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Unconventional Oil and Gas Potential in Indonesia with Special Attention to Shale Gas and Coal-bed Methane

R. Sukhyar & R. Fakhruddin

GEOLOGICAL AGENCY, MINISTRY OF ENERGY AND MINERAL RESOURCES, REPUBLIC OF INDONESIA

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Outline

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1. Introduction
2. Geological Setting
3. Shale Hydrocarbon (Shale Gas & Oil Shale)
4. Coal-bed Methane (CBM)
5. Closing Remarks

Introduction

- Goverment of Indonesia (GOI) has identified 128 Sedimentary Basins. Basin assessments will reveal the conventional and unconventional hydrocarbon potential.

- The National oil production declines up to 12% per year, therefore the GOI expects to re-evaluate geosciences concept and prepare more data and information in order to attract many investors to involve for non-conventional oil and gas exploration.

- Distribution and occurrence of Pre-Tertiary to Tertiary shale hydrocarbon and coal bearing formation in Indonesia sedimentary basins are remarkably abundant. Most of them indicate to contain shale oil and gas and coal-bed methane (CBM).

Resources Triangle (Holditch)

- *Conventional reservoirs* : smaller volume, easily developed economically at current technological conditions.
- *Unconventional oil and gas reservoirs* are very abundant, but it is more difficult to develop.
- This requires to be able to be accessed easily, technological improvements, appropriate price and motivation to develop economically

Current estimated of potential unconventional gas reserves (tight sand, CBM and shale) ranging from 1,500 TCF to 2,500 TCF are likely to underestimate the true resources base (Source: Wood Machenzie "Unconventional Hydrocarbon – The Hidden Opportunity)

The role of Geological Agency in Unconventional Gas Development

- Shale Gas and CBM Survey
- Data and Information services of Shale Gas and CBM

GEOLOGICAL SETTING

Geological Map of Indonesia

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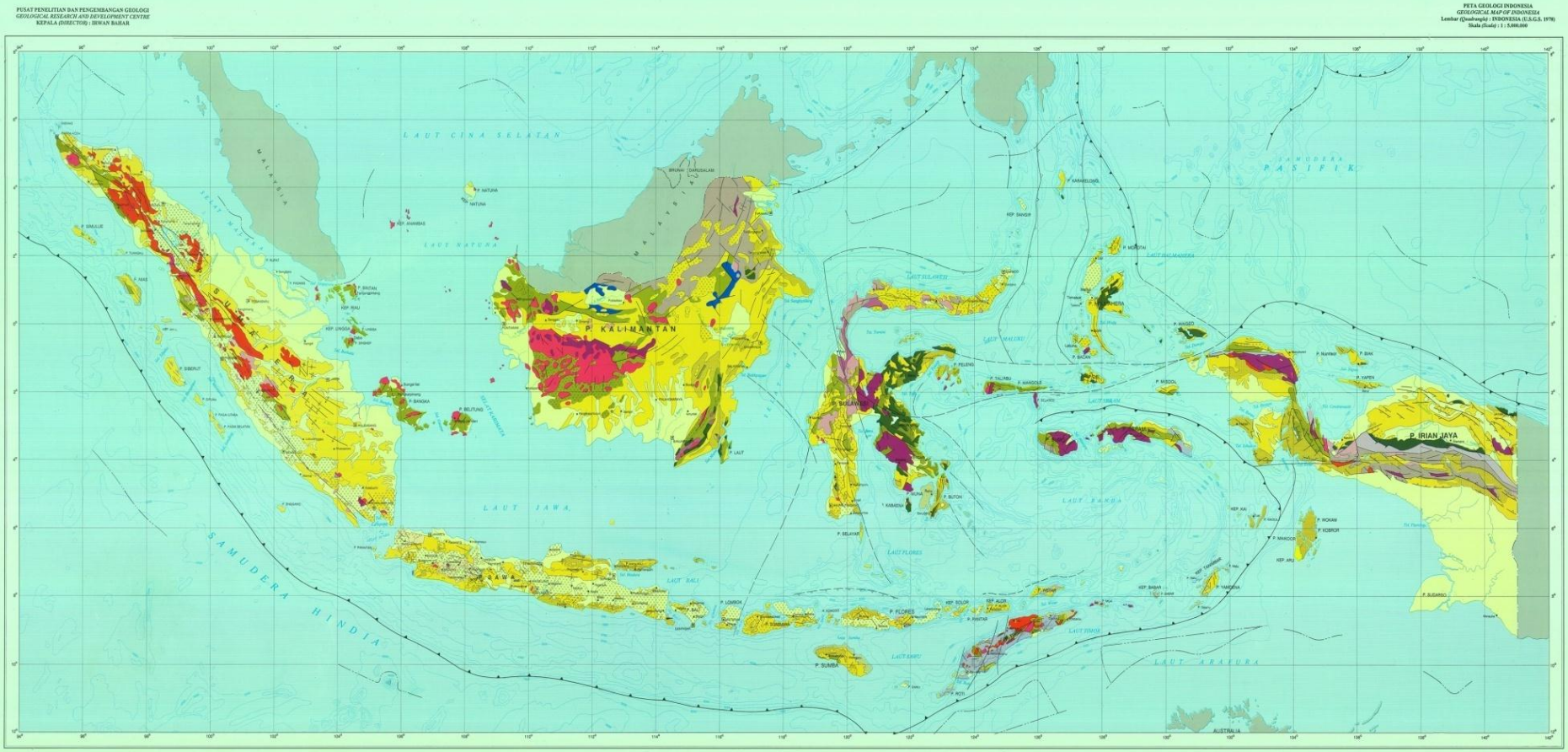

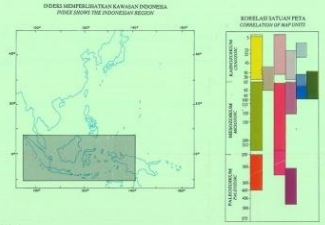

Geological Agency, 1996

Sedimentary Basin Map of Indonesia

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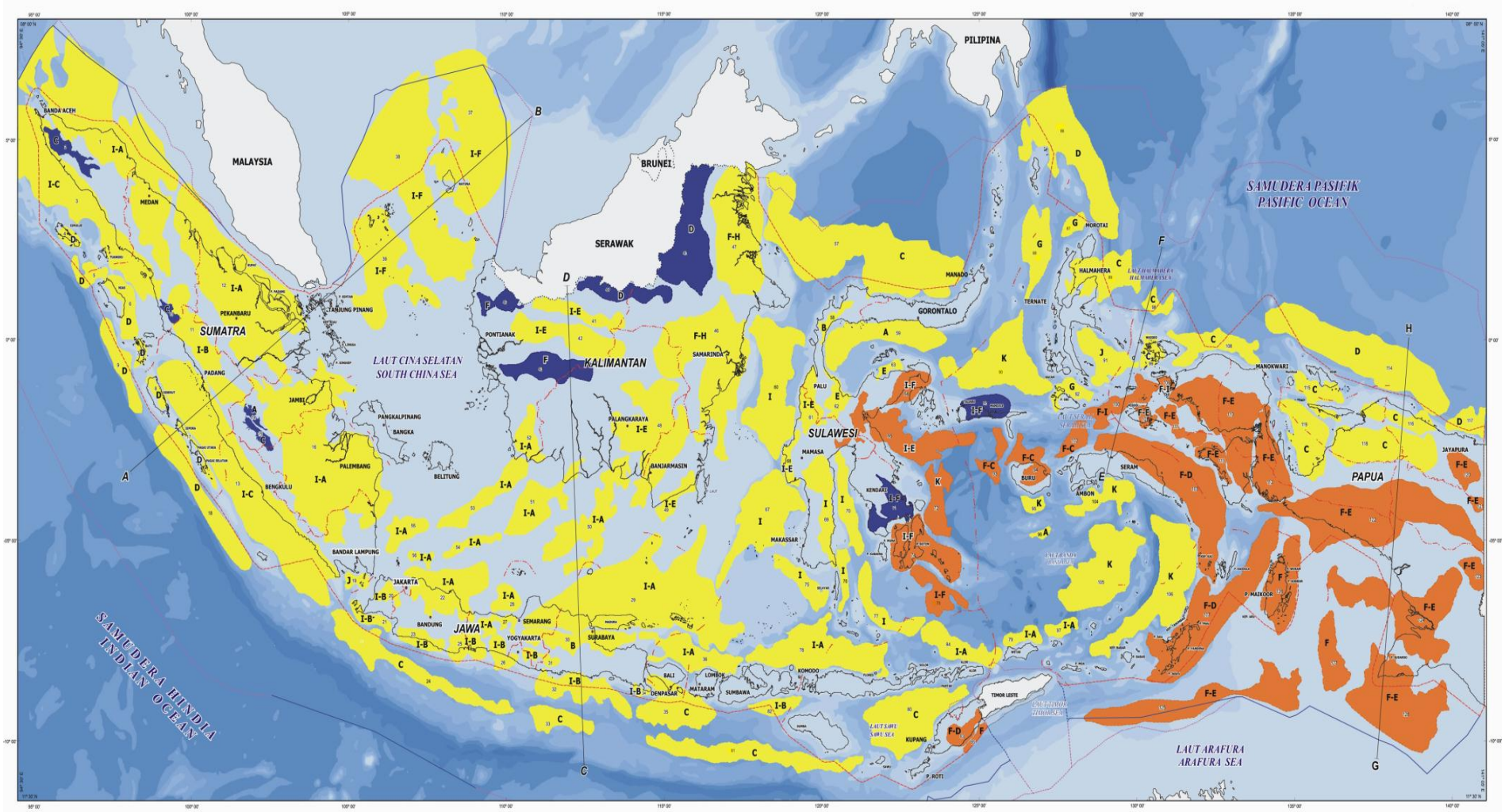

Tertiary Basins

Pre-Tertiary - Tertiary Basins

Pre-Tertiary Basins

Geological Agency, 2009

SHALE GAS & OIL SHALE RESOURCES

SHALE GAS RESOURCES OF MAIN SEDIMENTARY BASINS OF INDONESIA

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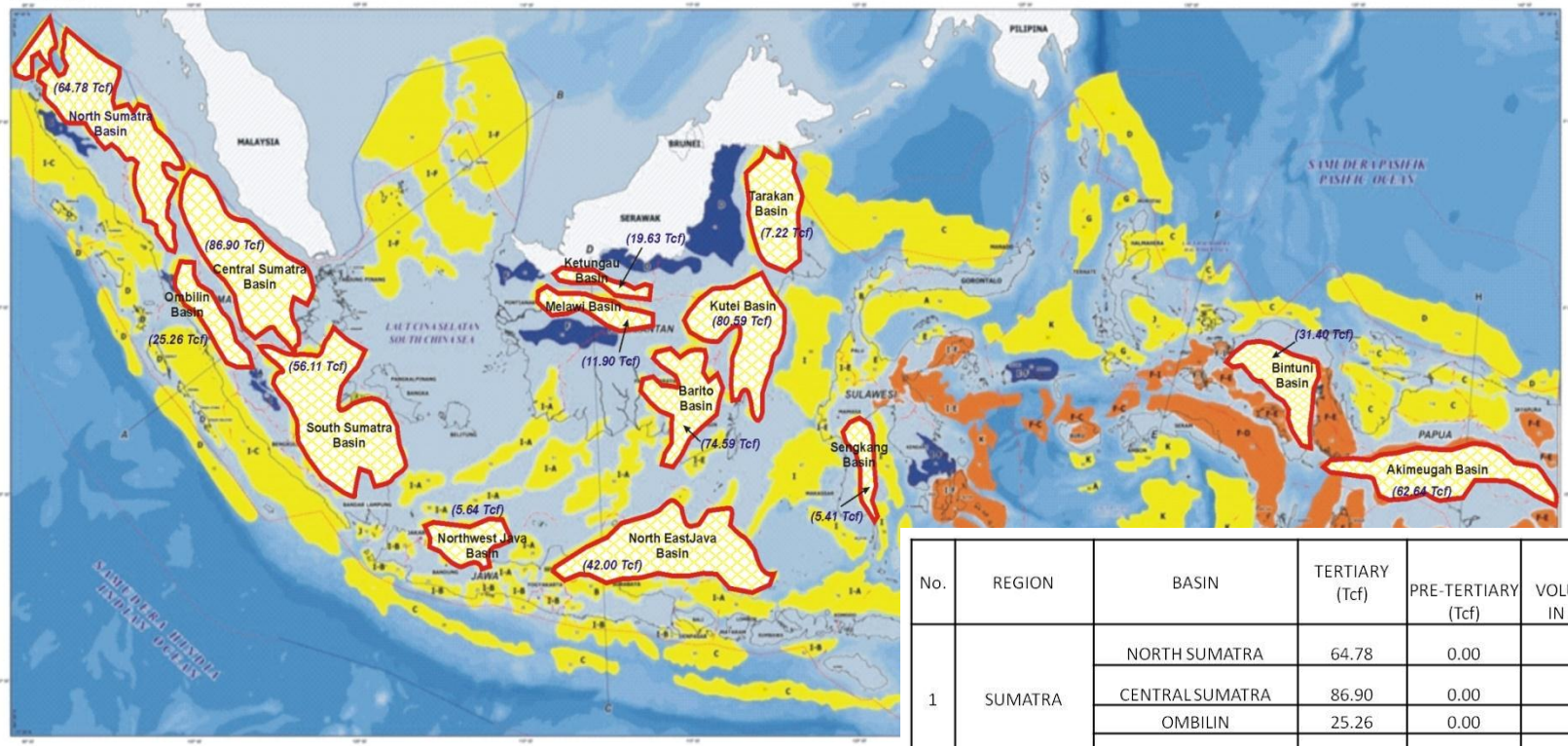

No.	REGION	BASIN	TERTIARY (Tcf)	PRE-TERTIARY (Tcf)	VOLUME OF GAS IN PLACE (Tcf)	TOTAL VOLUME OF GAS IN PLACE (Tcf)
1	SUMATRA	NORTH SUMATRA	64.78	0.00	64.78	233.05
		CENTRAL SUMATRA	86.90	0.00	86.90	
		OMBILIN	25.26	0.00	25.26	
		SOUTH SUMATRA	56.11	0.00	56.11	
2	JAWA					47.64
		NW JAWA	5.64	0.00	5.64	
		NE JAWA	42.00	0.00	42.00	
3	KALIMANTAN					193.93
		BARITO	74.59	0.00	74.59	
		KUTEI	80.59	0.00	80.59	
		TARAKAN	7.22	0.00	7.22	
		MELAWI	11.90	0.00	11.90	
		KETUNGAU	19.63	0.00	19.63	
4	SULAWESI					5.41
		SENGKANG	5.41	0.00	5.41	
5	PAPUA					94.04
		AKIMEUGAH	5.50	57.14	62.64	
		BINTUNI	1.15	30.25	31.40	
	TOTAL SPECULATIVE RESOURCES OF SHALE GAS					574.07

Total Speculative Resources of Shale gas in Indonesia = 574.07 Tcf

Geological Agency, 2011

Map of Distribution and Potential of Shale Oil and Gas Bearing Formation of Indonesia

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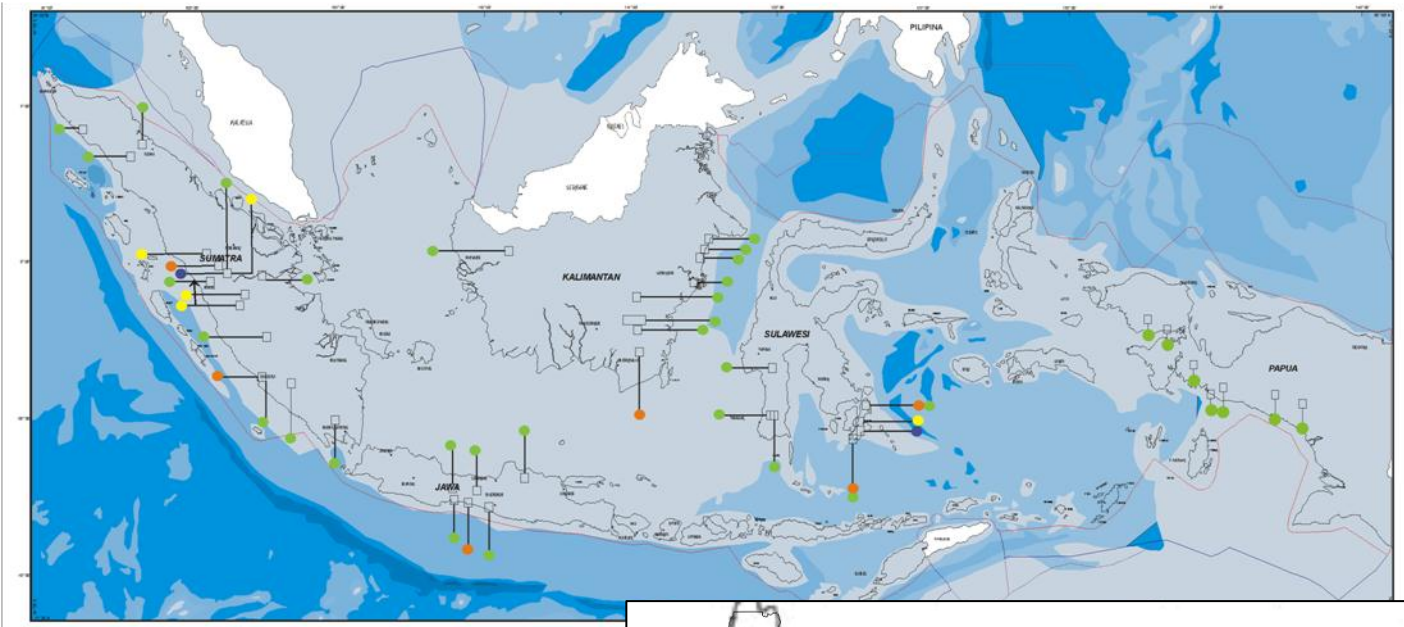
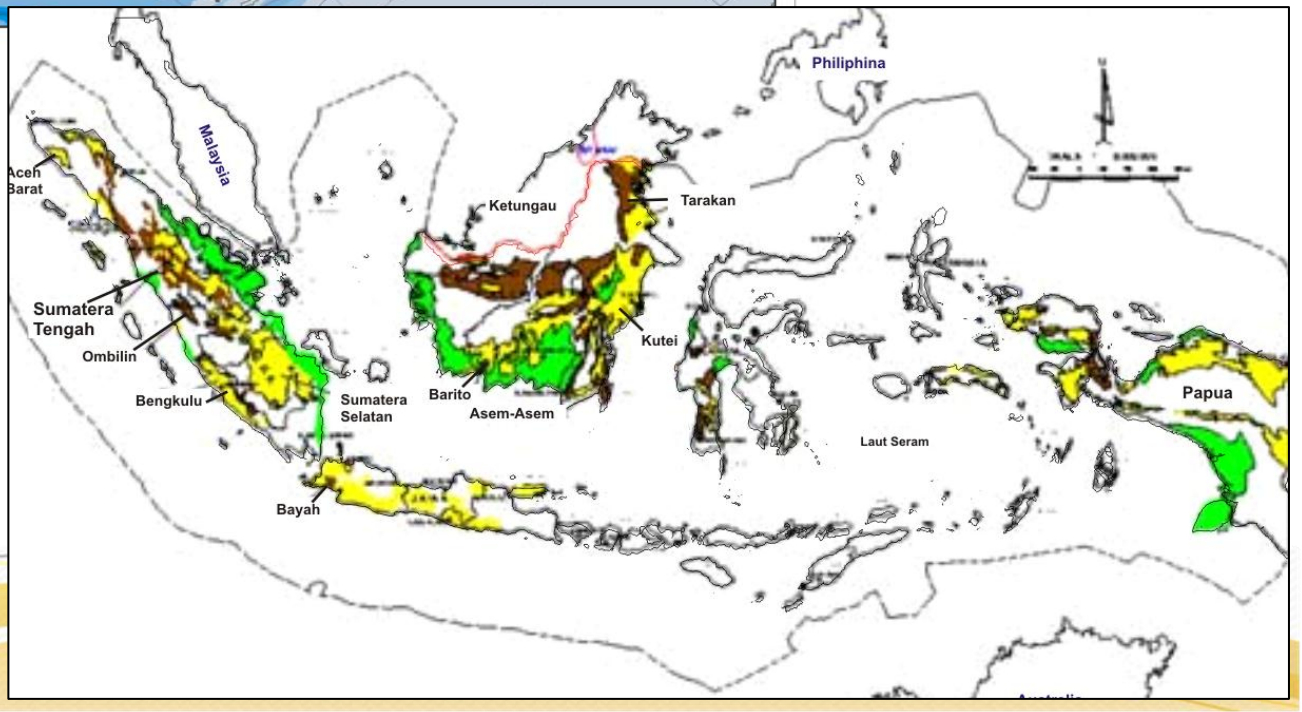


Oil and Gas Potency

- Predominantly Gas
- Oil and Gas
- Predominantly Oil
- VeryPredominantly Oil



- Quaternary
- Neogene
- Paleogene

Geological Agency, 2011

Oil Shale Speculative Resources in Indonesia

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No	Lokasi	Provinsi	Oil Yield (Lt/Ton)	Sumber Daya (Juta Ton)		
				Hipotetik	Tereka	Total
1	Maros	Sulawesi Selatan	12	0,84	-	0,84
2	Pangkep	Sulawesi Selatan	4	2,63	-	2,63
3	Lok Paikat	Kalimantan Selatan	1-102	6,4	-	6,4
4	Sepaso	Kalimantan Timur	-		-	-
5	Kotabaru	Kalimantan Selatan	7-100	4,5	-	4,5
6	Kiliranjau	Sumatera Barat	-		-	-
7	Kotabuluh	Sumetera Utara	-		-	-
8	Kandui	Kalimantan Tengah	2-5		-	-
9	Kebon Tinggi	Riau dan Sumbar	1-140	236,86	-	236,86
10	Tapin	Kalimantan Selatan	1-102	2,4	-	2,4
11	Pasar Wajo	Sulawesi Tenggara	14-248	40,59	-	40,59
12	Talawi	Sumatera Barat	5-50	1003,86	-	1003,86
13	Tangko	Riau	5-212	57,49	-	57,49
14	Tiga Binanga	Sumatera Utara	-	152,82	-	152,82
15	Ayah	Jawa Tengah	8-140	3,23	-	3,23
16	Air Napal	Bengkulu	70-150	0,54	-	0,54
17	Ampah	Kalimantan Tengah	5-10	9,81	-	9,81
18	Banjarnegara	Jawa Tengah	0-5		-	-
19	Bentarsari	Jawa Tengah	5-30	24,54	-	24,54
20	Galugur	Sumatera Barat	15-60	3,35	-	3,35
21	Kalibawang	DIY	-		-	-
22	Loa Janan	Kalimantan Timur	5-15	1,17	-	1,17
23	Mengkua Limun	Jambi	20-30	14,7	-	14,7
24	Muara Uya	Kalimantan Selatan	4		-	-
25	Sampolawa	Sulawesi Tenggara	5-180	7,69	-	-

Indonesia oil shale resources up to 2007 amounts to 11.24 million tons, 10.09 million tons with the details of the speculative resources and 1.15 million tones inferred resource.

Geological Agency, 2007

SHALE DISTRIBUTION

Sumatra Backarc Basins Tectono-Stratigraphic Scheme

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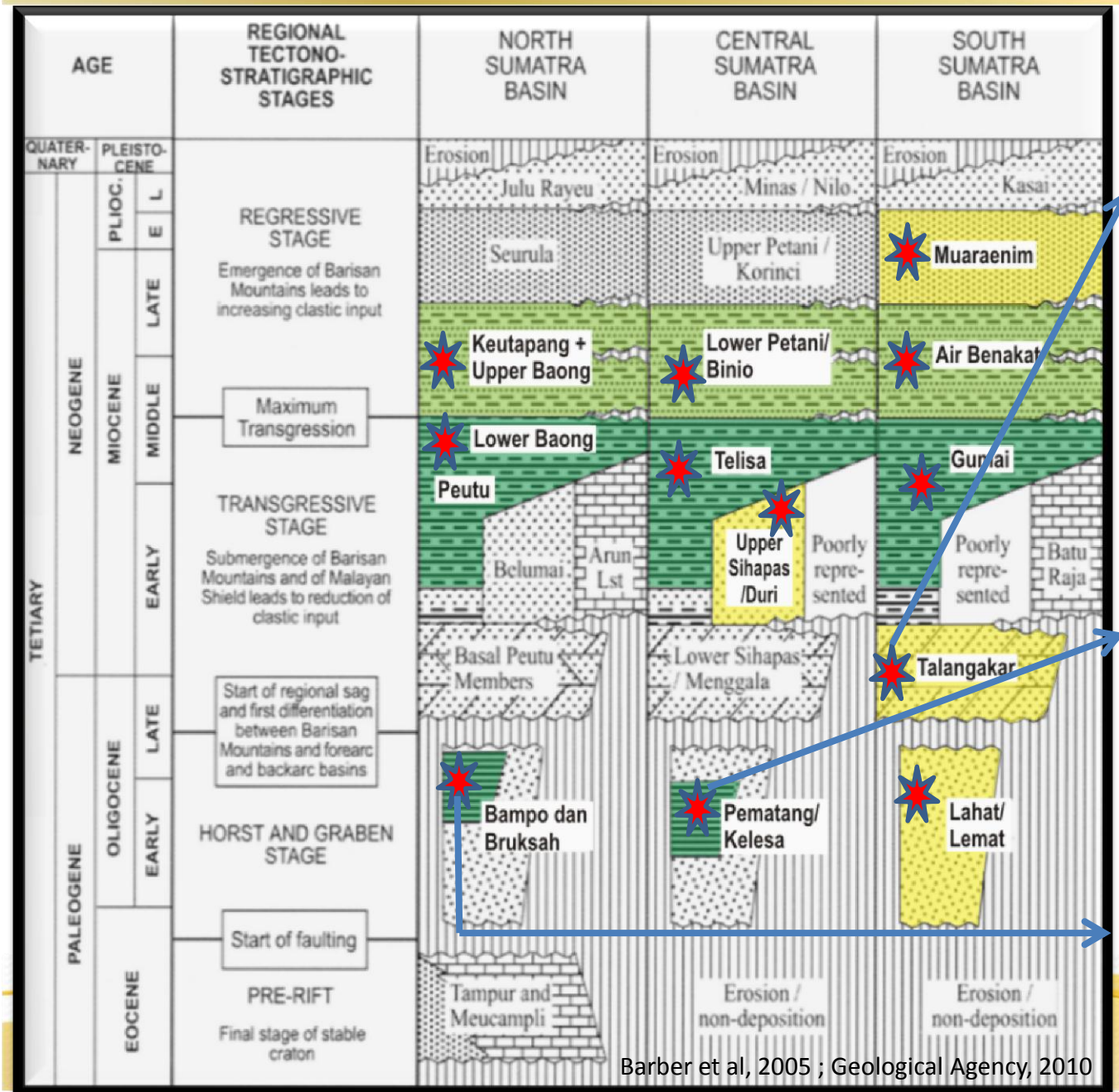

Barber et al, 2005 ; Geological Agency, 2010

Sungai Namaran, Tebingtinggi

Bukitsusah, Riau

Kota Buluh, North Sumatra

Intramontane Basins in Sumatra

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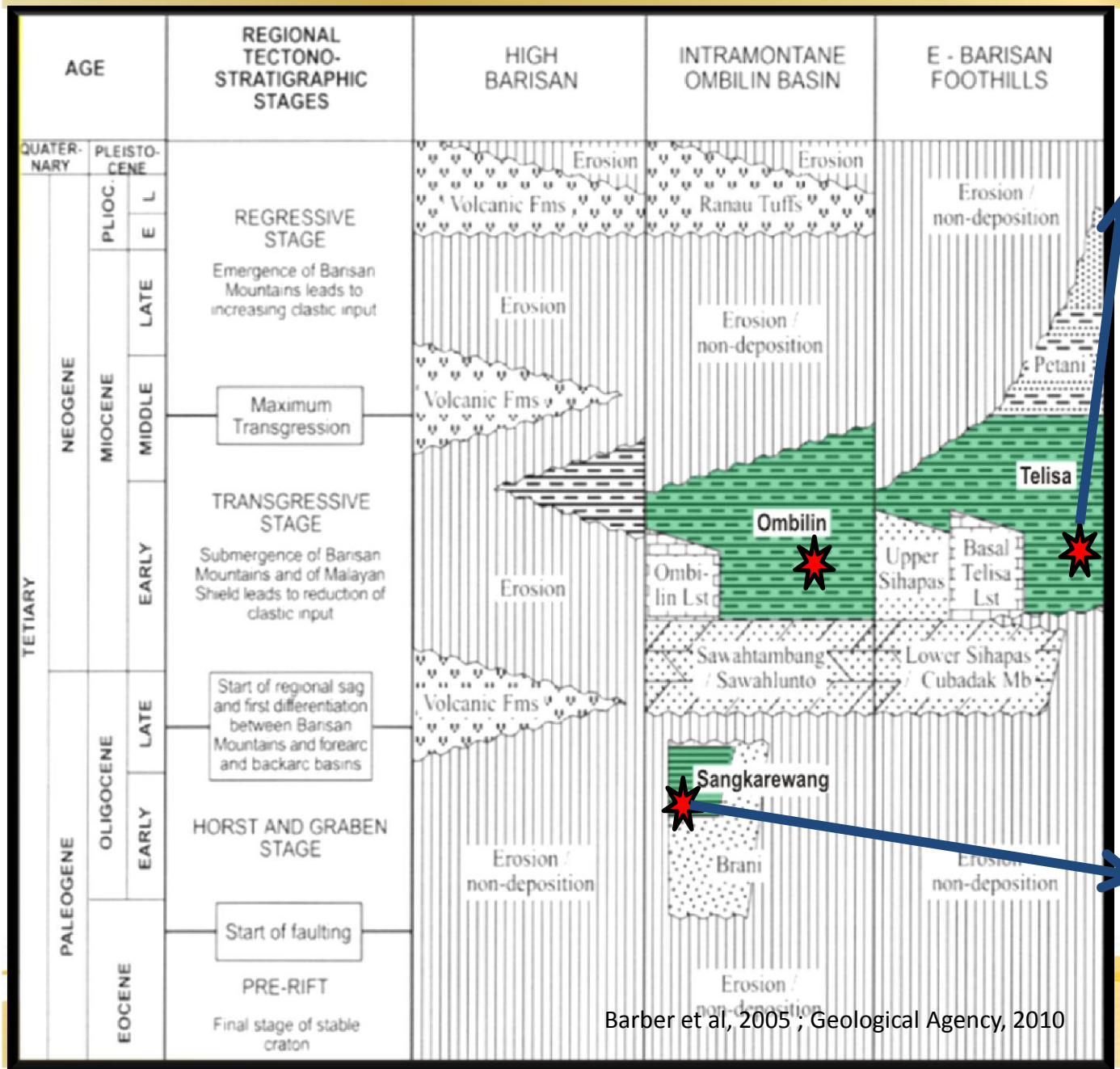

Barber et al, 2005 ; Geological Agency, 2010

Pre-Tertiary Shale Hydrocarbon in Sumatra

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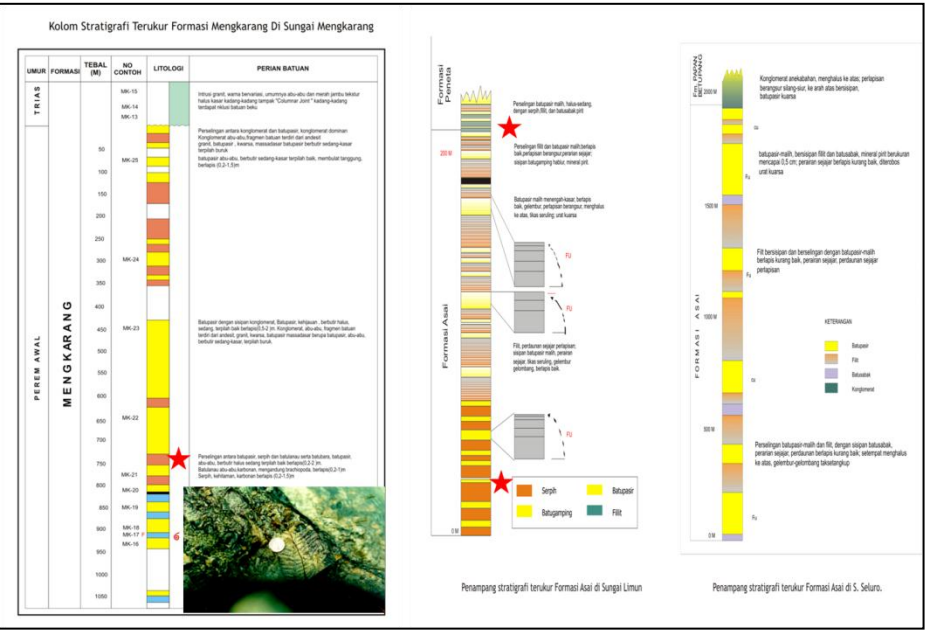
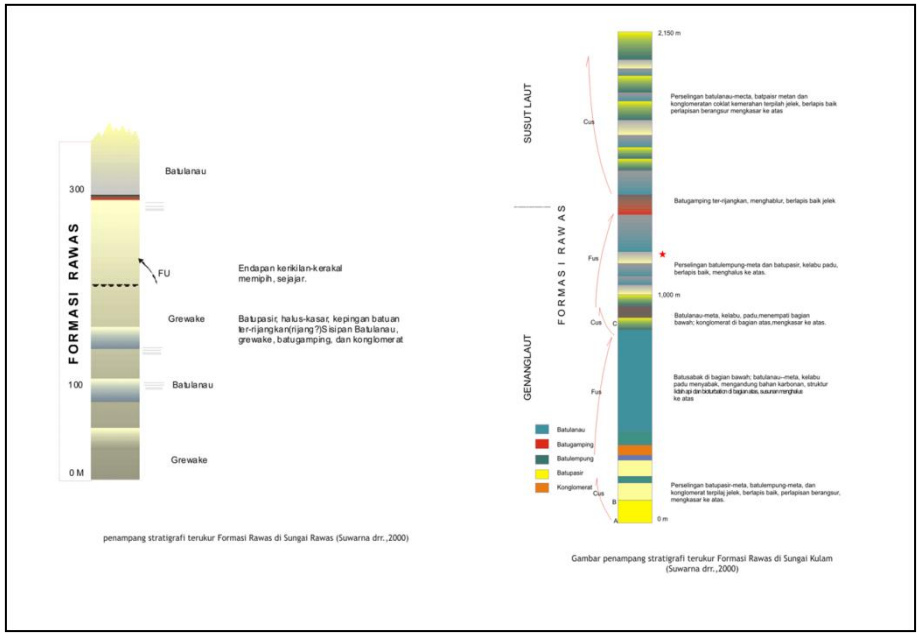
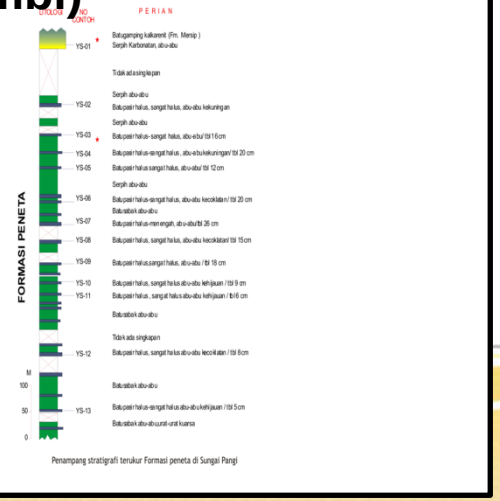
Shale of Mengkarang Formation (Jambi)



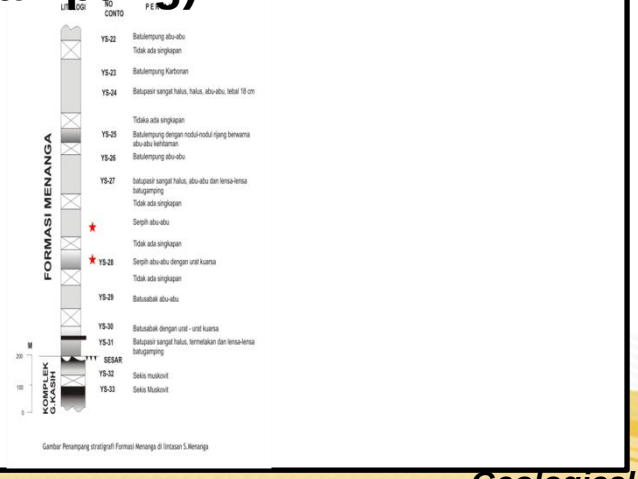
Shale of Rawas Formation (Jambi)



Shale of Peneta Fm (Jambi)



Shale of Menanga Fm (Lampung)



Geological Agency, 2000

Stratigraphy of North West and East Java Basin

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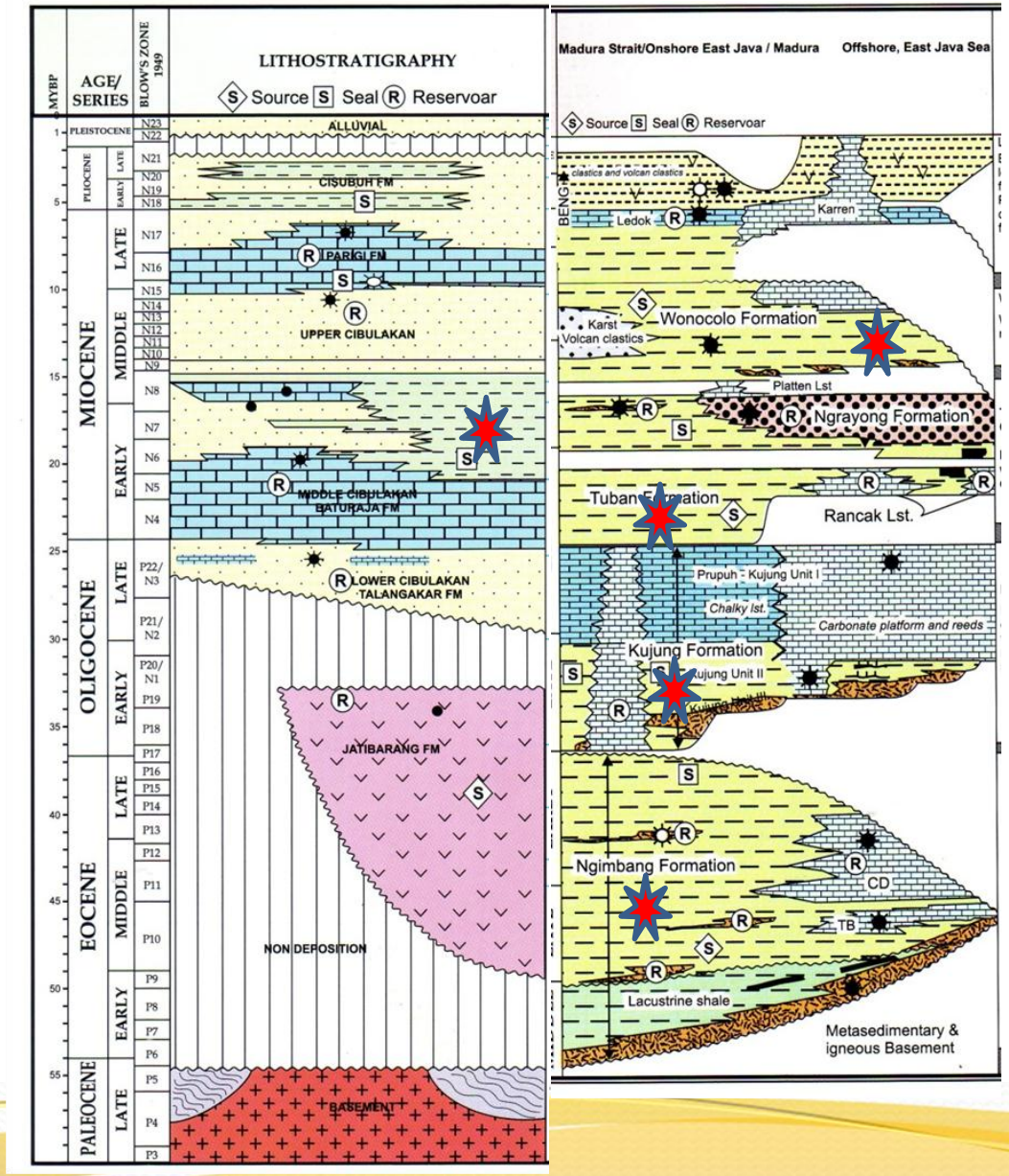

Indonesia Basins Summaries, 2006

Stratigraphy of Melawi, Barito, Kutei and Tarakan Basins, East Kalimantan

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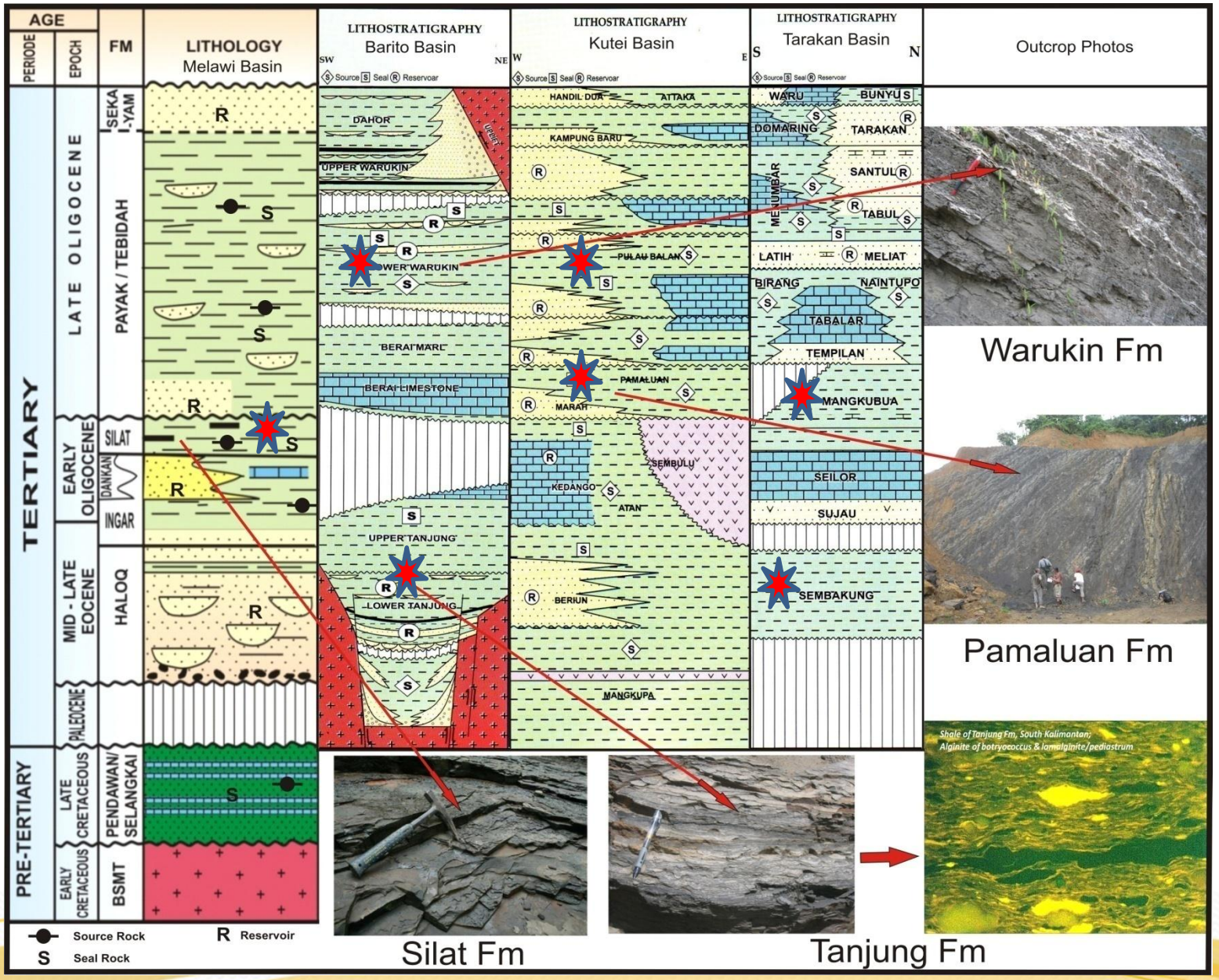

Geological Agency, 1993; Indonesia basins Summaries, 2006

Stratigraphic Correlation of Eastern Indonesia

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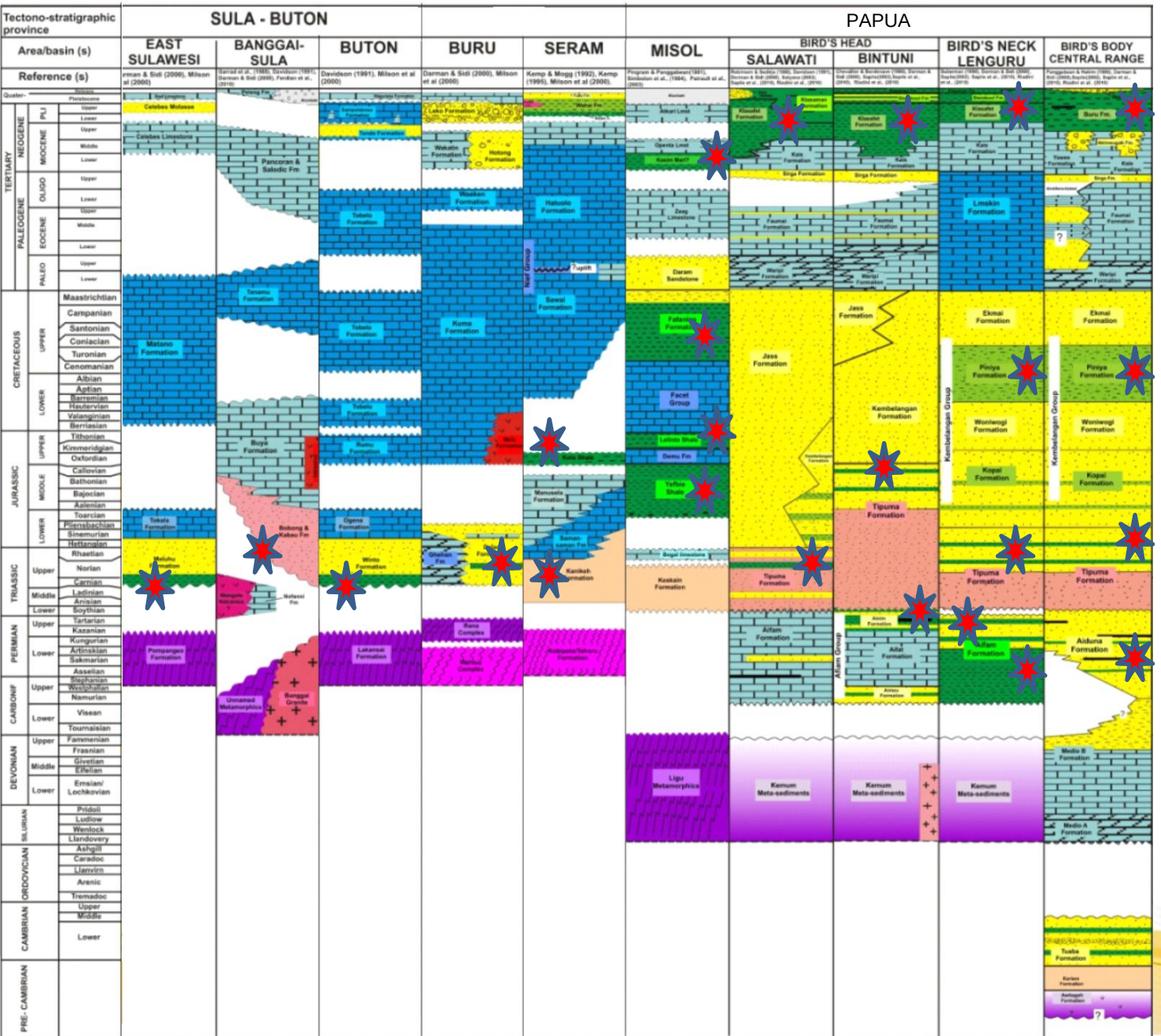

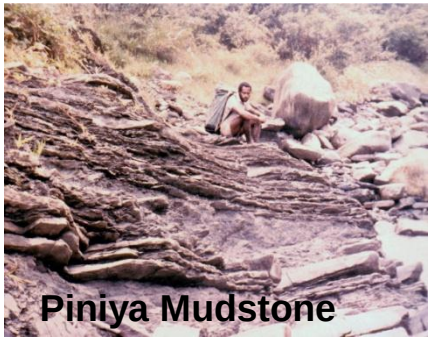

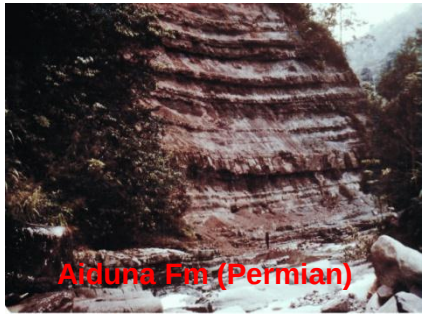

Geological Agency, 2011

Important elements in shale gas play

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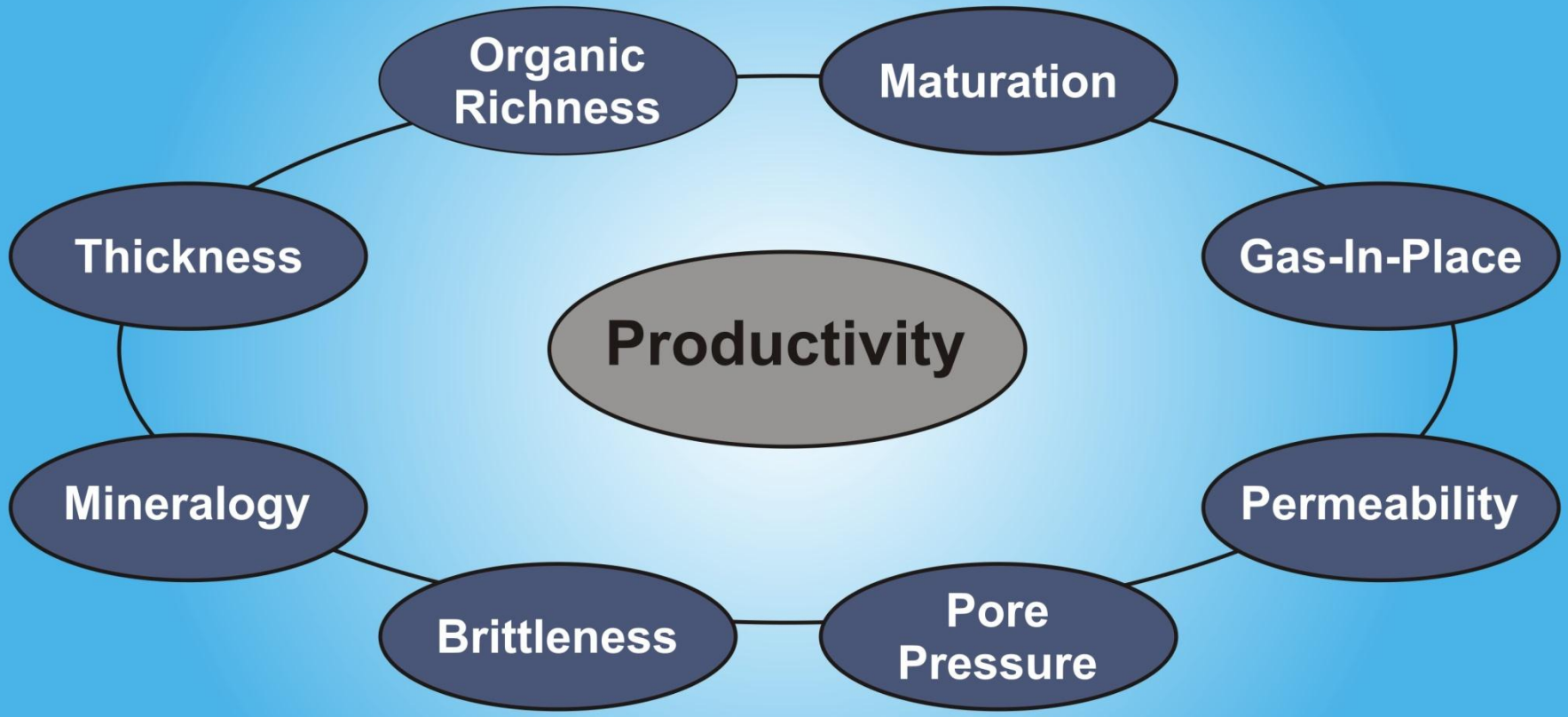

SHALE HYDROCARBON ASSESMENT WORK FLOW

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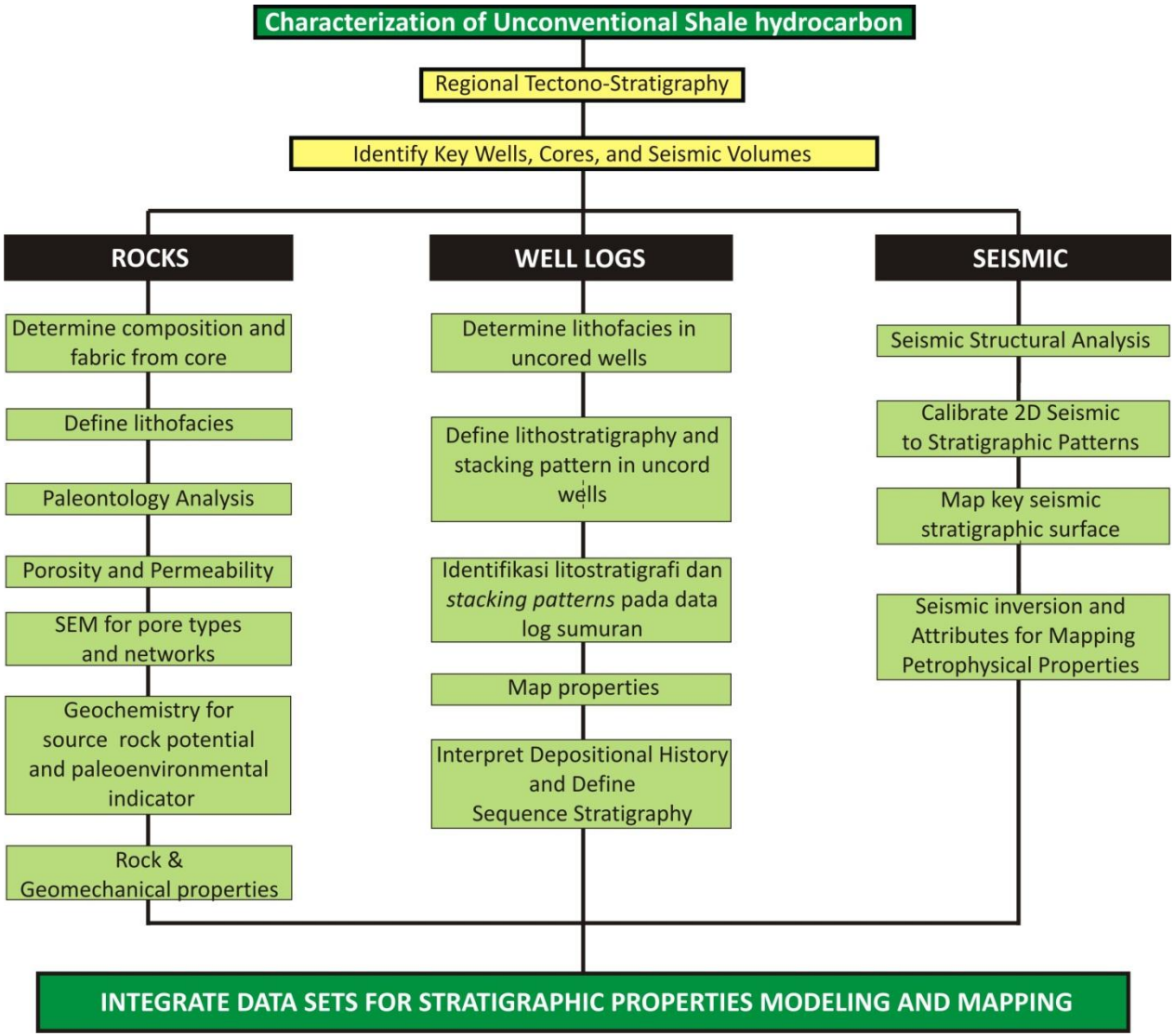

Pematang Fm. samples lab analysis

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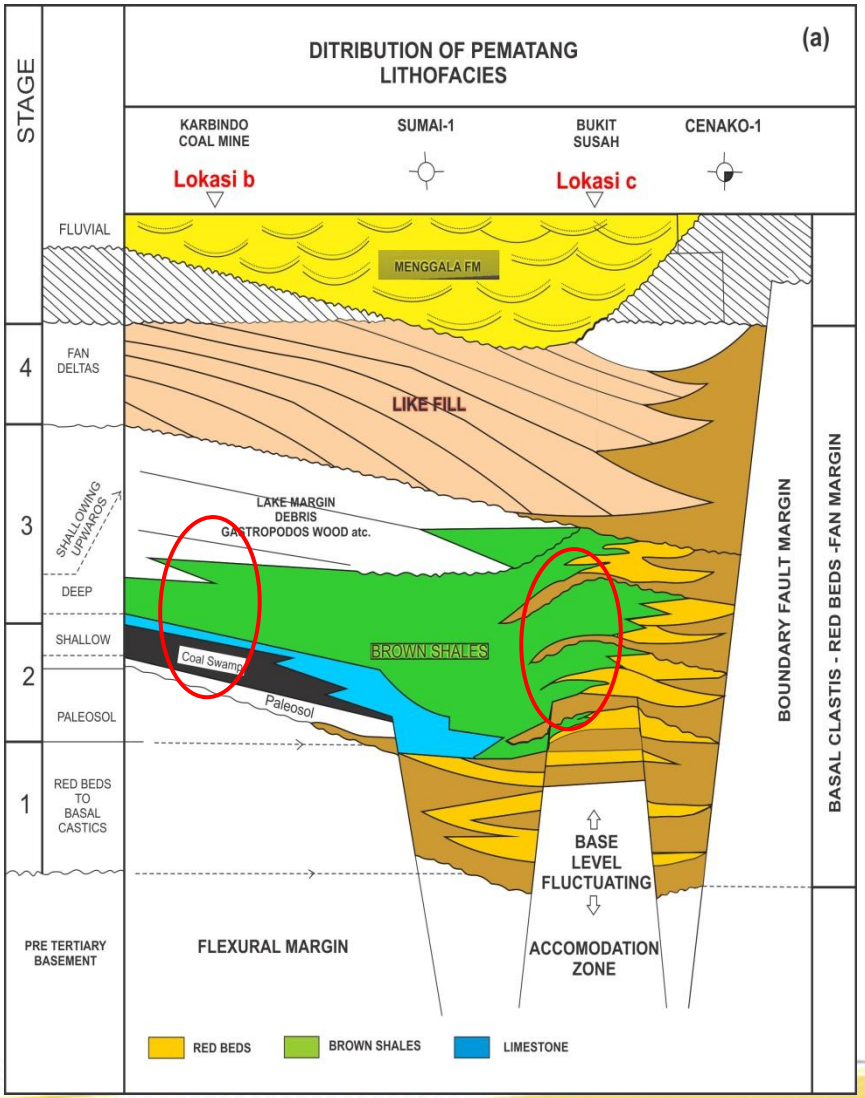
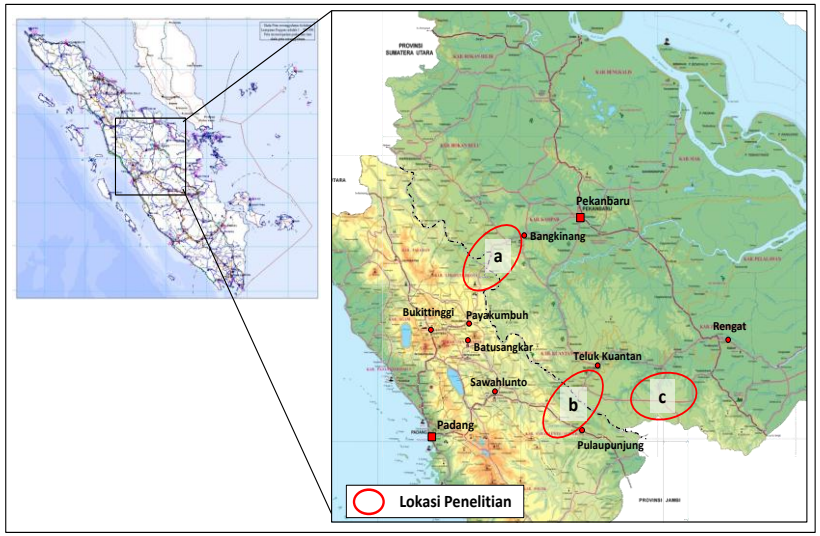
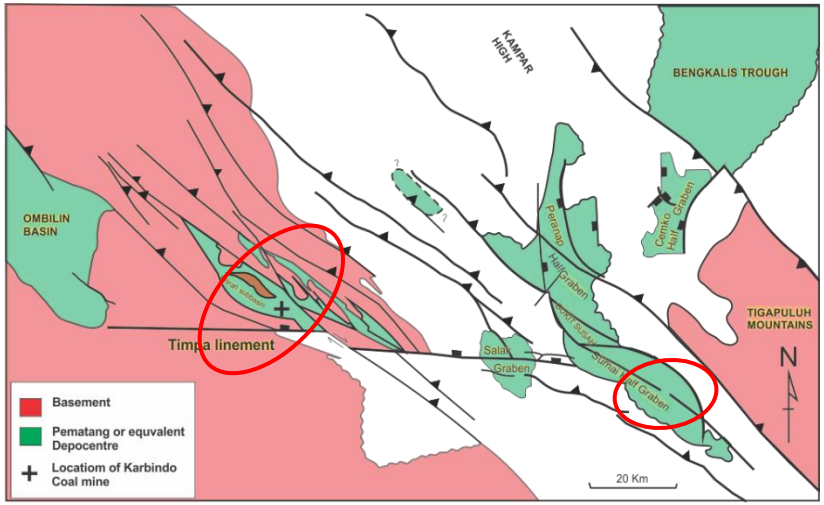
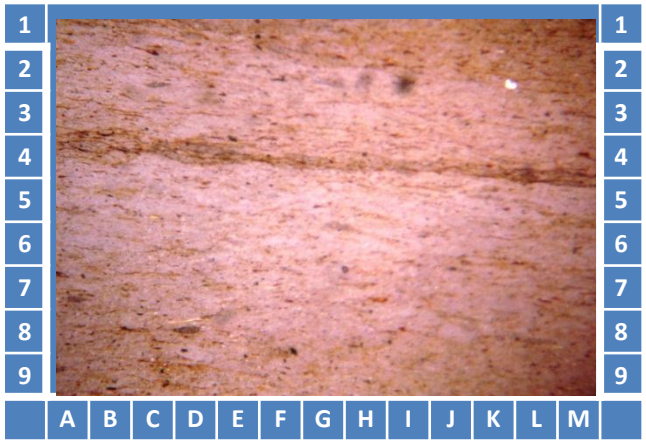




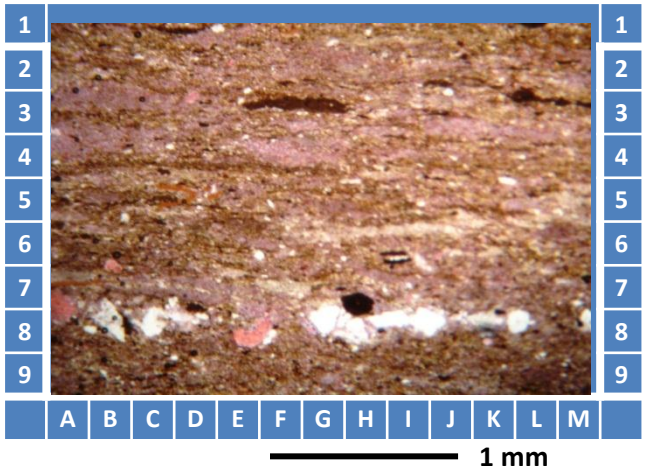


Lithofacies



CLASSIFICATION: CALCAREOUS CLAYSTONE

Petrography view shows a textural of shale, mostly composed of detrital clays such as quartz, calcite (pink color), siderite, dolomite and pyrite mixed with clay mineral. Shale is characterized by massif clay. Framework grain components include of quartz, sedimentary rock fragment, and the grains are commonly floating on detrital clays.
Diagenetic event consist of replacement of the unstable grain and organic material mostly to siderite, and calcite. Visual porosity is very low.



CLASSIFICATION: SILTY CLAYSTONE

Petrography view shows a textural of shale, mostly composed of detrital clays such as quartz, siderite and feldspar mixed with clay mineral. Shale is characterized by laminated clay. Framework grain components include of quartz, sedimentary rock fragment, and the grains are commonly floating on detrital clays.
Diagenetic event consist of replacement of the unstable grain and organic material mostly to siderite, and calcite. Visual porosity is moderately as dissolution and fracture.

Determinasi komposisi batuan

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X-RAY DIFFRACTION ANALYSIS																
No	Sample ID	CLAY MINERALS (%)				CARBONATE MINERALS (%)			OTHER MINERALS (%)				TOTAL (%)			BI (%)
		SMECTITE	ILLITE	KAOLINITE	CHLORITE	CALCITE	DOLOMITE	SIDERITE	QUARTZ	K - FELDSPAR	PLAGIOCLASE	PYRITE	CLAY	CARBONATE	OTHER	
1	A	-	11	23	-	6	-	25	35	-	-	-	34	31	35	45
2	B	-	5	22	-	40	-	8	21	-	-	4	27	48	25	22
3	C	-	5	16	-	40	-	4	30	-	-	5	21	44	35	31
4	D	-	5	15	-	52	-	4	20	-	-	4	20	56	24	21
5	E	-	8	26	-	20	-	10	36	-	-	-	34	30	36	38
6	F	-	4	10	-	48	-	4	30	-	-	4	14	52	34	31
7	G	-	3	6	-	66	-	4	18	-	-	3	9	70	21	18
8	H	-	6	12	-	41	-	5	30	2	-	4	18	46	36	32
9	I	-	35	17	-	-	-	3	41	1	3	-	52	3	45	43
10	J	-	5	12	-	50	-	5	28	-	-	-	17	55	28	28
11	K	-	6	12	-	50	2	-	30	-	-	-	18	52	30	31
12	L	-	5	7	-	43	1	5	35	-	-	4	12	49	39	38
13	M	-	3	7	-	60	-	4	23	-	-	3	10	64	26	24
14	N	-	2	2	-	95	-	-	1	-	-	-	4	95	1	1
15	O	-	6	12	-	12	5	10	53	-	-	2	18	27	55	63
16	P	-	-	-	-	97	-	-	1	-	-	2	0	97	3	1
17	Q	-	8	16	-	6	-	17	50	-	-	3	24	23	53	60
18	R	-	4	10	-	60	-	8	10	-	-	8	14	68	18	11
19	S	-	5	12	-	52	6	-	20	-	-	5	17	58	25	27

Dua metode yang umum dilakukan dalam analisa mineral *shale :*

- *XRD (X-Ray Diffraction)*
- *FTIR (Infra-red Spectometry)*

Mineral yang mempengaruhi pada *brittleness*

$$BI = (Q + Dol) / (Q + Dol + Lm + Cl + TOC)$$

Di mana:

BI = Brittleness Index

Q = kuarsa

Cl = mineral lempung

Dol = Dolomit

Lm = Batugamping (Kalsit)

TOC = Total Organic Carbon)

Mineral lainnya yang mempengaruhi secara minor antara lain:

(fosfat, pirit, organisme (kalsit, silika, kerang, dll)

(Wang dan Gale, 2009)

Brittleness:

< 30% = poor

30 – 50% = moderate

> 50% =good

Porosity and Permeability

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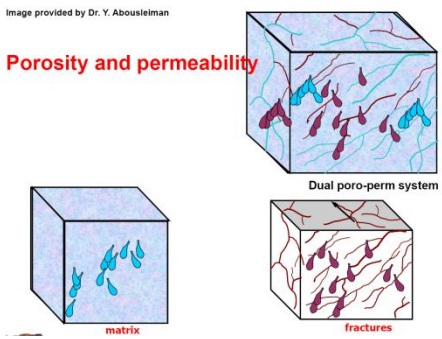
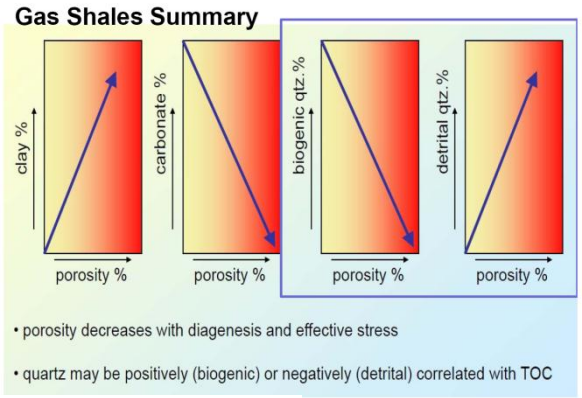
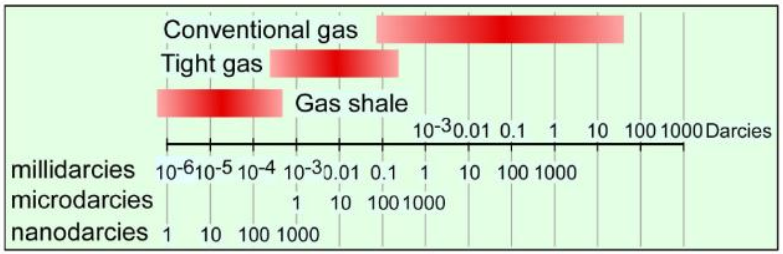
Sample no	PERMIABILITY	POROSITY	Grain Dens
	mD	(%)	(g/cc)
A	1.27	13.02	2.506
B	0.04	5.8	2.424
C	0.01	5.04	2.459
D	0.1	8.36	2.393
E	0.1	9.52	2.427
F	0.13	8.86	2.386
G	0.09	8.41	2.376
H	7.65	10.71	2.405
I	0.08	8.15	2.422
J	0.73	8.08	2.369
K	0.08	8.72	2.465
L	0.08	7.88	2.372
M	0.14	7.79	2.417
N	0.1	7.4	2.37
O	0.08	7.32	2.392
P	0.36	6.61	2.454
Q	0.09	5.32	2.405
R	0.09	5.88	2.369
S	0.06	4.76	2.412





Matrix Permeability of Reservoirs



- Gas shales have very low matrix permeability, in the 1 - 100 nanodarcy range
  - a nanodarcy is to a millidarcy as a millidarcy is to 1000 darcys.
- Tight-gas reservoirs are typically 1-10 microdarcy reservoirs, 100 to 1000 times more permeable than gas shales.

SEM for Pore type & Networks

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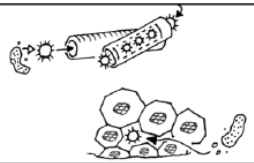
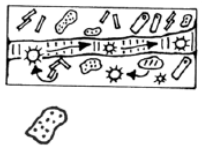
Pore Type	Image	Distinctive Features
Porous Floccules		Clumps of electrostatically charged clay flakes arranged in edge-face or edge-edge cardhouse structure. Pores up to 10's of microns in diameter. Pores may be connected.
Organo-porosity		Pores in smooth surfaces of organic flakes or kerogen. Pore diameters are at nanometer scale. Pores are generally isolated. Porous organic coatings can also be adsorbed on clays.
Fecal Pellets		Spheres/ellipsoids with randomly oriented internal particles, giving rise to intrapellet pores. Pellets are sand-size and may be aligned into laminae.
Fossil Fragments		Porous fossil particles, including sponge spicules, radiolaria, and spores (Tasmanites?). Interior chamber may be open or filled with detrital or authigenic minerals.
Intraparticle Grains/Pores		Porous grains, such as pyrite framboids which have internal pores between micro-crystals. Grains are of secondary origin, and are usually dispersed within the shale matrix.
Microchannels and Microfractures		Linear nano-micrometer-sized openings that often cross-cuts bedding planes. Occur at nano-meter and larger scales.

SEM for Pore type & Networks

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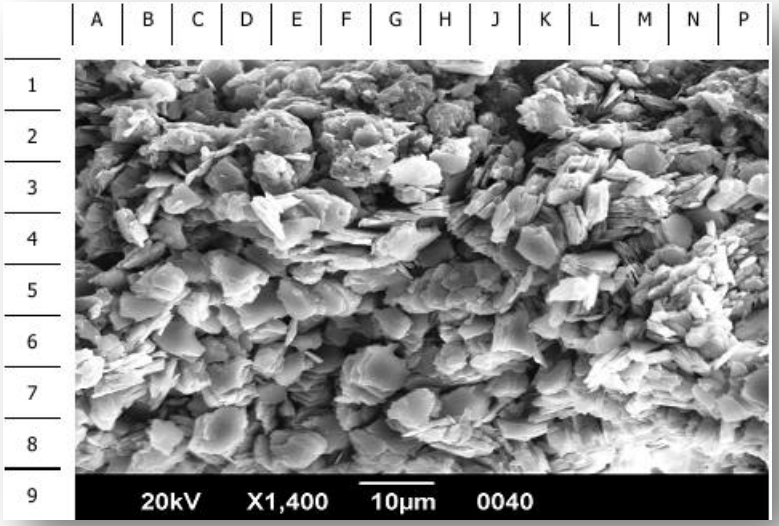
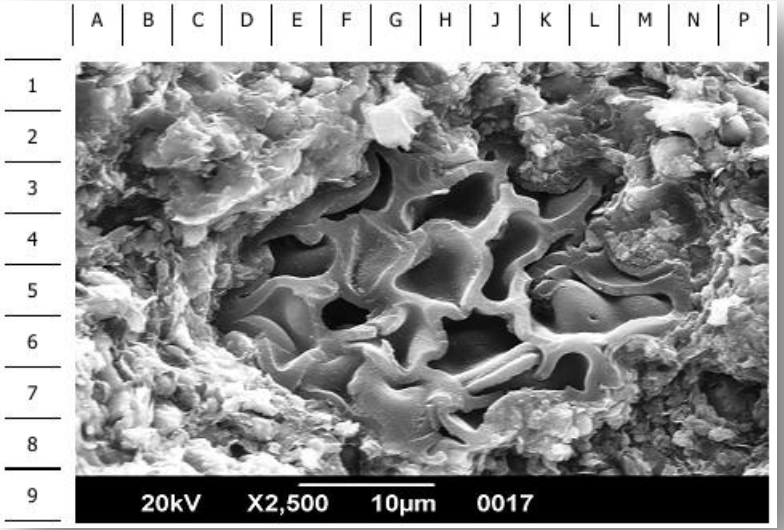
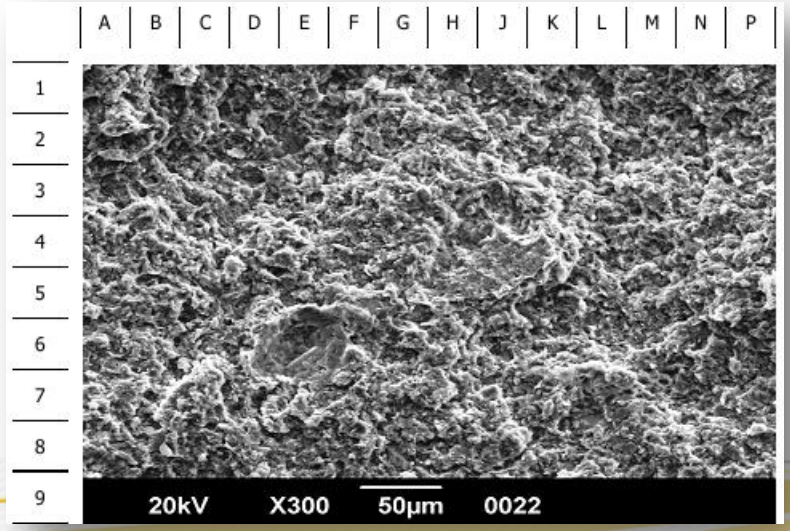


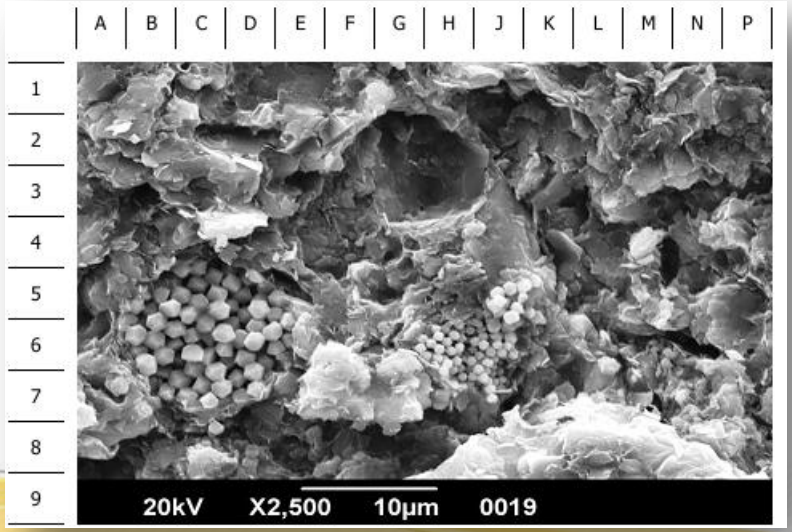
Porous Floccules



Organo-porosity

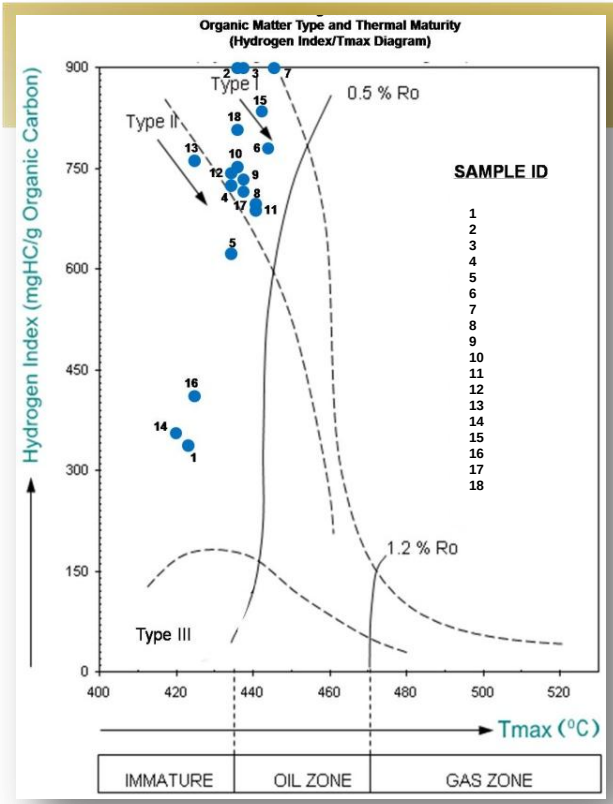


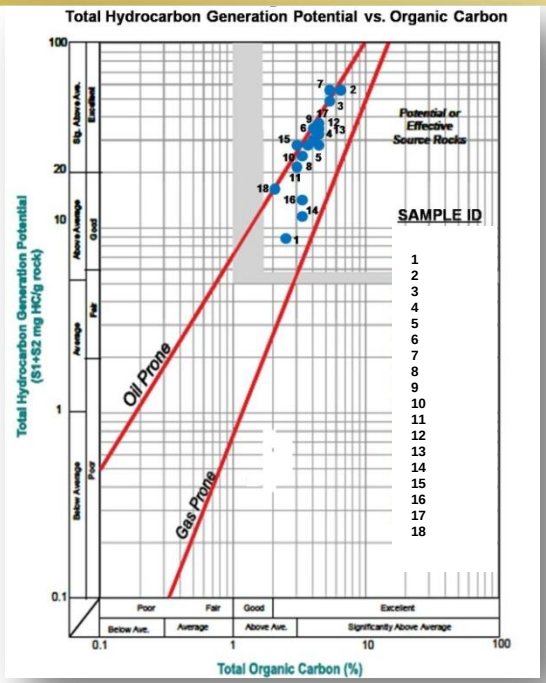
Microfractures

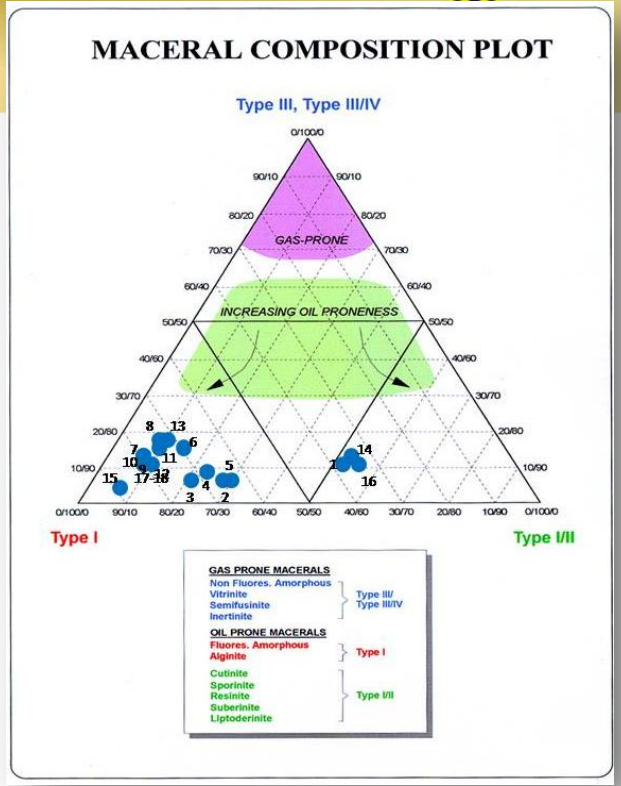


Intraparticle grains/ pores

Geochemistry







- Geochemical screening results from the samples characterized by **very good to excellent organic richness (2.00 to 6.23 wt.%)**.
- Rock-Eval pyrolysis data reveal high to **very high Hydrogen Indices (318-937)** suggesting the presence of **mainly oil-prone kerogen (Type I and II)** with minor gas-prone kerogen.
- These samples are considered to have **mostly excellent hydrocarbon generative capacity** based on excellent pyrolysis potential yields **(S_1+S_2 8.17 to 58.30 mgHC/gm rock)**.
- Vitrinite reflectance results reveal that **most of the samples are immature**. Only one sample shows early mature.
- Kerogen typing analysis data for all the samples indicate the presence of **predominantly oil-prone kerogen (Type I)** comprising minor non-fluorescent amorphous debris (5-30% NFA) except three samples with NFA more than 48% (48-51%) are **Type I/II.**
- All the samples were submitted for spore colouration (TAS) analysis. The maturity results show a good agreement with the vitrinite reflectivity data. Thermal Alteration Scale results indicate consistent values of TAS 3 throughout the all samples. **This confirms that the claystone are immature.**
- Biomarkers present in these extracts have been analysed by computerised Gas Chromatography-Mass Spectrometry performed on saturate fraction. Liquid chromatographic separation results show a predominance of polar compounds (NSO's) plus asphaltene constitute a significant proportion of the total extract yields (40 to 66%), saturates aromatic compounds (11-38%). Aromatics coumpunds are present in relatively secondary levels (5-31%). Relatively low abundance of 18α(H)-Oleanane compound, together with C_{30} resins for all extracts. It can be interpreted as environment with **very little terrigenous input**.

Paleontologi

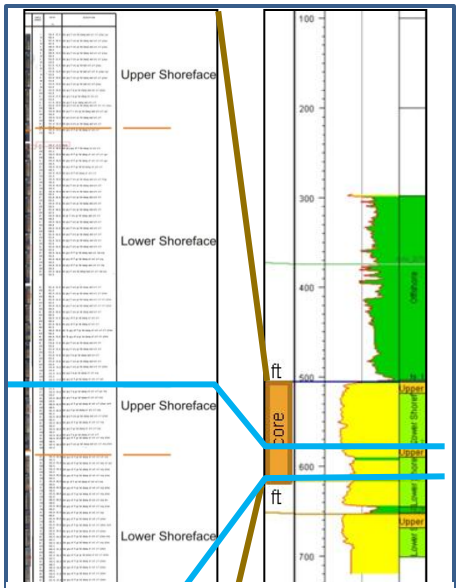
BADAN GEOLOGI KESDM

| | | | Back mangrove | | | Mangrove | | | | | | Other Pollen | | | | | |

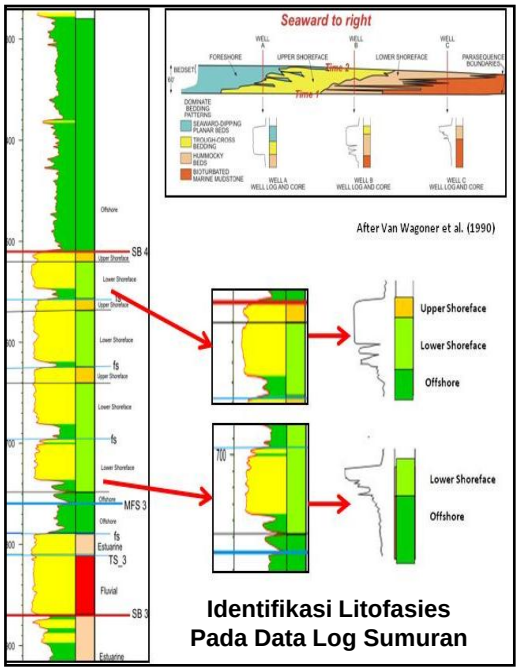
WELL LOGS

Well Logs

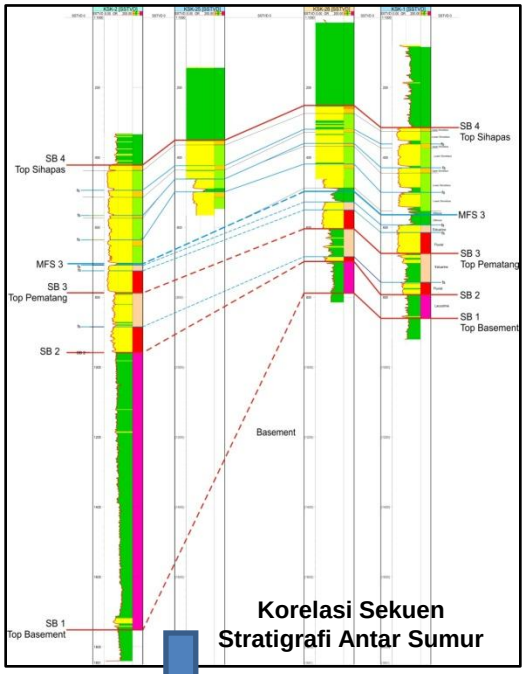
BADAN GEOLOGI KESDM



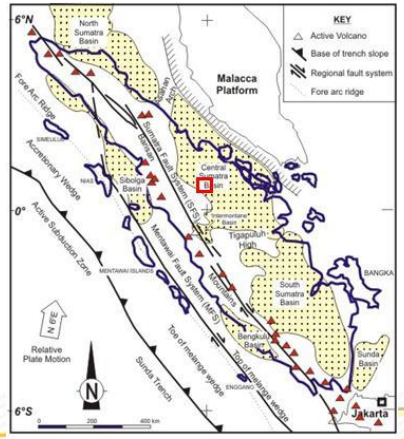
Kalibrasi Data Batuan inti dan Data Log Sumuran

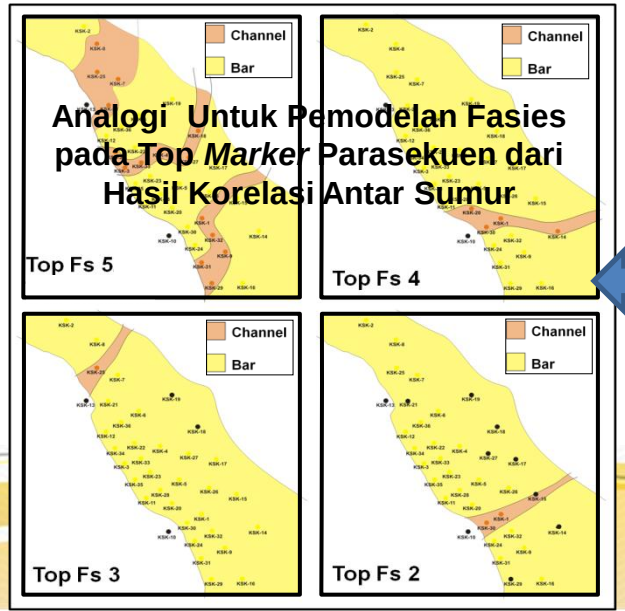


Identifikasi Litofasies Pada Data Log Sumuran

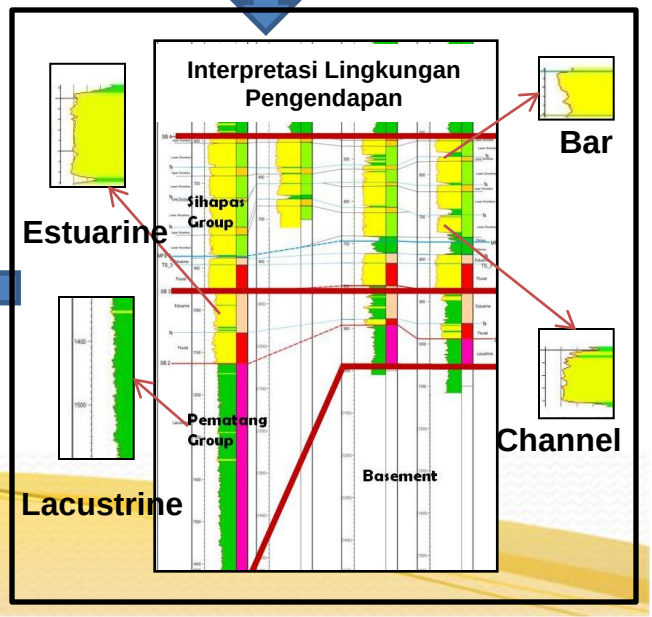


Korelasi Sekuen Stratigrafi Antar Sumur



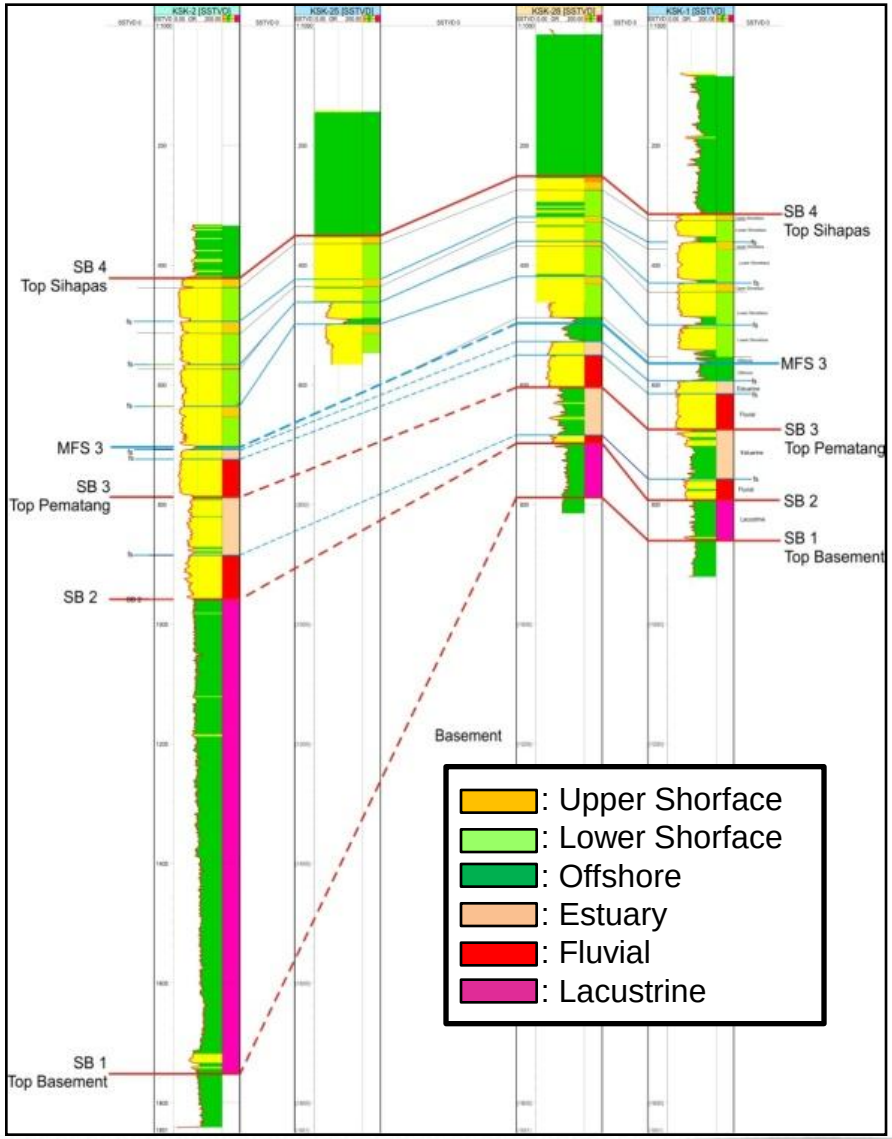


Analogi Untuk Pemodelan Fasies pada Top *Marker* Parasekuen dari Hasil Korelasi Antar Sumur



Well Sequence Stratigraphic Correlation

BADAN GEOLOGI KESDM



Outcrop Models

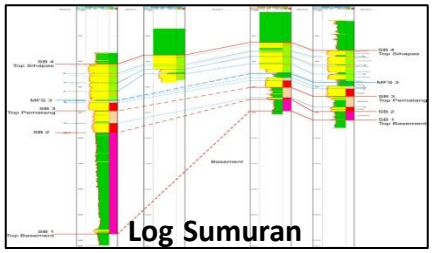
Penampakan struktur lembaran dari serpih Formasi Kelesa di sungai Punti Kayu, Kawasan Kuburanpanjang, Bukit Susah, Rengat, Riau (1 &2); Musi Rawas (3), dan Kuantan Sengingi (4)

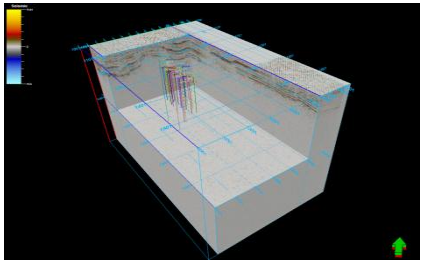
SEISMIC

SEISMIC

BADAN GEOLOGI KESDM

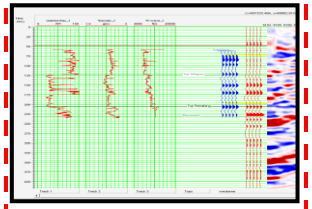
DATA



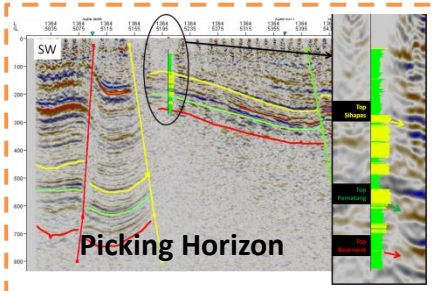


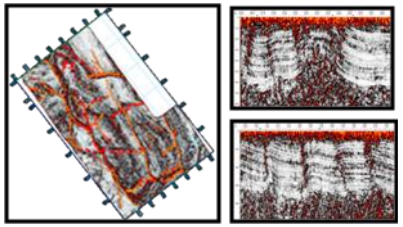
Seismik

WELL-SEISMIC TIE

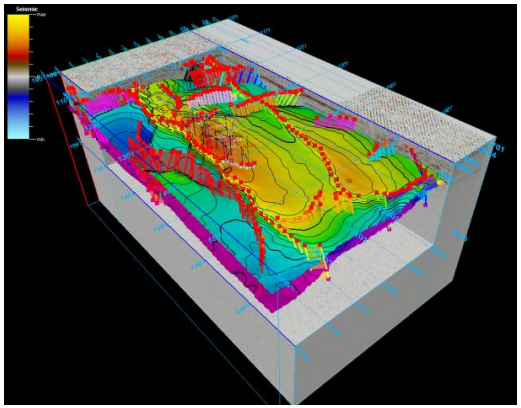


SEISMIC INTERPRETATION

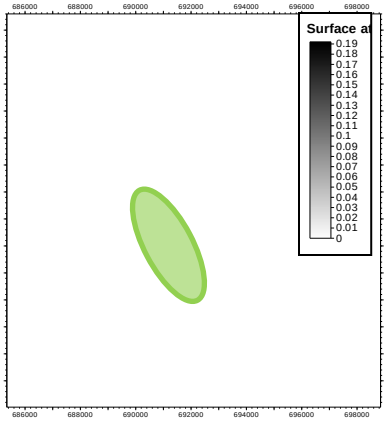




Interpretasi Struktur

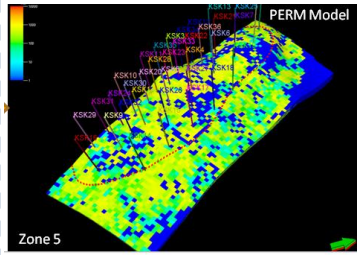


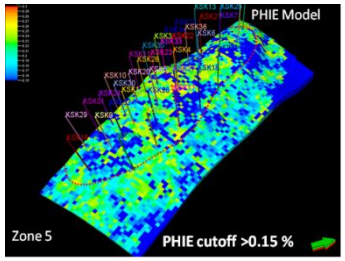
Run RMS Attribute on Top Pematang Fm.

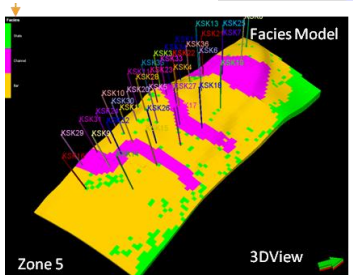


RMS AMPLITUDE OF PEMATANG FM

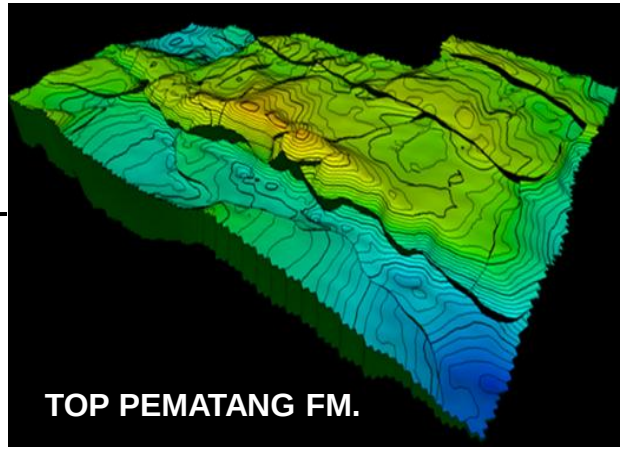
PERMODELAN DARI HASIL INTEGRASI DATA SEISMIK DAN LOG SUMURAN







Fault Modeling and Time to Depth Conversion

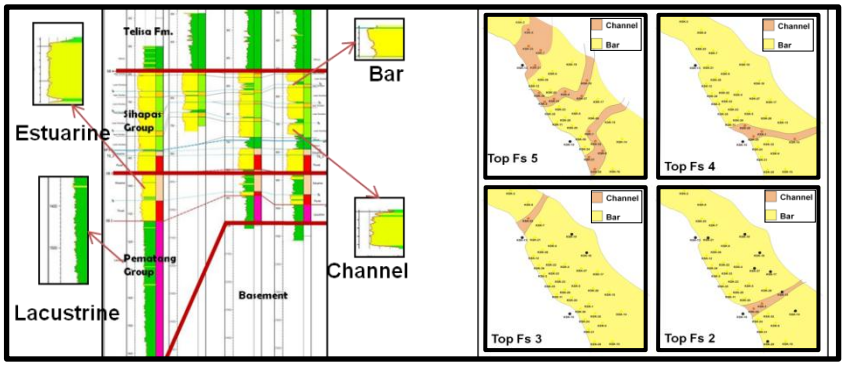


DATA INTEGRATION FOR STRATIGRAPHIC PROPERTY MODELLING

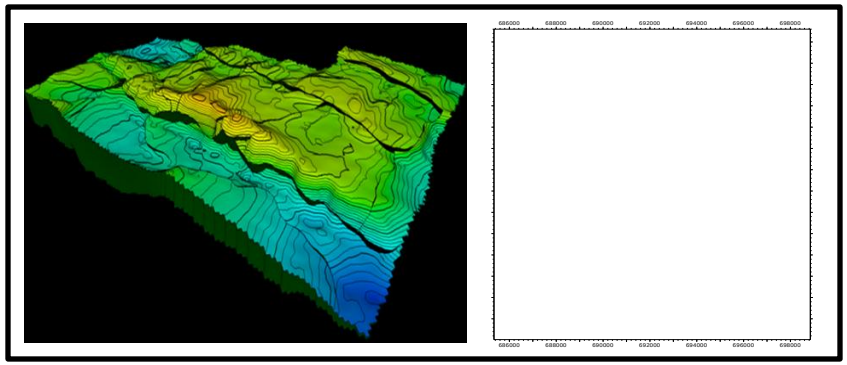
DATA INTEGRATION

BADAN GEOLOGI KESDM

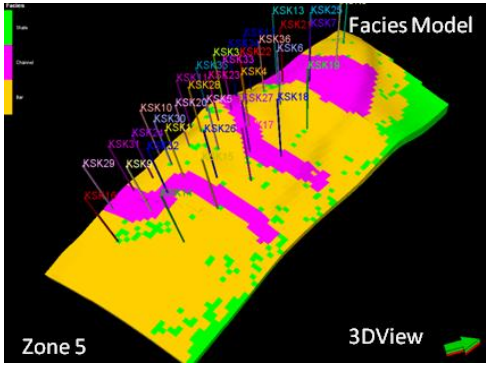
INTERPRETASI WELL LOG KALIBRASI DENGAN DATA CORE

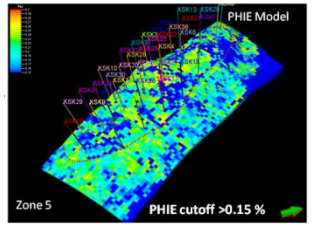


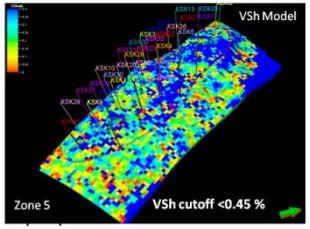
INTERPRETASI SEISMIK

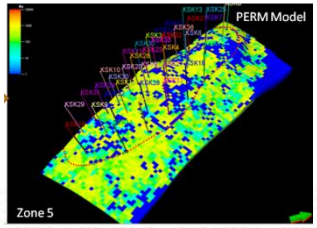


PERMODELAN PROPERTI

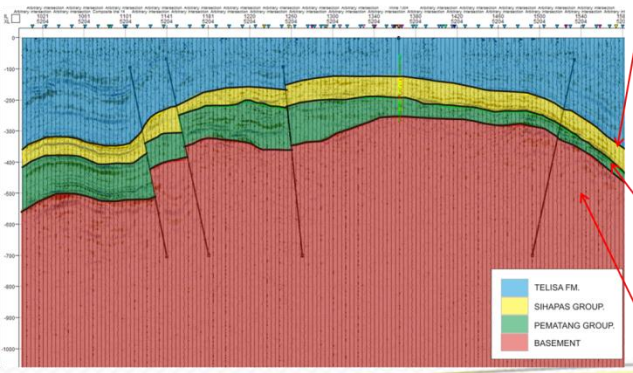


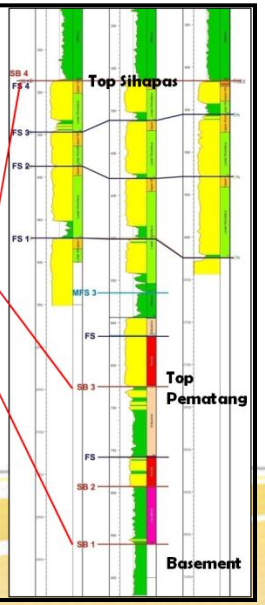






GEOLOGICAL PROGNOSIS





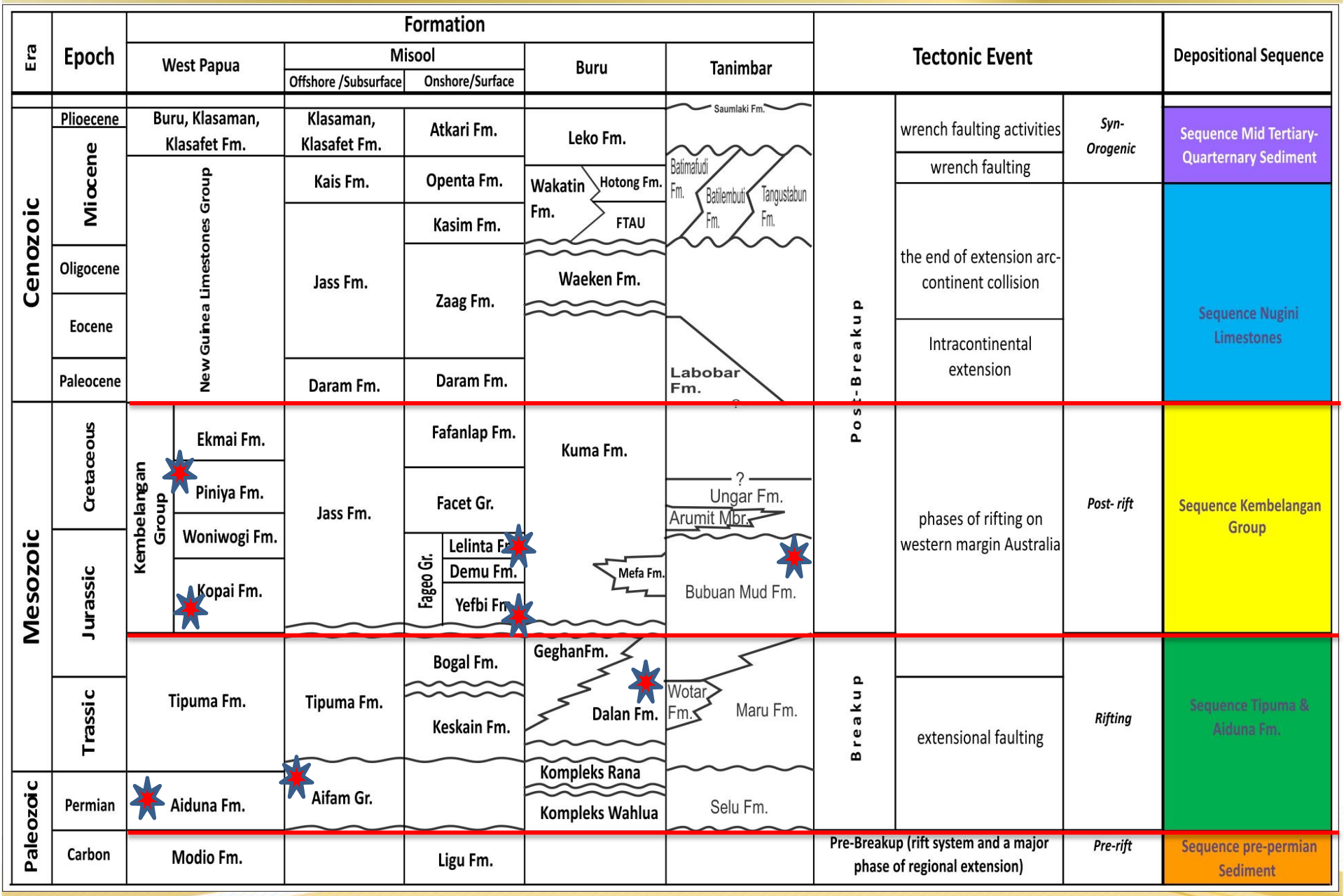
Working plan for shale gas investigation in Central Sumatera Basin for 2013

- Eocene to Oligocene vertically depositional environment and kerogen type changes
- Eocene to Oligocene sequence stratigraphy
- Burial History
- Paleogeography
- G&G analysis to calculate GIP

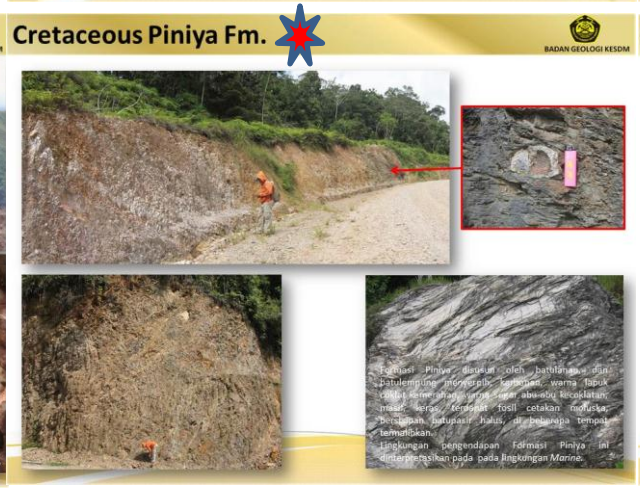
SHALE HIDROCARBON POTENTIAL IN PAPUA

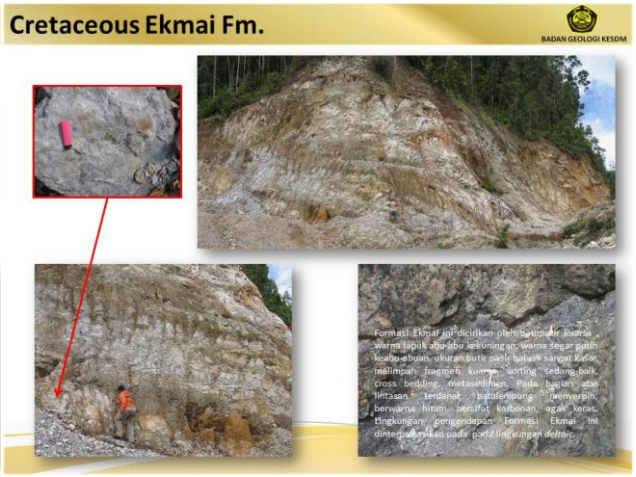
Tectonostratigraphic Correlation of Papua-Misool-Buru-Tanimbar

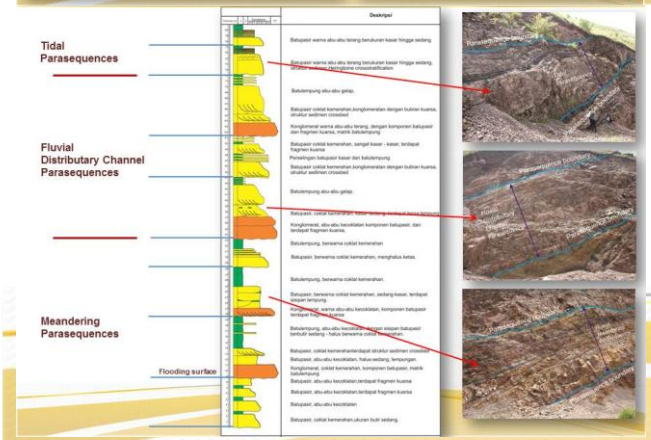
BADAN GEOLOGI KESDM



Korelasi stratigrafi, modifikasi dari Pigram & Panggabean (1984), Hasibuan (1991), *Indonesia Basin Summaries (2006)* dan Charlton (2010)







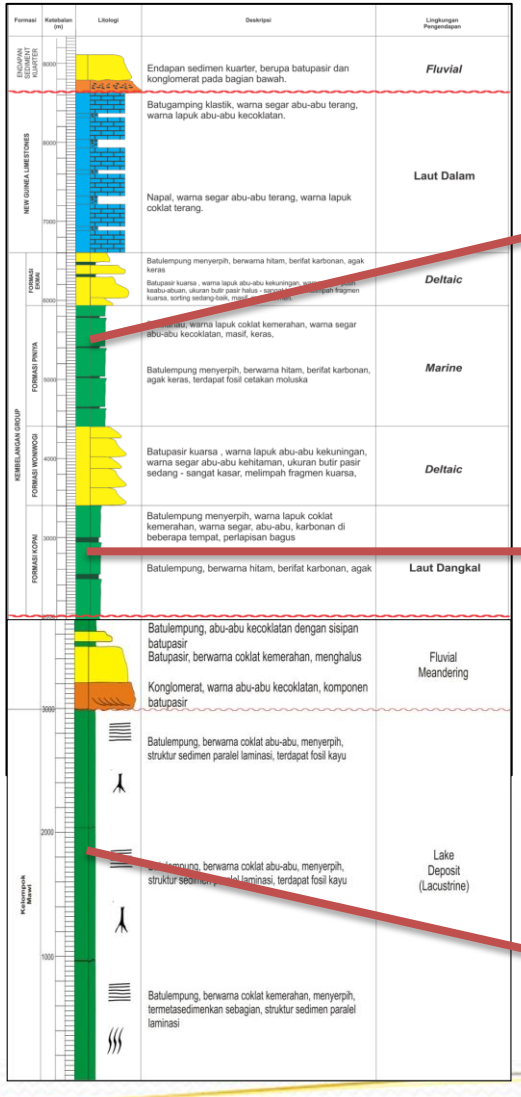
Geology of Papua (Ransiki – Bintuni, Teluk Wondama and Enarotali-Waghete-Moenamani-Mapia transect)

Shale hydrocarbon potential target are:

1. Tipuma – Aiduna Sequence (Aiduna Fm.)
2. Kembelangan Sequence (Kopai Fm. & Piniya Fm.)

Shale Hydrocarbon Potential Target in Papua

BADAN GEOLOGI KESDM



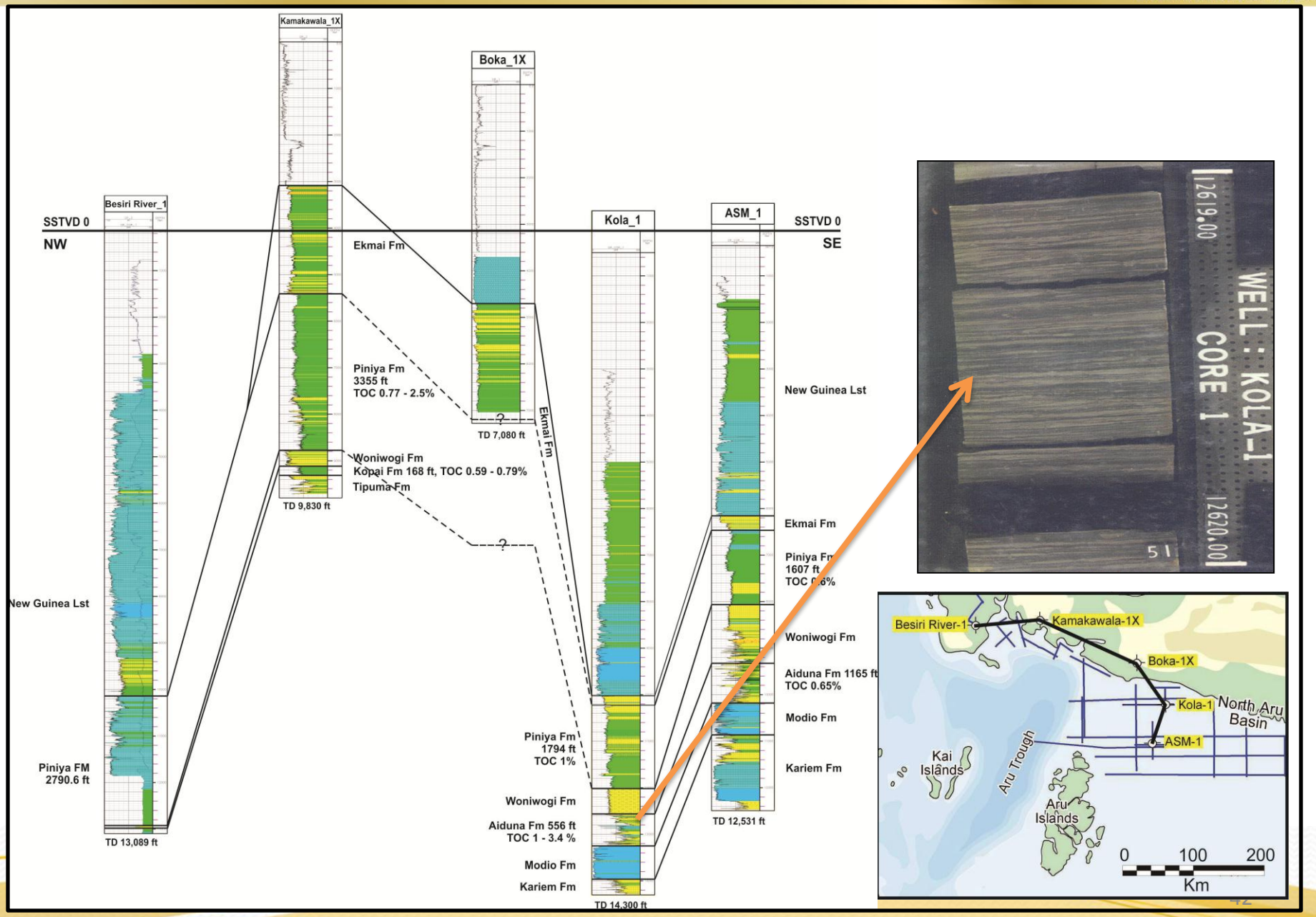
Cretaceous Piniya Fm.

Jurassic Kopai Fm.

Permian Aiduna Fm.

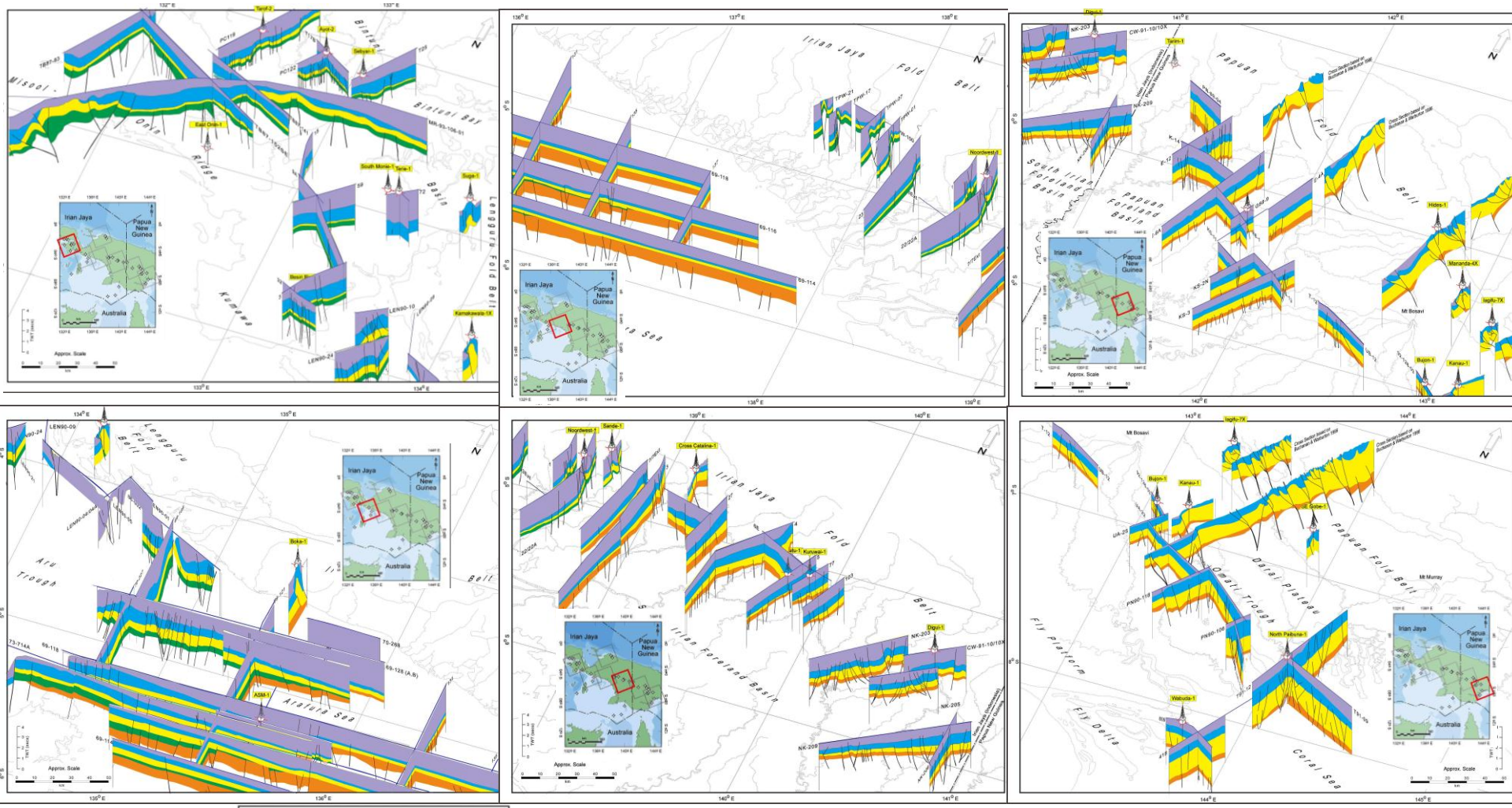
Well Correlation Showing Shale Hydrocarbon Target at Papua

BADAN GEOLOGI KESDM



*Regional Sequence Correlation (*Papua*)*

BADAN GEOLOGI KESDM

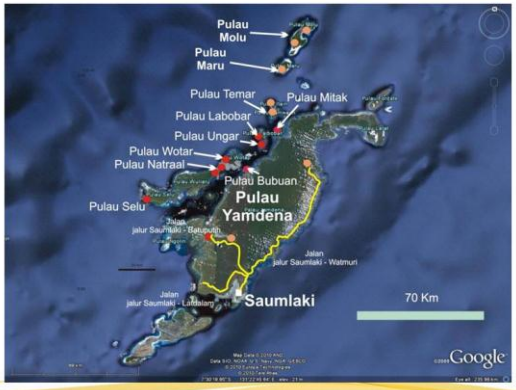


Legenda :

- Mid Tertiery - Quartenary Sediment
- Nugini Limestones
- Kembelangan Group
- Tipuma and Aiduna Fm.
- Pre-Permian Sediment
- Basement

Modified from Pertamina and Corelab (1993)

Lintasan Kepulauan Tanimbar



Permian Selu Fm.

Formasi Selu dicirikan oleh batupasir gampingan, coklat tua sampai muda, vulkaniklastik, berbutir halus sampai kasar, batulempung abu tua dan batugamping pasiran kemerahan, struktur sedimen *cross bedding, herringbone cross stratification,* parallel laminasi, *lenticular, flaser bedding* dan *cannonball concretion*, serta di beberapa tempat ditemukan konglomerat basaltik.

Dengan adanya struktur sedimen *cross bedding, herringbone cross stratification,* parallel laminasi, *lenticular, flaser bedding* dan *cannonball concretion* diinterpretasikan bahwa Formasi Selu bagian ini diendapkan pada lingkungan *tidal* (pasang surut).

Triassic Wotar Fm.

Batugamping pasiran berbutir halus sampai sedang, abu terang, *highly fractured*, perlapisan sulit diamati akibat *highly fractured*, di beberapa tempat *marbly*. struktur sedimen yang dapat diamati antara lain *cross bedding* dan parallel laminasi dan *packstone-wackstone*, abu terang dengan sisipan batulempung dan batulanau, coklat gelap. Struktur sedimen antara lain *cross bedding, hummocky cross stratification* dan parallel laminasi. Diinterpretasikan bahwa formasi ini diendapkan pada lingkungan *shoreface* pada *storm dominated shelf*.

Triassic Maru Fm.

Formasi ini dicirikan oleh batupasir kwarsa, coklat terang-tua, berbutir halus sampai sedang, sortasi buruk sampai sedang, sisipan batulempung pasiran, gampingan, coklat. Struktur sedimen *hummocky cross stratification* dan *climbing ripple*.

Struktur sedimen *hummocky cross stratification* memberikan indikasi bahwa Formasi Maru pada lokasi ini diendapkan pada lingkungan *shoreface* pada *storm dominated shelf*. Struktur sedimen *climbing ripple* memberikan indikasi proses sedimentasi yang cepat.

Jurassic Bubuan Mud Fm.

Unit batuan ini dicirikan oleh batuan hasil semburan *mud volcano*, matriks penyusunnya adalah batulempung hijau kecoklatan. Fragmen dari *mud volcano* ini bervariasi antara lain, batupasir, batulanau dan breksi. Adanya kandungan nanofosil pada matriks batulempung memberikan indikasi lingkungan pengendapan laut.

Jurassic – Cretaceous Ungar Fm.

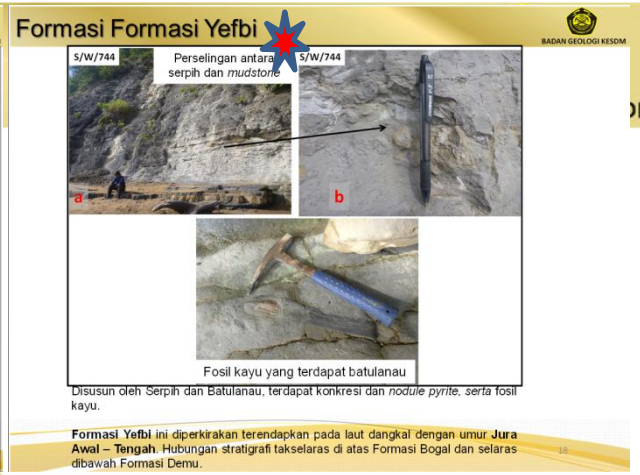
Shoreface to foreshore deposit of Jurassic well sorted sandstone, Ungar Fm. Ungar Island, Tanimbar.

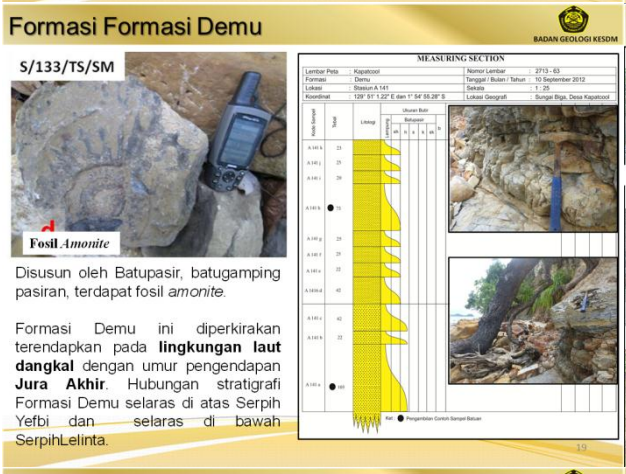
Adanya struktur sedimen *ripple mark* memberikan indikasi lingkungan pengendapan yang cukup dangkal, struktur sedimen *flame structure* pada batupasir berwarna kemerahan memberikan indikasi struktur pembebanan pada sedimen yang belum terkompaksi secara penuh, warna merah pada batuan ini kemungkinan disebabkan oleh proses oksidasi akibat lingkungan pengendapan yang dekat dengan permukaan. Adanya sisipan batulempung merah kemungkinan disebabkan oleh proses oksidasi akibat batuan yang tersingkap ke permukaan. Batulempung hitam yang bersifat karbonan mengindikasikan lingkungan pengendapan yang ditumbuhi vegetasi. Struktur sedimen *dune cross bedding* disebabkan oleh lingkungan pengendapan batuan yang ditemukan di lokasi ini berada di bawah pengaruh reaksi angin. Disimpulkan bahwa Formasi Ungar di lokasi ini diendapkan di lingkungan pantai.

Geology of Tanimbar Islands

Shale hydrocarbon potential target:

1. Kembelangan Sequence (Bubuan Mud Fm.)

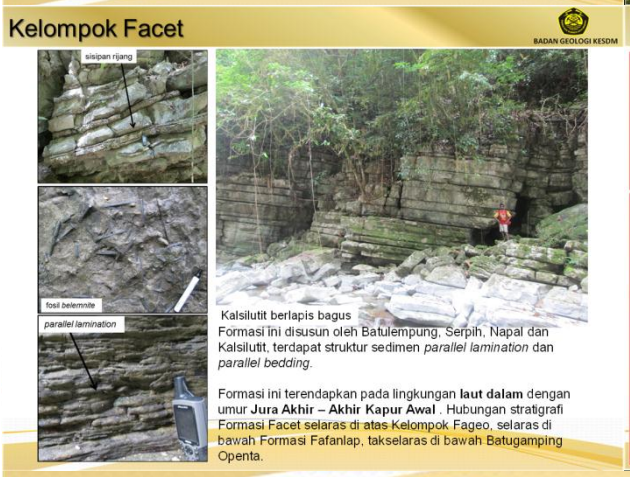


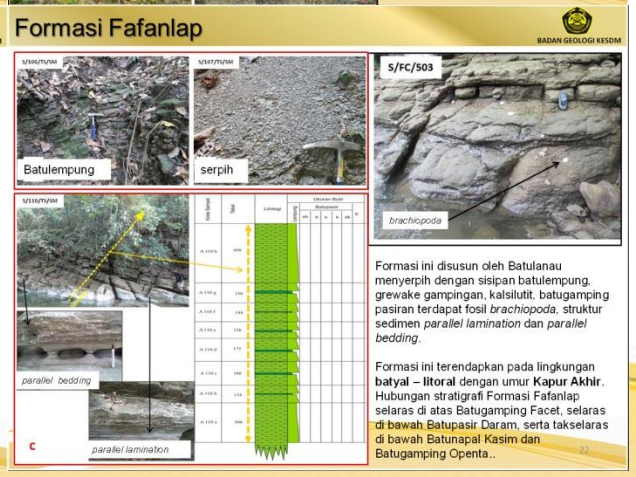


Geology of Misool Islands

Shale hydrocarbon potential target:

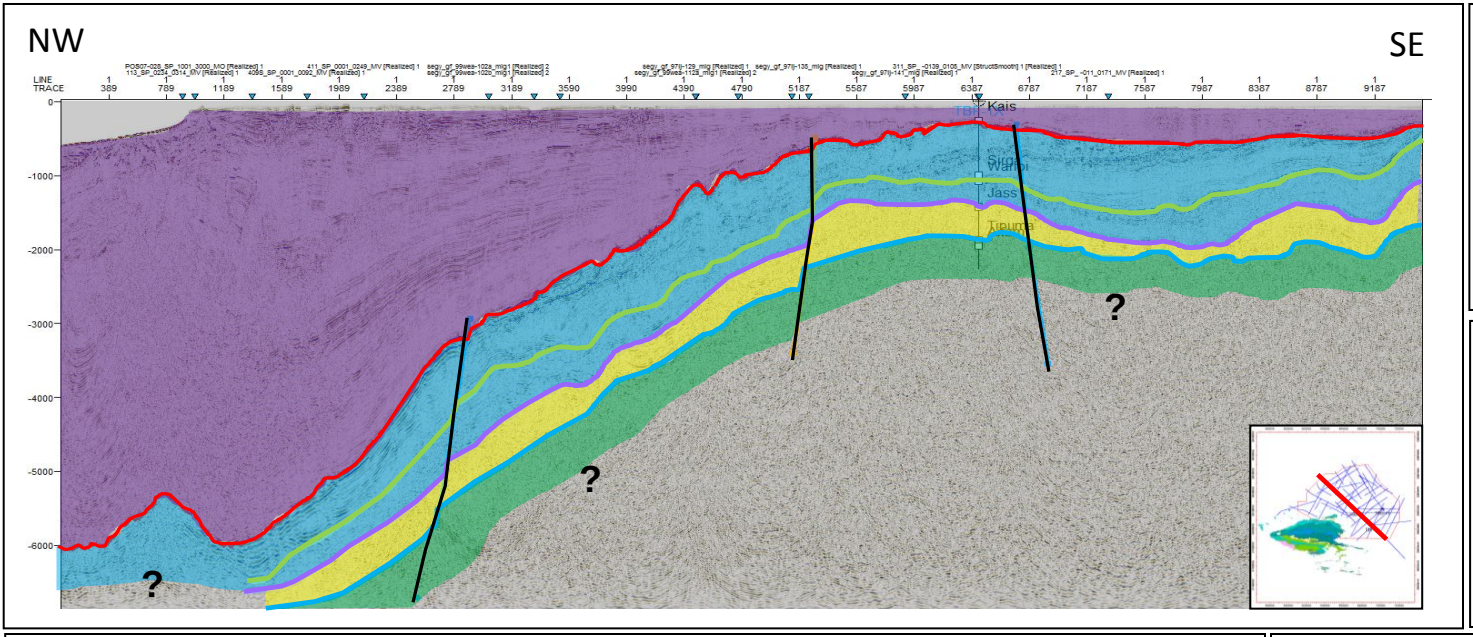
1. Kembelangan Sequence (Yefbi Fm. & Lelinta Fm)





Regional Sequence Correlation (Misool)

BADAN GEOLOGI KESDM

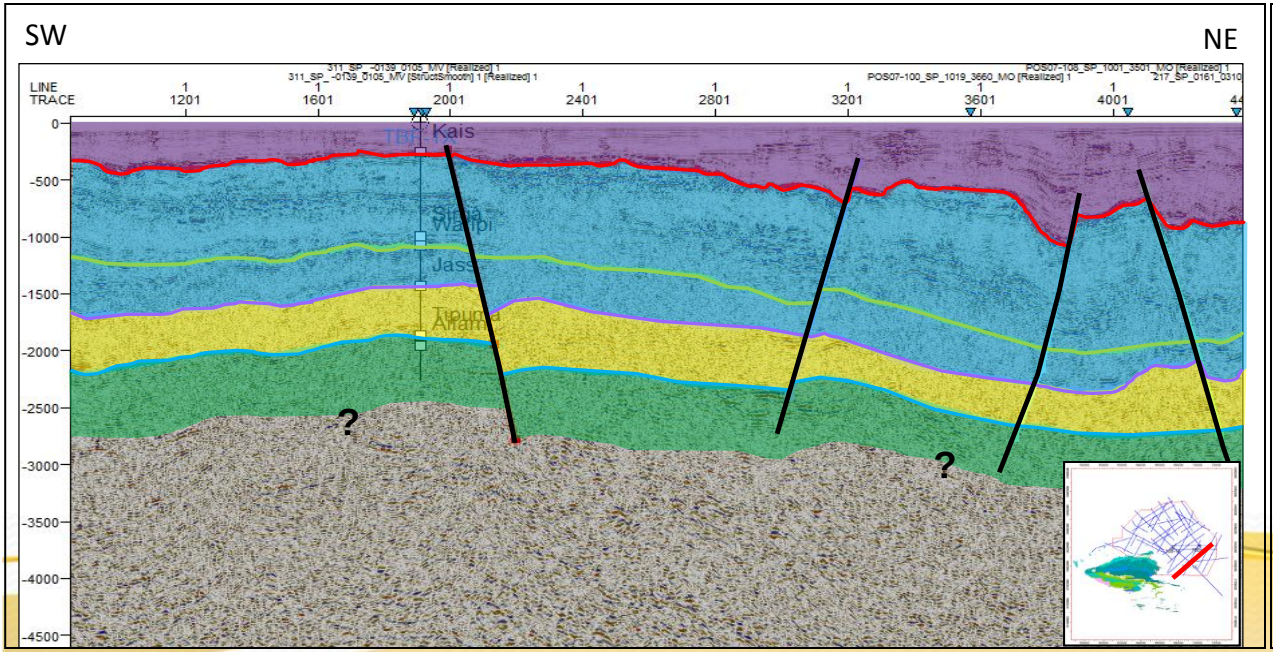


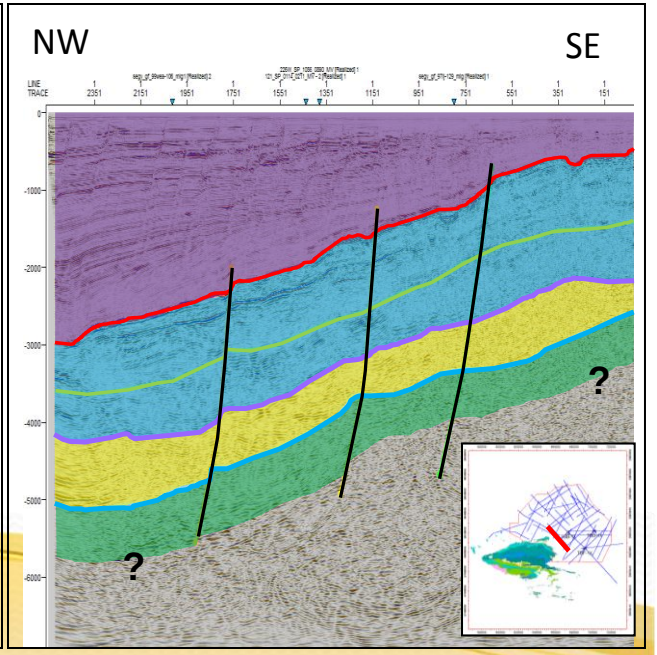
Sekuen Pengendapan

- Mid Tertiery - Quartenary Sediment
- Nugini Limestones
- Kembelangan Group
- Tipuma and Aiduna Fm.
- Pre-Permian Sediment
- Basement

***Top Marker* Formasi**

- : Top Kais (Upper Miocne)
- : Top Waripi (Eocene)
- : Top Jass (Upper Cretaceous)
- : Top Tipuma (Triassic)





Geology of Buru Island

Shale hydrocarbon potential target:

1. Tipuma – Aiduna Sequence (Dalan Fm.)

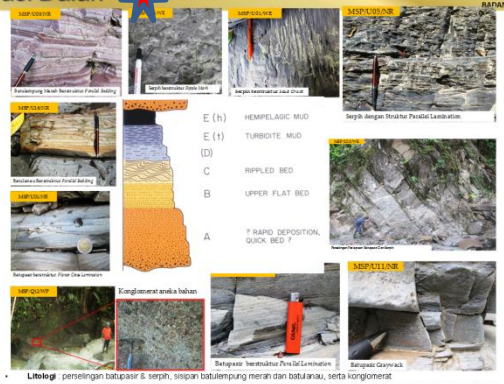
Kompleks Wahlua

- **Litologi** : Sekis, Batusabak, dan Kuarsit.
- **Umur** : Karbon Akhir – Perm Awal.
- **Hubungan stratigrafi** : Tidak salaras dengan Kompleks Rana yang lebih muda.

Kompleks Rana

- **Litologi** : Arkose Malih, Filit, Sekis Klorit, Sekis Amphibolit, dan Graywack Malih
- **Umur** : Perm Akhir.
- **Hubungan stratigrafi** : tidak salaras dengan Formasi Dalan dan Formasi Ghegan yang berumur lebih muda

Formasi Dalan



- **Litologi** : perselingan batupasir & serpih, sisipan batulempung merah dan batulanau, serta konglomerat
- **Struktur Sedimen** : Pararel bedding & laminasi sangat umum dijumpai pada semua lapisan batuan. Planar cross lamination, dijumpai setempat pada lapisan batupasir; serta struktur ripple in ark dan mud crack dijumpai setempat pada serpih.
- **Umur** : Trias Tengah hingga Jura Awal
- **Ling. Pengendapan** : Lingkungan neritik pada lereng benua dapat digolongkan ke dalam turbidit.
- **Hubungan Stratigrafi** : Menjemari dengan Formasi Ghegan dan tertindih tak selaras oleh Formasi Kuma. Tebal kurang dari 2000 meter

Formasi Ghegan

- **Litologi** : batugamping dolomitan dan kalkarenit, serta setemapat dijumpai sisipan napal.
- **Struktur Sedimen** : kesan bersisik pada lapisasan kalkarenit
- **Umur** : Trias
- **Ling. Pengendapan** : Lingkungan litoral sampai neritik
- **Hubungan Stratigrafi**: Menjemari dengan Formasi Dalan dan tertindih tak selaras oleh Formasi Kuma. Tebal satuan tidak lebih dari 2000 meter.

Formasi Kuma

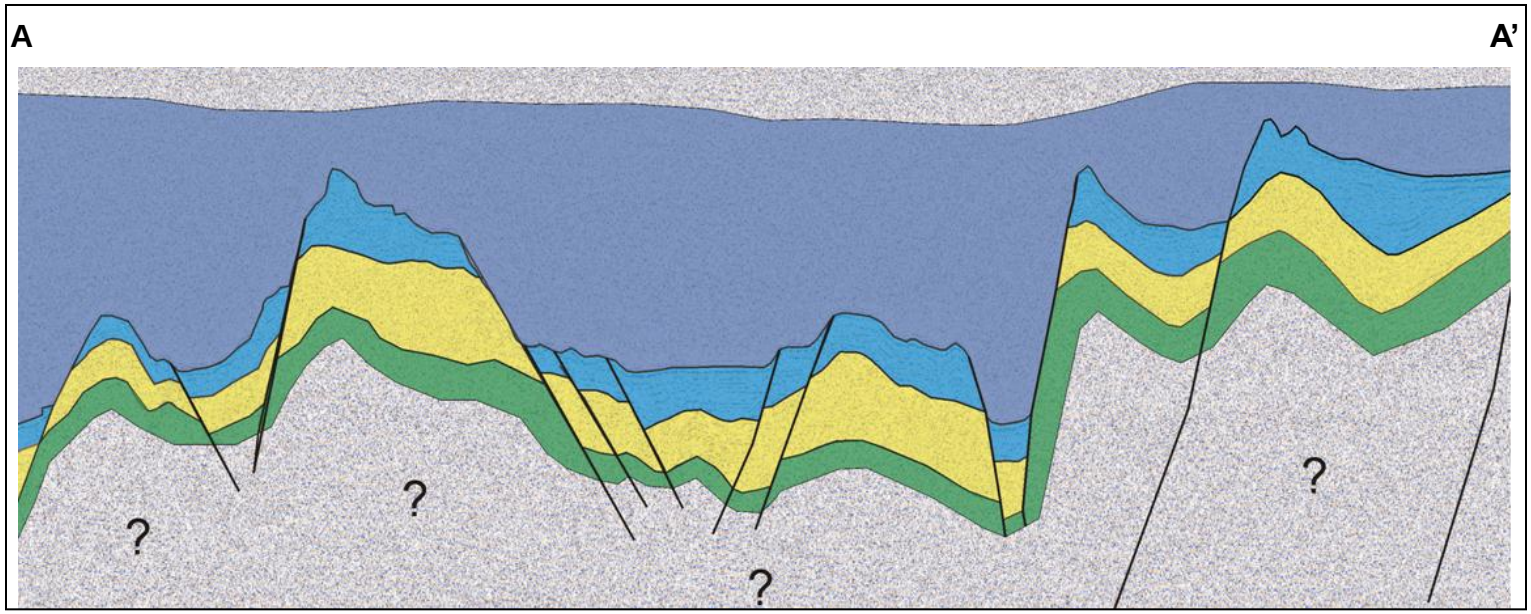
- **Litologi** : kalsilutit glaukonitan, perselingan (interbedded) kalsilutit dan rijang (chert), kalsilutit ,serta sisipan napal
- **Umur** : Kapur hingga Eosen
- **Ling. Pengendapan** : Lingkungan bathial sampai neritik
- **Hubungan Stratigrafi**: Tidak selaras dengan Formasi Dalan dan Ghegan yang berumur lebih tua, serta berhubungan tidak selaras dengan Formasi Waeken yang berumur lebih muda. Tebal satuan tidak lebih dari 1000 meter.

Formasi Mefa

- **Litologi** : lava dan tuf.
- **Umur** batuan diperkirakan Jura
- **Hubungan stratigrafi**, kemungkinan tidak salaras dengan Formasi Dalan dan Formasi Ghegan yang berumur lebih tua (Trias) , sedang dengan Formasi Kuma yang berumur lebih muda (Kapur – Eosen) juga diperkirakan tidak selaras.

Regional Sequence Correlation (Buru)

BADAN GEOLOGI KESDM



Sekuen Pengendapan

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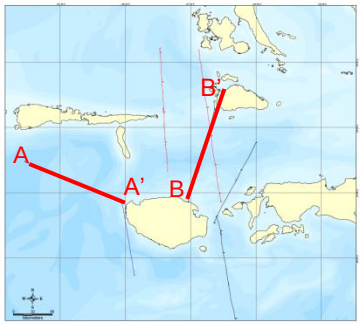
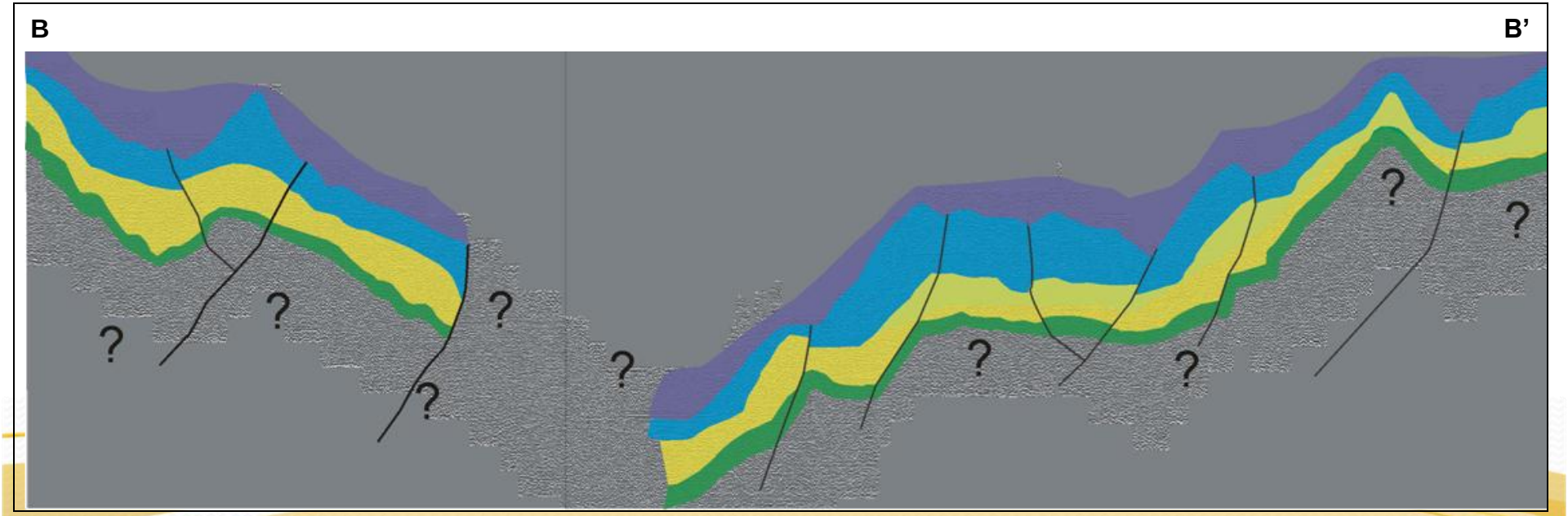
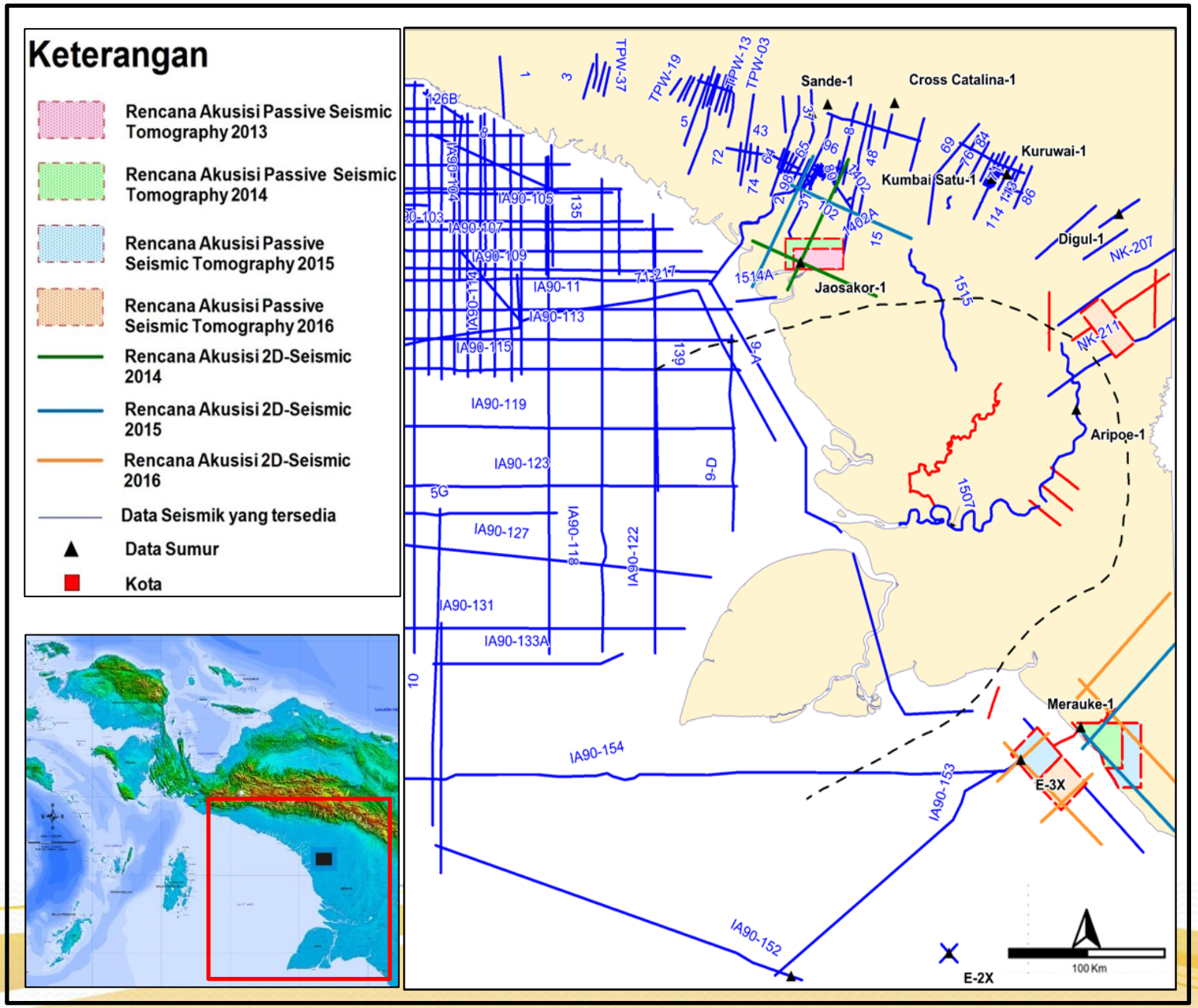
- Basement





South Papua Passive Seismic Tomography Acquisition 2013

BADAN GEOLOGI KESDM

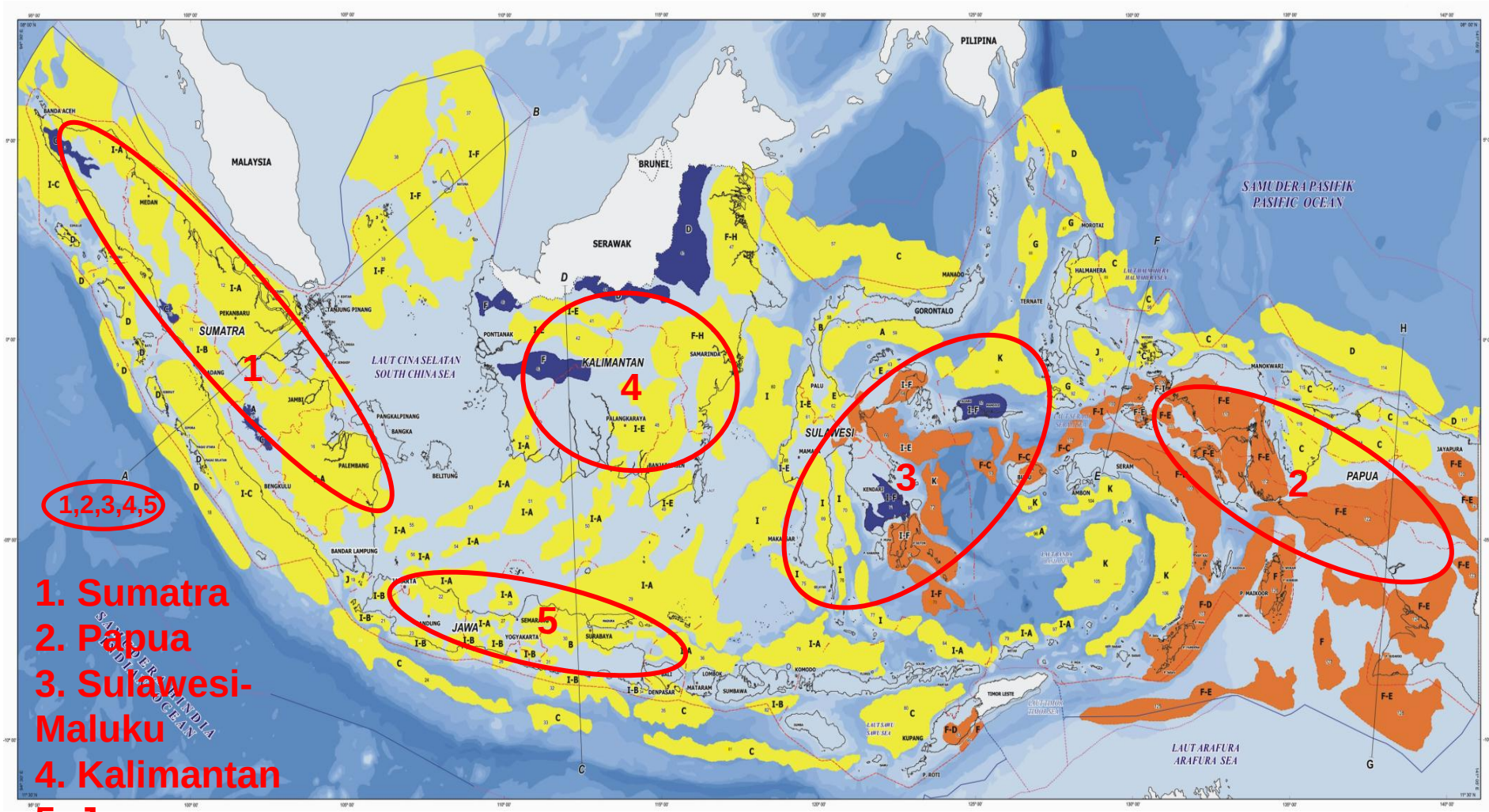


General Survey Location Plan at South Papua

BADAN GEOLOGI KESDM

Kegiatan \ Tahun	2013	2014	2015	2016
Passive Seismic Tomography (PST)	1 Lokasi, Papua Selatan, Cekungan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Sahul dan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Akimeugah dan Sahul	2 Lokasi, Papua Selatan, Cekungan Arafuru dan Iwur
2D *Seismic*		1 Lokasi, Papua Selatan, Cekungan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Sahul dan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Sahul dan Arafuru
Detail Gravity Mapping		1 Lokasi, Papua Selatan, Cekungan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Sahul dan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Iwur dan Sahul
Magnetoteluric Mapping		1 Lokasi, Papua Selatan, Cekungan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Sahul dan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Iwur dan Sahul
GMT (Geo-Microbial Technology)		1 Lokasi, Papua Selatan, Cekungan Sahul	2 Lokasi, Papua Selatan, Cekungan Sahul dan Akimeugah	2 Lokasi, Papua Selatan, Cekungan Akimeugah dan Arafuru
Drilling			1 Well, Papua Selatan, Cekungan Sahul	2 Well, Papua Selatan, Cekungan Sahul dan Akimeugah

SHALE HIDROCARBON RESEARCH PLAN



Proposed Areas For Shale Hydrocarbon Research

SHALE HYDROCARBON RESEARCH PLAN AND SCOPE OF WORK PROPOSED IN INDONESIA (GEOLOGICAL AGENCY)

BADAN GEOLOGI KESDM

BASIC AREA SELECTED:

- SELECTED SEDIMENTARY BASINS HAVING HIGH POTENTIAL OF SHALE HYDROCARBON
- ADEQUATE INFRASTRUCTURE AREA
- AN EFFORT TO IMPROVE REGIONAL AND NATIONAL ECONOMY
- AN EFFORT TO IMPROVE UNCONVENTIONAL ENERGY RESOURCES

PRIORITY OF PROPOSED AREA

- SUMATRA
- PAPUA
- SULAWESI – MALUKU
- KALIMANTAN
- JAWA

SCOPE OF WORK

- Preliminary Survey & Research - "In House" & field work and laboratory
- Shale hydrocarbon Assessment (Detailed Geophysics and Geology: Seismic, Gravity, Magnetic, Drilling, Laboratory; Modeling play)
- Pilot Plan in Laboratory Scale (Risk, Amdal, Economic and Production)

COAL-BED METHANE

Program of CBM Survey

Completable Coal Thickness

Direct Gas Measurement/ Dessorpt Test

Sorption Isotherm Test

- Basin Studies, localized most prospective cbm areas in each basin
- Data Digitalization: South Sumatra 2007, Kalimantan 2009
- Desorption test (direct gas measured), most prospective basins – Barito, Kutai, South Sumatera, and Ombilin Basins
- Sorption isotherm (Storage gas capacity)
- Human Resources Development

DATA ACQUISITION

BADAN GEOLOGI KESDM

Pengeboran CBM di Cekungan Ombilin oleh Badan Geologi (2009)

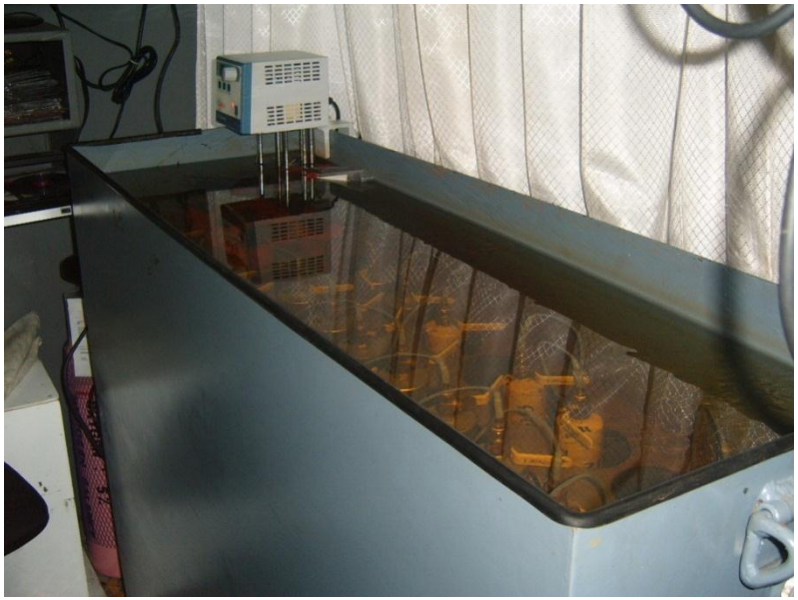
DATA ACQUISITION

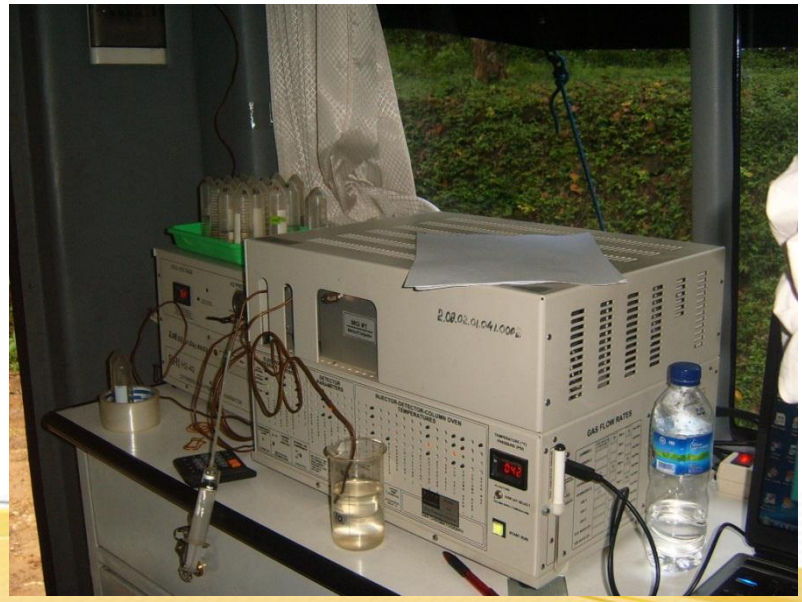
BADAN GEOLOGI KESDM

Coal sampling for desorbtion gas analysis

DATA ACQUISITION

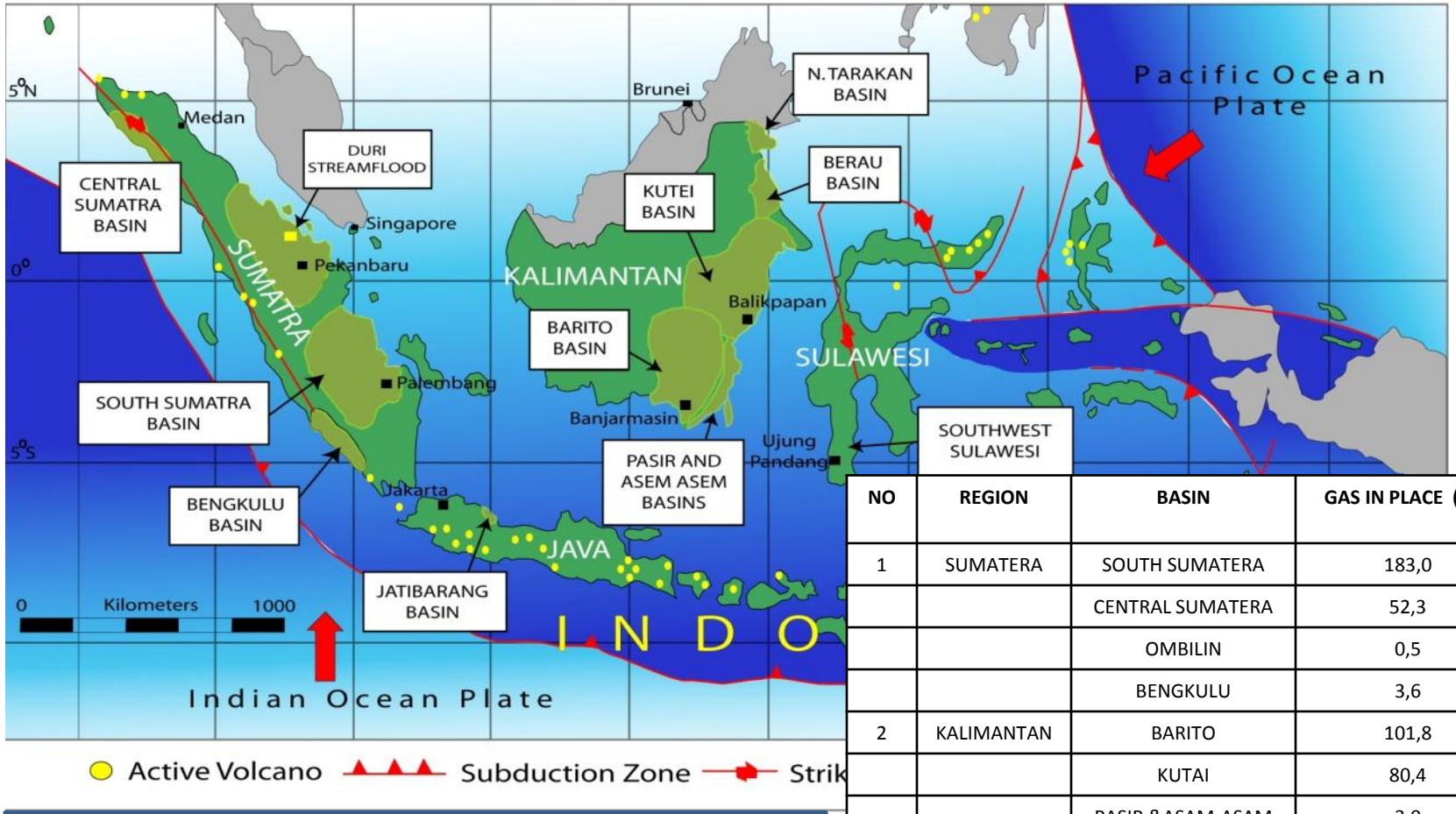
BADAN GEOLOGI KESDM





Desorbtion and composition gas measured

CBM RESOURCES (SPECULATIVE) IN SEDIMENTARY BASIN OF INDONESIA (ARII, 2003)



NO	REGION	BASIN	GAS IN PLACE (Tcf)
1	SUMATERA	SOUTH SUMATERA	183,0
		CENTRAL SUMATERA	52,3
		OMBILIN	0,5
		BENGKULU	3,6
2	KALIMANTAN	BARITO	101,8
		KUTAI	80,4
		PASIR &ASAM-ASAM	3,0
		NORTH TARAKAN	17,5
		BERAU	8,4
3	JAWA	JATIBARANG	0,8
4	SULAWESI	SOUTH SULAWESI	2,0
		Total Gas In Place	453,3

TOTAL SPECULATIVE RESOURCES OF CBM INDONESIA: 453,3 TCF

ARII : Advance Resource International Inc.

CBM RESOURCES OF INDONESIA (ARII, 2003)

NO	BASIN	FORMATION	COAL THICKNESS (FT)	COAL RANK Ro (%)	DEPTH (FT)	GAS CONTENT (ft3/ton)	ASH (%)	MOIST (%)	CO2 (%)	AREA (Mi2)	GAS IN PLACE (TFt3)
1	SOUTH SUMATRA	MUARA ENIM	120	0.47	2500	223	10	7.5	3	7350	183
2	BARITO	WARUKIN	90	0.45	3000	195	10	10	2	6330	102
3	KUTAI	BALIKPAPAN	70	0.5	3000	195	10	5	2	6100	80.4
4	CENTRAL SUMATRA	MUARA ENIM	50	0.4	2500	223	10	10	2	5150	52.5
5	NORTH TARAKAN	TABUL	48	0.45	2300	147	12	6	5	2734	17.5
6	BERAU	LATIH	80	0.45	2200	144	10	7.5	2	780	8.4
7	OMBILIN	SAWAH TAMBANG	80	0.8	2500	267	10	3	50	47	0.5
8	PASIR-ASAM2	WARUKIN	50	0.45	2300	164	7.5	7.5	2	385	3.0
9	NW JAVA	T. AKAR	20	0.70	5000	422	15	3	5	100	0.8
10	SULAWESI	TORAJA	20	0.55	2000	223	15	4	5	500	2
11	BENGKULU	LEMAU	40	0.4	2000	133	10	10	5	772	3.6
	TOTAL										453.3

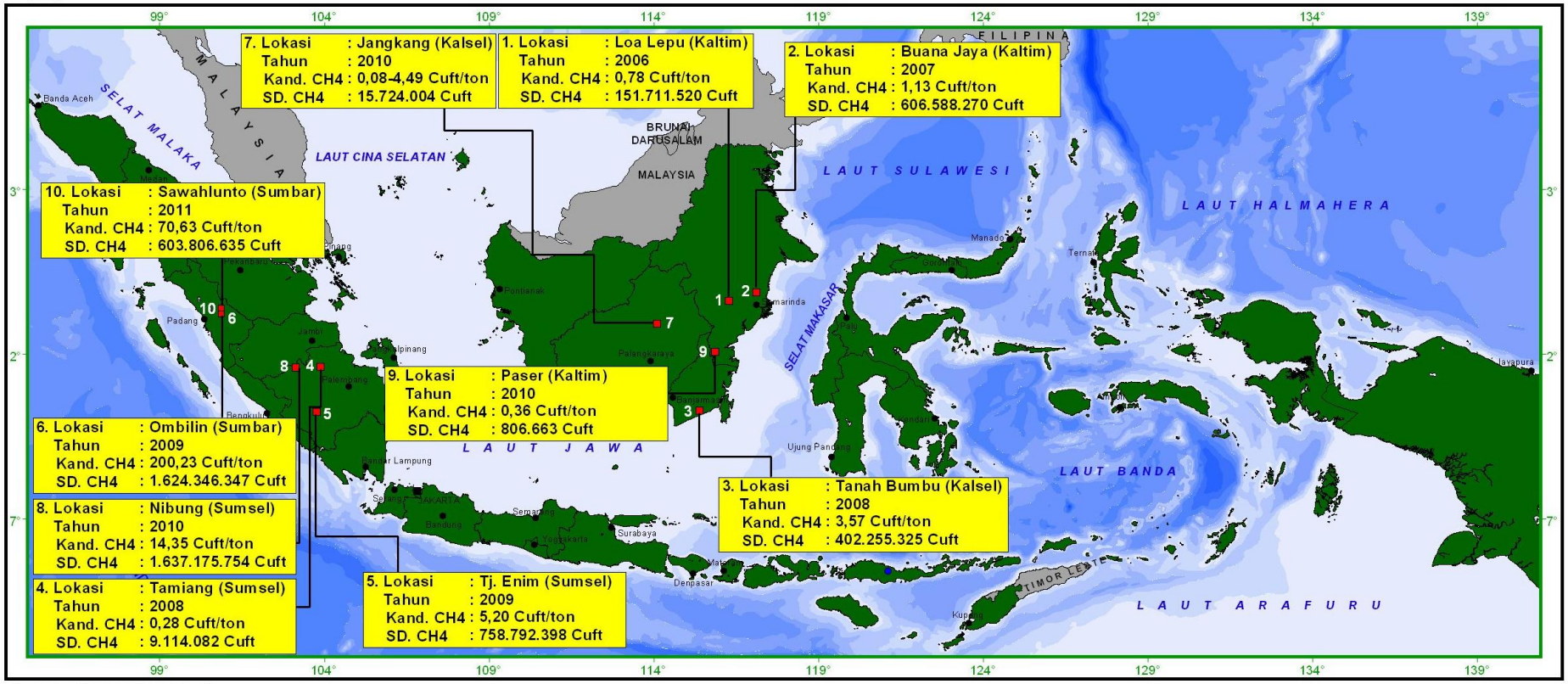
ARII : Advance Resource International Inc.)

DATA OF CBM FROM SOME DRILLING LOCATIONS (Geological Agency, 2012)

BADAN GEOLOGI KESDM

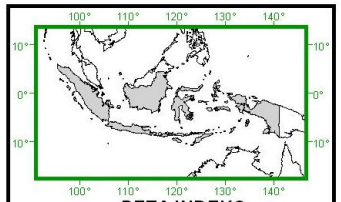
KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

BADAN GEOLOGI



L E G E N D A :

- Wilayah Penyelidikan CBM Badan Geologi
- Ibukota Negara
- Kota Provinsi
- Batas Provinsi



PETA INDEKS

COAL-BED METHANE RESOURCES OF INDONESIA (Geological Agency, 2012)

BADAN GEOLOGI KESDM

No	Location	Year	Area (Km^2)	Hypothetic Resources		Average CH4 Content (SCF/Ton)	CO_2 Content (%)
				Coal (Ton)	CH4 (SCF)		
1	Loa Lepu (East Kalimantan)	2006	2 x 1	191.726.612	150.711.520	0,78	0,21 – 71,86
2	Buana Jaya (East Kalimantan)	2007	2 x 1	534.261.545	606.588.270	1,13	20,43 – 26,89
3	Tanah Bumbu (South Kalimantan)	2008	2 x 1	112.733.226	402.255.325	3,57	0,71 – 1,58
4	Tamiang (South Sumatera)	2008	1 x 1	31.792.000	9.114.082	0.28	0,00 – 0,17
5	Tanjung Enim (South Sumatera)	2009	2 x 1	1.181.594.858	758.792.398	5,20	0,05 – 0,86
6	Ombilin (East Sumatera)	2009	1 x 0,4	7.987.200	1.624.346.374	200,23	8,84 – 35,20
7	Jangkang (Central Kalimantan)	2010	-	16.567.200	15.724.004	0,08-4,49	0,00 – 1,12
8	Nibung (South Sumatera)	2010	7,5 x 0,58	100.394.426	1.637.175.754	14,35	0,00 – 9, 01
9	Paser (East Kalimantan)	2010	2,7 x 1,00	1.858.168	806.663	0,36	0,00 – 1, 20
10	Sawahlunto (East Sumatera)	2011		10.995.060	603.806.535	70,63	
11	**Bayunglencir**	**2012**		**17.170.000**	**83.446.200**	**4,86**	

Total Resources (hypothetic) : 2.201.786.038 tons *(coal)* ; 6.64 BCF *(methane)*

PROPORTION OF CBM GAS CONTENT GEOLOGICAL AGENCY (GA) VS ARII

No	Basin	Gas Content (SCF)	
		GA (Direct Measured)	ARII (assumption)
1	Ombilin	216 - 356	267
2	South Sumatera	4.86 – 14.35	223

ARII : Advance Resource International Inc.

SELECTION SITE AND SCOPE OF WORK OF CBM RESEARCH OF GEOLOGICAL AGENCY

BASIS OF SELECTION OF RESEARCH SITE

1. Sedimentary basin that have the potential of coal
2. Areas with good infrastructure
3. To advance the national economy
4. To develop the potential of unconventional energy

SELECTION OF SITE

1. Sumatera Selatan Basin
2. Barito Basin
3. Kutai Basin
4. Central Sumatera Basin
5. Ombilin Basin
6. Berau Basin
7. Pasir & Asam-asam Basin

SCOPE OF WORK

1. Preliminary survey, drilling work, and laboratorium work to identify distribution, thickness and depth of coal seam and coal quality
2. CBM asessment CBM(geology and geophysic works and data interpretation to identify the 3D form of subsurface coal seam)
3. Determination of drilling site to gain sweet-spot CBM

CLOSING REMARKS

BADAN GEOLOGI KESDM

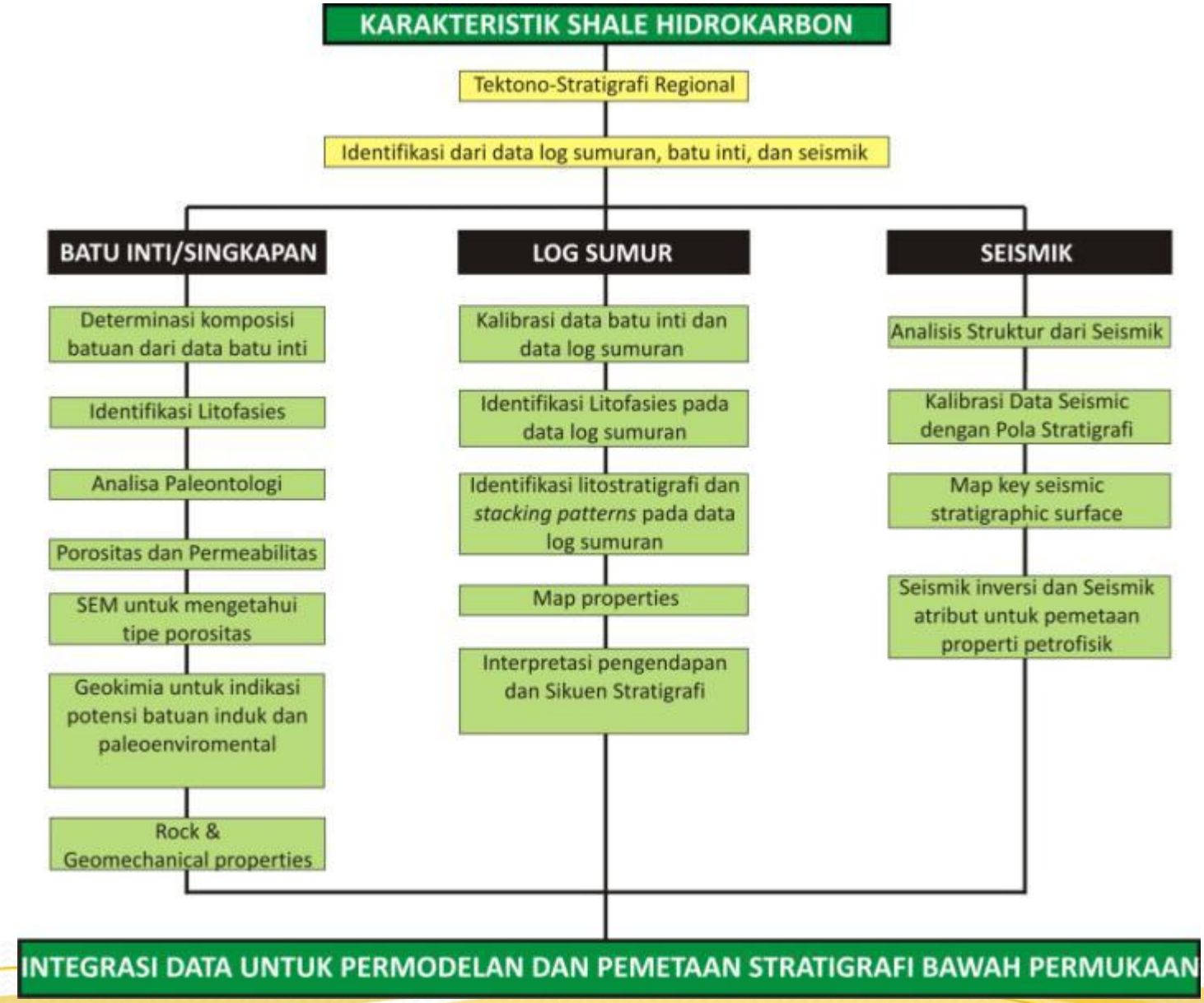
- Indonesia has 128 sedimentary basins of various types.
- Indonesia is very impressive and promising potential to conduct shale hydrocarbon and CBM exploration.
- Total speculative resources of shale gas is 574.07 tcf, distributed in 14 major basins (brown and green basins).
- Indonesia oil shale resources in 2007 up to 11.24 million tons where 10.09 million tons is speculative resources and 1.15 million tones inferred resource
- Indonesia CBM resources up to 453,3 TCF (speculative) or 6.64 BCF (hypothetic)
- Shale hydrocarbon and CBM potential is remarkably large, therefore need a comprehensive and integrated research to be done in order to proof its resource and reserve.
- Surface and subsurface geological & geophysical data have to be done in order to discover unconventional shale hydrocarbon and CBM resource and reserve.

THANK YOU

LAMPIRAN

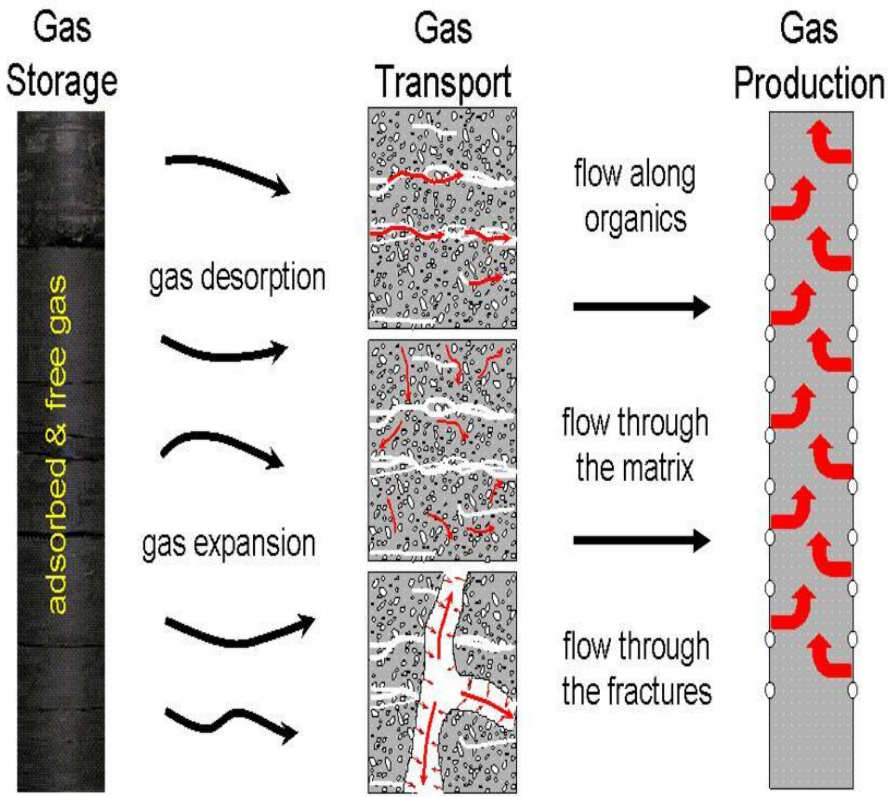
WORK FLOW

BADAN GEOLOGI KESDM



SYARAT SHALE GAS UNTUK DIEKSPLORASI

BADAN GEOLOGI KESDM

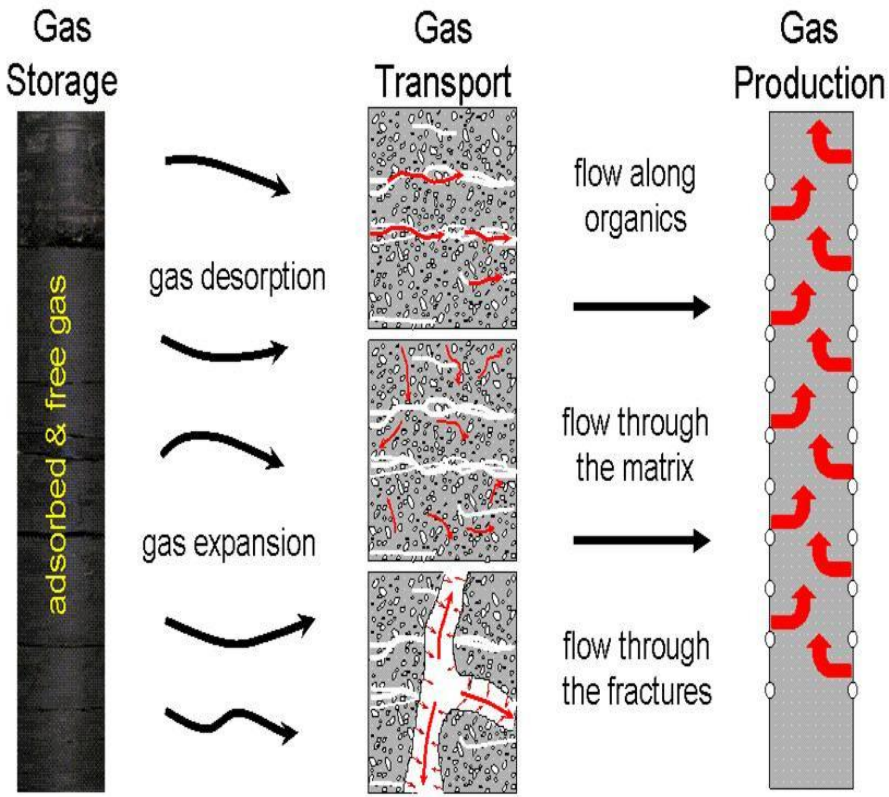


Gambar : Haley, 2009

- Komposisi terdiri dari serpih ≤ 50%, dan mineral getas (*brittle minerals*) ≥ 50%, agar mudah saat dilakukan *fracturing.*
- Kehadiran mineral lempung (*clay minerals*) sebaiknya < 10%, dengan komponen campuran perlapisan sangat rendah.
- Kandungan TOC (*total organic carbon*) > 2%.
- Tipe kerogen, umumnya kerogen tipe II, dari lingkungan *marine*, atau tipe III dari lingkungan *terrestrial.*
- Tingkat kematangan termal tinggi, pada *gas window*; untuk kerogen tipe II Ro > 1.1% hingga 1.4%; tingkat BTU dan kandungan CO_2 rendah.

SYARAT SHALE GAS UNTUK DIEKSPLORASI

BADAN GEOLOGI KESDM

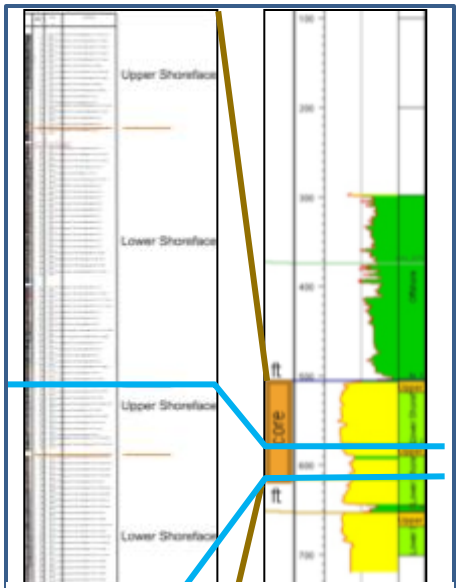


Gambar : Haley, 2009

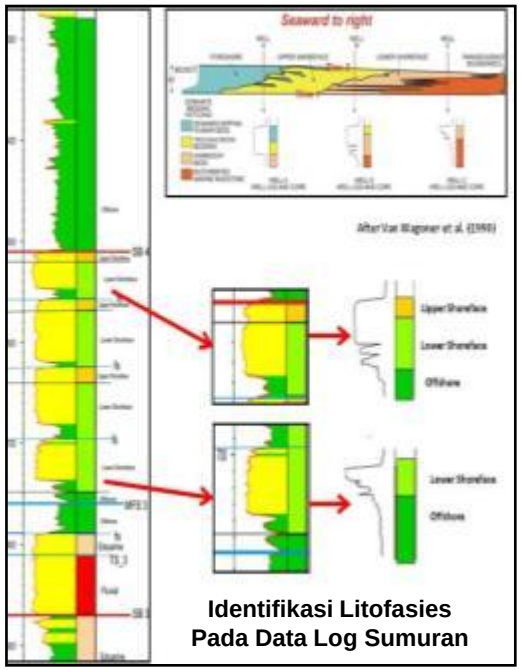
- Ketebalan sedimen > 100 ft atau sekitar 30 meter. Batas ketebalan dan kedalaman berkaitan dengan rasio kesuksesan proses *fracturing* pada reservoir *shale gas.*
- Kedalaman antara 1000 hingga 5000 meter, dengan gradient tekanan > 0.5 psi/ft.
- Porositas > 5%, berupa *microporosity* maupun dari rekahan alami (*natural fractures*).
- Tingkat kegetasan (*brittleness*) diindikasikan oleh nilai rasio *Poisson* yang rendah dan nilai modulus *Young* yang tinggi.
- Memiliki nilai *Gas in Place (GIP)* yang tinggi.

Well Logs

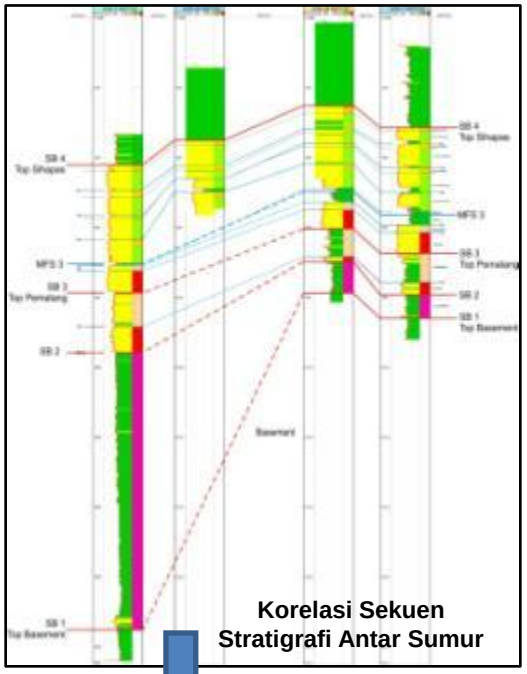
BADAN GEOLOGI KESDM



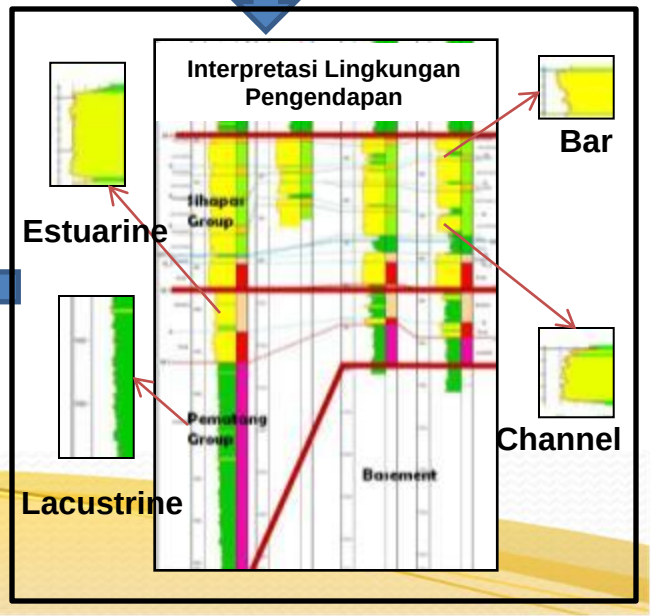
Kalibrasi Data Batuan inti dan Data Log Sumuran

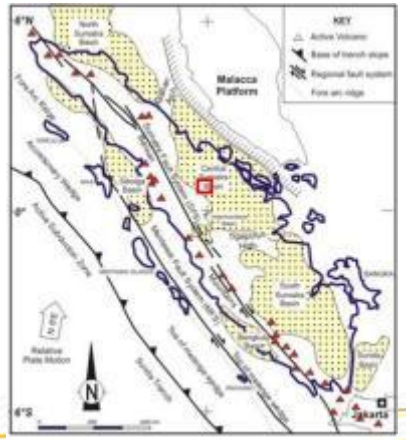


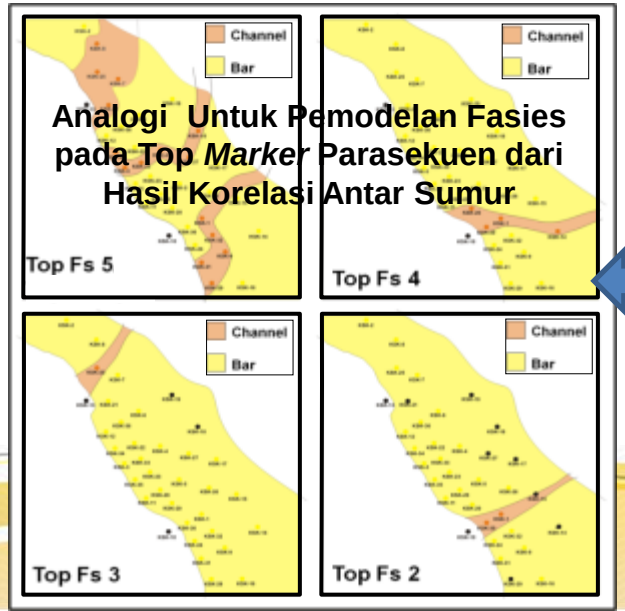
Identifikasi Litofasies Pada Data Log Sumuran



Korelasi Sekuen Stratigrafi Antar Sumur





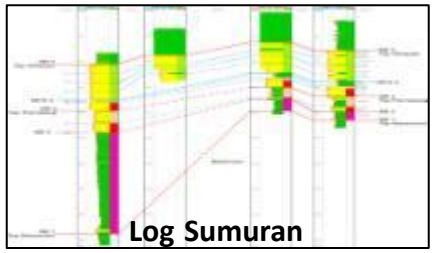


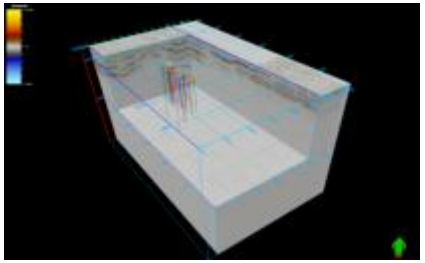
Analogi Untuk Pemodelan Fasies pada Top *Marker* Parasekuen dari Hasil Korelasi Antar Sumur

SEISMIK

BADAN GEOLOGI KESDM

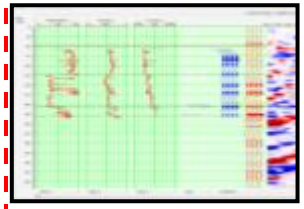
DATA



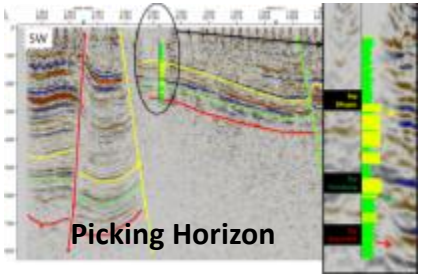


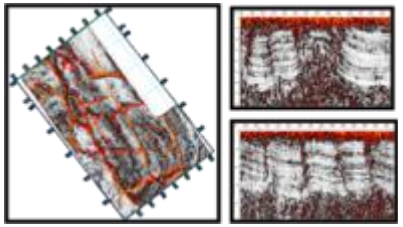
Seismik

WELL-SEISMIC TIE

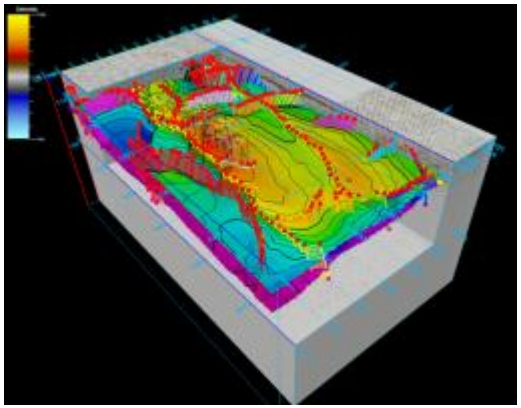


SEISMIC INTERPRETATION

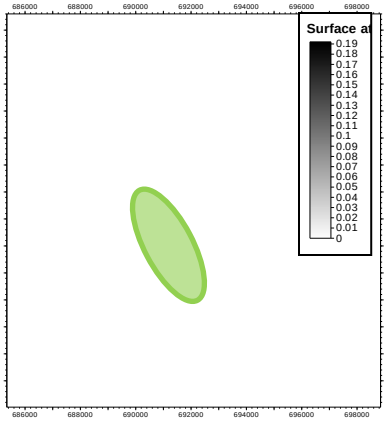




Interpretasi Struktur

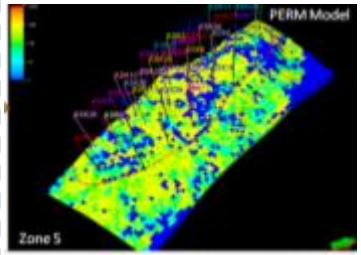


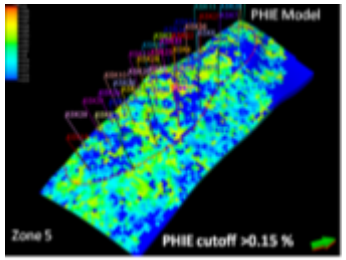
Run RMS Attribute on Top Pematang Fm.

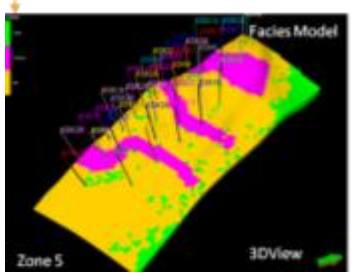


RMS AMPLITUDE OF PEMATANG FM

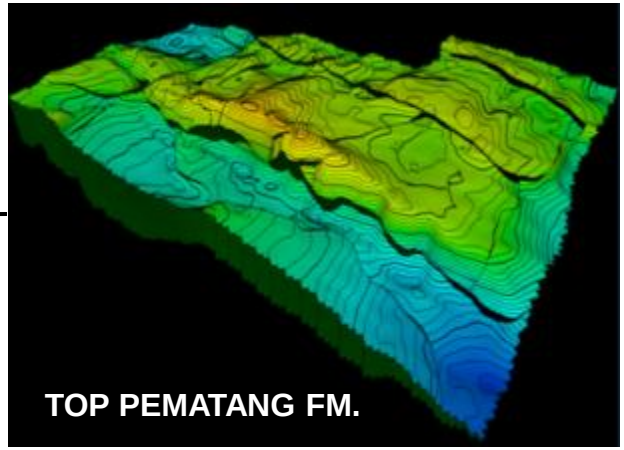
PERMODELAN DARI HASIL INTEGRASI DATA SEISMIK DAN LOG SUMURAN







Fault Modeling and Time to Depth Conversion

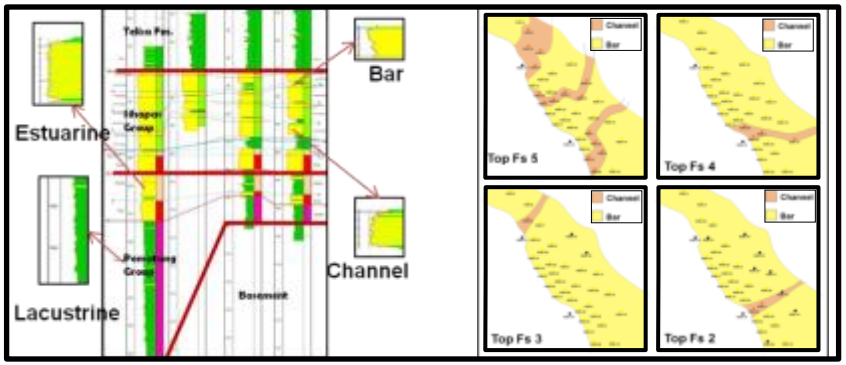


TOP PEMATANG FM.

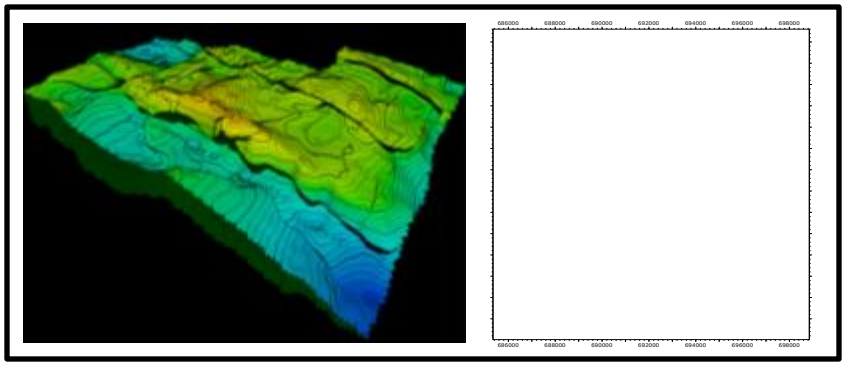
INTEGRASI DATA

BADAN GEOLOGI KESDM

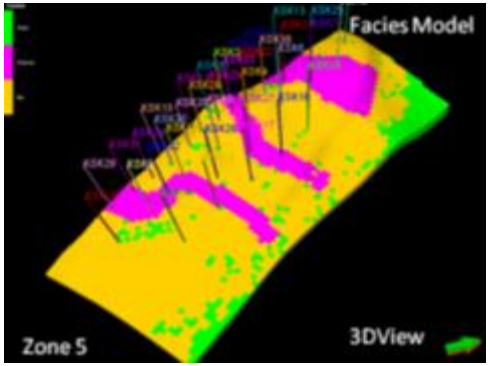
INTERPRETASI WELL LOG KALIBRASI DENGAN DATA CORE

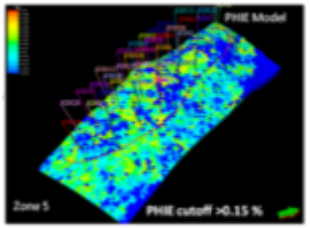


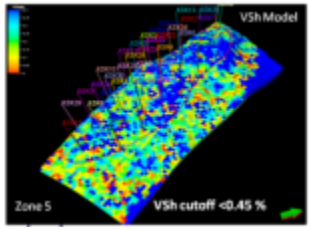
INTERPRETASI SEISMIK

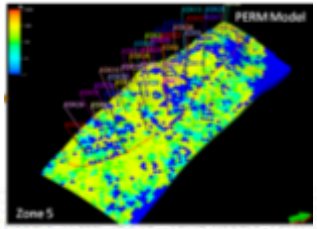


PERMODELAN PROPERTI

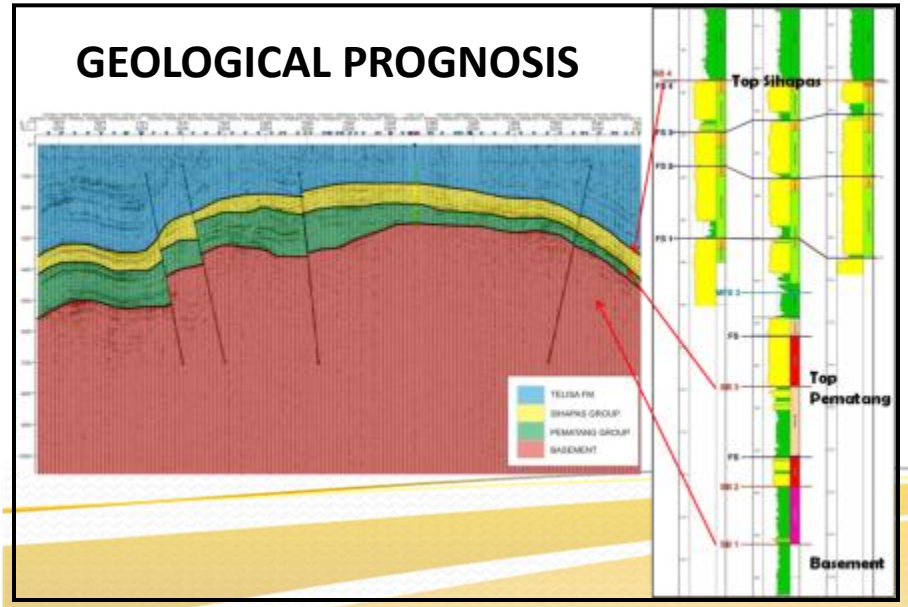




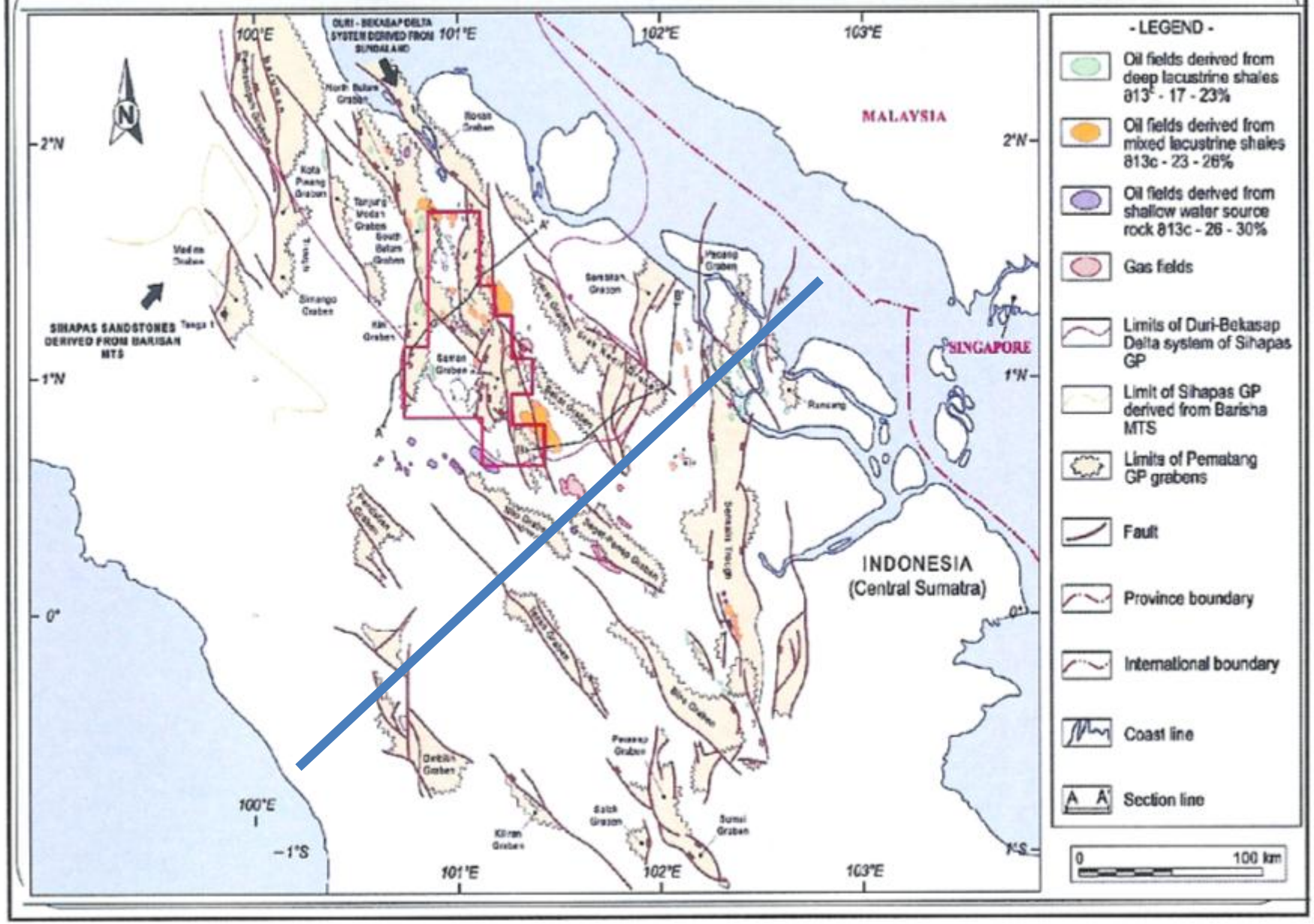




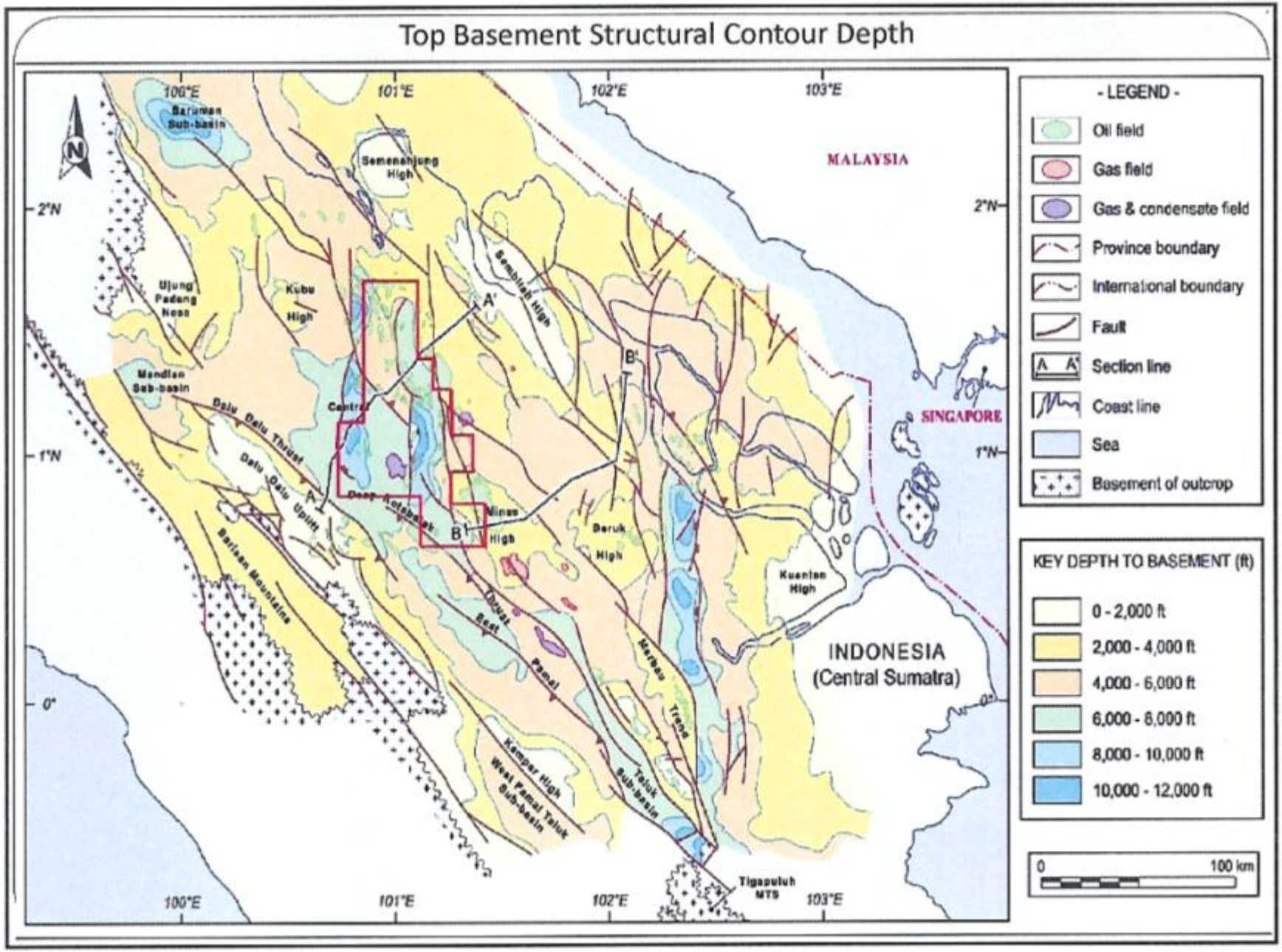
GEOLOGICAL PROGNOSIS



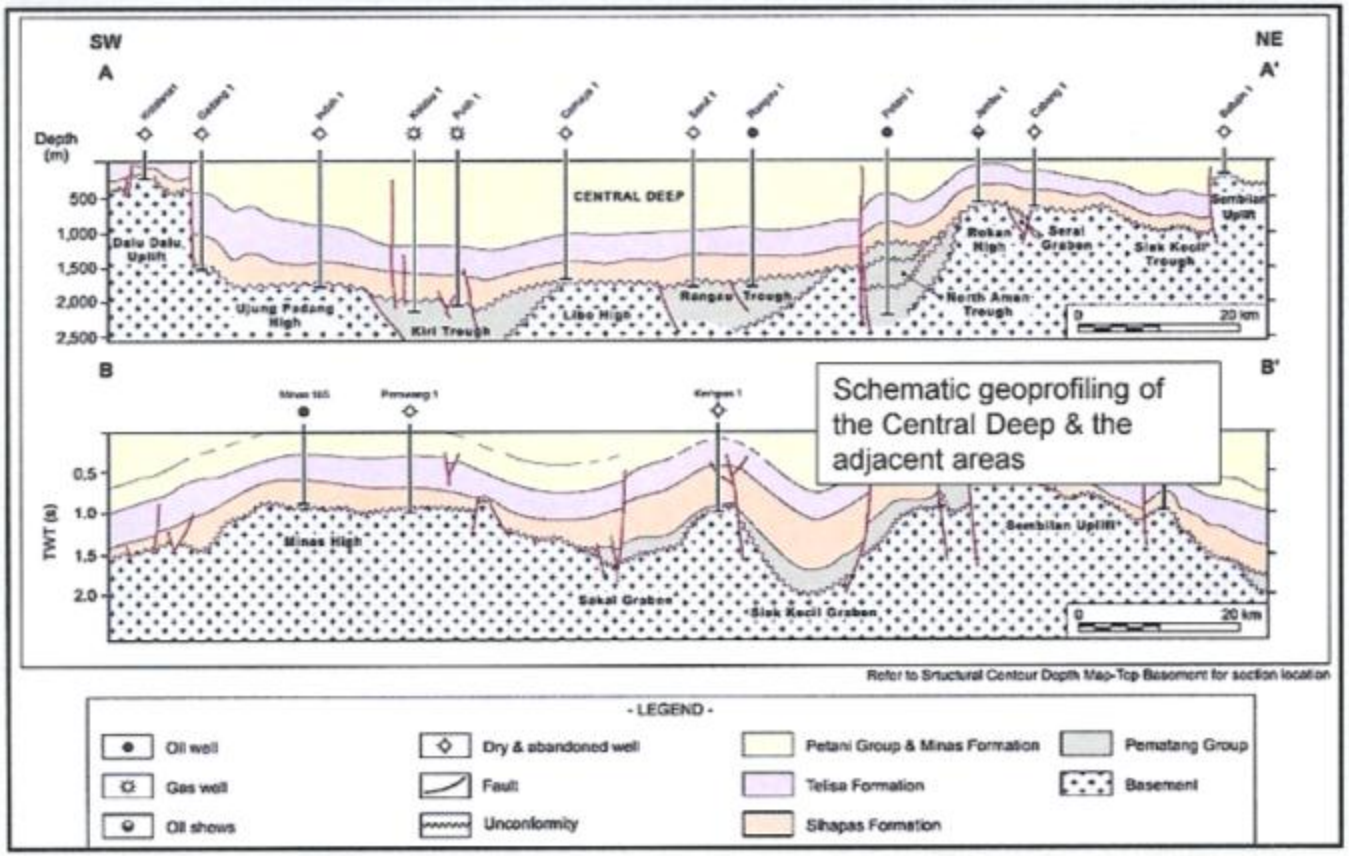
PEMATANG GROUP GRABENS AND OIL TYPES



Top Basement Structural Contour Depth



NE-SW Geological Crosssection



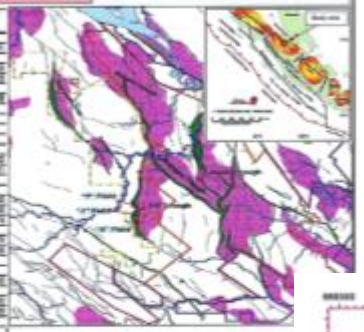
2013-2014

- Eocene to Oligocene vertically depositional environment and kerogen type changes
- Eocene to Oligocene sequence stratigraphy
- Burial History
- Paleogeography
- G&G analysis to calculate GIP

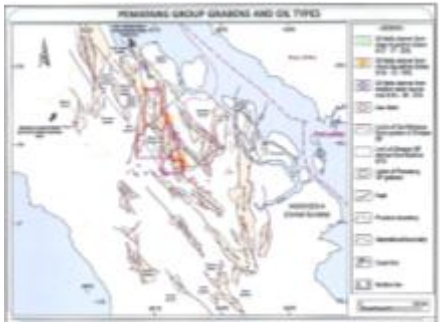
NO	WELL ID NOTATION	CHECK SHOT	MUD LOG	SOURCE ROCK EVAL.	GEOCHEM. ANAL.	BIOSTRAT. PALEONTO.	WELL REPORT	PETROGRAPH. MORFOLOGIAL
	AMAN DEEP							
1	BALAM SOUTH STRAT - 1	√	√	N/A	N/A	N/A	√	N/A
2	GULAMO - 1	N/A	√	N/A	N/A	N/A	√	N/A
3	GUNTUR - 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	JINGGA - 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	KELABU - 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	KIRANA - 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	NELLA - 1	√	√	N/A	N/A	N/A	√	N/A
8	OBOR - 1	N/A	N/A	N/A	N/A	N/A	√	N/A
9	PETANI - 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A

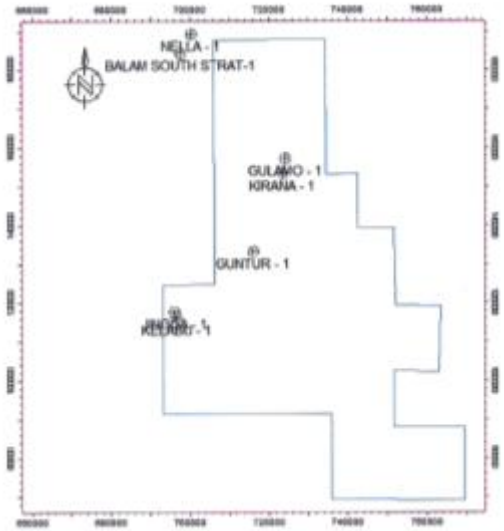
WELLS	BALAM SOUTH STRAT - 1	GULAMO - 1	GUNTUR - 1	JINGGA - 1	KELABU - 1	KIRANA - 1	NELLA - 1	OBOR - 1	PETANI - 2
CALIPER LOG	CALI	CALI	CALI	CALI	CALI	HCAL	CALI		
DENSITY CORRECTION LOG	DRHO	DRHO	DRHO	DRHO	DRHO	HDRA	DRHO		
SONIC LOG	DT	DT DTL	DT	DT	DT		DT		
GAMMA RAY LOG	GR	GR	GR	GR	GR	GR	GR		
DEEP RESISTIVITY LOG	IND	ILD ILD	LLD	LLD	LLD	HLLD	ILD		IND
MICRO SHALLOW RESISTIVITY LOG	SN	LL8 LL3	LL3	LL3	LL3	HLLS			SN
SPHERICAL RESISTIVITY LOG		MRP1 SFLU					SFLU		
FLUSH ZONE RESISTIVITY			RXO	RXO	RXO	RXO2			
NEUTRON LOG		NPHI	NPHI	NPHI	NPHI	TPNH			
PHOTOELECTRIC FACTOR LOG		PEF				PEF2			
DENSITY LOG	RHOB RHOB	RHOB	RHOB	RHOB	RHOB	RHOZ	RHOB RHOB		
SPONTANEOUS POTENTIAL LOG	SP	SP	SP	SP	SP	SP	SP		SP

GEOCHEMISTRY ANALYSIS



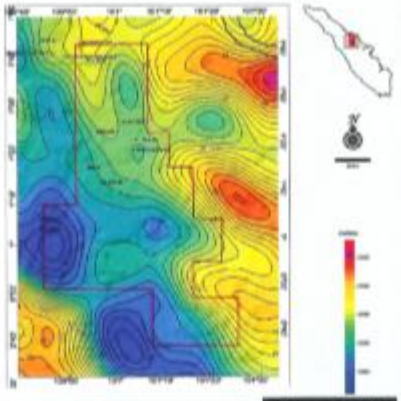
Total Organic Carbon, Rock Eval Pyrolisis, Vitrinite Reflectance, Kerogen and Carbon
Isotopc of Rock Samples in Kiri Trough. (Marpaung, 2010)



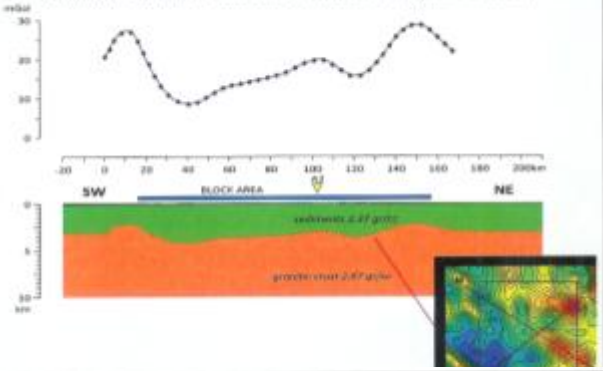


GRAVITY ANALYSIS OF AMAN DEEP

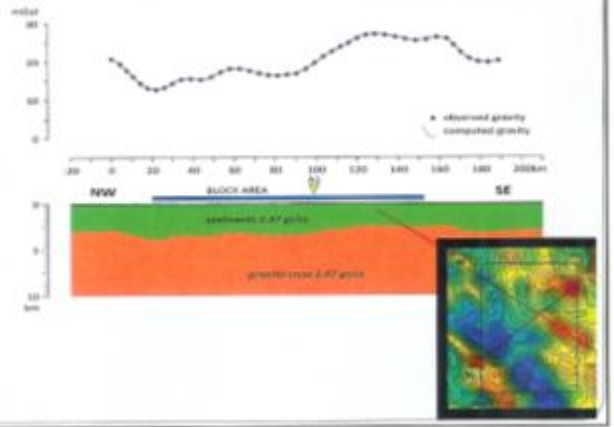
DEPTH TO TOP GRANITIC BASEMENT



CRUSTAL GRAVITY MODEL TRANSECT A1 (shallow section)

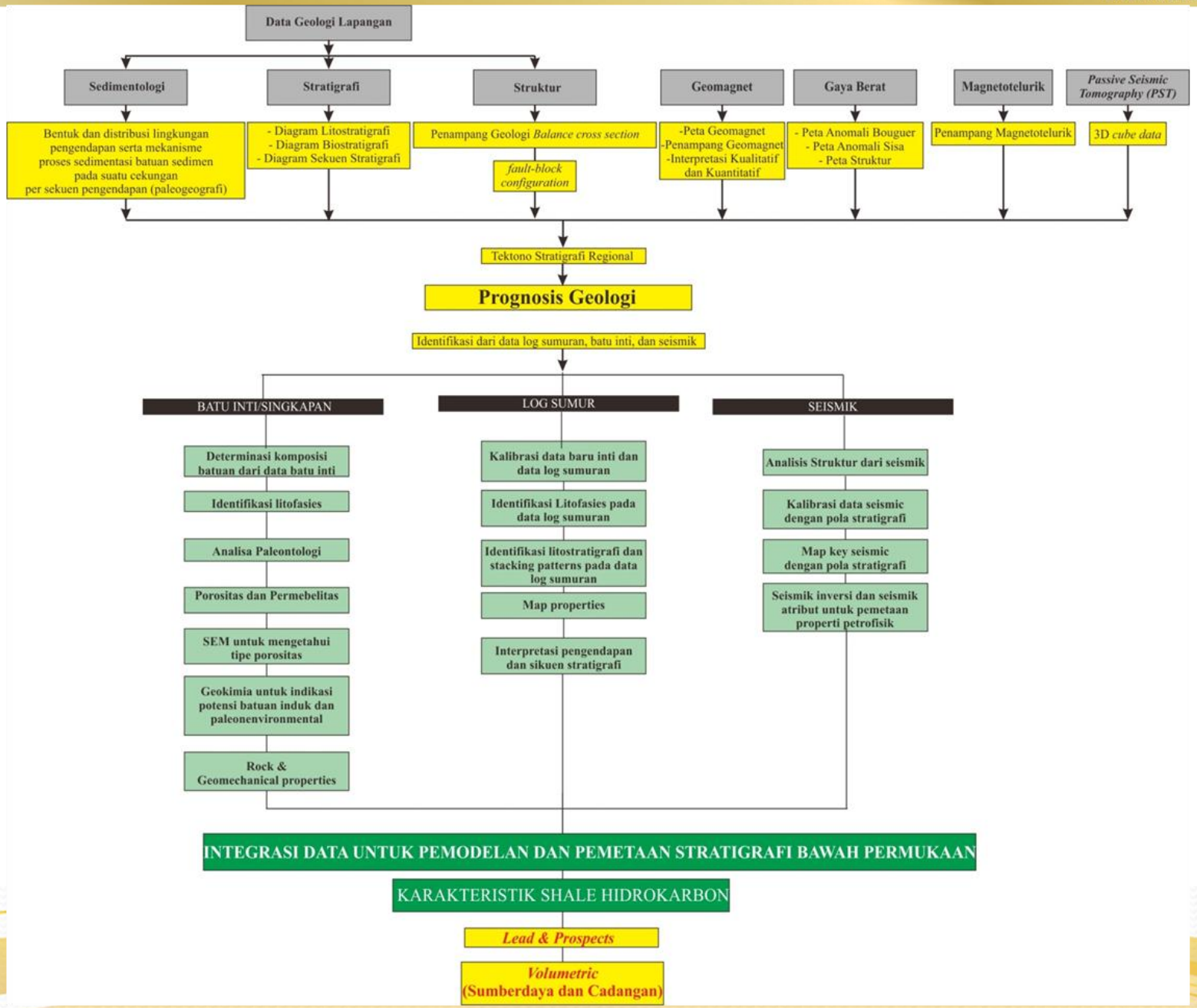


CRUSTAL GRAVITY MODEL TRANSECT A2 (shallow section)



WORK FLOW

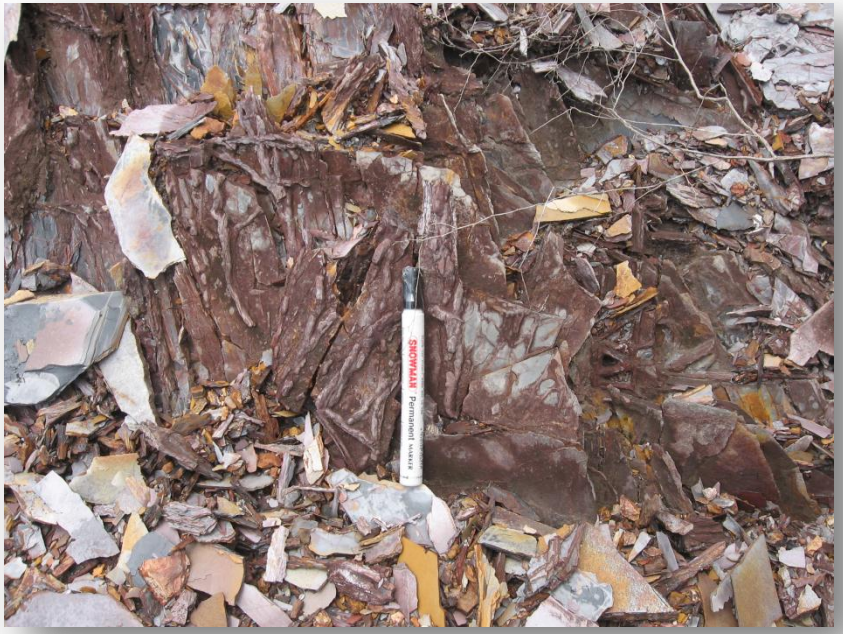
BADAN GEOLOGI KESDM



Permian Aiduna Fm.

BADAN GEOLOGI KESDM

Interbedded & interlamination of clay and very fine grain sst with intercalation of coal, lacustrine Permian deposit, Aiduna Fm. Gunung Botak, Ransiki transect.


SNOWMAN
Permanent MARKER

Jurassic Kopai Fm.

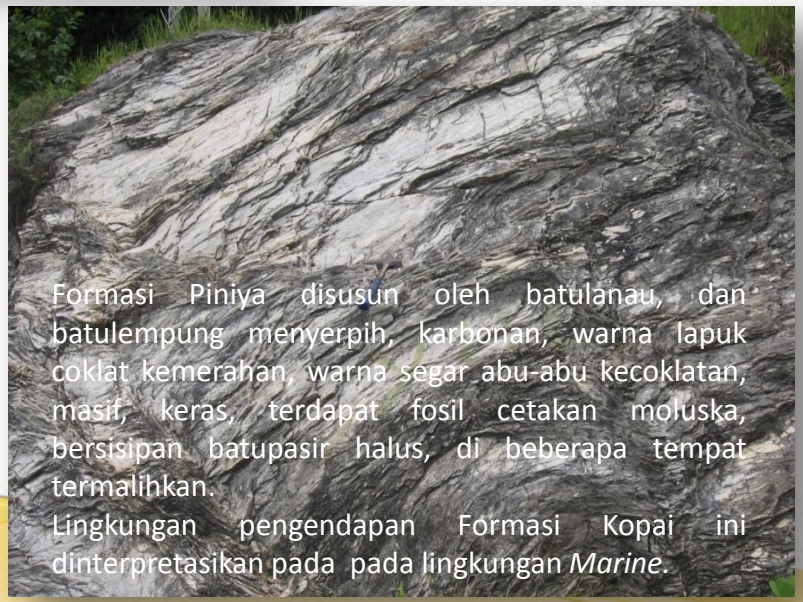
BADAN GEOLOGI KESDM

Formasi Kopai ini dicirikan oleh batulempung menyerpih, berlapis baik, warna lapuk coklat kemerahan, warna segar, abu-abu, karbonan di beberapa tempat, terdapat pirit, dan di beberapa stasiun pengamatan ditemui struktur sedimen parallel laminasi.

Lingkungan pengendapan Formasi Kopai ini dinterpretasikan diendapkan pada laut dangkal/*shallow marine*.

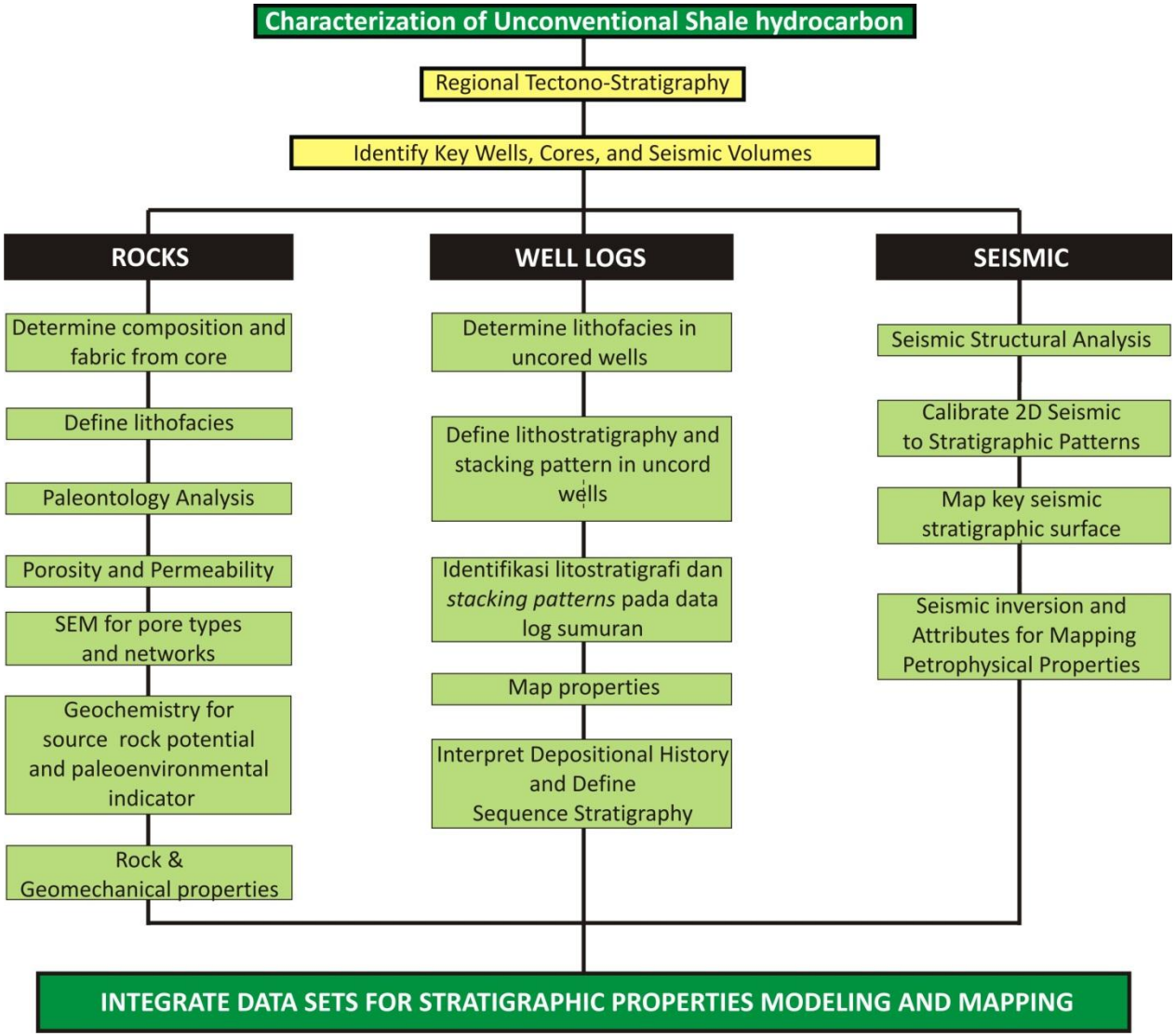
Cretaceous Piniya Fm.

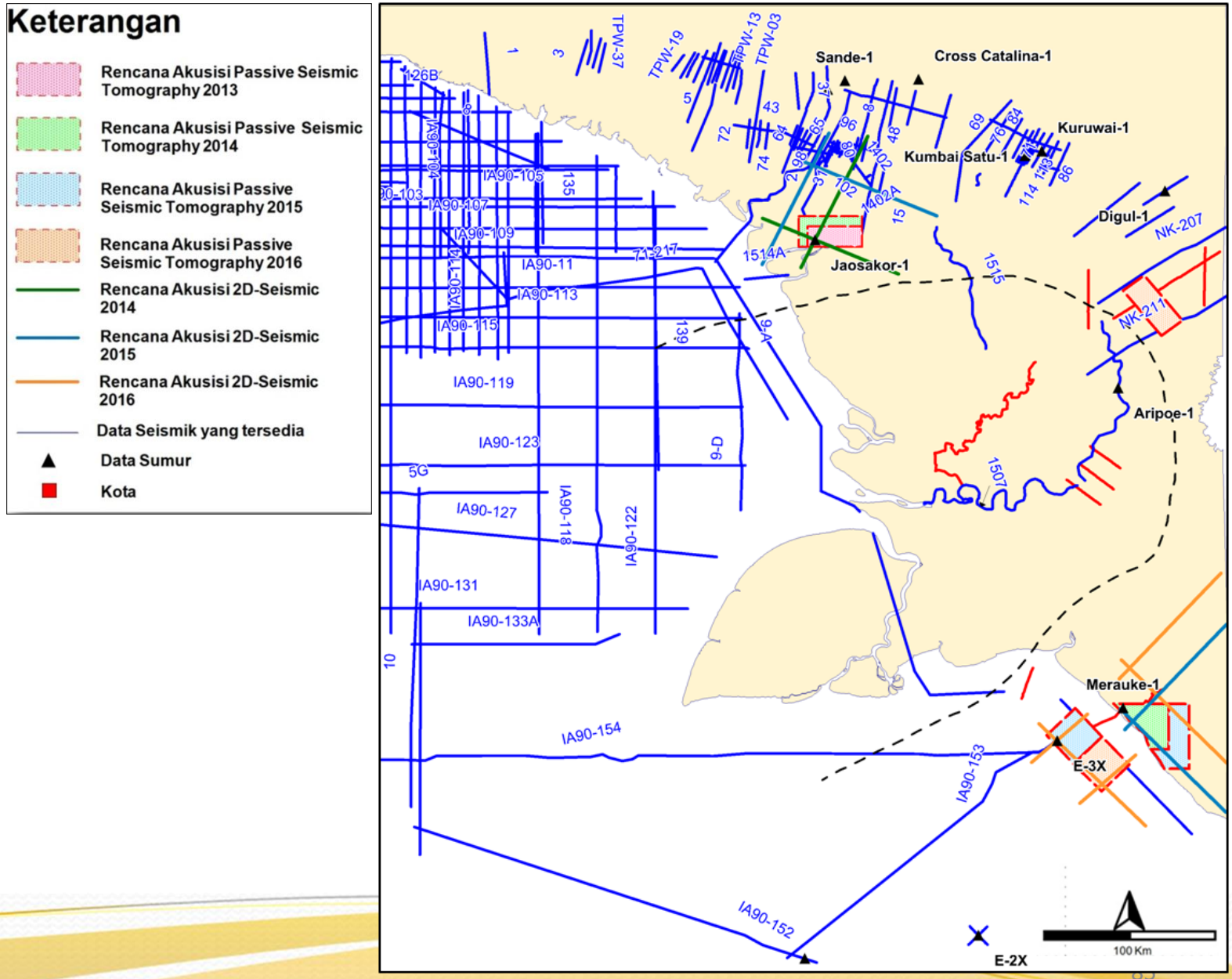
BADAN GEOLOGI KESDM



Formasi Piniya disusun oleh batulanau, dan batulempung menyerpih, karbonan, warna lapuk coklat kemerahan, warna segar abu-abu kecoklatan, masif, keras, terdapat fosil cetakan moluska, bersisipan batupasir halus, di beberapa tempat termalihkan.

Lingkungan pengendapan Formasi Kopai ini dinterpretasikan pada pada lingkungan *Marine*.


Characterization of Unconventional Shale hydrocarbon
Regional Tectono-Stratigraphy
Identify Key Wells, Cores, and Seismic Volumes
ROCKS
Determine composition and fabric from core
Define lithofacies
Paleontology Analysis
Porosity and Permeability
SEM for pore types and networks
Geochemistry for source rock potential and paleoenvironmental indicator
Rock & Geomechanical properties
WELL LOGS
Determine lithofacies in uncored wells
Define lithostratigraphy and stacking pattern in uncord wells
Identifikasi litostratigrafi dan stacking patterns pada data log sumuran
Map properties
Interpret Depositional History and Define Sequence Stratigraphy
SEISMIC
Seismic Structural Analysis
Calibrate 2D Seismic to Stratigraphic Patterns
Map key seismic stratigraphic surface
Seismic inversion and Attributes for Mapping Petrophysical Properties
INTEGRATE DATA SETS FOR STRATIGRAPHIC PROPERTIES MODELING AND MAPPING

Peta rencana lokasi survei umum di Papua Selatan

BADAN GEOLOGI KESDM