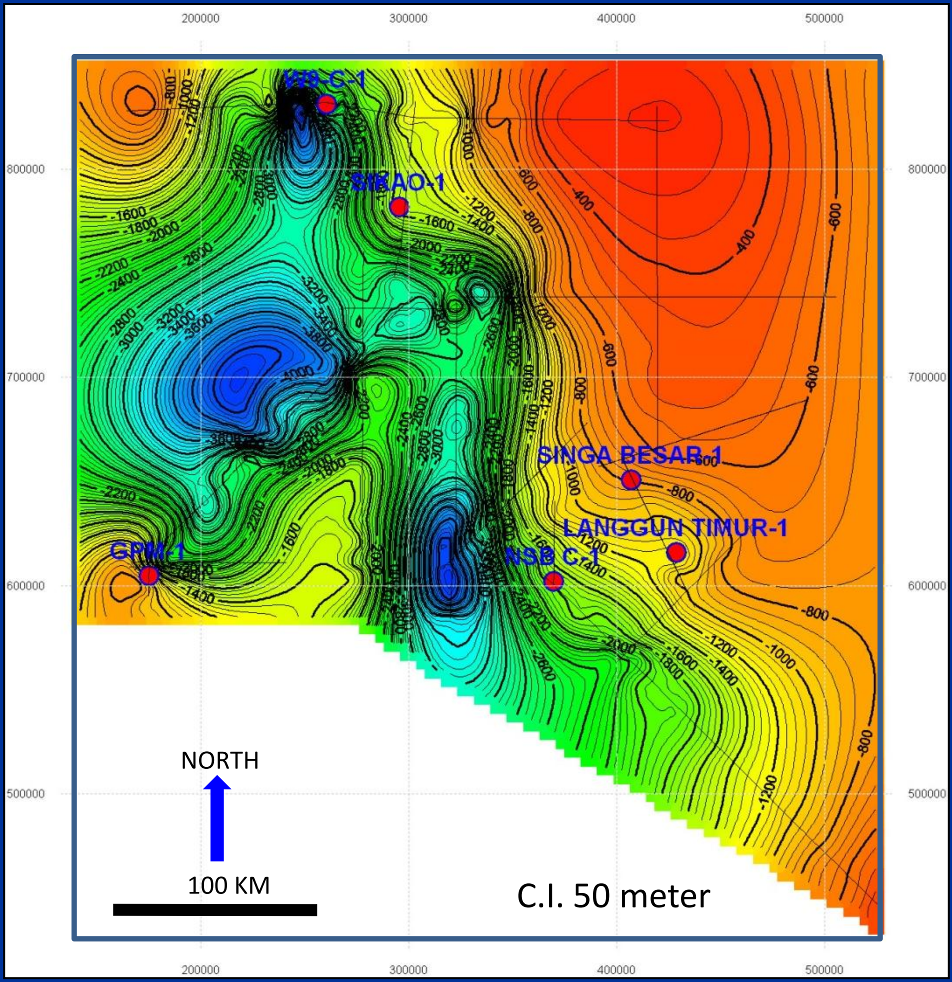
TIME STRUCTURE MAP BASEMENT



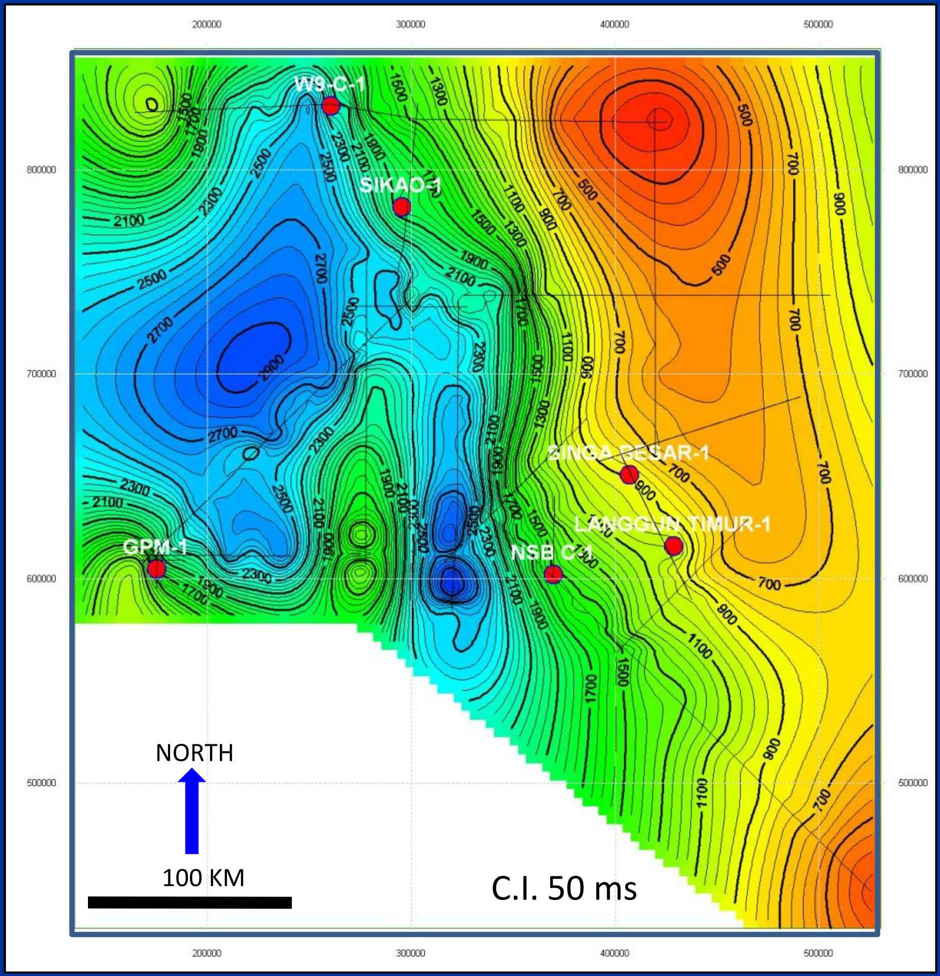
DEPTH STRUCTURE MAP BASEMENT



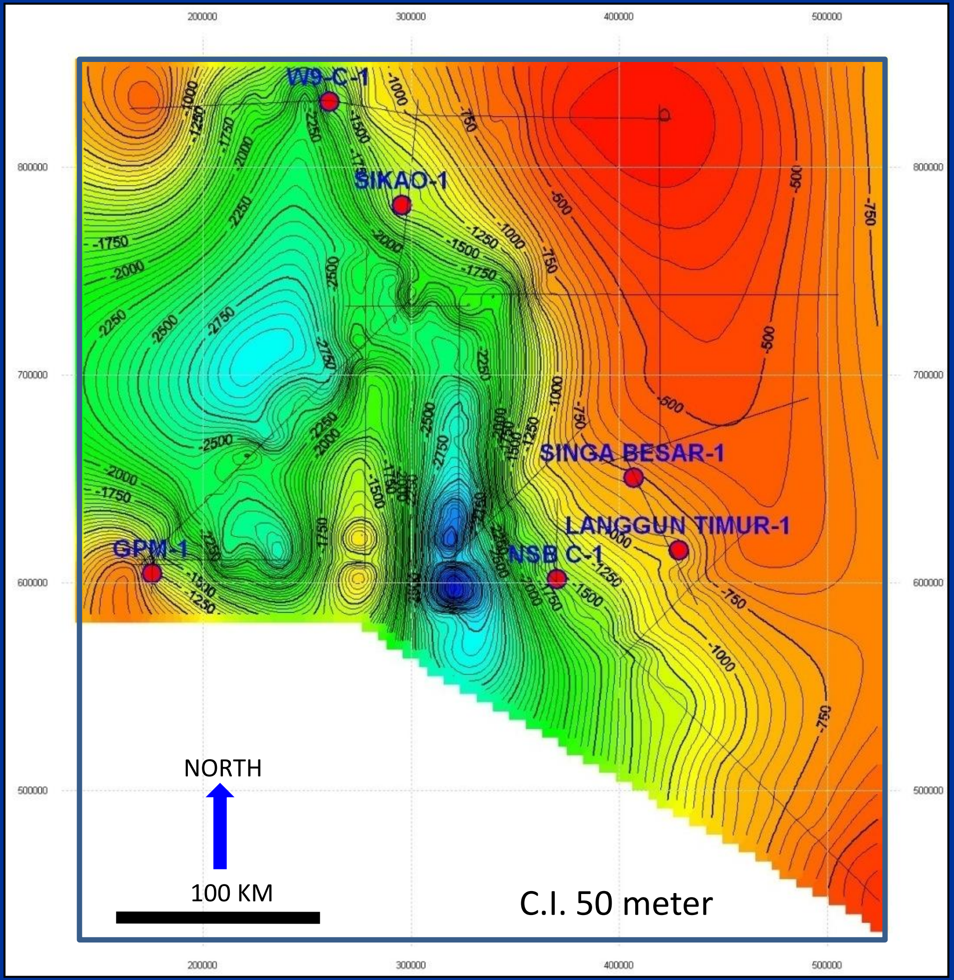
TIME STRUCTURE MAP
TOP SYN-RIFT



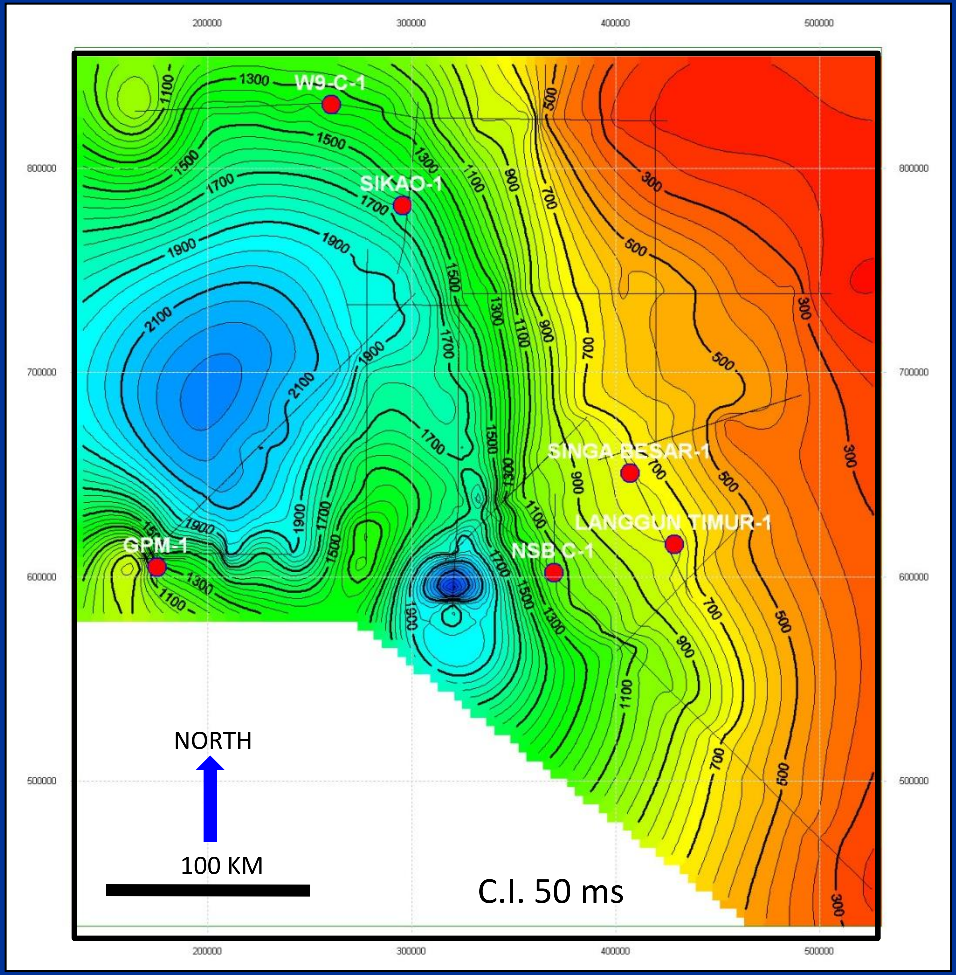
DEPTH STRUCTURE MAP
TOP SYN-RIFT

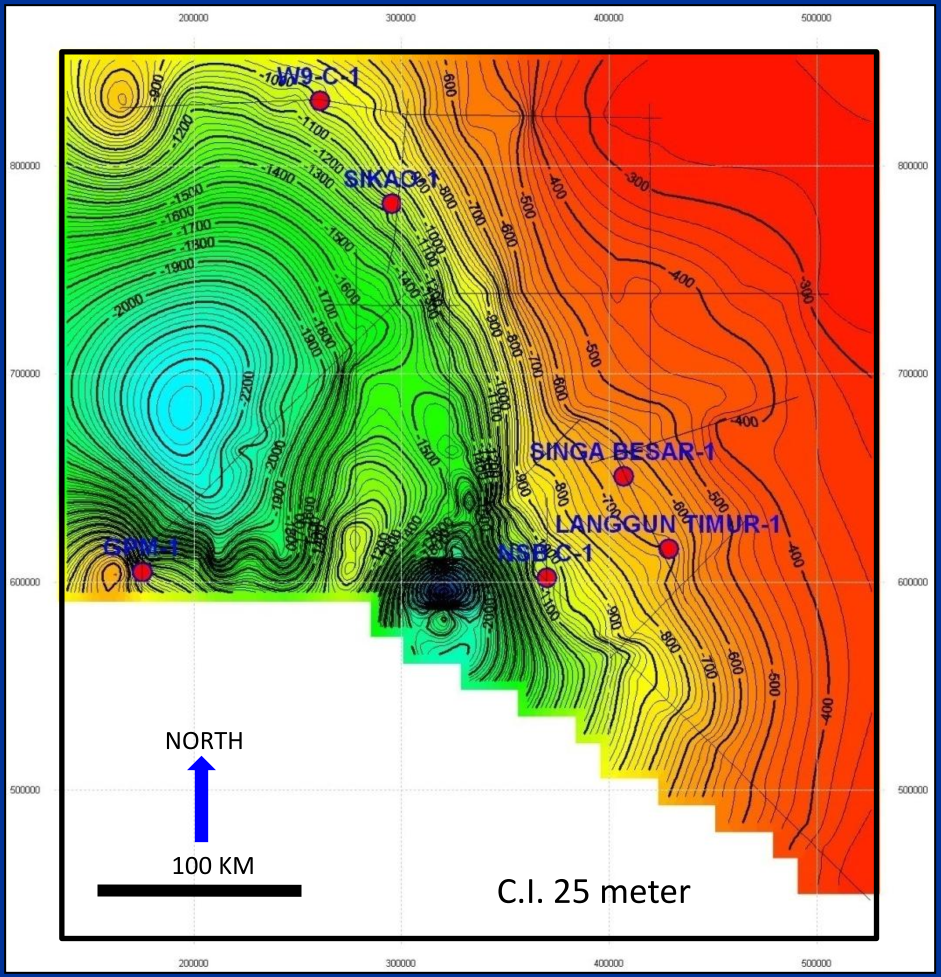


TIME STRUCTURE MAP
MIOCENE UNCONFORMITY



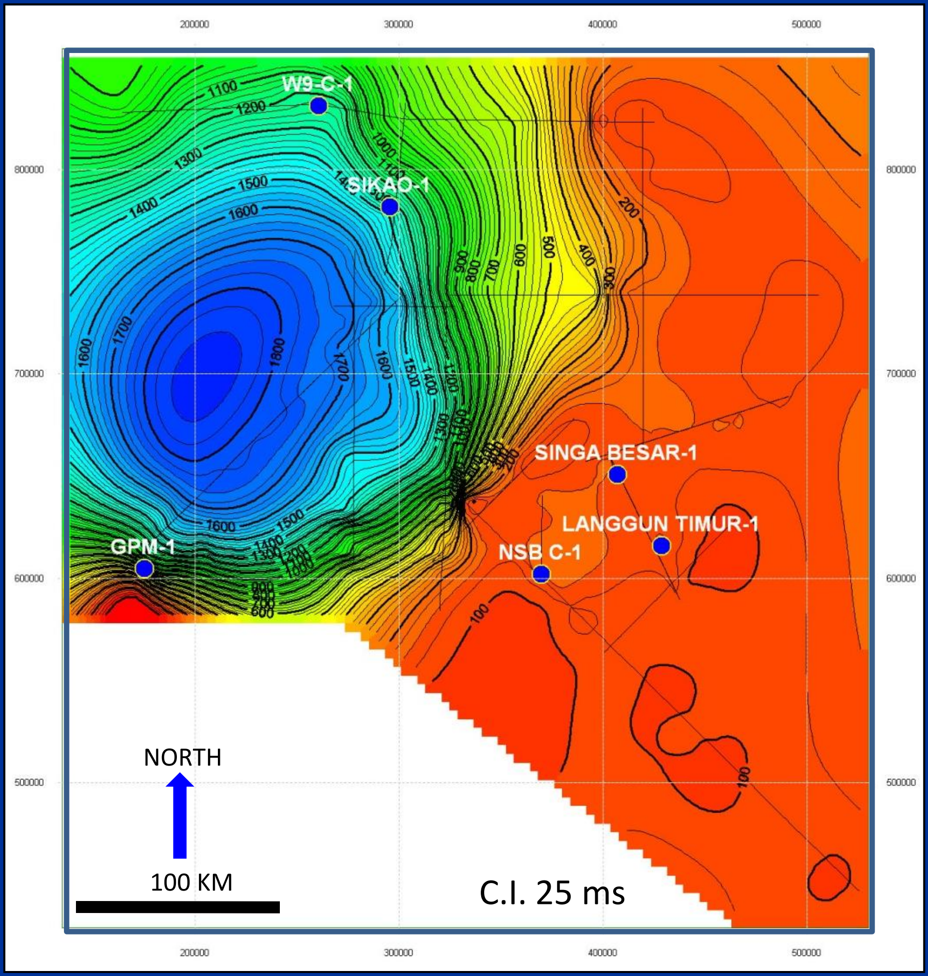
DEPTH STRUCTURE MAP
MIOCENE UNCONFORMITY



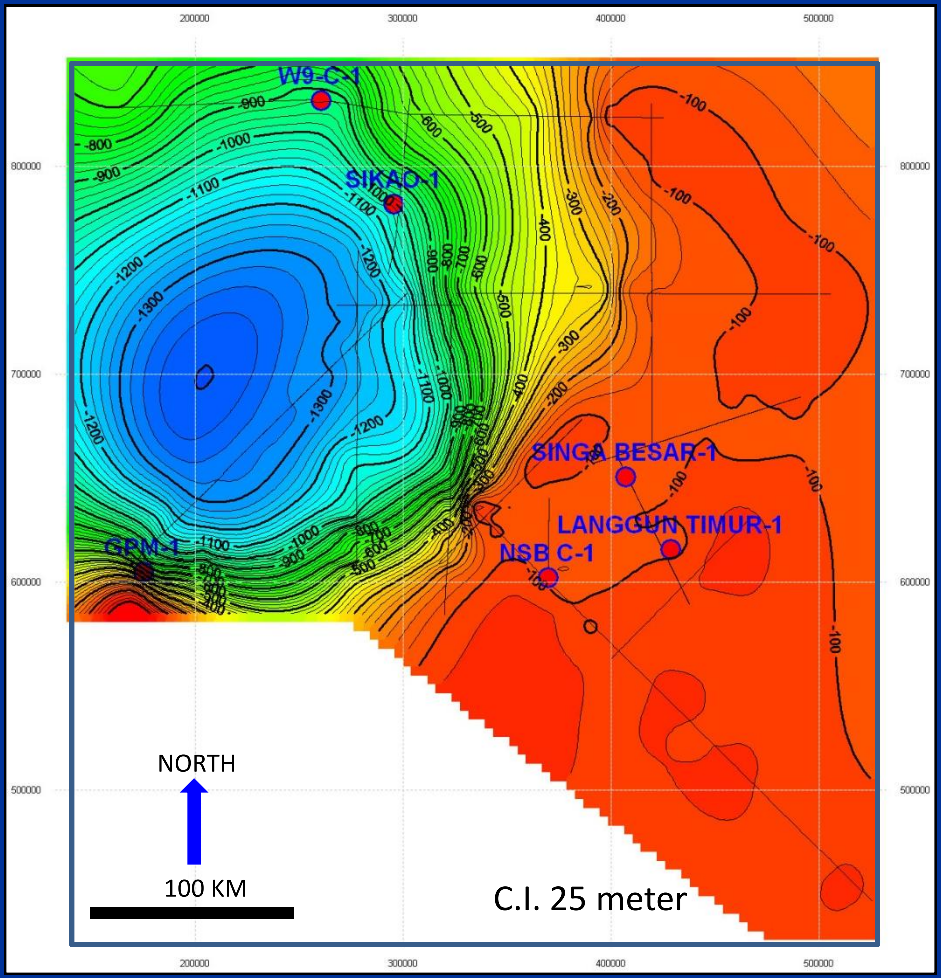


TIME STRUCTURE MAP KEUTAPANG Fm. (TOP UPPER MIOCNE)

DEPTH STRUCTURE MAP KEUTAPANG Fm. (TOP UPPER MIOCENE)

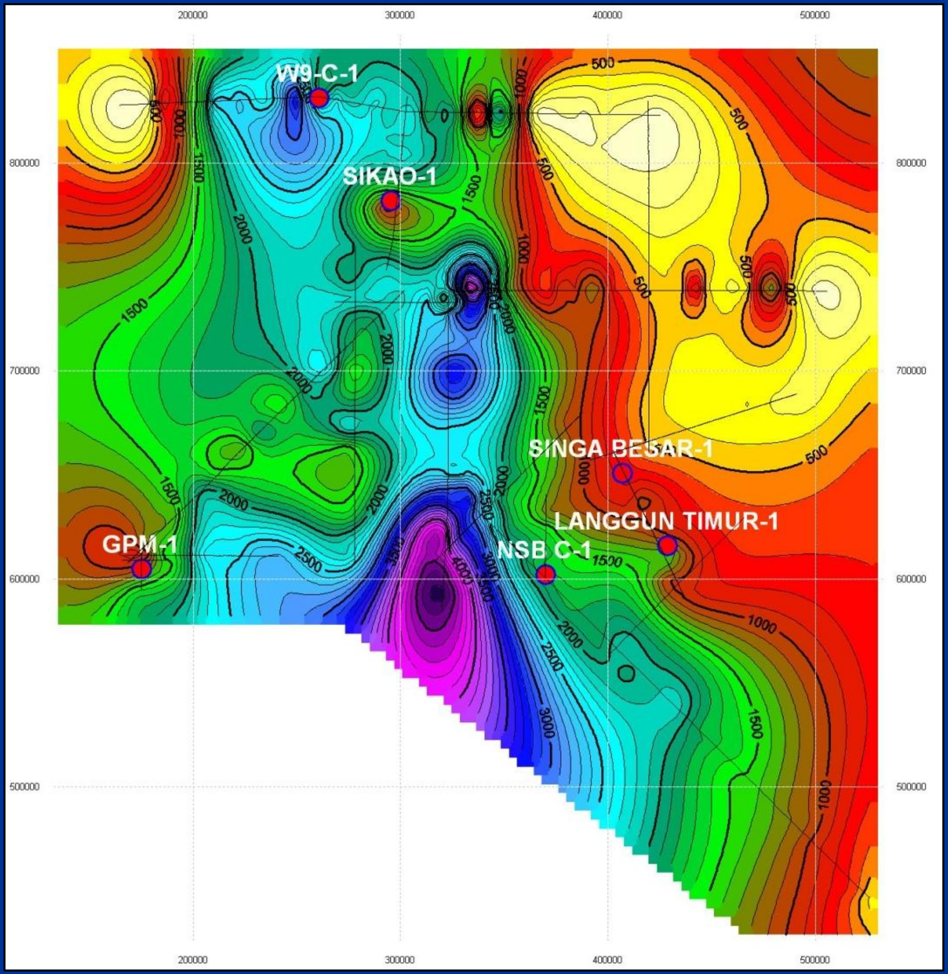


TIME STRUCTURE MAP
SEA BED

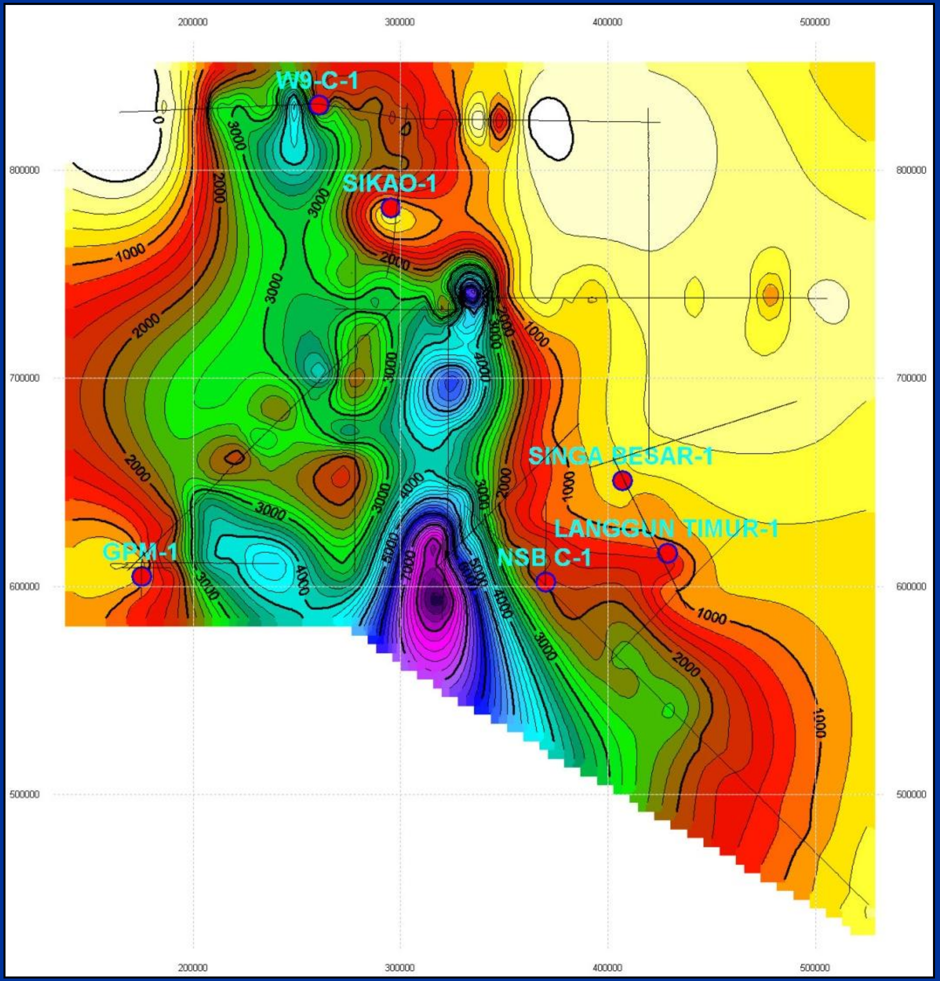


DEPTH STRUCTURE MAP
SEA BED

There is no top marker information in sea bed, so we generate depth structure map with giving sea water velocity assumption = 1500 m/s



ISOCHRONE MAP
BASEMENT-SEA BED



ISOPACH MAP
BASEMENT-SEABED
(SEDIMENT THICKNESS)

Conclusion and Recommendation

This study is supported by seismic and well data in minimum amount, for regional study the structure maps have given description of basement low and high but for detailed study needs more densely seismic data and also velocity data.

Ideally, the existing seismic data doesn’t consist of many seismic vintages, so seismic data will have almost the same of amplitude, phase, resolution. With good data quality we can interpret stratigraphic and structural events more detail and yields more reliable maps. And also we can create some seismic attribute maps.

In this study, the well data is very minimum. The well data are not supported by complete log and check-shot data. For creating synthetic seismogram needs complete sonic and density log data. We need also better check-shot data quality in order to get the reliable well tie to seismic.

2D Basin Modeling of JOINT STUDY AREA

Introduction

The 2D Basin modeling was carried out in order to reconstruct the geohistory model of sedimentary layers; Source Rock maturation and distribution; HC generation and Migration within the selected sections,

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↓

BETTER UNDERSTANDING OF PETROLEUM SYSTEM

↓

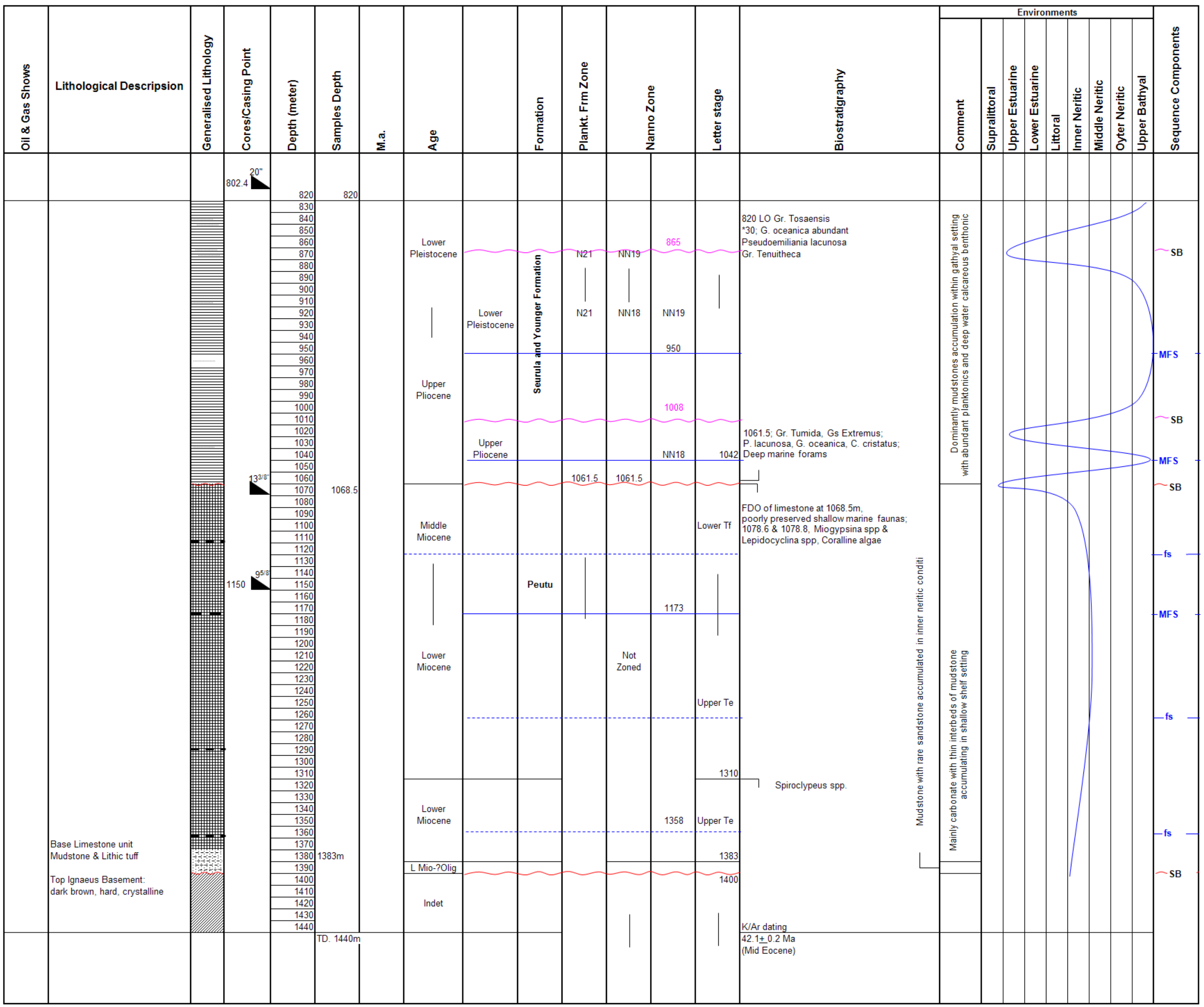
IMPROVE EXPLORATION SUCCES RATIO

Method

In general, basin modeling work method can be divided into :

- Building the geometric model,
- setting the input parameter,
- validation, trial and error,
- and interpretation.

SOME INPUT FOR BASIN MODELING

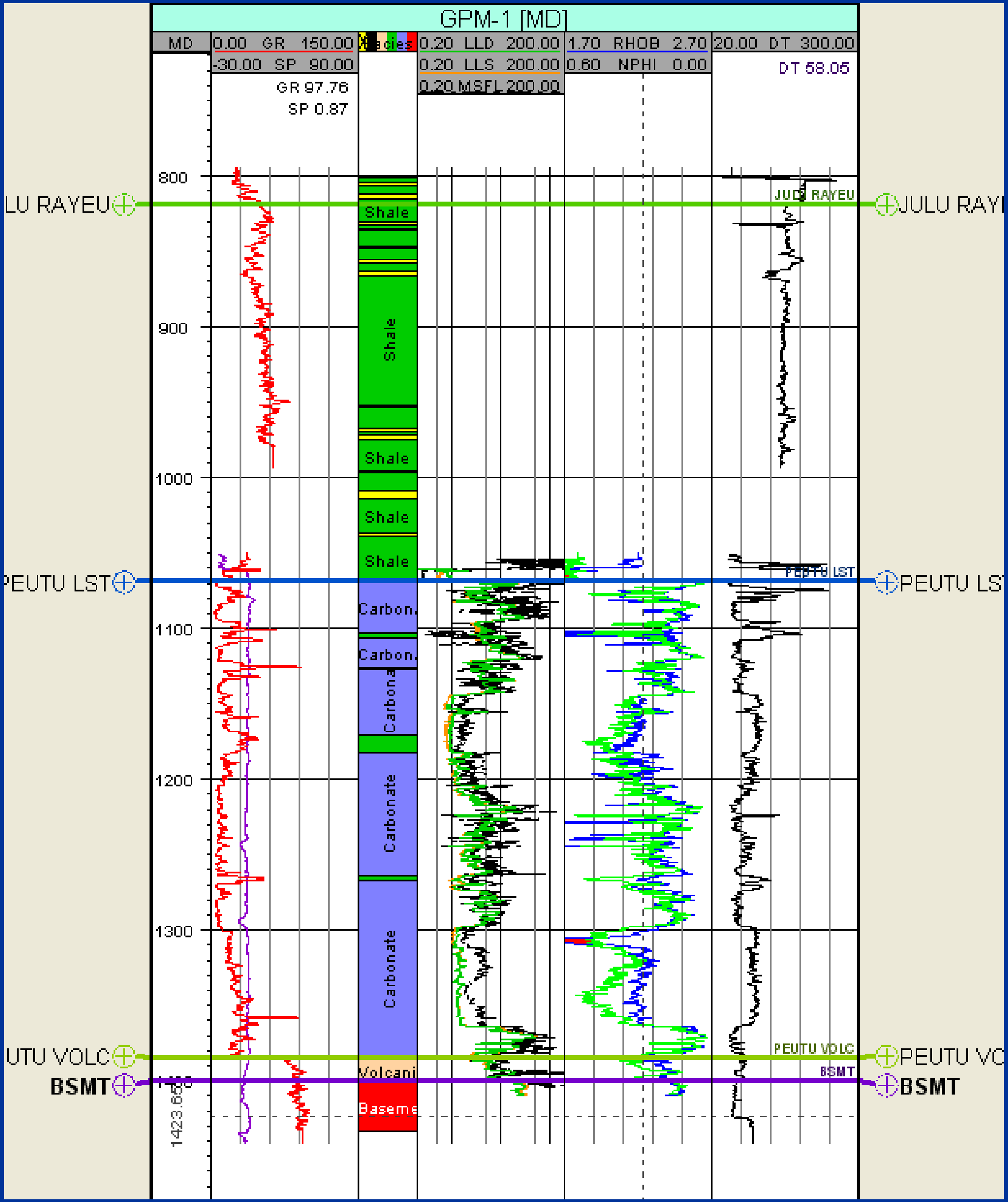


Age determination for Horizons

Relative age of the horizons

Convert Absolute age for Horizons

BIOSTRATIGRAPHIC CHART OF GPM-1



Well log interpretatiopn

Lithology Composition

Determinating Thermal conductivity of the Formations/Horizons

Volcanic Peutu considered to be Bampo/Parapat Formation equivalent (Syn-rift).

Thermal Conductivity of Rocks in the NSB

AGE		FORMATION	CONDUCTIVITY (mcal/cm sec °C)		
			Shale	Sandstone	Limestone
QUARTERNARY			3.60 ± 0.28	5.80 ± 0.17	6.69 ± 0.15
PLIOCENE		JULURAYEU			
		SEURULA			
MIOCENE	LATE	KEUTAPANG	4.37 ± 0.23	6.08 ± 0.16	
	MIDDLE	BAONG	4.64 + 0.22	7.13 + 0.14	
	EARLY	BELUMAI	4.70 ± 0.21	8.35 ± 0.12	8.29 + 0.12
		BAMPO	5.86 + 0.17	7.72 + 0.13	
OLIGOCENE		PARAPAT			
EOCENE		BASEMENT	Dolomite : 9.86 ± 0.1		Mean = 10.11 ± 0.10
PRETERTIARY			Quarzite: 10.30 ± 0.1		

Thamrin, et. al, 1983

Thermal Conductivity of Rocks Formation from GPM-1 Well

No.	TOP FORMATION/HORIZON	DEPTH (m)	AGE (Ma)	LITHOLOGY COMPOSITION	Solid Density (Kg/m3)	Thermal Conductivity (K)	
						mCal/cm°C sec	W/m/C
1	**Sea Bottom (Julu Rayeu & younger formations)**	**477.5 (465)**	0	Sandstone (15%), Shale (85%)	2649.5	**3.93**	**1.64**
2	**Top Upper Miocene**	**1068.5**	5.3	ERODED	-	**-**	**-**
3	**Miocene Unconformity (Peutu)**	**1068.5**	13.8	Sandstone (1%), Shale (4%), Limestone (95%)	2707.05	**8.24**	**3.45**
4	**Top Syn-rift (Bampo/Parapat?)**	**1384.9**	20.4	Sandstone (10%), Shale (76%), silt (14%)	2650.1	**6.18**	**2.58**
5	**Basement**	**1400**	65	Volcanic breccia & lava (assuming as Quartzite)	2650	**10.01**	**4.19**

Calculating Thermal Gradient (TG) & Heatflow on GPM-1 Well

Well : Gleumpang Minyeuk-1
RTE = 12.5 m above sea level
Water depth = 465 m
Temperature at sea bottom = 10 °C
Corrected BHT at 1436 m = 58.9 °C
Average Thermal Gradient = (58.9 - 10) °C /1436 m - (465 + 12.5) m = 0.051 °C/m = 5.1 °C/100 m

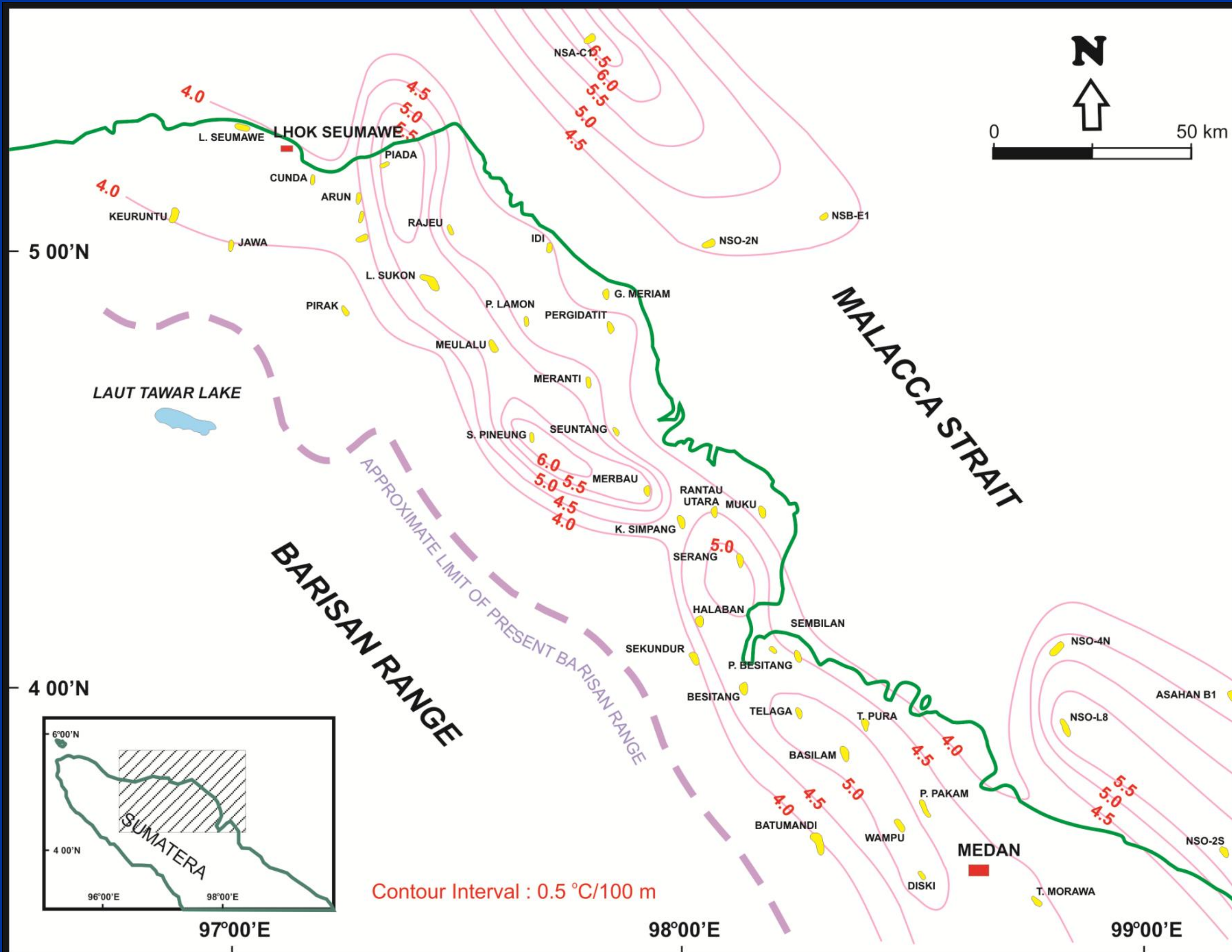
Average Thermal Gradient (TG) = 5.1 °C/100 m = **0.051** °C/m

No.	FORMATION	Thickness (m)	Thermal Conductivity (K) W/m/C	K x Thickness
1	**Sea Bottom (Julu Rayeu & younger formations)**	591	1.64	971.81
2	**Miocene Unconformity (Peutu)**	316.4	3.45	1091.10
3	**Top Syn-rift (Bampo/Parapat?)**	15.1	2.58	39.02
	Basement	40	4.19	167.60
	∑ Thickness =	**962.5**	∑(K * TG) =	**2101.94**

Avg. K = (∑(K x Thickness))/∑T = **2101.94/962.5 =** **2.18** W/m/C

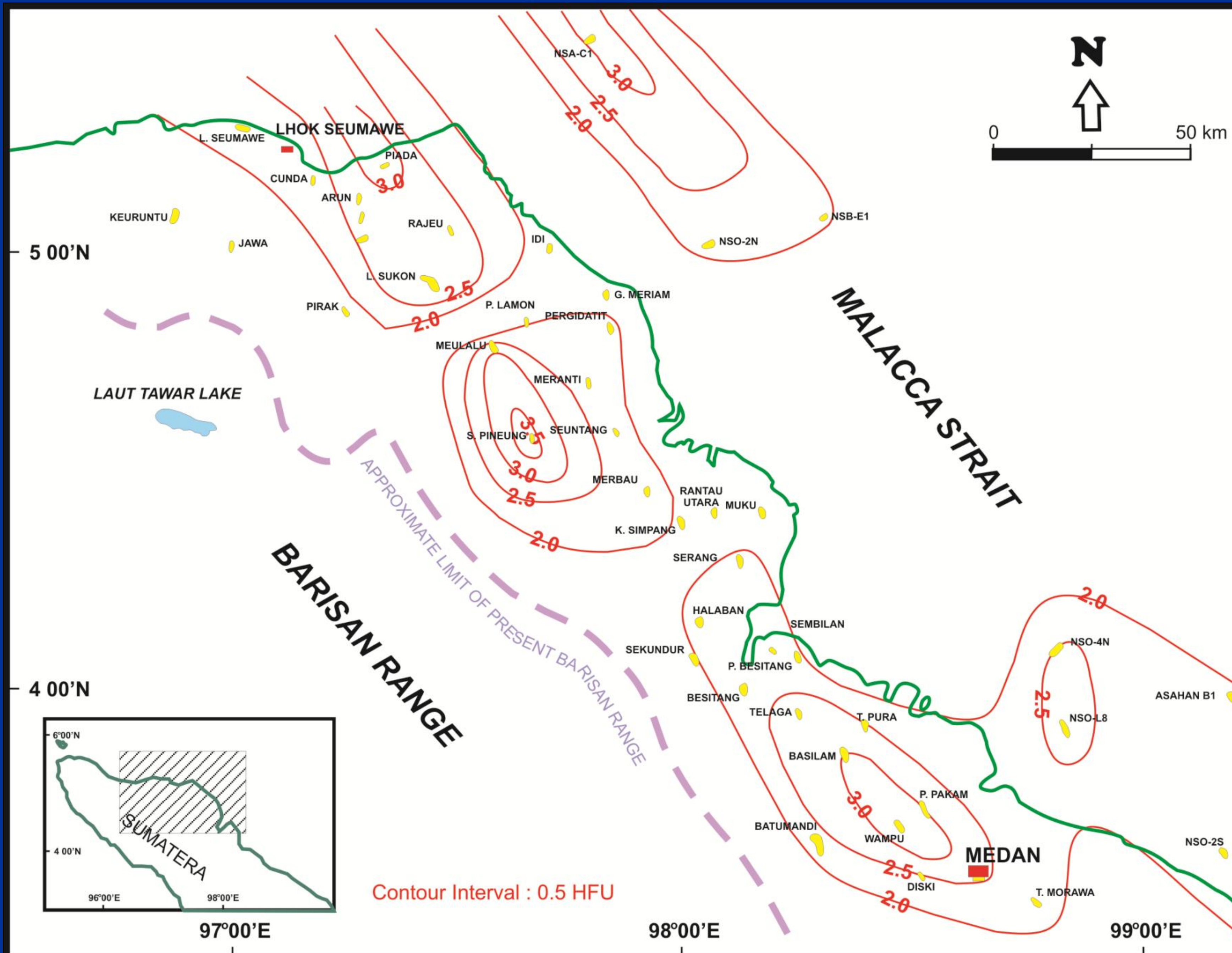
Heatflow (Q) = avg. K x TG = 2.18 * 0.051 = **0.111375327** Wm^{-2} = **2.66** **HFU**

HFU = Heatflow Unit (10^{-6} cal/cm^2 sec) = 1/23.9 Wm-2



THERMAL GRADIENT MAP

Thamrin, et. al, 1983



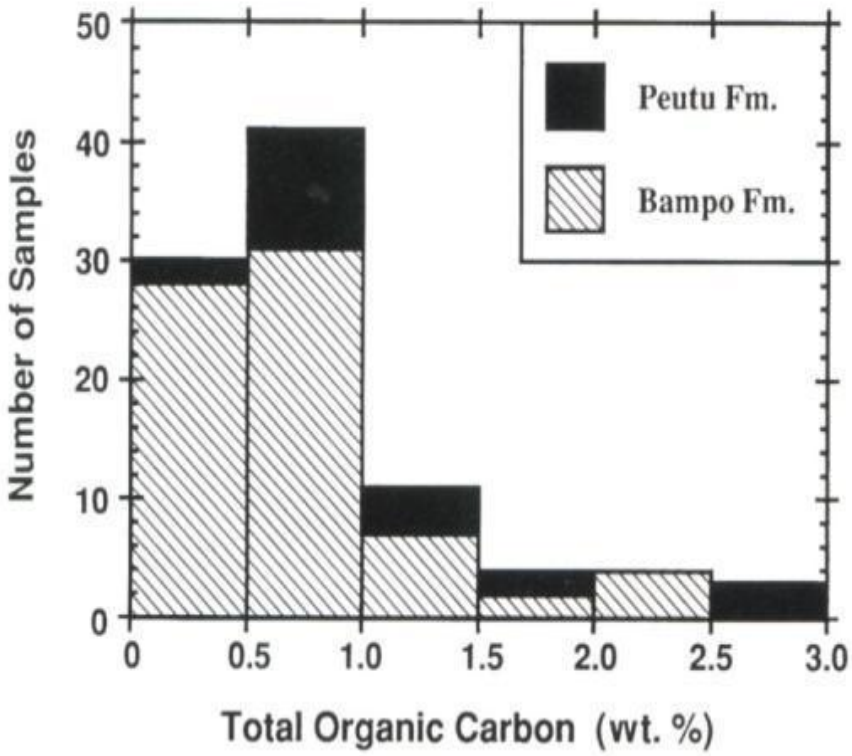
HEATFLOW MAP

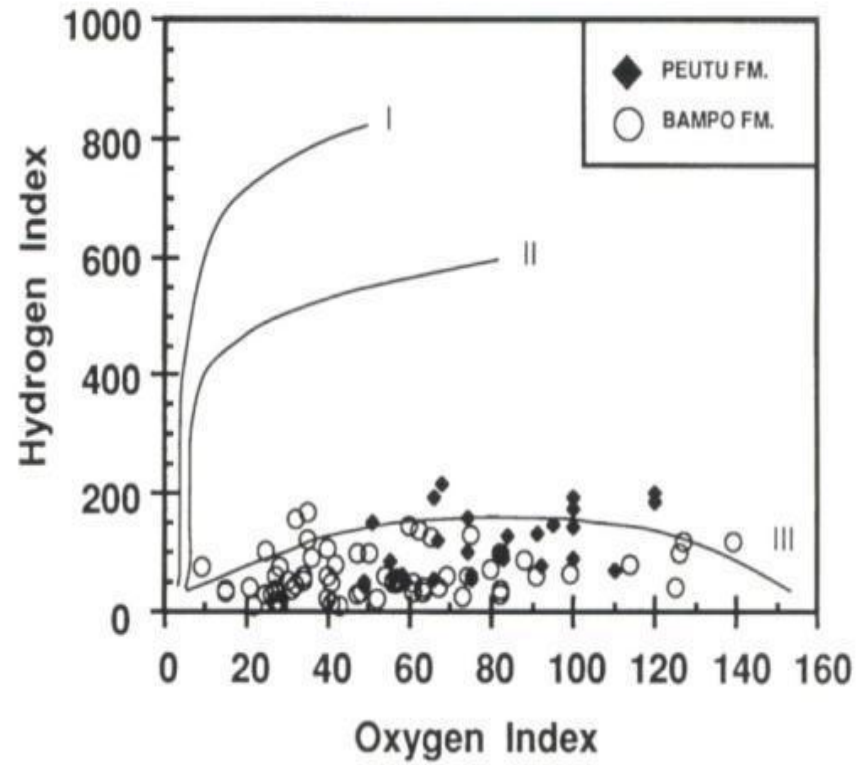
Thamrin, et. al, 1983

A. Geochemical Data

Gleumpang Minyeuk-1 Well

Formation	Lithology	Number of samples	TOC (WT %) range	TOC (WT %) average	S1+S2 (mg/g rock)	Dominant Kerogen Type	HI range	HI average	Ro (%)	TMAX (°C)
Julu Rayeu	Shale/Claystone	12	0.88 – 1.47	1.025	1.00 – 5.78	III/II	103 - 131	115	0.25 – 0.41	426 - 432
Peutu	Shale/Claystone	2	0.73 - 0.95	0.83	2.31 - 5.78	III/II	196 - 226	211	0.53 – 0.59	354 - 358
	Limestone	10	0.08 – 0.18	0.13	-	-	-	-	0.77 – 1.57	-
	Ls/Clyst	10	0.1 – 1.52	0.422	0.1 – 2.63 (2)	-	80 – 106 (3)	115	0.32 – 2.09	429 (1)
Basement	Sst/Volc.	2	0.22 – 0.24	0.23	-	-	-	-	-	-





Buck & Mc. Culloh (1994)

- Shales & mudstones of Bampo & Peutu Formation were dominantly tipe III kerogen with TOC range from 0.5 % to 3 %.

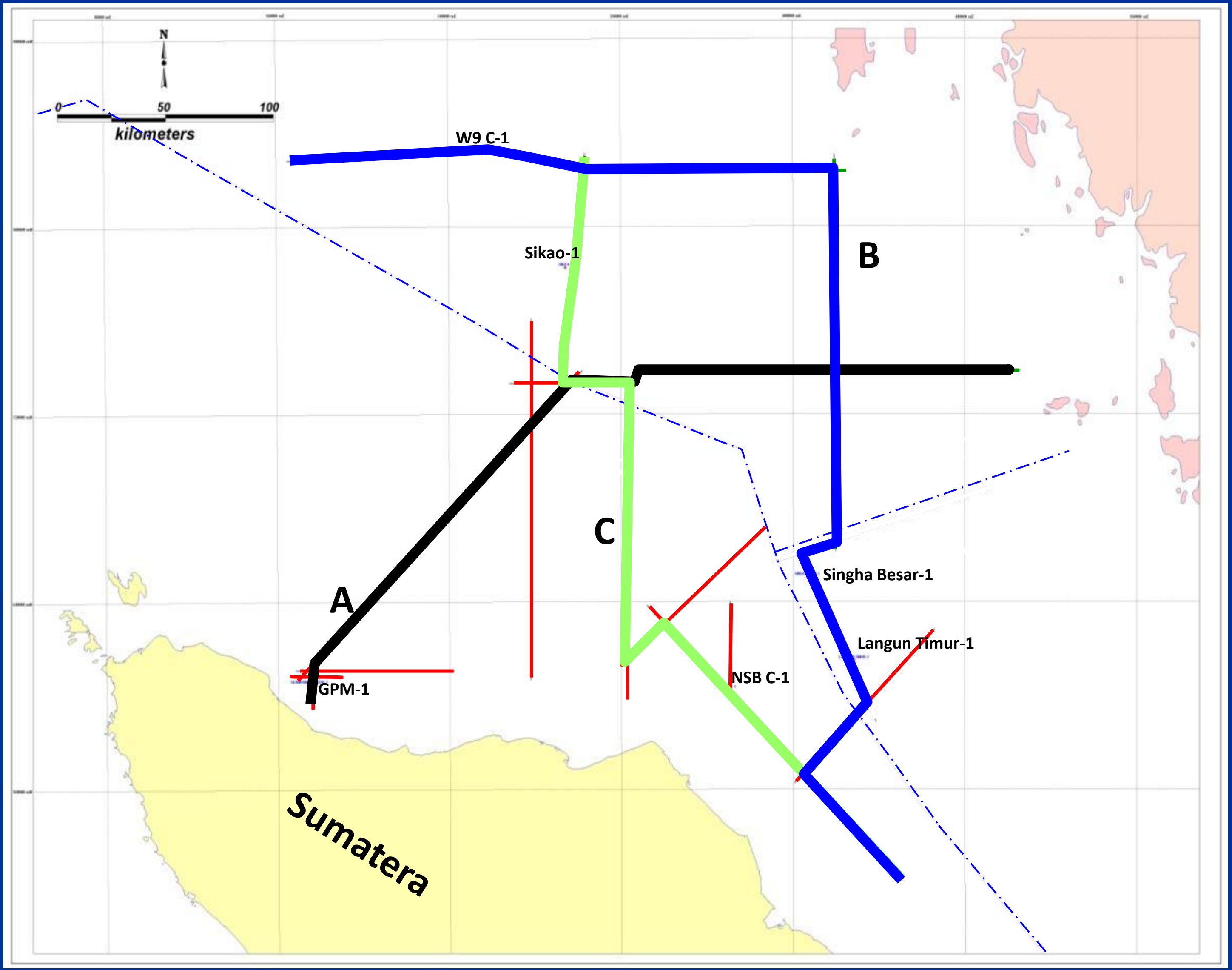
Gleumpang Minyeuk-1

VITRINITE REFLECTANCE

For Modeling Validation

No.	FORMATION	Sample Depth (m)	Mean Ro (%)	No. of readings	Minimum Ref. %	Maximum Ref. %	Sd
1	JULU RAYEU	830	0.25	18	021	029	0.023
2		850	0.27	15	023	03	0.023
3		870	0.28	18	023	032	0.023
4		890	0.28	5	025	03	0.022
5		910	0.3	23	024	0.35	0.034
6		930	0.35	20	0.30	0.4	0.031
7		950	0.37	5	0.32	0.4	0.034
8		970	0.39	23	0.31	0.44	0.042
9		990	0.37	18	031	0.45	0.047
10		1010	0.41	4	037	0.44	0.033
11		1030	0.39	13	0.34	0.43	0.032
12		1050	0.4	5	0.38	0.43	0.019
13	PEUTU	1070	0.44	9	0.38	0.55	0.061
14		1076.43	0.53	35	0.46	0.64	0.05
15		1078. 32	0.59	16	0.52	0.67	0.046
16		1090	0.43	2	0.41	0.45	0.028
17		1110	0.32	2	03	033	0.021
18		1130	BARREN				
19		1150	0.76	7	0.69	0.81	0.04
20		1170	BARREN				
21		1190	1.03	2	1.02	1.05	0.021
22		1210	1.57	2	1.56	1.56	0.014
23		1230	0.77	3	0.71	081	0.049
24		1250	0.79	I	0.79	0.79	
25		1270	0.98	2	0.92	1.05	0.092
26		1290	1.01	8	0.91	1.1	0.063
27		1310	0.32	8	025	037	0.041
28		1330	1.05	2	0.94	1.16	0.016
29		1350	0.47	6	021	0.64	0.18
30		1370	0.55	11	0.48	065	0.074
31		1390	2.09	6	1.78	2.46	0.02
32	BASEMENT	1408	4.06	4	3.37	5.17	0.85

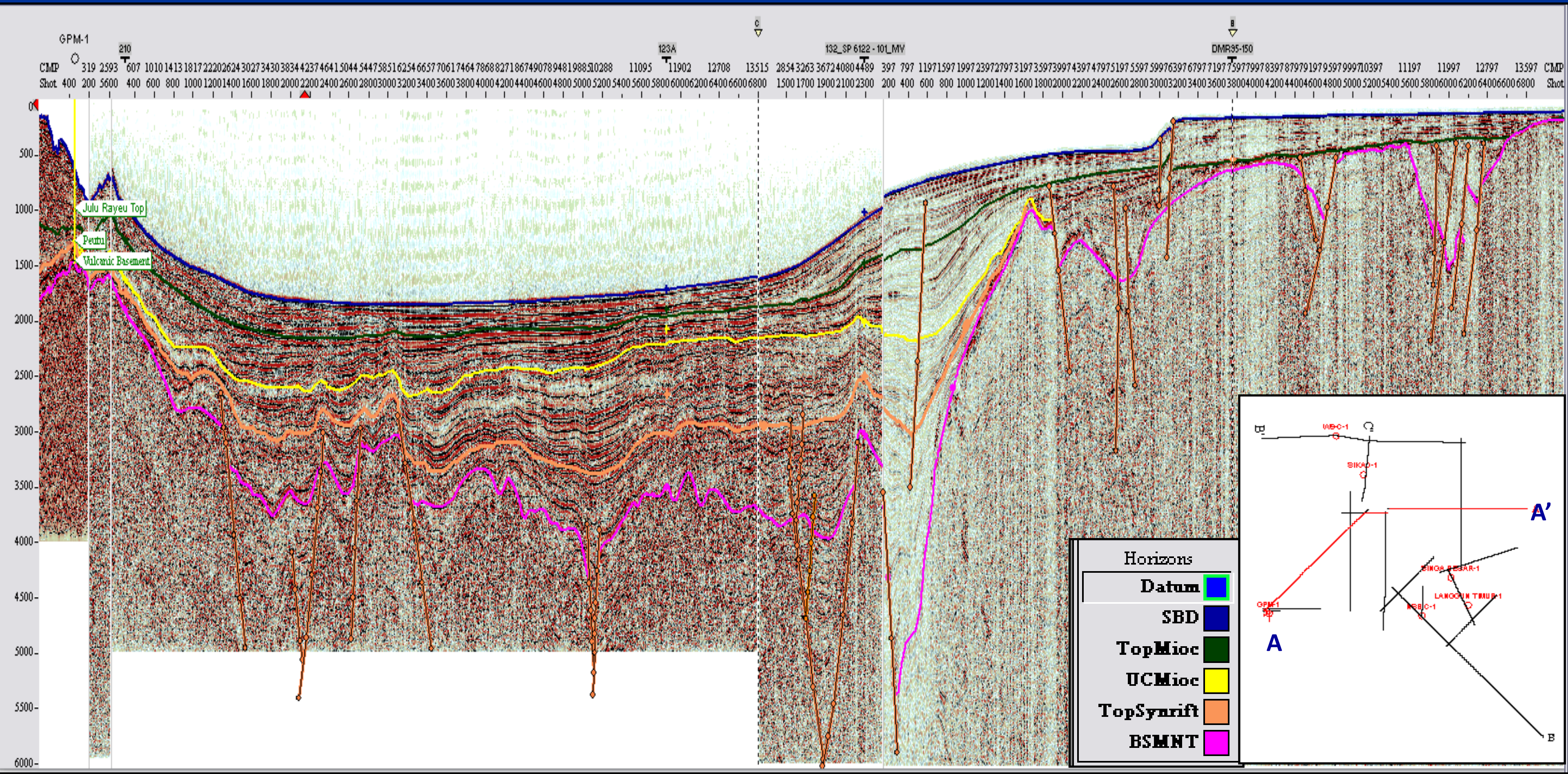
REGIONAL COMPOSITE SEISMIC LINES FOR 2D BASIN MODELING



BASIN MODELING RESULTS

COMPOSITE SECTION A

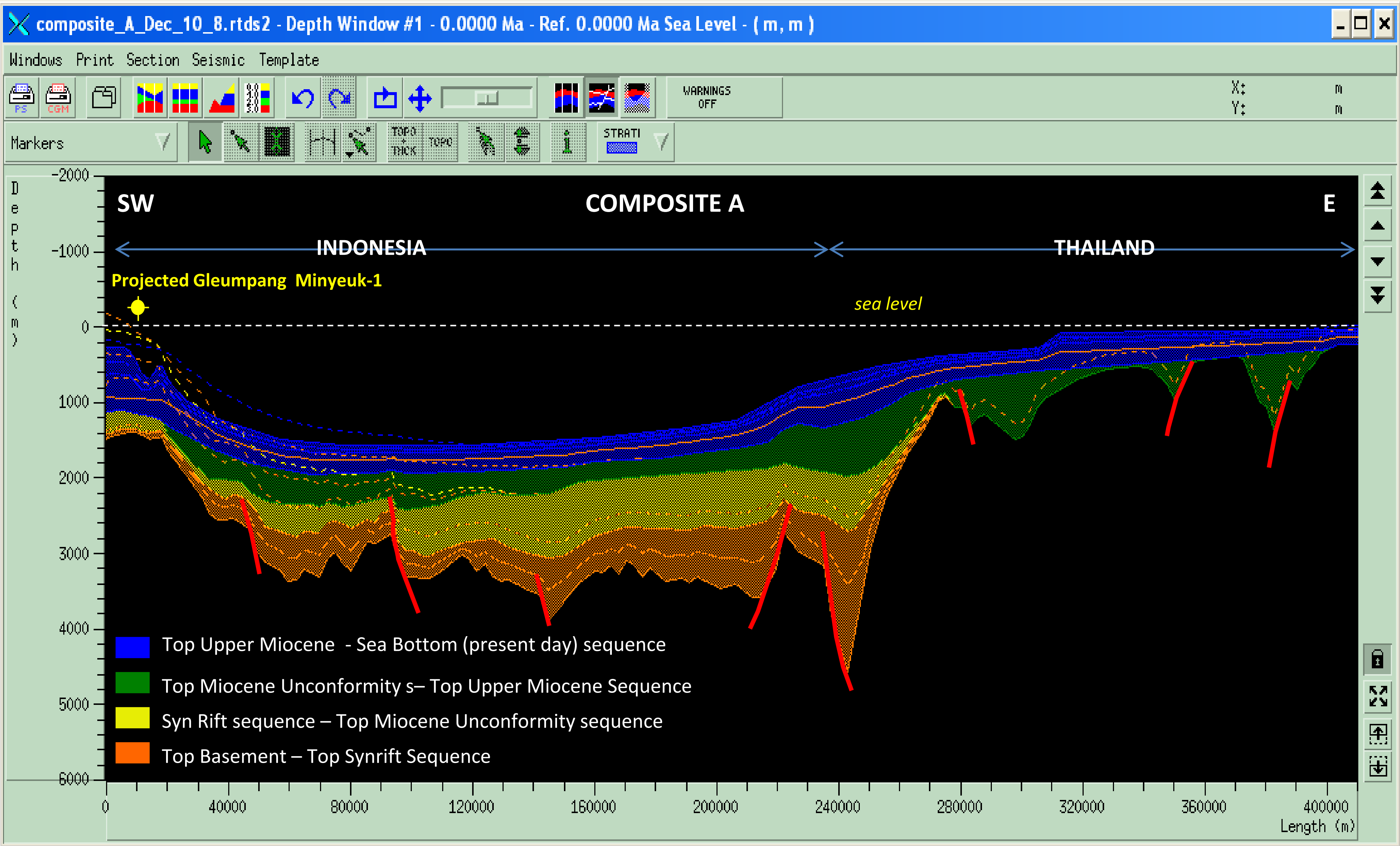
A A’



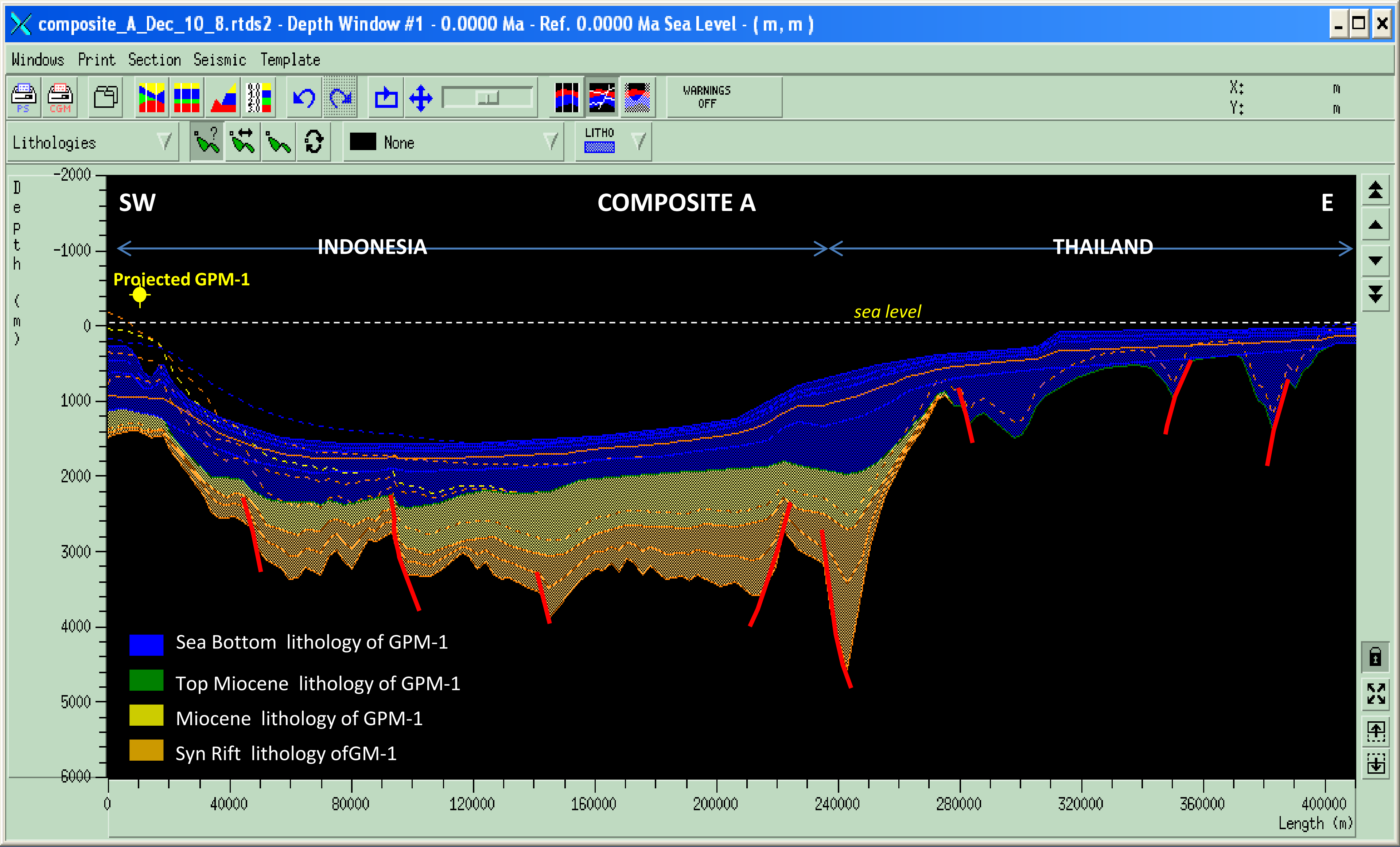
CROSSING OR NEAR Gleumpang Minyeuk-1

Section length : + 420 km

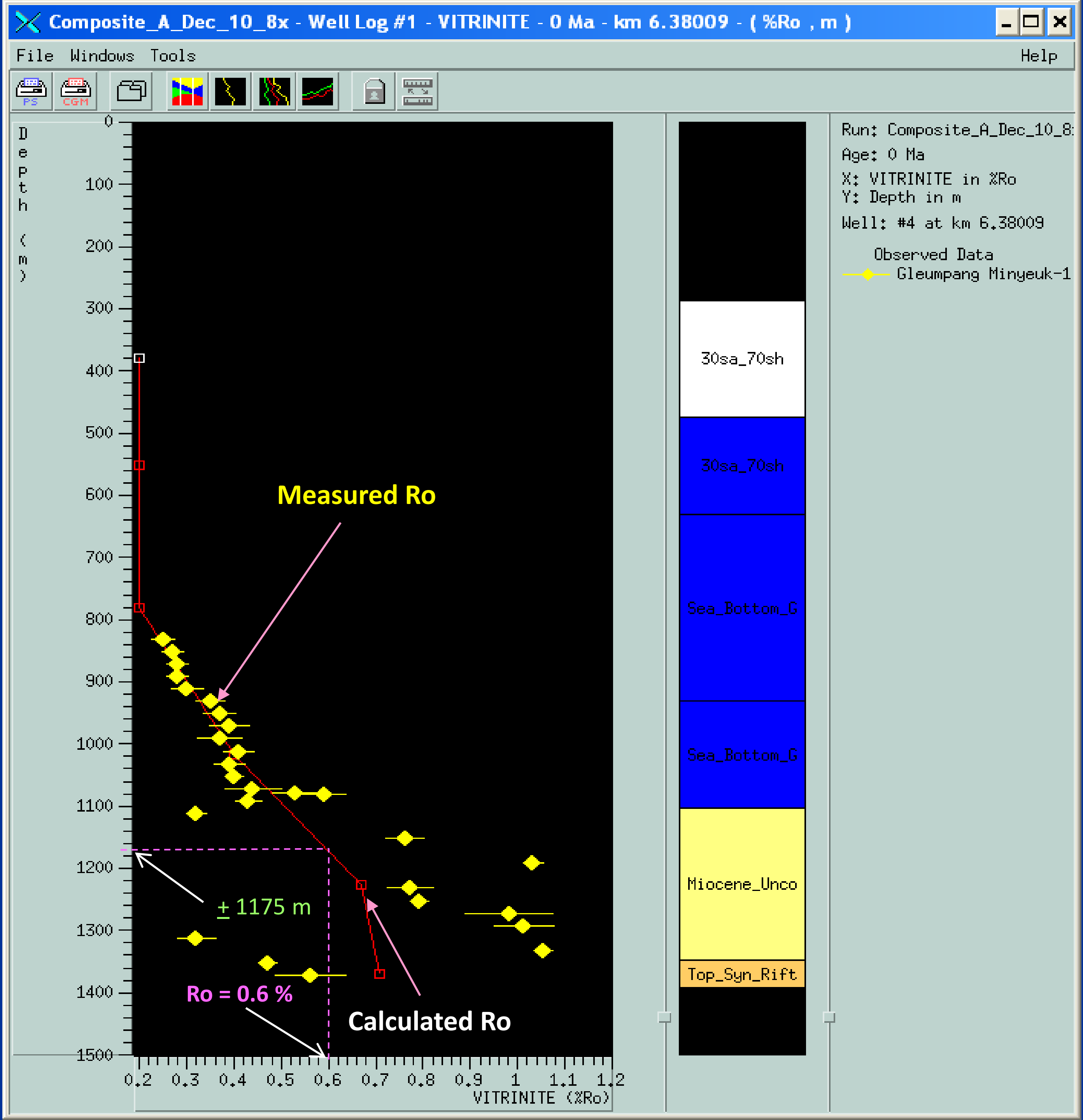
STRATIGRAPHY

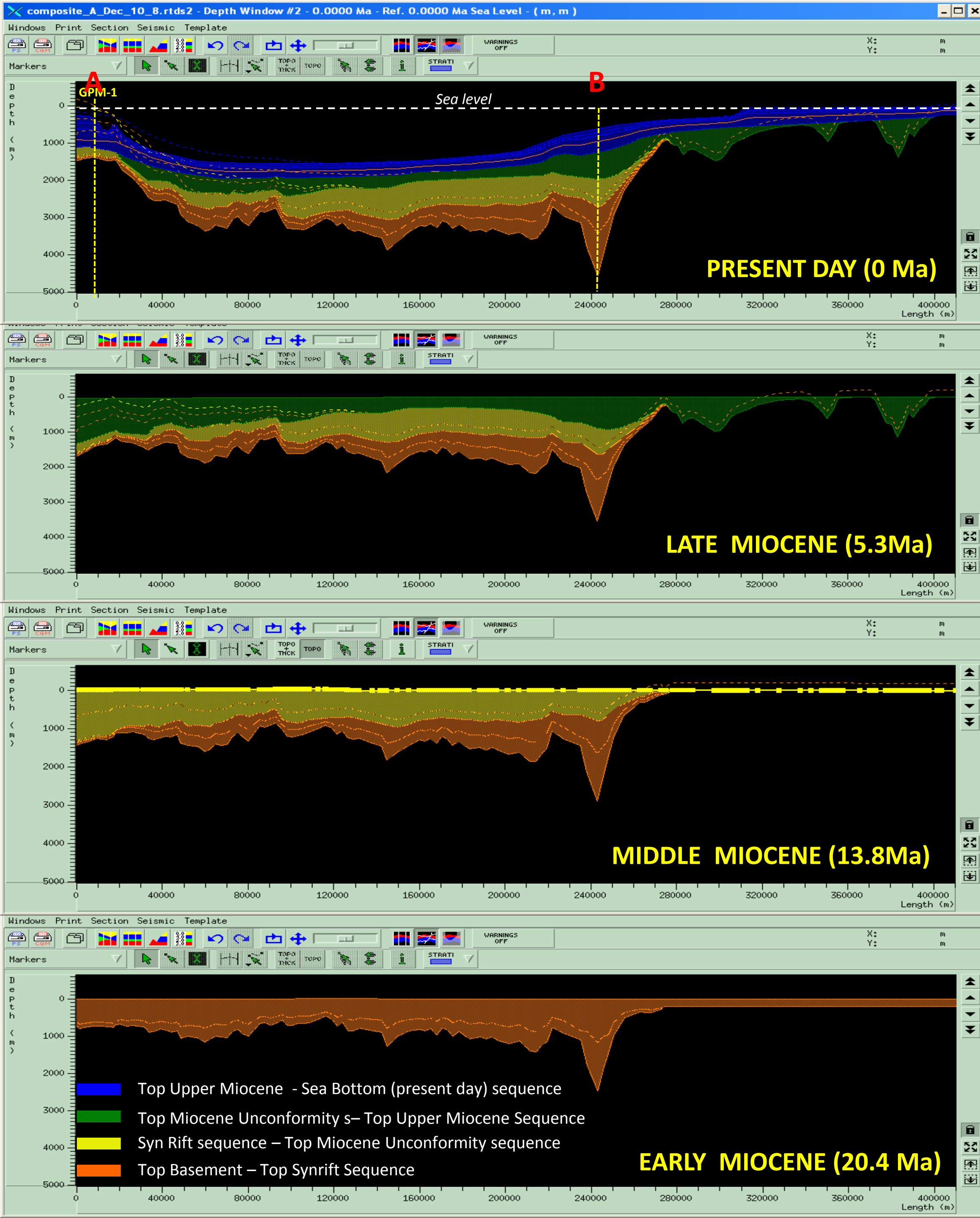


LITHOLOGY

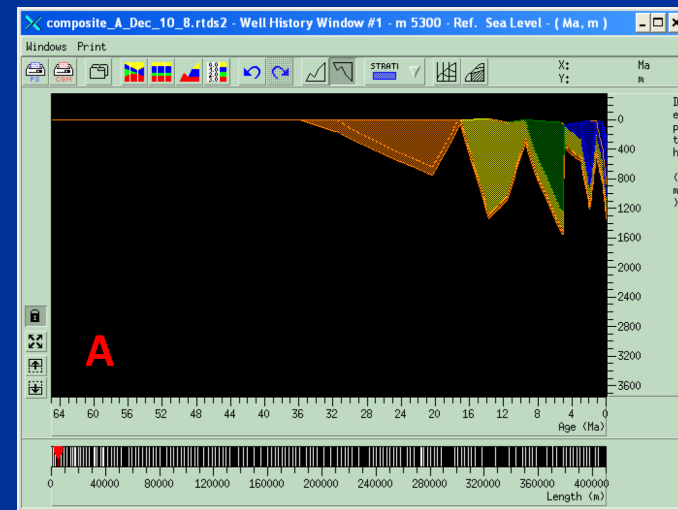

composite_A_Dec_10_8.rtds2 - Depth Window #1 - 0.0000 Ma - Ref. 0.0000 Ma Sea Level - (m, m)
Windows Print Section Seismic Template
WARNINGS OFF
X: m
Y: m
Lithologies
None
LITHO
SW
COMPOSITE A
E
INDONESIA
THAILAND
Projected GPM-1
sea level
Depth (m)
-2000
-1000
0
1000
2000
3000
4000
5000
6000
0
40000
80000
120000
160000
200000
240000
280000
320000
360000
400000
Length (m)
Sea Bottom lithology of GPM-1
Top Miocene lithology of GPM-1
Miocene lithology of GPM-1
Syn Rift lithology ofGM-1

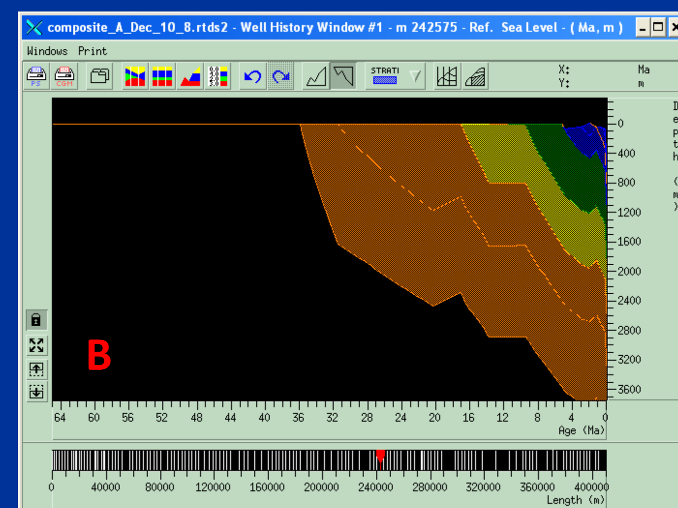
Modeling Validation

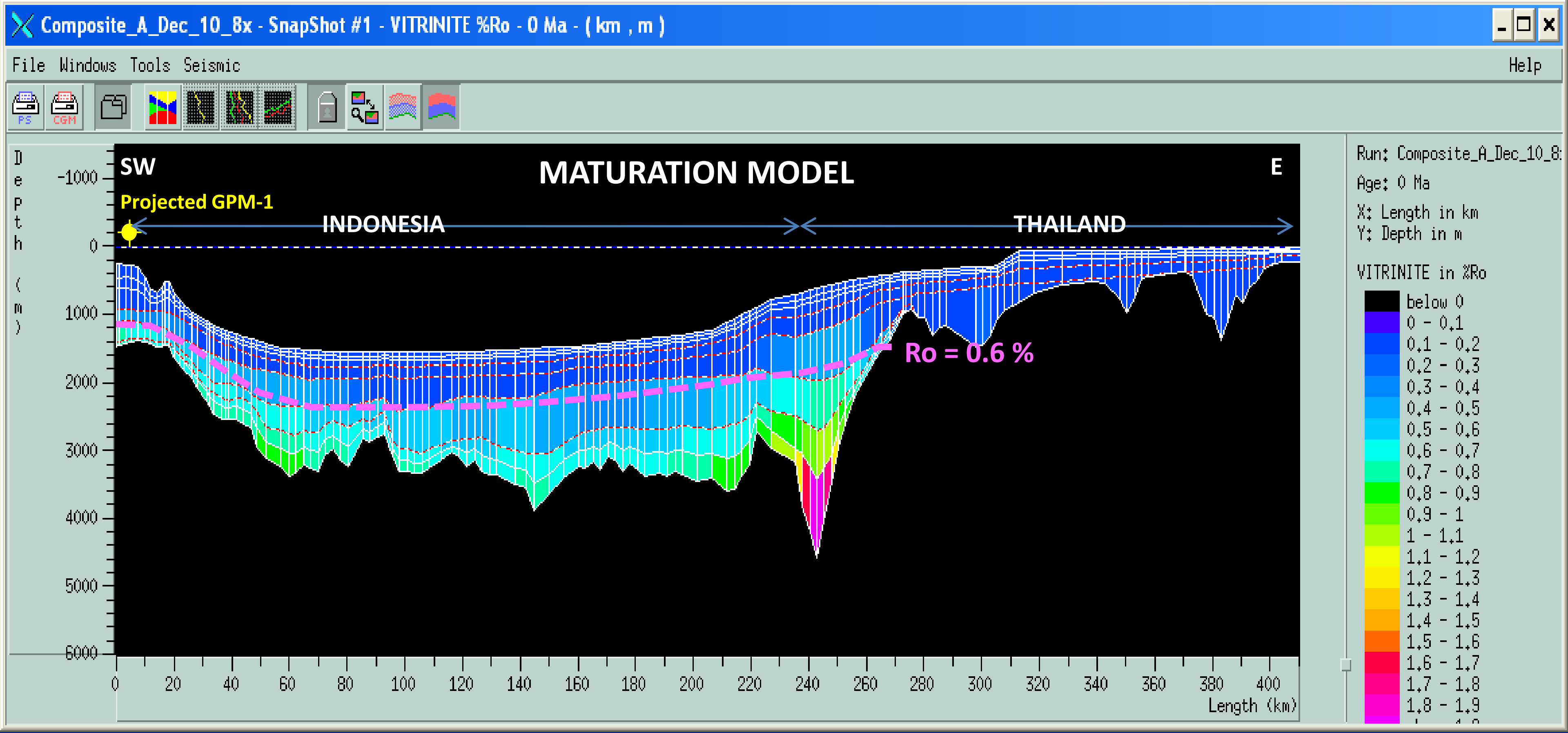




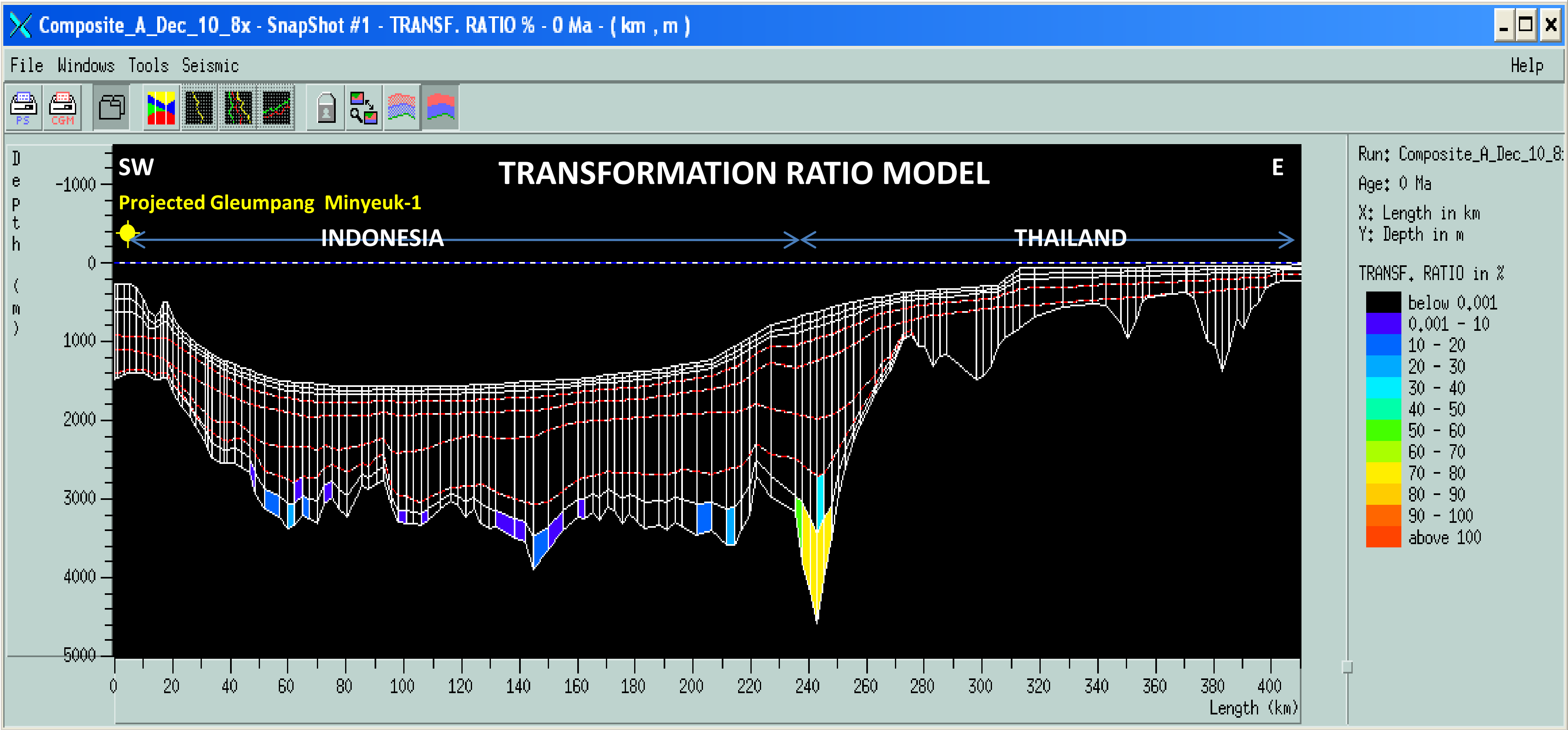
SIMPLIFIED BURIAL HISTORY MODEL

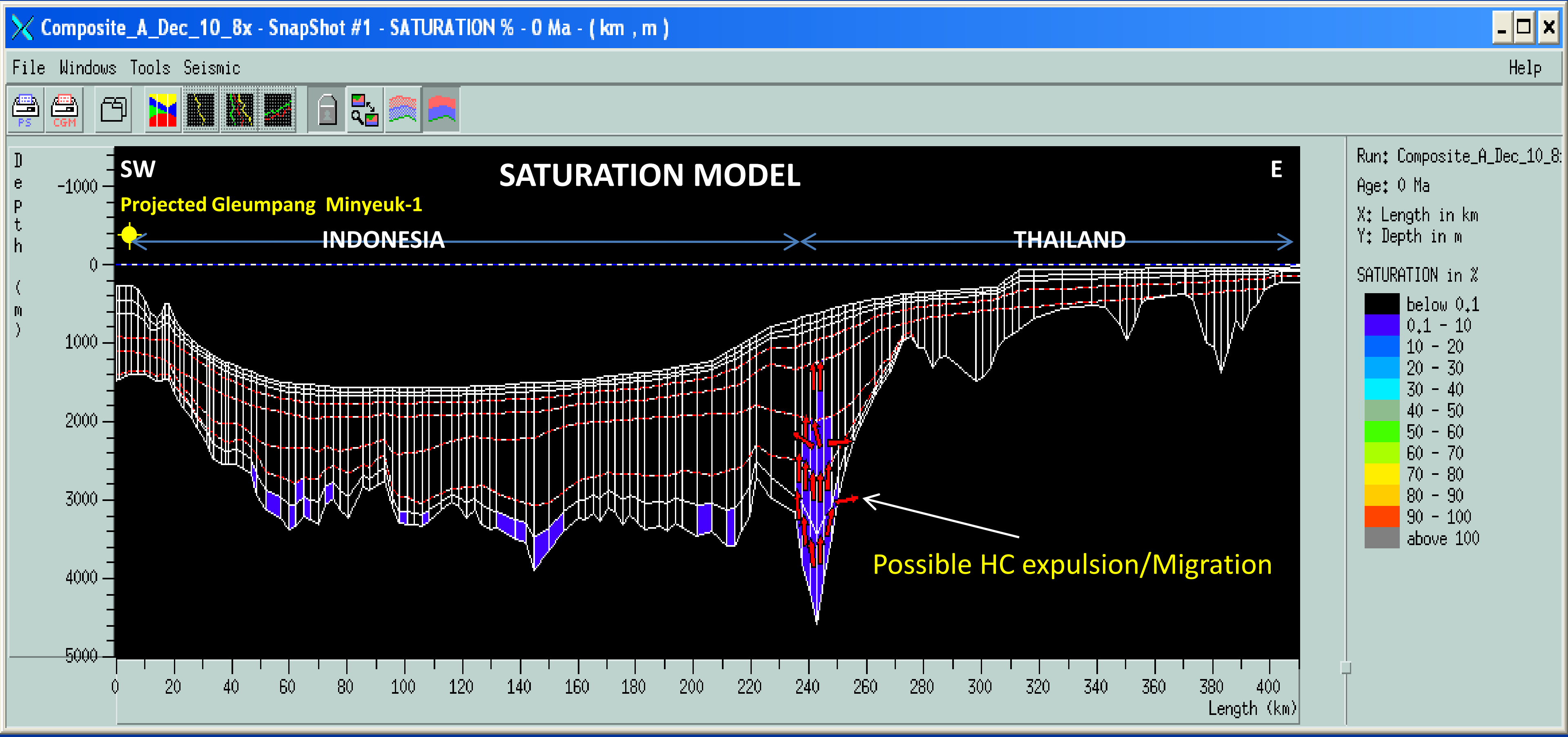






Composite_A_Dec_10_8x - SnapShot #1 - VITRINITE %Ro - 0 Ma - (km , m)
File Windows Tools Seismic
Help
MATURATION MODEL
SW
E
Projected GPM-1
INDONESIA
THAILAND
Ro = 0.6 %
Depth (m)
Length (km)
Run: Composite_A_Dec_10_8
Age: 0 Ma
X: Length in km
Y: Depth in m
VITRINITE in %Ro
below 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
1 - 1.1
1.1 - 1.2
1.2 - 1.3
1.3 - 1.4
1.4 - 1.5
1.5 - 1.6
1.6 - 1.7
1.7 - 1.8
1.8 - 1.9


Composite_A_Dec_10_8x - SnapShot #1 - TRANSF. RATIO % - 0 Ma - (km , m)
File Windows Tools Seismic
Help
SW
TRANSFORMATION RATIO MODEL
E
Projected Gleumpang Minyeuk-1
INDONESIA
THAILAND
Depth (m)
-1000
0
1000
2000
3000
4000
5000
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
Length (km)
Run: Composite_A_Dec_10_8
Age: 0 Ma
X: Length in km
Y: Depth in m
TRANSF. RATIO in %
below 0.001
0.001 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
above 100

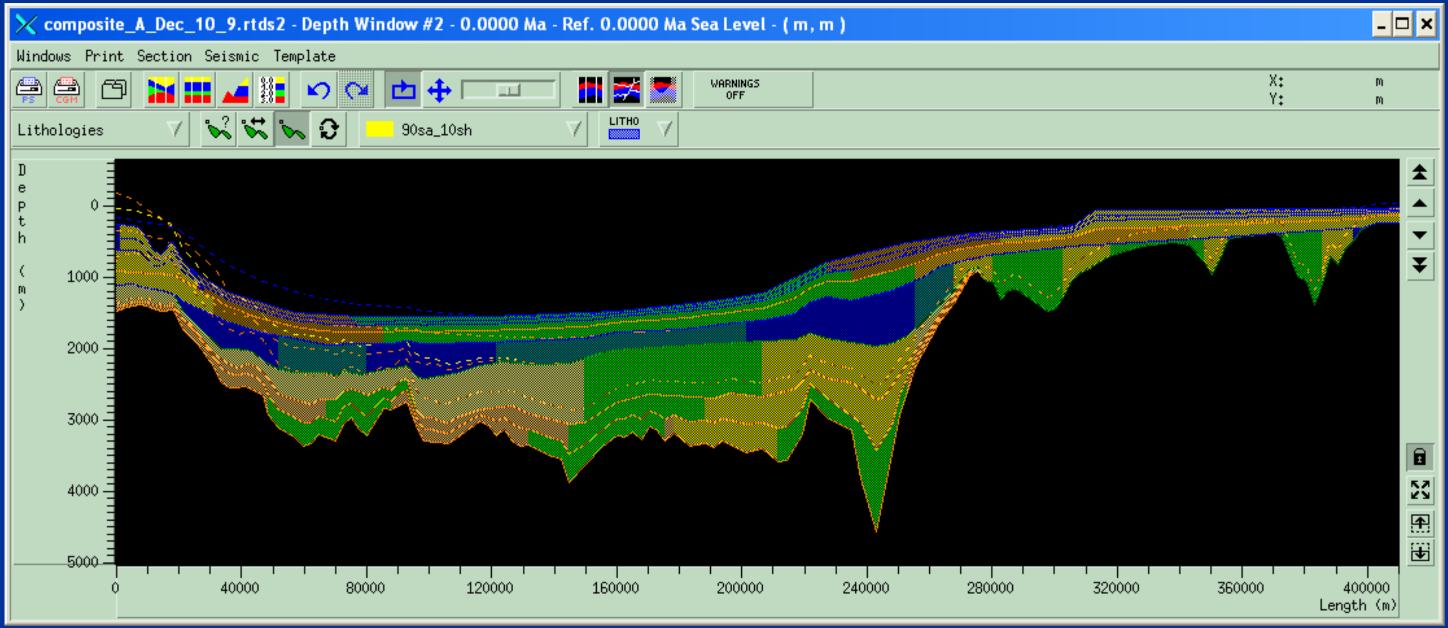

Composite_A_Dec_10_8x - SnapShot #1 - SATURATION % - 0 Ma - (km , m)
File Windows Tools Seismic
Help
SATURATION MODEL
SW
E
Projected Gleumpang Minyeuk-1
INDONESIA
THAILAND
Possible HC expulsion/Migration
Depth (m)
Length (km)
Run: Composite_A_Dec_10_8
Age: 0 Ma
X: Length in km
Y: Depth in m
SATURATION in %
below 0.1
0.1 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
above 100

Note on Basin Modeling

For better results or more realistic results, there are some items that must be considered :

facies map or facies distribution along the composite line for 2D modeling is needed to guide lithology model along the 2D section line

Example of facies didtribution along the 2d Section



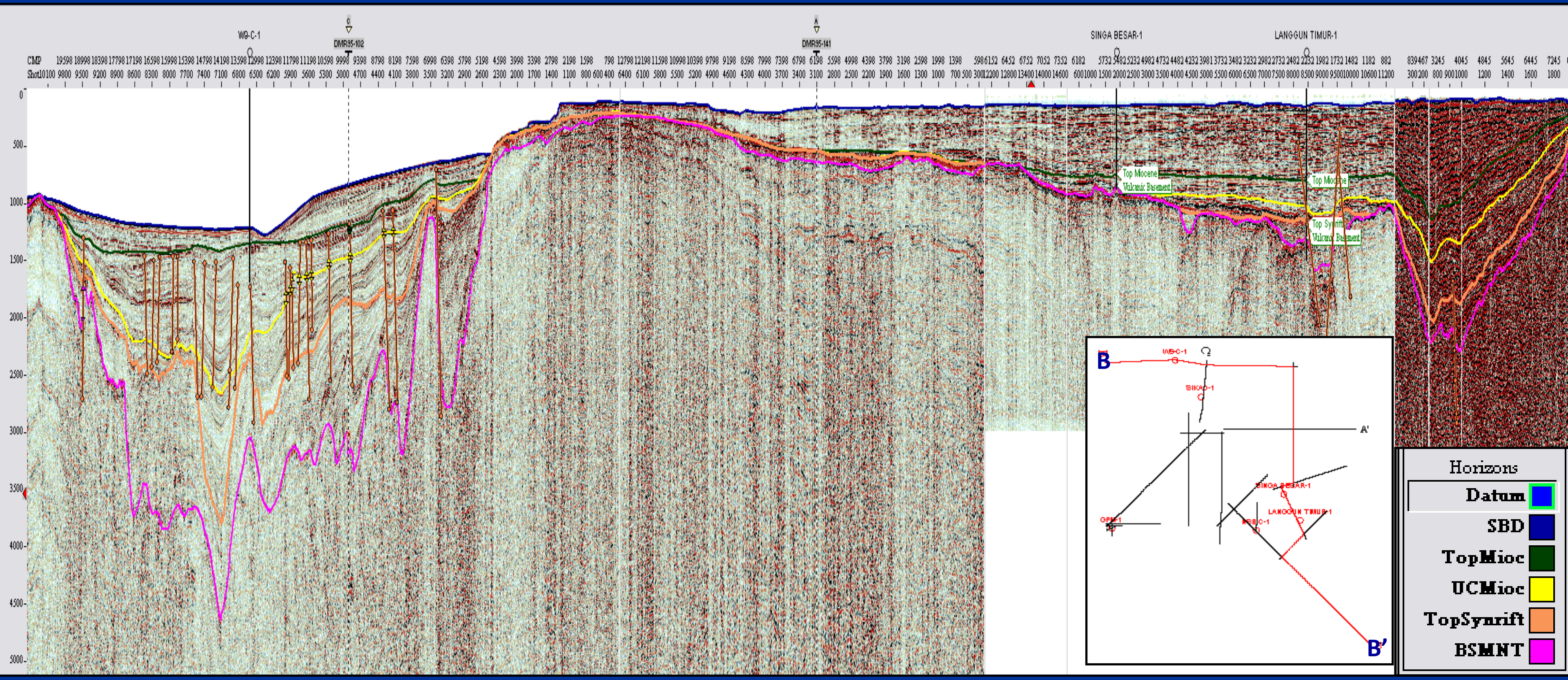
Eroded section (missing rocks/formations) must be predicted if unconformities occurs.

Absolute age for every horizons if it is possible must be controlled by biostratigraphic data or dating

COMPOSITE SECTION B

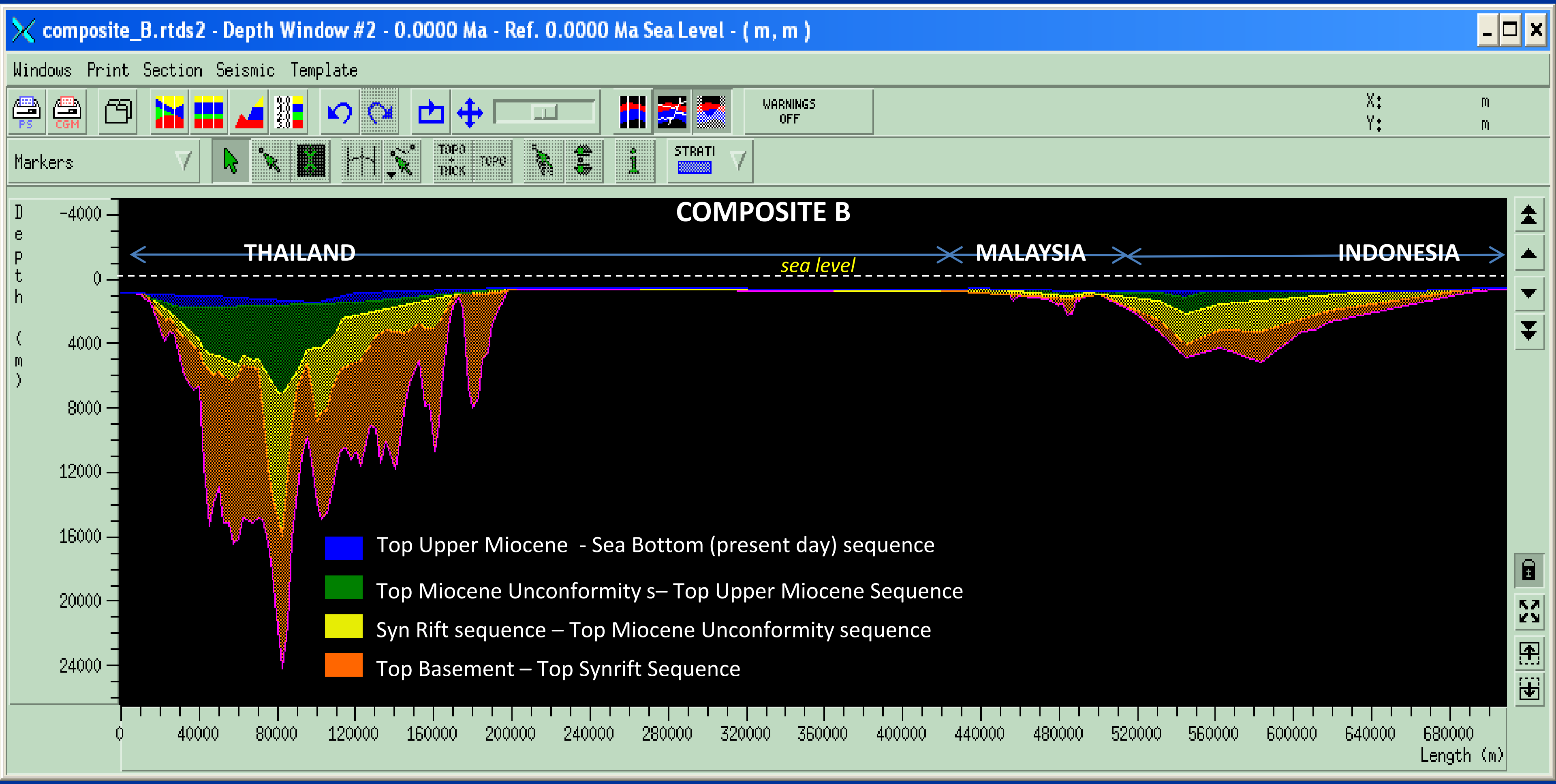
B

B'



CROSSING OR NEAR : Langgun Timur-1, Singha Besar-1, W9 C-1 Wells

Section length : + 686 km


composite_B.rtds2 - Depth Window #2 - 0.0000 Ma - Ref. 0.0000 Ma Sea Level - (m, m)
Windows Print Section Seismic Template
WARNINGS OFF
Markers
STRATI
COMPOSITE B
THAILAND
MALAYSIA
INDONESIA
sea level
Depth (m)
-4000
0
4000
8000
12000
16000
20000
24000
Top Upper Miocene - Sea Bottom (present day) sequence
Top Miocene Unconformity s– Top Upper Miocene Sequence
Syn Rift sequence – Top Miocene Unconformity sequence
Top Basement – Top Synrift Sequence
0
40000
80000
120000
160000
200000
240000
280000
320000
360000
400000
440000
480000
520000
560000
600000
640000
680000
Length (m)

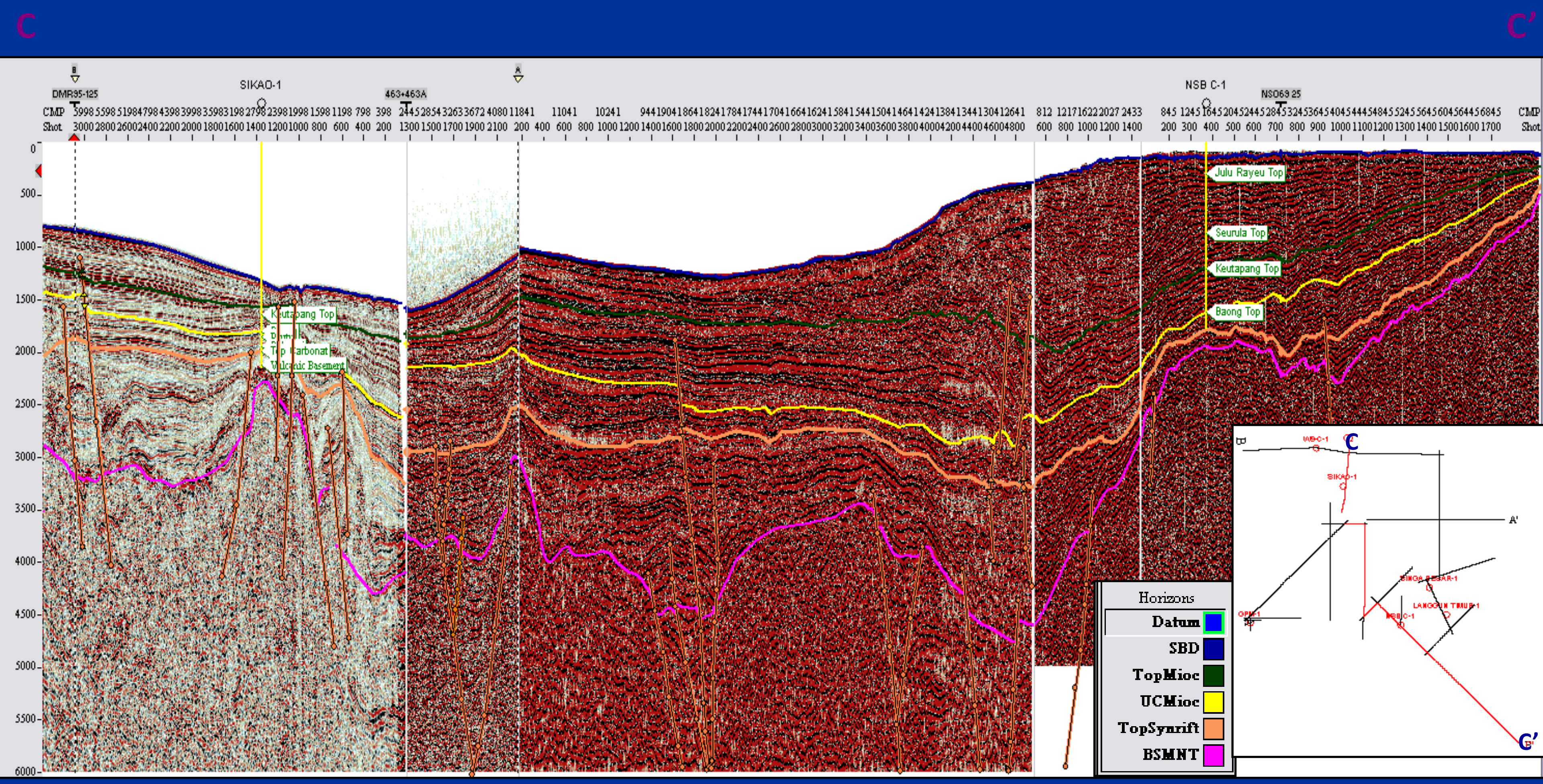
MODELING COMPOSITE B

Need VR PROFILE From Langgun Timur-1 or Singha Besar-1, W9 C1 Wells for modeling validation
Need Lithology Composition from Langgun Timur-1, Singha Besar-1, W9 C-1 Wells

VR data of Langgun Timur -1

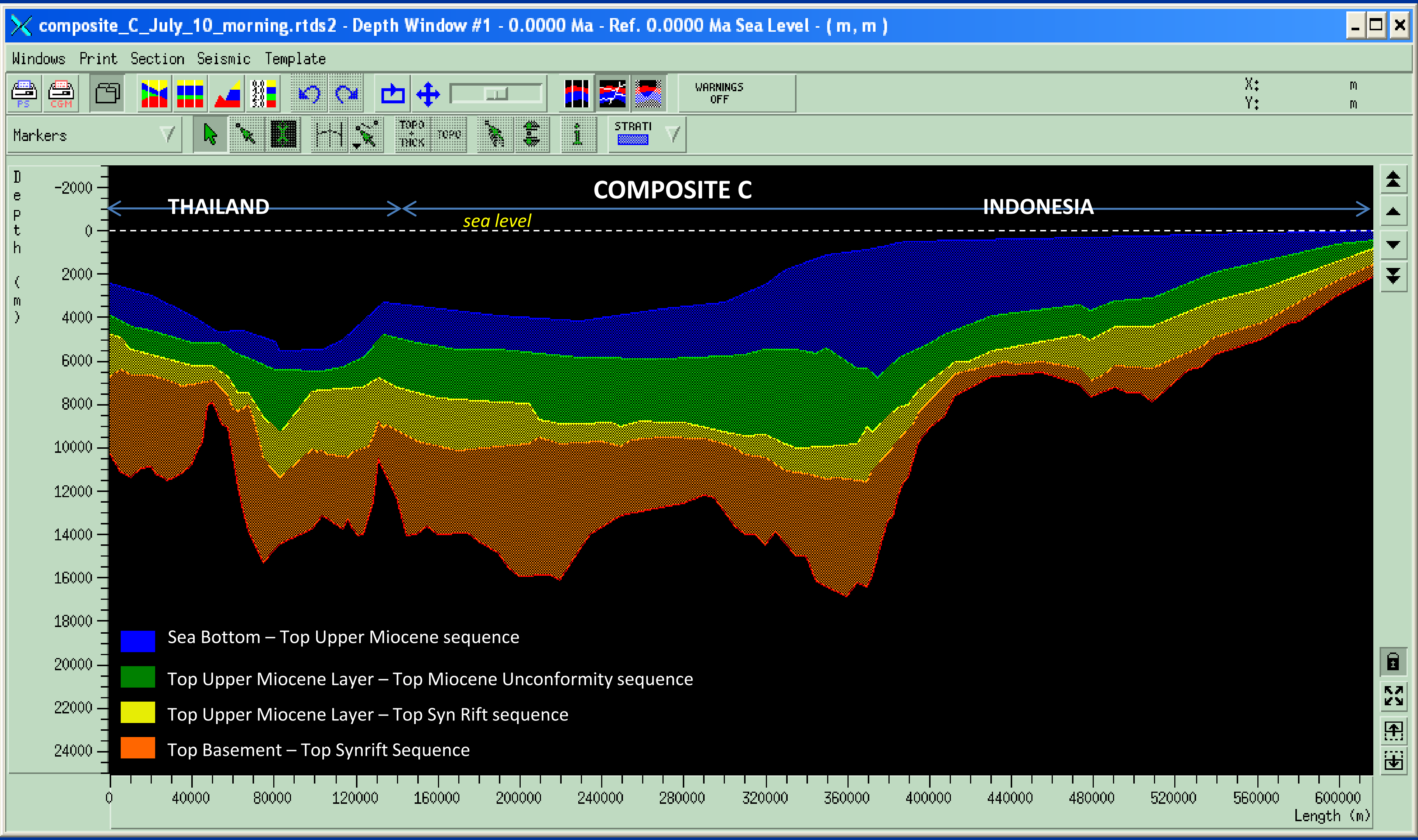
No	FORMATION	Sample Depth		VR
		(ft)	(m)	
1	Keutapang	3020	914	0.30
2	Baong	3290	996	0.31
3		3650	1105	0.28
4		3715	1125	0.31
5		3885	1176	0.31
6		3920	1187	0.30
7	Peutu	4280	1296	0.36
8		4398	1332	1.09
9		4568	1383	1.11
10	Basement	4640	1405	1.44
11		4685	1419	1.15

COMPOSITE SECTION C



CROSSING OR NEAR : NSB C-1, Sikao-1 Well

Section length : ± 620 km

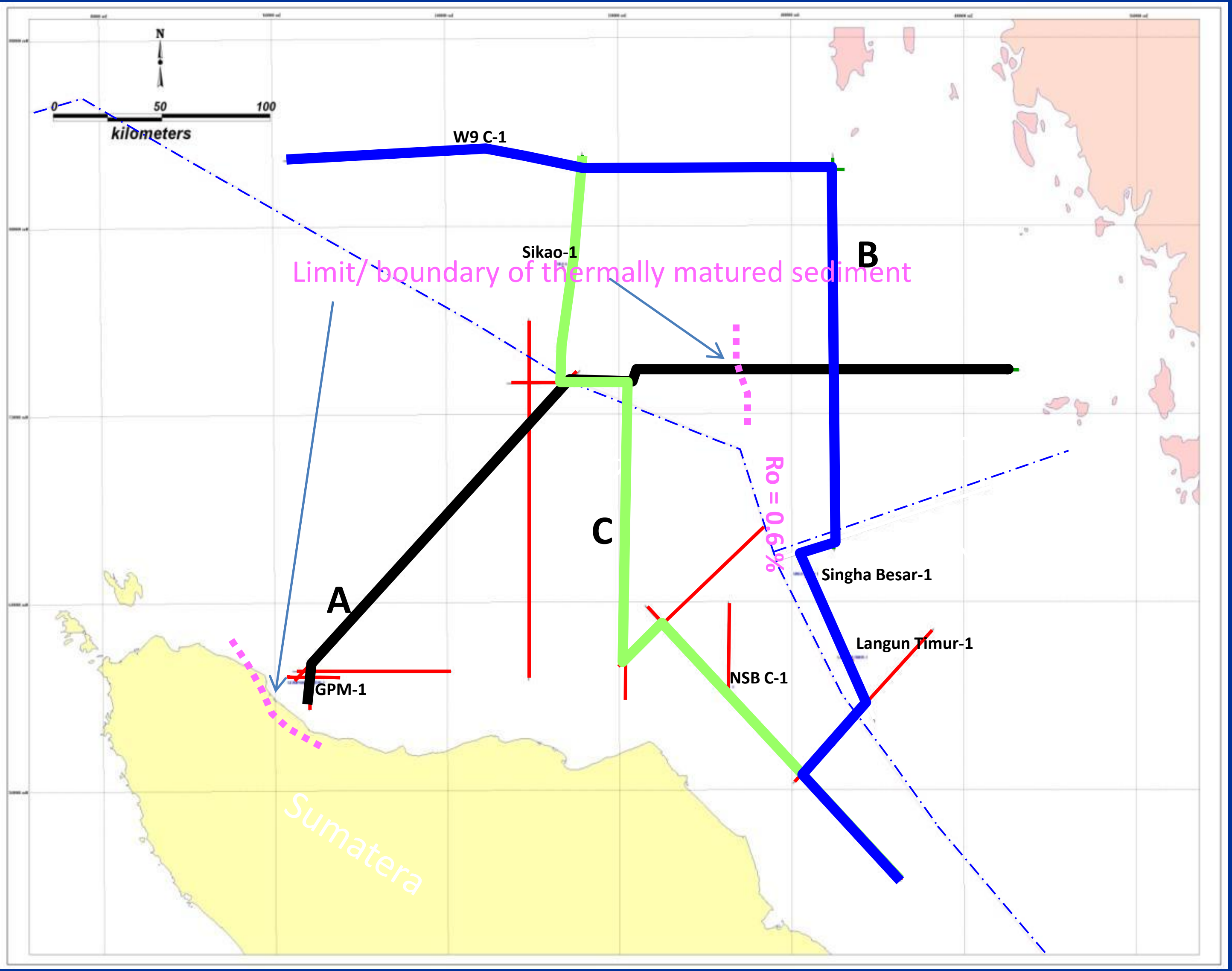

composite_C_July_10_morning.rtds2 - Depth Window #1 - 0.0000 Ma - Ref. 0.0000 Ma Sea Level - (m, m)
Windows Print Section Seismic Template
WARNINGS OFF
Markers
STRATI
COMPOSITE C
THAILAND
INDONESIA
sea level
Depth (m)
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
Sea Bottom – Top Upper Miocene sequence
Top Upper Miocene Layer – Top Miocene Unconformity sequence
Top Upper Miocene Layer – Top Syn Rift sequence
Top Basement – Top Synrift Sequence
0
40000
80000
120000
160000
200000
240000
280000
320000
360000
400000
440000
480000
520000
560000
600000
Length (m)

MODELING COMPOSITE C

Need VR PROFILE From Sikao-1 Wells for Modeling validation
Need Lithology Composition from Sikao-1 Well & NSB-C-1 Well

Table 2-5 : Sikao-1 Formation Temperature.

	Depth		Max Temp	Circ Time	Time Since Circ	Log (T1+T2)/T2	Static BHT	Geothermal Gradient
Log	MD	SS	°F	T1	T2		°F	°F/100'
Sea bottom	3347	3347					60	
CSI	5650	5567	110	1	8	0.051	110	2.3
MSCT	5625	5542	110	1	12	0.035	110	2.3
AIT/HILT/NG	5694	5611	110	1	7.75	0.053	110	2.2
/DSI								
RFT/GR	5609	5526	110	1	19	0.022	110	2.3



MATURITY MAP DERIVED FROM 2D MODELING

From the 3 regional 2D modeling sections we can create regional maturity map by limitating an area with Ro = 0.6 %

Two others 2D lines must be completed.

Need data of Sikao-1, langgun Timur-1/Singha Besar-1, and W9 C-1 as mentioned above

THANK YOU