Challenges Related to the 3D Geo-Cellular Modeling of the Volcaniclastic Mature Meruap Oil Field in Central Sumatra, Indonesia*

Valentin Ivanov[1], Muhammad Prakoso[2], Nioman Witasta[3], Wahue Nainggoloam[2], Irwan Kurmiawan[2], and Azzalzalah Azzalzalah[2]

[1]Veta Energy Inc, Calgary, Alberta (ivanovv@telus.net)
[2]Samudra Energy
[3]Pertamina EP

Abstract

In the last decade, the construction of 3D static models for oil and gas fields became a routine practice. The availability of specially designed software such as Schlumberger Petrel ^{TM} provided elaborate interface and algorithms for conducting such tasks in timely fashion. The benefits of having a realistic 3D static model are related to the opportunity to integrate all available geological, geophysical and reservoir engineering data in a single model. Such a model can be constantly updated and fine-tuned using fresh field data and provides the means for intelligent reservoir management. The ultimate goal of intelligent reservoir management is to maximize the economical extraction of the hydrocarbons. The robust 3D static model provides for quick update of the commercial hydrocarbon reserves. Those reserves are often necessary to report regularly to the shareholders, and creditors of the oil and gas companies. Finally, when the operator of an oil field is planning enhanced oil recovery (EOR) it is necessary to design such works with a clear understanding of the geometry, pore volume, saturation and permeability of the oil reservoirs/flow units. Such understanding can be obtained and visualized from the 3D static model and subsequent EOR works can be designed with reasonable expectation for success.

The above statements were the bases for the creation of the 3D static model for Meruap Field - a mature clastic field in Central Sumatra, Indonesia. The field belongs to the Indonesian National Oil company PERTAMINA and is operated by Samudra Energy. It was discovered by British Petroleum in 1974 with the drilling of well M-1, which penetrated a Miocene anticline structure identified by a 2D seismic survey. Subsequent drilling of delineation wells M-2, M3 and M-6 confirmed the presence of oil accumulation in 20 zones with total gross thickness of about 2000 feet and total area of the closure of about 5 km^2. The anticlinal structure is bounded on the east and south with two almost perpendicular faults. Numerous smaller branching faults are splitting the reservoirs into different compartments. All reservoirs are associated with the Miocene age Air Benekat Formation which is represented by fluvial delta/prodelta clastics amalgamated with abundant volcanoiclastics.

The commercial development of the field started in 1995, and by 2010 about 40 wells had been drilled and completed. By that time those wells had extracted about 9 million barrels of oil. Most of the producing wells were perforated and commingled in various reservoirs based on well logs analyses. As of today there are 68 wells drilled in the field and the total extracted oil amounts to about 17 million barrels.

In 2011 Samudra Energy decided to create a 3D geo-cellular static model for the Meruap Field in order to: (1) update the field reserves, (2) optimize the infield drilling, and (3) to conduct pressure maintenance by water injection and possible chemical flooding. Two of the existing wells were already injecting water into the reservoirs but the pressure response from the surrounding wells was somewhat erratic and the operator needed a robust model for optimizing the pressure maintenance water flooding.

In the next 4 years different editions of 3D static models were constructed, sometimes by inviting third parties. Those models were used primarily to make assessment of the initial and remaining oil and gas reserves. The latest model was constructed in 2015 by Samudra's in-house geo-science team and our presentation will focus on that.

This presentation will discuss the challenges faced by the geo-modelers during the building of the Meruap geo-cellular model. It will also share our experiences and the unique solutions applied by Samudra geo-science team during the modeling journey.

The challenges are related to:

1.   Depositional model for the Meruap reservoirs - it is understood that the Meruap reservoirs and the interbedded seal rocks are forming the depositional cake which is a product of uninterrupted sequential deposition during Miocene in shallow marine and terrestrial deltaic sediments. The depositional history includes episodes of major volcanic eruption and in-situ rapid deposition of volcanic ash and pyroclastics. Regardless of relatively close proximity of the Meruap wells for some of the reservoirs, the correlation of the flow units is challenging and the lateral continuity is uncertain. The available 3D seismic survey was not able to provide recognition of the depositional patterns and depositional trends due to the low vertical resolution and high attenuation of the seismic signals by the gas cups, interbedded shales and volcanic tuff. Therefore, image training and object modeling were not attempted and the priority was given to the stochastic modeling of the facies with the use of variograms.

2.   The saturation model has been build based on the John Leveret J Function and the concept of the equilibrium between the capillary pressure and buoyancy force. Buoyancy force has been calculated based on the height of the oil and gas columns from the free-water level (FWL) and taking into consideration the gravity of the hydrocarbons and formation water. The special core analyses conducted on 22 core plugs taken from three wells have been used to construct the J Function. The biggest challenge during the building of the saturation model is the determination of the FWL. Only a few wells have indicated clear water bearing zones. By comparing the water saturation (Sw) predicted by the saturation model and the Sw calculated by the conventional log analyses, adjustment of the FWL for different reservoirs have been applied.

3.   The recognition of the pay zones by traditional log analyses is very difficult due to the presence of high resistivity pyroclastics (consisting of high resistivity volcanic glass). They are contributing to high resistivity readings of the Deep Lateral Logs. In addition, the

presence of meteoric water with low salinity in the Air Benekat reservoirs are contributing to the high resistivity readings, especially in the shallower reservoirs. Therefore a resistivity property has been introduced in the model which has been distributed by co-Kriging with the Sw generated by the saturation model . This resistivity property has been used as additional criteria for the determination of the net thickness in each reservoir.

4.   Individual Net-to-Gross (NTG) equation was designed for each zone based on the porosity, Sw and resistivity cut-offs. The well testing results were considered to be the ultimate Quality Control for the model. If the well testing is reporting influx of water but the 3D model (including the conventional log analyses) is predicting the presence of oil, an adjustment was made to the cut-offs for the NTG in such a way that the modeled NTG fully agrees with the well testing results. If the cement bond is reasonable, the actual formation influx during the well testing is assumed to reflect the actual saturation of the particular reservoir/flow units.

We believe that we found reasonable solutions to the above challenges during our work for the construction of the Meruap Field 3D Static model. The current model provides for the reasonable calculation of the initial original oil and gas in place. Currently the model is undergoing Dynamic modeling for the first priority reservoir candidates for EOR. Our approach and solutions can be applied to similar oil and gas fields where volcanoclastics are present.

References Cited

Darman, H., 2015, Geology of Indonesia: Wikipedia. Website accessed November 16, 2016, https://en.wikipedia.org/wiki/Geology_of_Indonesia

Hall, R., 2009, Southeast Asia's changing palaeogeography: Blumea, v. 54, p. 148-161.

Presenter's notes: Welcome everybody to our presentation. I am homered to make this presentation on behalf of my co-authors. We want to share with you some of our experience obtained during the construction of the Petrel Geo-cellular Geological model for a mature oil field in the island of Sumatra, Indonesia. The field is called Meruap, belongs to Pertamina and is operated by Samudra Energy. The oil has been discovered in multi-layered Miocene reservoirs heavily influenced by cyclic volcanic activity. It was discovered by BP in 1973 and was put on production in 1985. Today there are 72 wells in the field and so far about 17 million bbl of oil have been extracted. The picture of the background is giving you a hint about the volcanic activity during the deposition of Meruap reservoirs. It is showing the recent eruption of Sinabung volcano in North Sumatra which produced a dramatic pyroclastic flow . In the next few slides we will provide you with some information about the regional geology of the field.

Regional geology
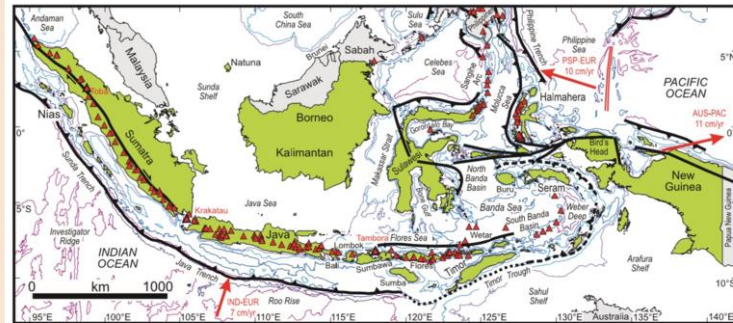
Geographical location of Indonesia (highlighted in green) showing present day tectonic boundaries and volcanic activities (Hall, 2009)

Presenter's notes: This map is showing the area of Indonesia with major tectonic boundaries and volcanic activities depicted with black cones. Essentially Indonesia is a product of plate tectonics. The most prominent feature is the Sunda trench which marks the subduction of the Indian Ocean Plate beneath the Sunda Plate to the NE The Volcanic arch extending for more than 2000 km and is a direct consequence of subduction.

Regional geology
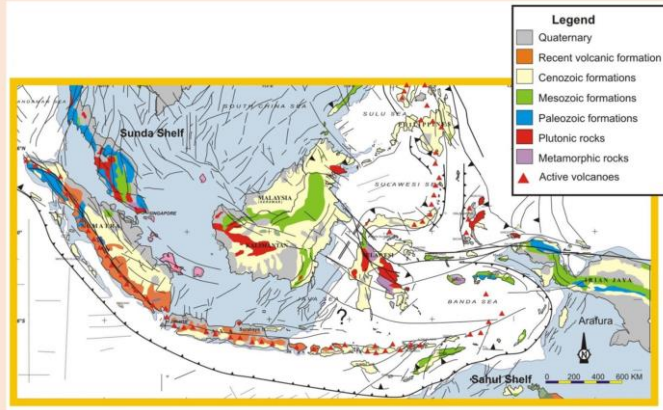
Regional stratigraphy of the outcrops in Indonesia (Darman 2015)

Presenter's notes: Previous and current volcanic activity generated enormous volumes of volcanic rock which is dominating the landscape and the outcrops in the islands of Sumatra and Jawa.

Regional geology
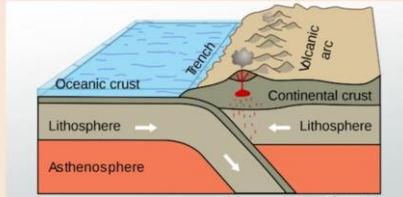
General diagram of an oceanic subduction zone (From online Study.com)
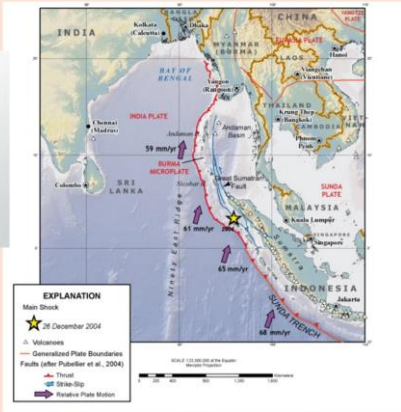
Tectonic base map of the Sumatra subduction zone showing annual rate of subduction of the Indian plate beneath the Sunda plate (From USGS earthquake Summary poster).

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Presenter's notes: Here we remind you the general schematic of the oceanic subduction zone. The Currently the Indian Plate is subducting with a speed of about 65 mm per year. If we project this speed back to the beginning of the Miocene 23 million years ago we are getting horizontal displacement of about 1500 km. This is just an assumption since we do not know the actual speeds for subduction in the past.

Brief overview of volcaniclastics
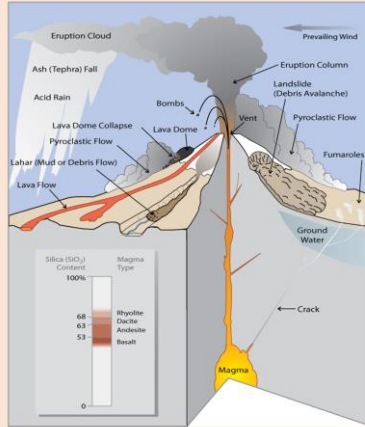
Main features of the Volcano (from USGS)

Mount Kerinci – a stratovolcano with height of 3805m and located 177 km west from Meruap field (from Panoramio)

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Presenter's notes: Volcaniclastic sediments are product of the volcanic eruptions. They are divided into autoclastic, pyroclastic, and epiclastic types. For the understanding of Meruap reservoirs we are mostly interested from the pyroclastic and epiclastic types. The pyroclastic can be the volcanic ash from the eruption cloud to pyroclastic flow containing fragments produced by volcanic explosion. Their deposition happens shortly after the actual volcanic eruption. The epiclastic volcanic rocks contain fragments produced by weathering and erosion of solidified or lithified volcanic rocks of any type. During the cycle of high volcanic activity the pyroclastics are dominating the sedimentation process with brief but very intensive precipitation. During the low cycle of volcanic activity the epiclastic volcanic rocks are deposited by the processes of normal erosion and transportation. On the right picture you can see the Kerinci volcano located 177 km west from Meruap Field. Those types of stratovolcano are built very rapidly sometimes, only within a few hundred years and reach significant height. Their erosion is also very rapid especially in the tropical country.

Regional geology

Satellite image from 560km of the Location of Meruap field (From Google Earth). Distances to the contemporary Vulcanes to the SW are 80-170 km.

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Presenter's notes: Here is the regional view of the location of Meruap Field. Currently a number of stratovolcanos are located South and SW from the field. The erosion of those volcanos are providing the main source of contemporary sediments for the lowlands to the north and northeast. The field is located in the center of Palembang Sub-Basin where the sedimentary thickness is reaching 5 km over a Mesozoic basement. The sedimentation regime was more or less similar for the Miocene time.

The Meruap Field
(view from above)

View of Meruap field from 7.5 km. Average elevation is 80 m above SL. Size of the field is about 6 km².

Presenter's notes: Finally getting close to the field – this is a picture depicting the Meruap well pad location and the town of Sarolangun to the west. The size of the field is about 8 km2.

Regional geology
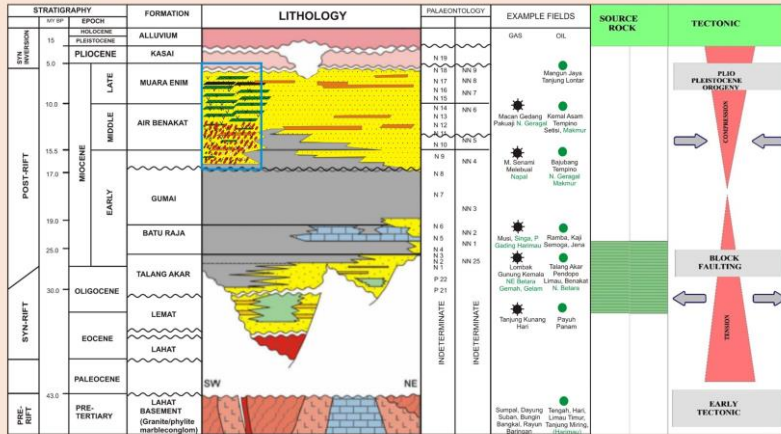
Stratigraphy column of South Palembang Basin

Presenter's notes: The reservoirs in Meruap Field are associated with Air Benekat Formation clastic sequence of Early and Middle Miocene age. The source rocks are the fluvial and marine shales of Eocene and Oligocene age which are currently in the oil window. The migration of the HC is assisted by a number of compressional faults. The Air Benekat is a fluvial deltaic/shallow marine clastic sequence composed of epiclastic volcanic sandstones interbedded with shale and devitrified tuffs. The tuffs are the product of pyroclastic sedimentation.

Depositional Environment

Presenter's notes: This picture is showing the tidal dominated flats of the Frazer river delta in Vancouver, Canada. Similar depositional environment is envision for the Air Benekat sequence in the area of the field.

Depositional Environment for Air Benekat
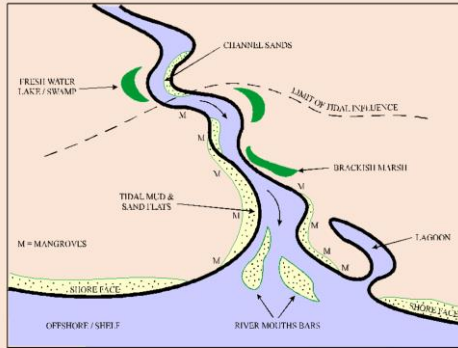
General understanding of the deltaic/shallow marine depositional environment
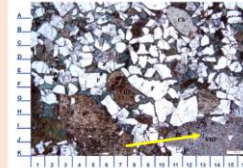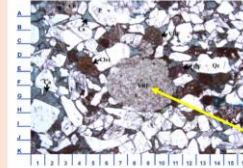
Thin sections of the conglomeratic volcanic sandstone at 2868.5ft in well M-64

Presenter's notes: In 2012 an extended study based on micropaleontology confirmed the deltaic/shallow marine sedimentation environment for Air Benekat. The cored intervals also confirmed that the Air Benekat has estuary to shallow marine origin with fluvial dominated sands, tidal flat sands and clays, lagoonal clays and shoreface shallow marine sands and clays. The sandstones are epiclastic volcanoclastic sediments. The volcanic fragments are often represented by devitrified volcanic glass. Those fragments are with high resistivity and their concentrations affecting the resistivity readings of the reservoir rock.

Regional palegeography
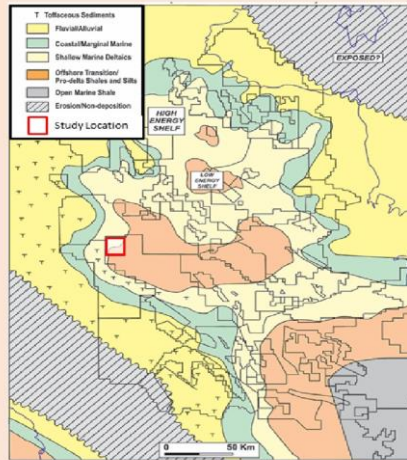
Regional Paleogeography for Air Benekat deposition

Presenter's notes: Regional paleogeography for the Air Benekat deposition is showing that the field is located in deltaic/sallow marine environment in the vicinity of volcanic mountains to the SW. The field is located in Palembang Sub-Basin where the sedimentary thickness is reaching 5 km over a Mesozoic basement.

Meruap Structure
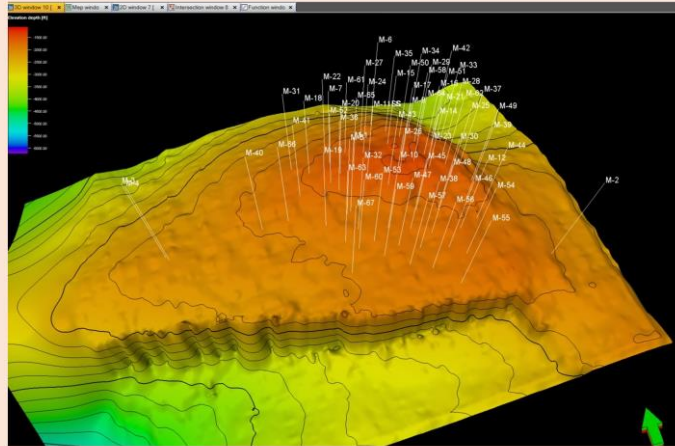
Depth Structure map of the Top of AB2-e – from interpretation of 3D seismic survey

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Presenter's notes: And now we will concentrate on the actual 3D model. The Meruap structure is a conform W-E elongated anticline bounded by two major intersecting faults with N-S and W-E direction. Originally the structure was detected with a 2D seismic survey conducted by BP in the early seventies which prompted the drilling of well M-1 in 1973 . This well discovered 700 meter of multilayered oil bearing Air Benekat. 3D seismic survey was conducted in 2007 and the map above depict the Seismic depth structure map for AB2-e layer based on the 3D seismic interpretation. For the construction of the structural model we used the well formation tops delivered from the well correlation and seismic structure maps as trend surfaces.

Meruap Structure
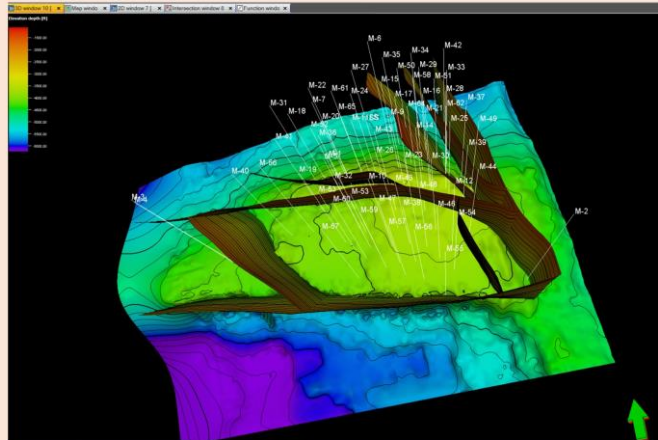
Structure map of the AB7 with faults surfaces as interpreted in the 3D seismic cube

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Presenter's notes: The AB7 is the lower most Air Benekat reservoir and here we are showing the fault configuration as established by the seismic. A total of 6 compartments have been identified. We suspect that some of those compartments are further complicated by minor faults which can not be detected by the seismic interpretation.
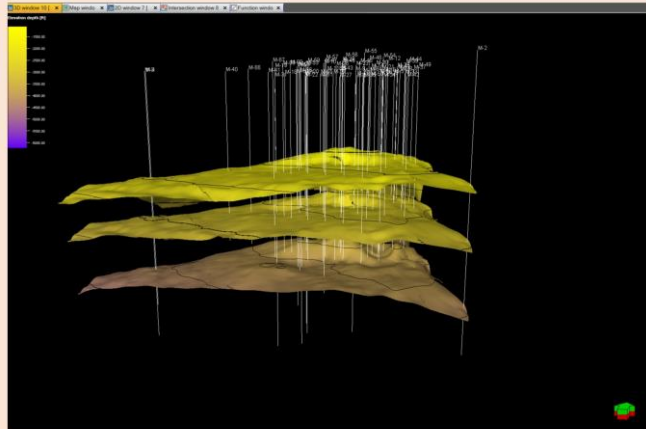
Meruap Structure

View from the South of the Tops of AB1-b, AB4-b and AB5-d

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Presenter's notes: This slide clearly depict the conform character of the Meruap reservoirs. The amplitude of the anticline is decreasing gradually towards the upper horizons.
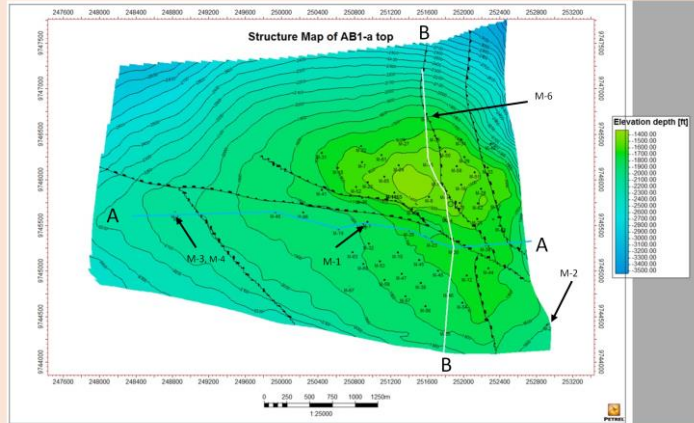
Meruap Structure

Structure map of the AB1-a top showing two perpendicular well cross-sections in the crest of the structure
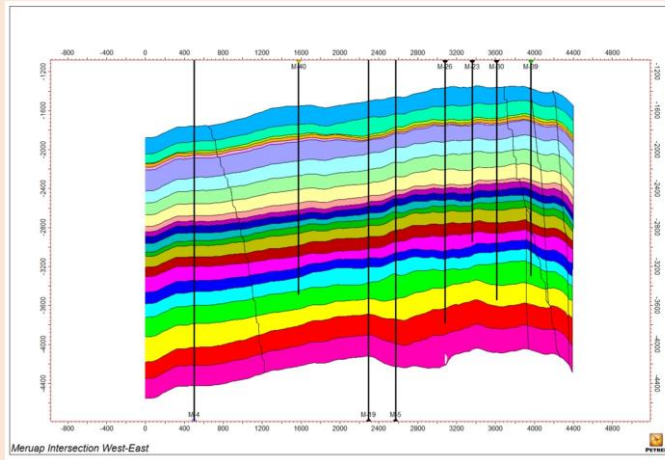
15

Presenter's notes: We are showing this map so you can see the well cross sections, which will be discussed in the following slides. On this map we can show you the discovery well M-1 and the first delineation wells M-2, M3, M4 and M6.

Meruap Air Benekat zones

Well cross-section of Air Benekat along A-A

Presenter's notes: The zonation of the Meruap along well cross section A-A from west to east direction. Notice the conform layering of the different zones.

Meruap Air Benekat zones

Well cross-section of Air Benekat along B-B

Presenter's notes: The zonation of the Meruap along well cross section B-B from the north to south direction.
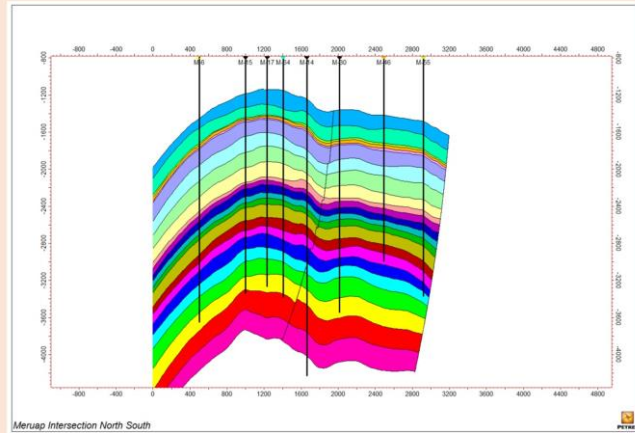
Meruap well correlation

Top of AB2e
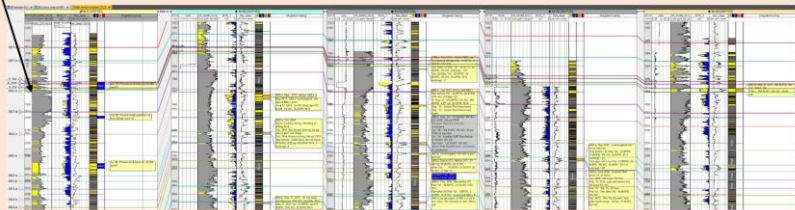
Top of AB5d

North- South well cross-section showing the correlation of the different zones

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Presenter's notes: The correlation of the fluvial volcanoclastic is difficult. The facies and the log signatures can change rapidly within a short distance. Here we are showing the upper and bottom portion of the logs used for correlation along A-A line. We started with processing the logs using conventional petrophysics so we obtained PHIE and BVW, Three simple facies were generated based on the porosity cut-offs. The conform character of the sedimentation was used to assign formation tops for the wells which did not penetrate the whole cake. The high GR is associated with cyclical volcanic activity which deposited in situ enormous amount of tuff and volcanic ash enriched in potassium. Later during the diagenesis those sediments were converted mainly into clays.

Meruap formation water salinity

No.	Reservoir	Field Measurement Cl-	References	Total Dissolved Solids	Cl-	References	Remarks	Cl- (ppm)	References
1	AB1-b			5567	3378	M-42???	-	1000	M-42
2	AB1-a	1500	M-2,M-44	6875	4172	M-44	-	3800	M-44
				6670	4047	M-12	-		
3	AB2-b	2500	M-22	10273	6234	M-51	-	3250	M-51
4	AB2-a	4000	M-14				-	3100	M-14
5	AB3-a						-		
6	AB4-b	4000	M-5, -31, -35				-	3000	M-31
7	AB4-a	3000	M-19				-	3000	M-19
8	AB5-d			3990	2421	M-06	-	3000	M-27
				7620	4624	M-22	Comm.5d,5c		
				7460	4527	M-24	Comm.5d,5c		
8	AB5-c	2000	M-22, -40,-45	8010	4860	M-09	Comm. 5a,5b,5c	3600	M-10
9	AB5-b	1600	M-21	5210	3711	M-16	Comm. 5c,5b	2150	M-09
10	AB5-a	2000	M-9		3888		Comm. 2a,5a (suspect 5a cause 2a intermitten/low		
				5270		M-11			
11	AB6-b	2000	M-26				-		
12	AB6-a						-		
13	AB6-d						-	???	M-48
14	AB7						-		

Presenter's notes: The formation water salinity in Meruap is relatively low. This brings challenges for the petrophysical interpretation, especially for the upper horizons where salinity is reaching less than 2g/l. The fresh water is indicator of influence of meteoric water. Also the partial biodegradation of the oil in some of the upper zones also suggest influence of meteoric water.

Meruap property modeling

- Six properties have been modeled in particular order for each cell:
- Lithology (based on simple 3 facies model)
- Effective porosity (PHIE)
- Permeability (Kwr)
- Sw saturation - based on Height above FWL and the results from Special Core Analyses
- Deep Resistivit (R-deep) – modeled in conjunction with Sw
- NTG – net to gross ratio
- Based on well testing and log analyses for each zone and segment the free water level (FWL) has been estimated.

Facies distribution
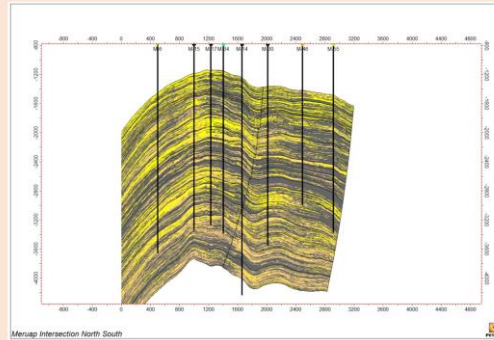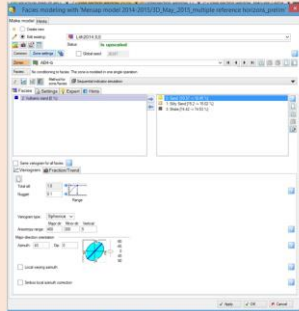
Example for the modeling parameters for the facies distribution and the final resulting distribution

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Presenter's notes: The body size and orientation have been obtained by the data analyses for each zone and the general understanding for the geometry of tide dominated delta facies

Distribution of the porosity and permeability

Presenter's notes: The permeability was obtained by conventional petrophysics using Willy-Rose equation in each well. Later it was distributed in the 3D space by using Porosity as a secondary variable.
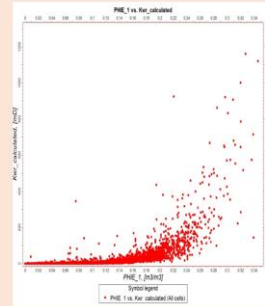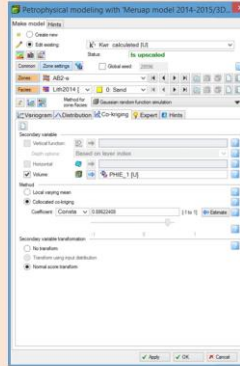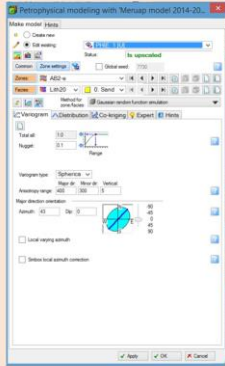
Assigning of WOC for 3P case

Make contact | Make regions proper | Hints

○ Create new: Contact set
◉ Edit existing: Contacst 3P

Gas oil contact 3
Oil water contact
Gas Water Conta

Contact type: Oil water contact
Contact name: Oil water contact 3P

Store
Populate →

Contact: ☐ Same for all zones ☐ Same for all segments ☐ Use regions property
Segments

	North Meruap	South Meruap	South East Meruap	West Meruap	East Meruap	Block Well 42
AB1-c	-1577.00	-1577.00	-1577.00		-1577.00	-1820.00
AB1-b	-1577.00	-1577.00	-1577.00		-1577.00	-1820.00
AB1-a_b_to	-1900.00	-1900.00	-1900.00		-1900.00	-2002.00
AB1-a_b_b	-1900.00	-1900.00	-1900.00		-1900.00	-2002.00
AB1-a_a_to	-1900.00	-1900.00	-1900.00		-1900.00	-2002.00
AB2-e	-1870.00	-1870.00	-1870.00		-1870.00	-2300.00
AB2-d	-2240.00	-2240.00	-2240.00		-2240.00	-2428.00
AB2-c	-2240.00	-2240.00	-2240.00		-2240.00	-2428.00
AB2-b	-2320.00	-2320.00	-2320.00		-2320.00	-2615.00
AB2-a	-2465.00	-2465.00	-2465.00		-2465.00	-2645.00
AB3-b	-2538.00	-2538.00	-2538.00		-2538.00	-2645.00
AB3-a	-2683.00	-2683.00	-2683.00		-2683.00	-2645.00
AB4-b	-2878.00	-2878.00	-2878.00		-2878.00	-2806.00
AB4-a	-2878.00	-2878.00	-2878.00		-2878.00	-2806.00
AB5-d	-2965.00	-2965.00	-2965.00		-2965.00	-2920.00
AB5-c	-2933.00	-2933.00	-2933.00		-2933.00	-2963.40
AB5-b	-3127.00	-3127.00	-3127.00		-3127.00	-3127.00
AB5-a	-3127.00	-3127.00	-3127.00		-3127.00	-3127.00
AB6-d	-3324.00	-3324.00	-3324.00	-3486.00	-3324.00	-3324.80
AB6-c	-3292.00	-3292.00	-3292.00		-3292.00	-3344.70
AB6-b	-3568.00	-3568.00	-3568.00		-3568.00	-3568.00
AB6-a	-3568.00	-3568.00	-3568.00		-3568.00	-3568.00
AB7	-3568.00	-3568.00	-3568.00	-4414.00	-3568.00	-3568.00

The contacts are selected based on well testing and log analyses. For some zones the 3P contacts are estimated.

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Presenter's notes: Here is the table showing the WOC for the 3P case {equivalent to the FWL} determined in each zone for each segments.
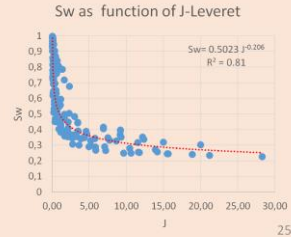
Meruap Free Water Levels

Meruap Intersection North South
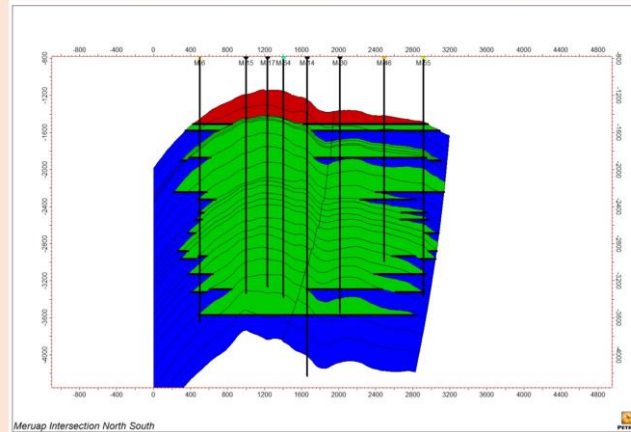
The FWL along B-B. It is assumed to correspond to the WOC for the 3P case

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Building of the saturation model

Sample	Depth, Ft	Zone	k, mD	Φ, %	Φ, frac	√(k/Φ)	(k/φ)^0.5	Wells
1(116)	2049	AB1_a_b_bot	340	23.2	0.232	38.28	**38.28**	
2(211)	2064.1	AB1_a_a_top	784	26.7	0.267	54.19	**54.19**	
3(315)	2088.2	AB2-e	115	23.6	0.236	22.07	**22.07**	M-59
4(406)	2874	AB5-d	4.49	13.5	0.135	5.77	**5.77**	
5(607)	3110.1	AB5-c	19.4	19.9	0.199	9.87	**9.87**	
6(608)	3111	AB5-c	24	19.9	0.199	10.98	**10.98**	
7(5-1)	2631.82	A82-c	1.57	11.1	0.111	3.76	**3.76**	
8(35C)	2907.25	A84-b	9.78	12.3	0.123	8.92	**8.92**	
9(66A)	2934.65	A84-b	85.6	15.3	0.153	23.65	**23.65**	M-19
10(1008)	3235.07	AB5-d	7.31	18.5	0.185	6.29	**6.29**	
11(138A)	3465.03	A86-d	4.78	17.6	0.176	5.21	**5.21**	
12(192A)	3854.2	A86-b	0.536	16.4	0.164	1.81	**1.81**	
13(101)	2247.7	**AB2-b**	121	21.6	0.216	23.67	**23.67**	
14(103)	2249.5	**AB2-b**	53.4	17.2	0.172	17.62	**17.62**	
15(104)	2250.1	**AB2-b**	199	22.6	0.226	29.67	**29.67**	
16(301)	2348.4	**AB2-a**	63.9	20.6	0.206	17.61	**17.61**	M-64
17(303)	2350	**AB2-a**	125	22.9	0.229	23.36	**23.36**	
18(312)	2359	**AB2-a**	210	23.4	0.234	29.96	**29.96**	
19(404)	2863.2	**AB5-c**	143	20.1	0.201	26.67	**26.67**	
20(411)	2870.1	**AB5-c**	40.2	18.4	0.184	14.78	**14.78**	
21(413)	2872.5	**AB5-c**	239	18.3	0.183	36.14	**36.14**	
22(417)	2876.1	**AB5-c**	69.1	20.4	0.204	18.40	**18.40**	

J as function of Sw

$J = 0.0645\ Sw^{-3.928}$
$R^2 = 0.81$

Sw as function of J-Leveret

$Sw = 0.5023\ J^{-0.206}$
$R^2 = 0.81$

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Presenter's notes: Here we are showing the data used for generationg J-Leveret function. The J function was build using low speed centrifuge capillary pressure for 21 core plugs from 3 wells. Not all zones are covered with SCAL but it was assumed that the obtained J-Sw function will be acceptable for all reservoirs.

Workflow for calculation of the J and Sw

Presenter's notes: In each cell the J has been calculated by J Leveret equation and Sw has been calculated and conditioned using the Sw = f(J) equation from the SCAL
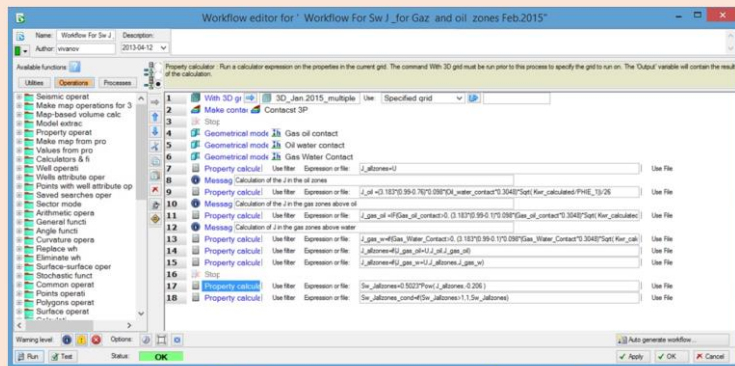
Distribution of the Deep Resistivity
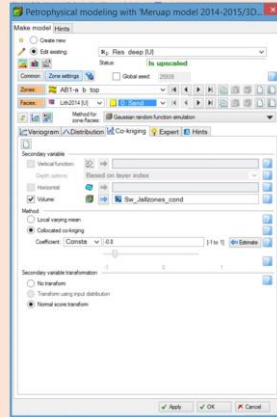
Collocated co-kriging with Sw was used to guide the R-deep distribution

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Workflow for NTG calculation with cut-offs
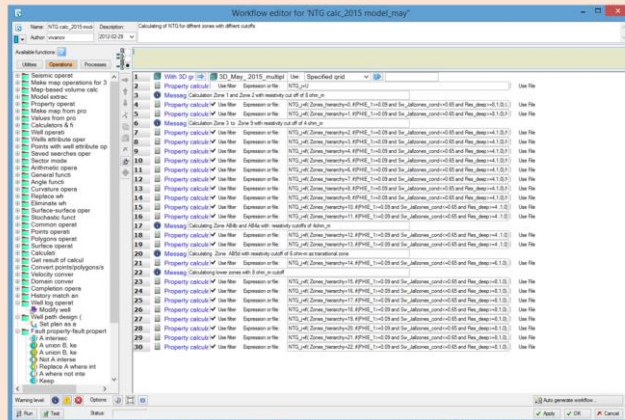
Presenter's notes: For each zone specific cut-offs have been designed in order to have agreement between the testing results and the NTG. The PHIE cut-off is 9% the Sw cut-off is from 0.65 to 0.75, the R-deep cut-offs is from 4 to 8 ohm_m.

Meruap NTG distribution

Meruap Intersection North South

Bellow the FWL no NTG has been distributed

Presenter's notes: Bellow the FWL no NTG has been distributed since the Sw is 100%.
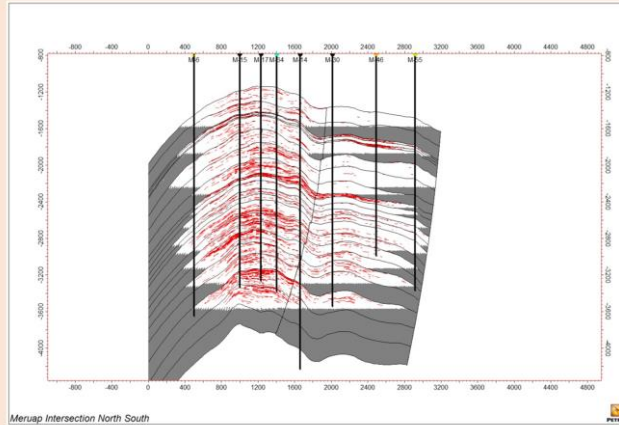
QC for the NTG distribution
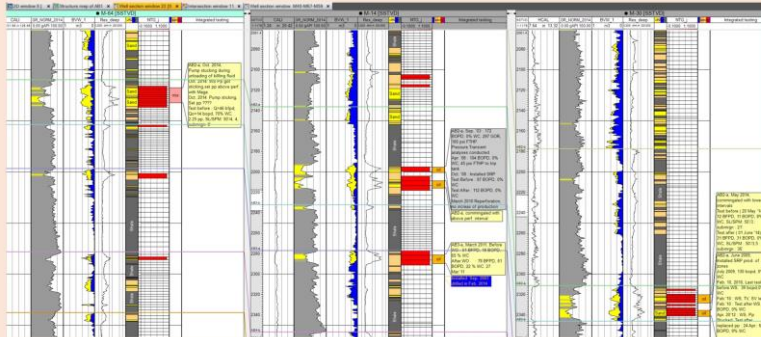
Example of good match of the well testing results and NTG

Presenter's notes: After the generation of the NTG property it is necessary to conduct QC of the NTG against the perforated intervals in each well. The goal is to make sure that the NTG is 1 against proven oil influx and 0 against proven water influx. Bypassed zones can be easily noticed when the NTG agrees with the testing.

Calculation of the OOIP and GIIP

Case	Bulk volume[*10^3 m3]	Net volume[*10^3 m3]	Pore volume[*10^3 m3]	HCPV oil[*10^3 m3]	HCPV gas[*10^3 m3]	STOIIP(in oil)[*10^3 sm3]	STOIIP[*10^3 sm3]	GIIP(in gas)[*10^3 sm3]	GIIP[*10^3 sm3]
rand_lin_j	3022936	226187	36860	18811	1420	16357	16357	85537	85537
Total all result types									
Zones									
AB1-c	204925	4474	1073	16	710	14	14	42761	42761
AB1-b	74327	6322	1422	160	710	139	139	42776	42776
AB1-a_b_top	38564	10106	1985	1168	0	1016	1016	0	0
AB1-a_b_bott	51440	1394	293	186	0	162	162	0	0
AB1-a_a_top	30675	11020	2187	1228	0	1068	1068	0	0
AB2-e	157151	6471	1200	717	0	624	624	0	0
AB2-d	302385	6616	1107	682	0	593	593	0	0
AB2-c	209073	6127	1054	637	0	554	554	0	0
AB2-b	152289	11535	1989	1128	0	983	983	0	0
AB2-a	66817	20021	3168	1593	0	1385	1385	0	0
AB3-b	68929	1242	189	104	0	91	91	0	0
AB3-a	130070	3253	510	302	0	263	263	0	0
AB4-b	135585	11741	1888	1073	0	933	933	0	0
AB4-a	134479	4801	781	459	0	399	399	0	0
AB5-d	253455	12930	1733	916	0	796	796	0	0
AB5-c	113458	13872	2239	1238	0	1059	1059	0	0
AB5-b	200171	16988	2920	1681	0	1461	1461	0	0
AB5-a	122964	31114	1826	1034	0	881	881	0	0
AB6-d	194723	15795	2474	1272	0	1106	1106	0	0
AB6-c	87025	6429	936	469	0	408	408	0	0
AB6-b	172848	19003	2593	1316	0	1144	1144	0	0
AB6-a	65330	7485	959	438	0	381	381	0	0
AB7	78254	17448	2337	1033	0	898	898	0	0
Segments									
North Merusap	1232959	122556	19766	10280	886	8939	8939	53381	53381
South Merusap	1042525	42030	7014	3560	26	3096	3096	1539	1539
South East Merusap	202996	6339	1125	566	18	492	492	1097	1097
West Merusap	79343	17183	2302	1019	0	886	886	0	0
East Merusap	315418	25018	4399	2085	469	1813	1813	28255	28255
Block Well 42	149694	13081	2255	1300	21	1130	1130	1265	1265

The OOIP and GIIP calculated for the 3P case

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Presenter's notes: This is the final volumetric calculation table for the 3P case. The OOIP of the field is about 107 million bbl.

Conclusions

1. The 3D seismic interpretation provided reasonable information only for identifying the trend seismic surfaces and the major faults in Meruap.

2. The distribution of the property in the 3D space has been done by using well log data and the understanding of the depositional environment

3. The prediction of the volcanic pyroclastic concentration in the reservoir is done by using a new property -R-deep, which has been distributed in the Meruap 3D space.

4. Specific cut-offs for PHIE, Kwr, R-deep and Sw have been designed for each zone /segment in order to generate NTG which is in agreement with the well testing data.

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Presenter's notes: The seismic resolution was not sufficient to attempt the mapping of the individual flow units or to provide depositional patterns for the image training. Reasons – difficult surface conditions (unconsolidated quaternary sands, presence of gas cups).

Thank you very much for your attention

Special thanks to Samudra Energy, Pertamina and MiGas for allowing us to use the geological/technical information for Meruap Field.