Sarawak Basin

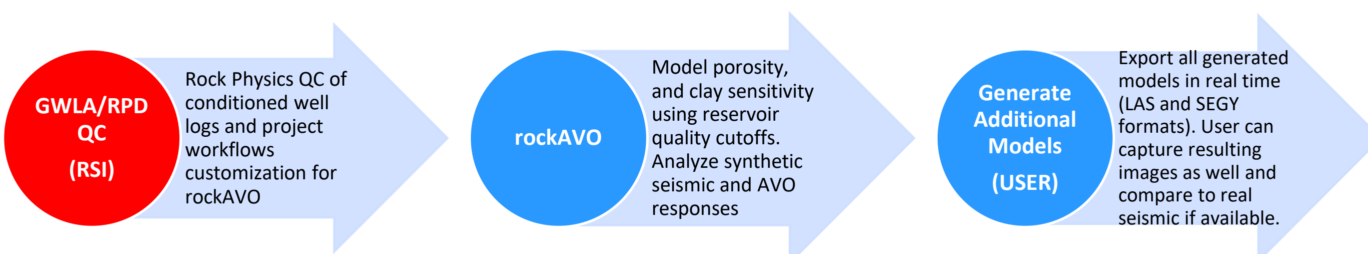
rockAVO Background Work and Deliverables

- *Geophysical Well Log Analysis* (GWLA) and *Rock Physics Diagnostics* (RPD) provided a consistent set of well log data ready for quantitative interpretation purposes.

- Rock physics Diagnostics indicated that the Intermediate Stiff, the Soft Sediment, and the Stiff Sediment models provided a good fit to the measured data trends in the bulk density versus velocity domain for the lithologies interpreted in wells of this study. The particular model used is indicated by a marker in the logplot views in this report.

- **rockAVO** provides an interactive visualization tool so that multiple hydrocarbon properties, porosity and clay content scenarios can be modelled in real time, and in addition to the existing deliverables of the conditioned well log data.

- Main workflow can be generalized in three main steps



LFP Workflow Details

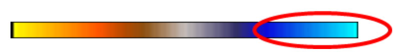
Workflow: LFP

Run | Restore Values

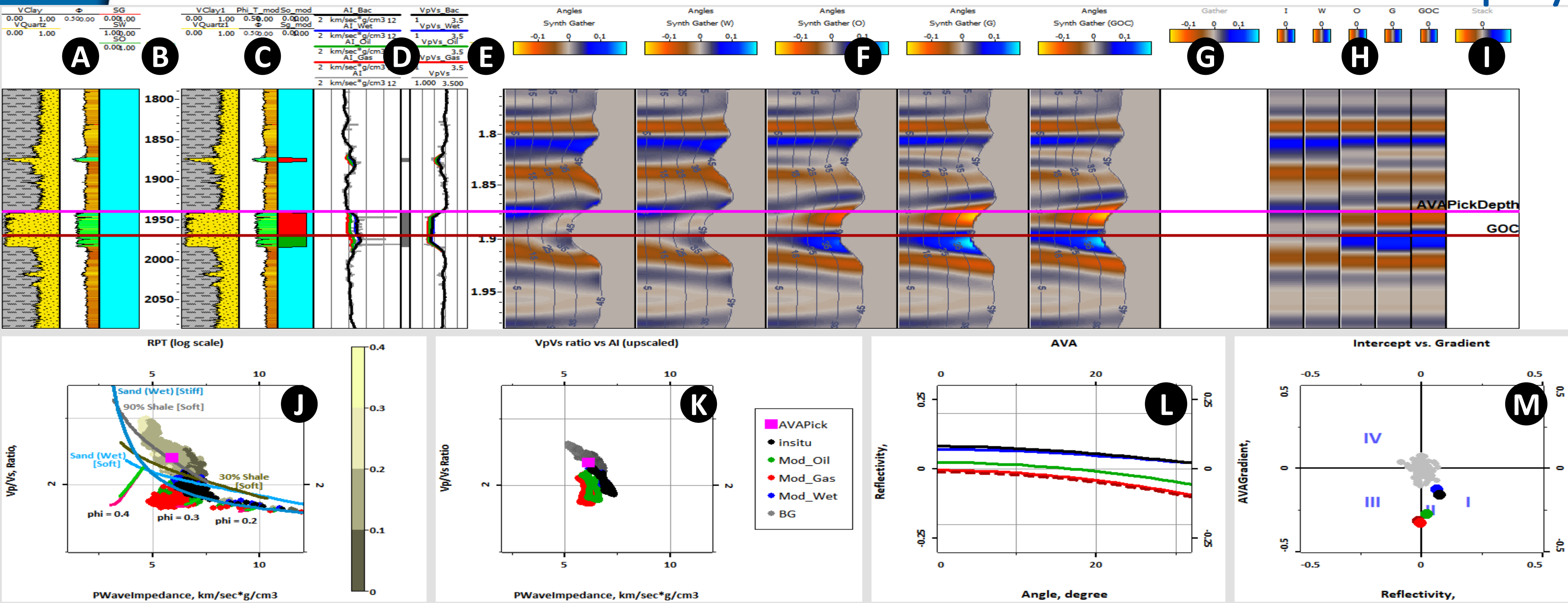
Parameter	Unit	Value	Description
ModelTop	m	2060	Defines top depth of modeling interval
ModelBase	m	3260	Defines bottom depth of modeling interval
AVAPickDepth	m	3120	Depth for extracting AVO signature from synthetics
GOC	m	3140	**Defines the Gas- Oil contact depth**
WaterSaturation		0.2	Water Saturation. Gas and Oil cases will be 1-Sw
PorosityShift		0	Controls porosity scenario*
ClayShift		0	Controls lithology (VQuartz scenario)*
WaveletType		Ricker	Controls wavelet type
SeismicFrequency	Hz	25	Dominant seismic frequency
ClayCutOff		0.45	Reservoir quality clay cutoff for **fluid sub marker**
PorosityCutOff		0.04	Reservoir quality porosity cutoff for fluid sub marker
GasGravity		0.8	Gas gravity parameter
OilGravity		41.5	Oil gravity parameter
GasOilRatio	L/L	29	GOR parameter
CalciteCutOff		0.5	**Reservoir quality calcite cutoff for fluid sub marker**
OffsetIncrement	m	100	**Seismic geometry parameter (offset increment)**
NTraces		40	**Seismic geometry parameter (number of traces)**
AmpMuteAngle	degree	37	**Amplitude mute for synthetic modeling**
BackgroundShale		0.3	**Clay cutoff to define background data in crossplots**

***All parameter default values are the RSI-recommended inputs for a base case where only fluid content changes (clay and porosity remain as *in situ*)**

Modelling Description and Parameterization

- Perturbational models are defined based on the clay volume and porosity cut-offs. The suggested values for the clay volume and porosity cut-offs vary by well but are generally 40% and 10%, respectively.
- In these wells quartz is used to balance the clay modelling, when clay is increased the quartz is decreased by an equal amount.
- Full Offset Synthetics created using Ray Tracing method.
- Synthetics generated for all fluid models on upscaled elastic curves Backus smoothed on variable window size based on velocities and Dominant Frequency.
- No multiples or mode conversions are included.
- Seismograms are generated using a Ricker wavelet with a dominant frequency that can vary as per user selection.
- Synthetic and AVA parameters included in the workflows that can be modified are:
  - Offset range: by modifying number of traces and offset increment
  - Amplitude Mute
- Increase in impedance is a peak (blue) 

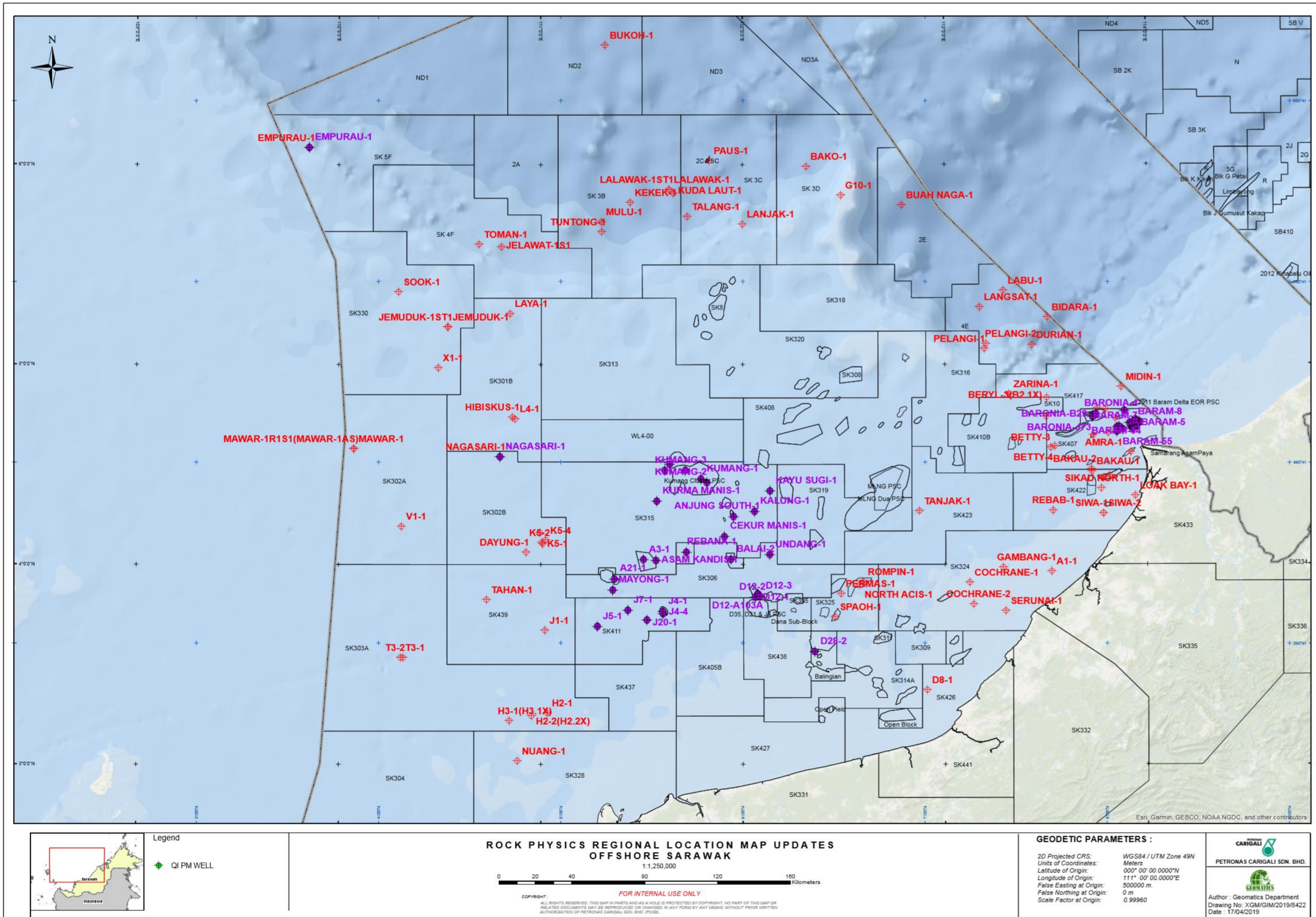
rockAVO Montage View* (LFP version) Main Display



A. In situ Scenarios: Mineralogy track (VClay, VQuartz, VCalcite); Total Porosity (left, 0.5 to 0 fract); and Saturations (right, 0 to 1 fract: green for oil, red for gas, and cyan for water)
B. Measured Depth (m)
C. Modelled Mineralogy track (e.g. VClay at the expense of VQuartz), Total Porosity (left, 0.5 to 0 fract) and Saturations based on marker (right, 0 to 1 fract: green for oil, red for gas, and cyan for water)
D. Upscaled p-wave impedance (left, in this case 0 to 15 km/s*g/cc) and Vp/Vs ratio (right, 1 to 3.5 ratio)
E. Computed two-way time (secs)
F. Synthetic gather seismograms based on modelling parameters (in situ Sw, 100% wet, oil, gas, and gas-oil contact cases)
G. Optional track for importing seismic gather data
H. Synthetic stack seismograms based on modelling parameters (in situ Sw, 100% wet, oil, gas, and gas-oil contact cases)
I. Optional track for importing seismic stack data
J. Well log scale P-Impedance vs Vp/Vs ratio crossplot (magenta dot indicates the values for the selected AVA Pick depth). RPT is overlaid to the data for comparison
K. Upscaled P-Impedance vs Vp/Vs ratio crossplot
L. Angle versus reflectivity plot for the depth selected in the AVA Pick depth input
M. Intercept versus gradient plot for the depth selected in the AVA Pick depth input

* - view has been stretched to fill screen

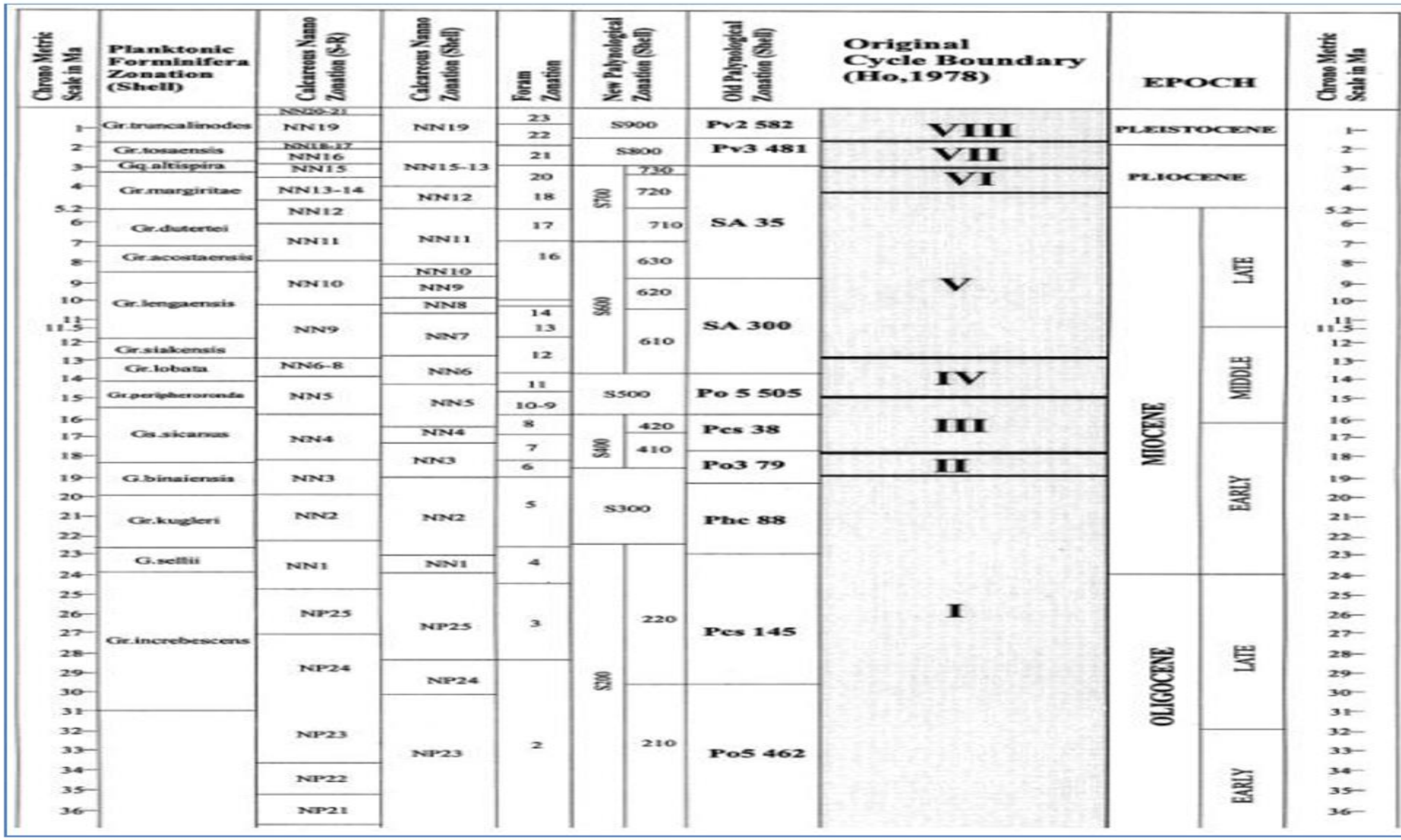
Overview Location Map



Wells List

ASAM-KANDIS-1	J1-1-Clastics	NUANG-1
BAKO-1	J5-1-Carbonates	NW-BAYAN-1
BARIO-WEST-1	J5-1-Clastics	PAUS-1
BARONIA-19	JELAWAT-1-ST1	PAUS-NORTH-1
BARONIA-20	JEMUDUK-1-ST1	PELANGI-1
BETTY-3	K5-2R1	PERMAS-1
BETTY-4	K5-3	REBAB-1
BETTY-TIMUR-1	K5-4	REBANA-1
BIDARA-1	KUDALAUT-1	ROMPIN-1
BUAH-NAGA-1	LABU-1	SERUNAI-1
BUKOH-1	LALAWAK-1	Sikau-North-1
D8-1	LALAWAK-1ST1	SIWA-101
DAYUNG-1	LANGSAT-1	SOOK-1S1
EMPURAU-1	LANJAK-1	SPAOH-1
G10-1-M1M2-O2M1	LAYA-1	T3-2
G10-1-M2M3-M2	MAWAR-1R1S1	TAHAN-1
GAMBANG-1	MAYONG-1	TALANG-1
H2-2	MIDIN-1	TANJAK-1
HIBISKUS-1	MULU-1	TANJUNG-BARAM-1
J1-1-Carbonates	NORTH-ACIS-1	TUKAU-TIMUR-WEST-1

Regional Stratigraphic Chart



A general stratigraphic column of the Sarawak basin is shown above. The cycles as defined by Ho in 1978 are used for zonation models in this study. Cycle depths are read from the well reports included in the available data. Carbonate reservoirs are penetrated in wells in blocks SK303A and SK302B and occur in cycles III and IV. Most of the clastic reservoirs occur in cycles IV and younger

X1-1 final geological report

Single Well Report

Asam Kandis-1

Asam Kandis-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Petrophysical interpretation and edited elastic curves are provided by Petronas. The final RSI curves are from the following provided curves (RSI curves in bold): VClay = VCLD_QI/(1-PHIT_QI); SW = SWT_QI; DTC(S)_ORG = DTC(S)_QI; RHOB_ORG = DENB_ED. In general, data quality appears strong. Density, compressional and shear velocities are available from 400m-1637m. Additionally the Petronas QI Rock Physics Model curves are also provided, though RSI performed individual model calibration and curve generation for rockAVO purposes.

Clay volume (VClay):

- VCLD_QI is provided by Petronas, though RSI models require VClay as a fraction of the rock matrix rather than the bulk rock therefore final VClay = VCLD_QI/(1-PHIT_QI).

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Cycle IV and V sandstones interbedded with claystones.

Volume of hydrocarbons:

- Some low gas saturations are present throughout the well, the strongest accumulation is at the 750m Cycle V sandstone with gas up to 55%.

Water saturation (Sw):

- SWT_QI has been provided by Petronas and final RSI Sw is mostly equal to SWT_QI. However, there are some very low gas saturations, <5%, in clay rich zones where Sw has been set to 0. The primary reason for this is for the impact the gas has on the rock physics models, leading to very low Vp and Vp/Vs compared to measured data.

Asam Kandis-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both sand rich and clay rich intervals when compared to the measured data and also when compared to good measured data in the nearby reference wells. The Petronas QI group RPM curves have been provided as well in order to help guide calibration.

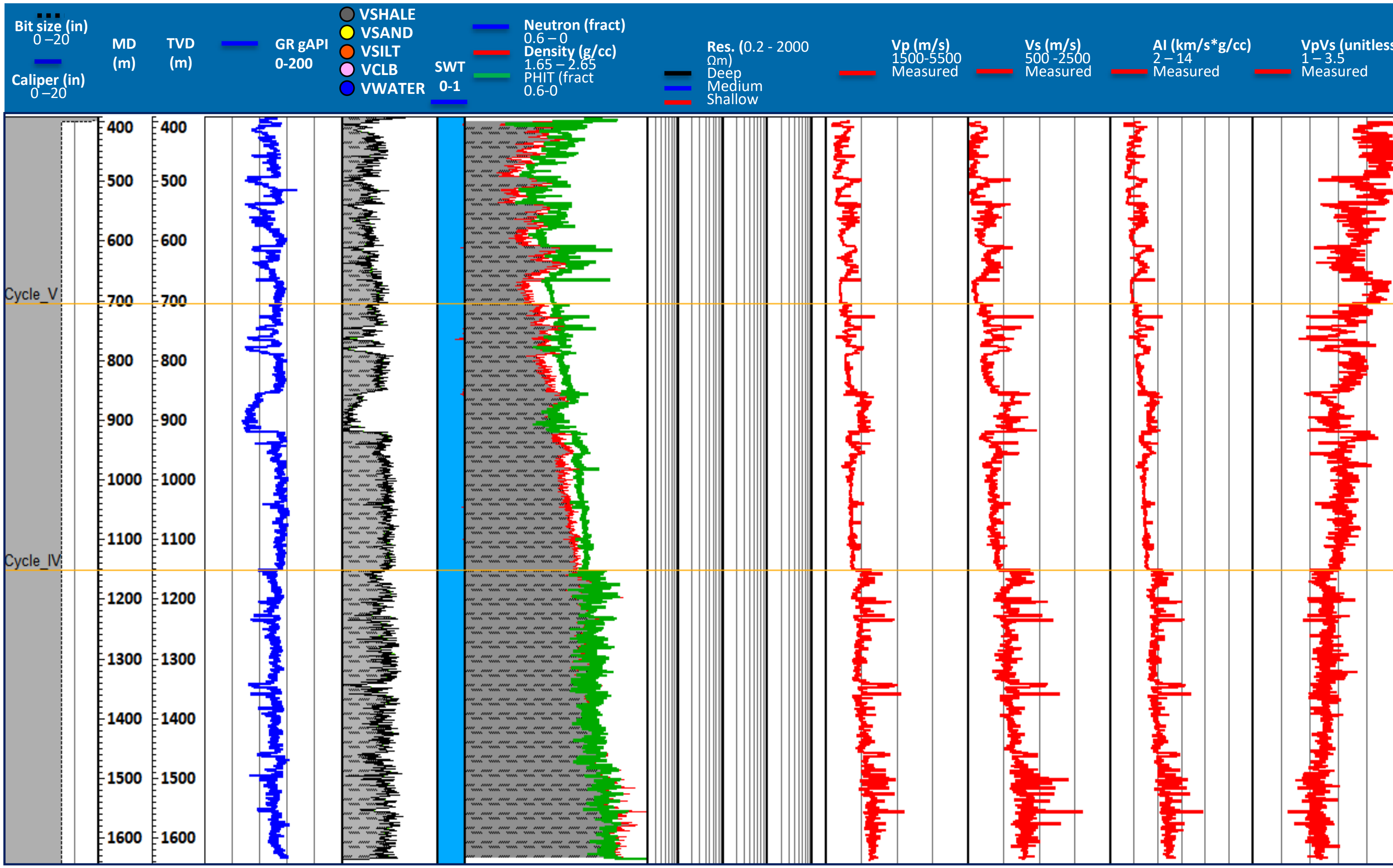
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 20000 ppm [Regional]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Cycle IV and V reservoir sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination with the brine sands.
- At in situ conditions the Cycle V reservoirs show a weak Class II response with good fluid discrimination, increasing porosity generates a weak Class III AVAO response with better fluid discrimination. The Cycle IV sand at 1340m shows no AVO response in the hydrocarbon case, though the wet case is a Class I, when increasing porosity the hydrocarbons show Class III and wet shows no response.

Asam Kandis-1 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

Asam Kandis-1 Geophysical Well Log Analysis (GWLA) – Full Well

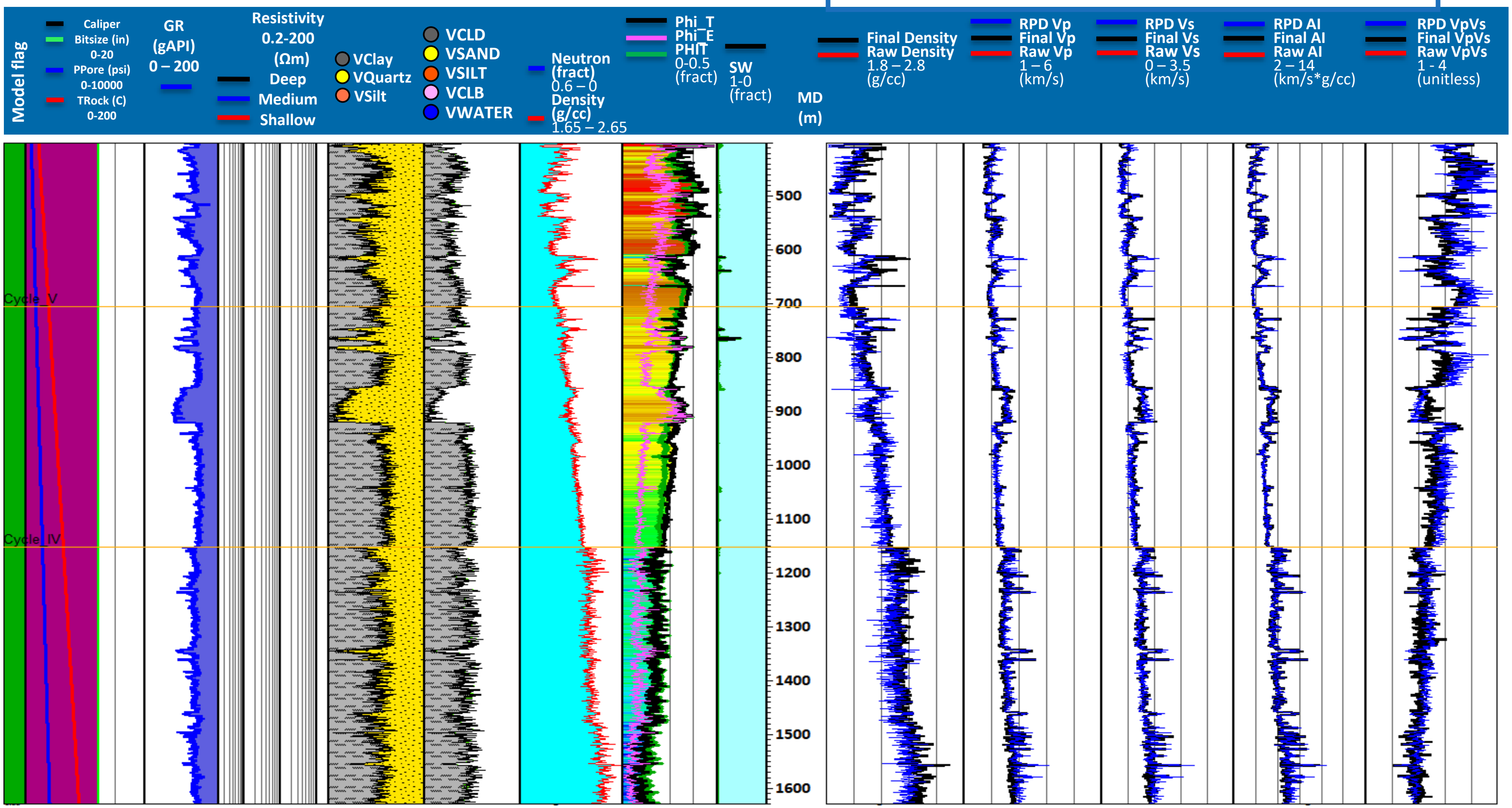
model type flag

Unconsolidated rock model

Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

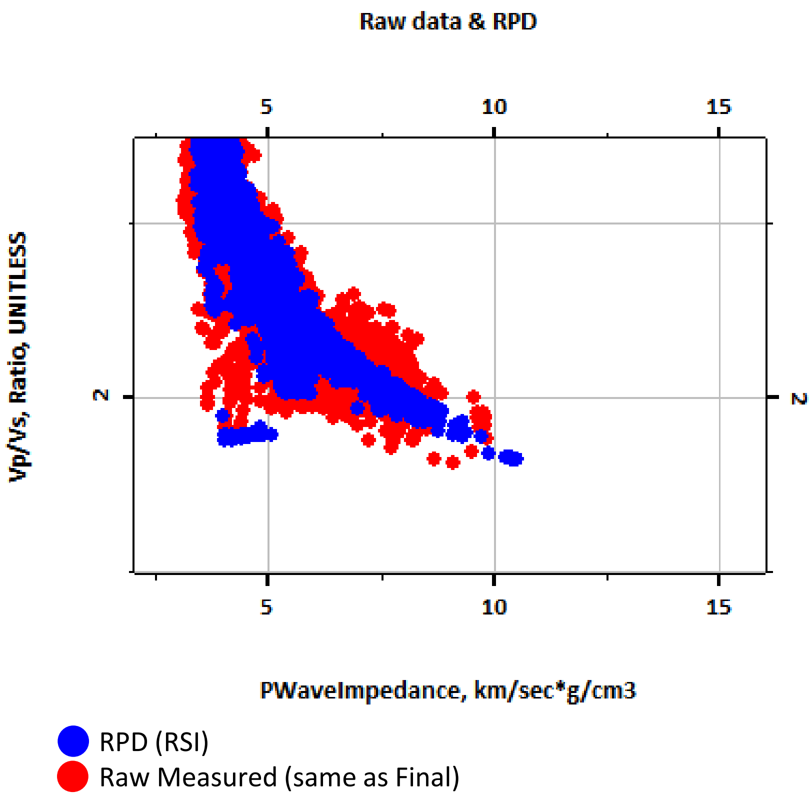
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

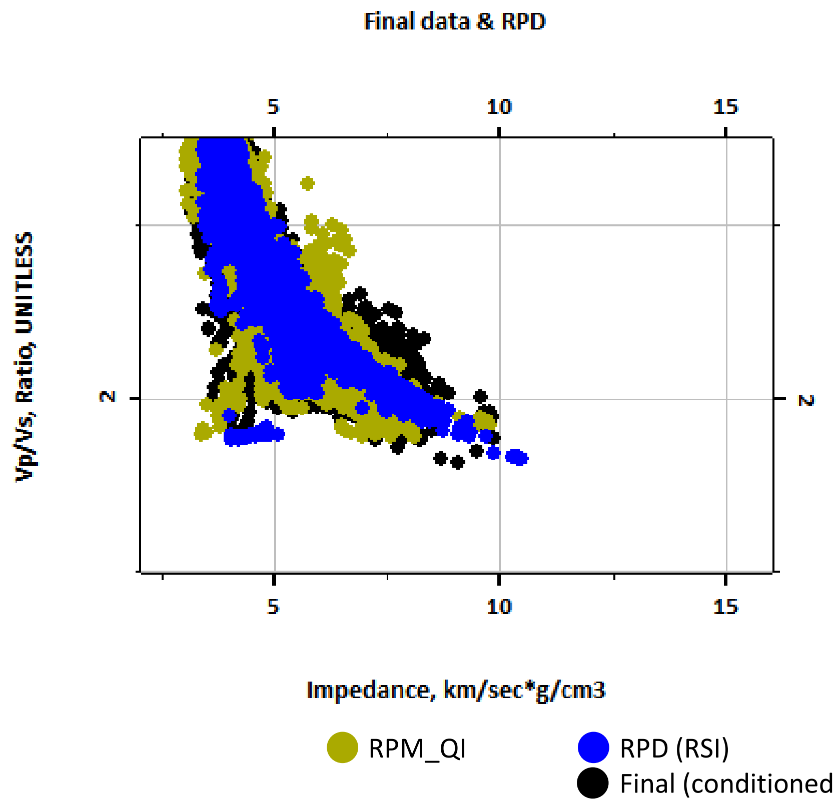


Asam Kandis-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the "measured" data (same as final data – could have edits).

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

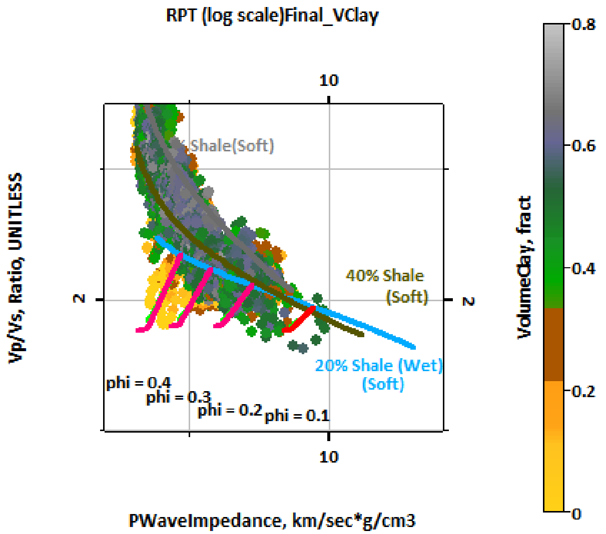


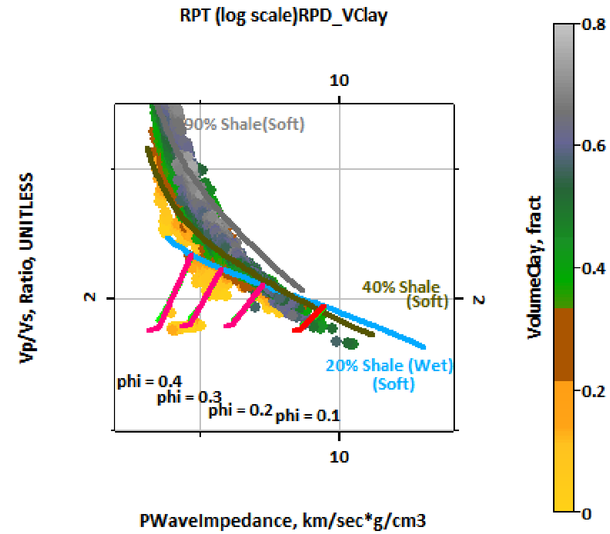


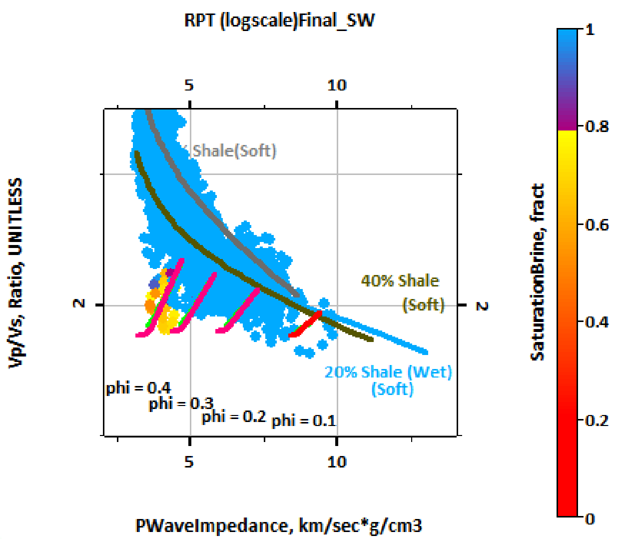
Asam Kandis-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

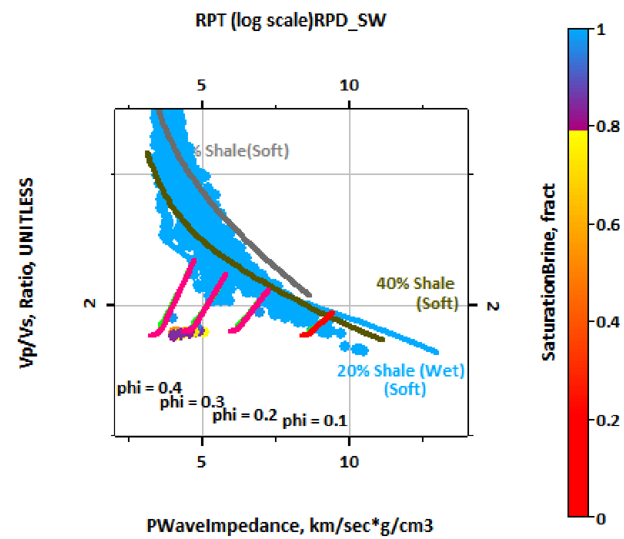
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Bako-1

Bako-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, available data quality is good. Most of the well logs were acquired in the 1907-3871 m interval.
- Density measurements are of good quality in most of the wellbore and little edits were performed. Density values were estimated close to the TD of the well (3861-3870 m) using rock physics models.
- In general, compressional velocity log is of good quality. Various edits were performed in the 2470-2655 m section. Based on the density log behaviour it seems this section is highly laminated and the sonic log is not entirely capable of capturing this heterogeneity; some small intervals of poor borehole quality are also present in this section. Other minor edits were performed based on local deviations off the Vp trend observed in the measured log.
- Vs was not available and hence, it was fully predicted in the well. The closest well to Bako-1 with a Vs log available was Talang-1. Although Talang-1 seems to be characterized by "slower" sands and shales compared to the section present in Bako, it was used along with the farther Pelangi well as references for the Vs prediction in this well.
- Other logs include, Neutron, Caliper, and Deep Resistivity.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method, but the density/neutron approach assisted the interpretation at certain sections.

Reservoir characteristics:

- The primary objective reservoirs of this well were the Late Oligocene to Early Miocene siliciclastics in the interval below the regional Mid-Miocene Unconformity, from 2900-4270 m subsea.
- Sands in N13_N14 down to N8 are fining upwards sequences. Sands are siltier in the former and tighter in the latter. As we enter the N6 interval, sand and claystone sequences start to be accompanied by layers of coals and limestone stringers. These sand beds can be as thick as 25 m and their reservoir characteristics, particularly their porosities become poorer below 3250 m where it decreases from 22% to 14% in average. The reported presence of organic matter and source rock shows in claystones within the 3002 m-TD section, might explain the softer response of several claystones in the elastic space.

Volume of hydrocarbons:

- The well has been interpreted as wet.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were estimated via Pickett Plot: Rw=0.05 Ohmm @ 161F (60,000 ppm), with a=1, m=2, and n=2.

Bako-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in the siliciclastic facies. However, below 2600 m (MD) and based on the elastic behavior of sands, an Intermediate Stiff Sediment Model with a variable Coordination Number with depth was more suitable. These models models have been used to edit the Vp and Rhob data in the siliciclastic facies where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock Physics Modelling (RPM) stage of the project. Vs data was entirely modelled in this well as no measured Vs data was acquired.

Fluid properties:

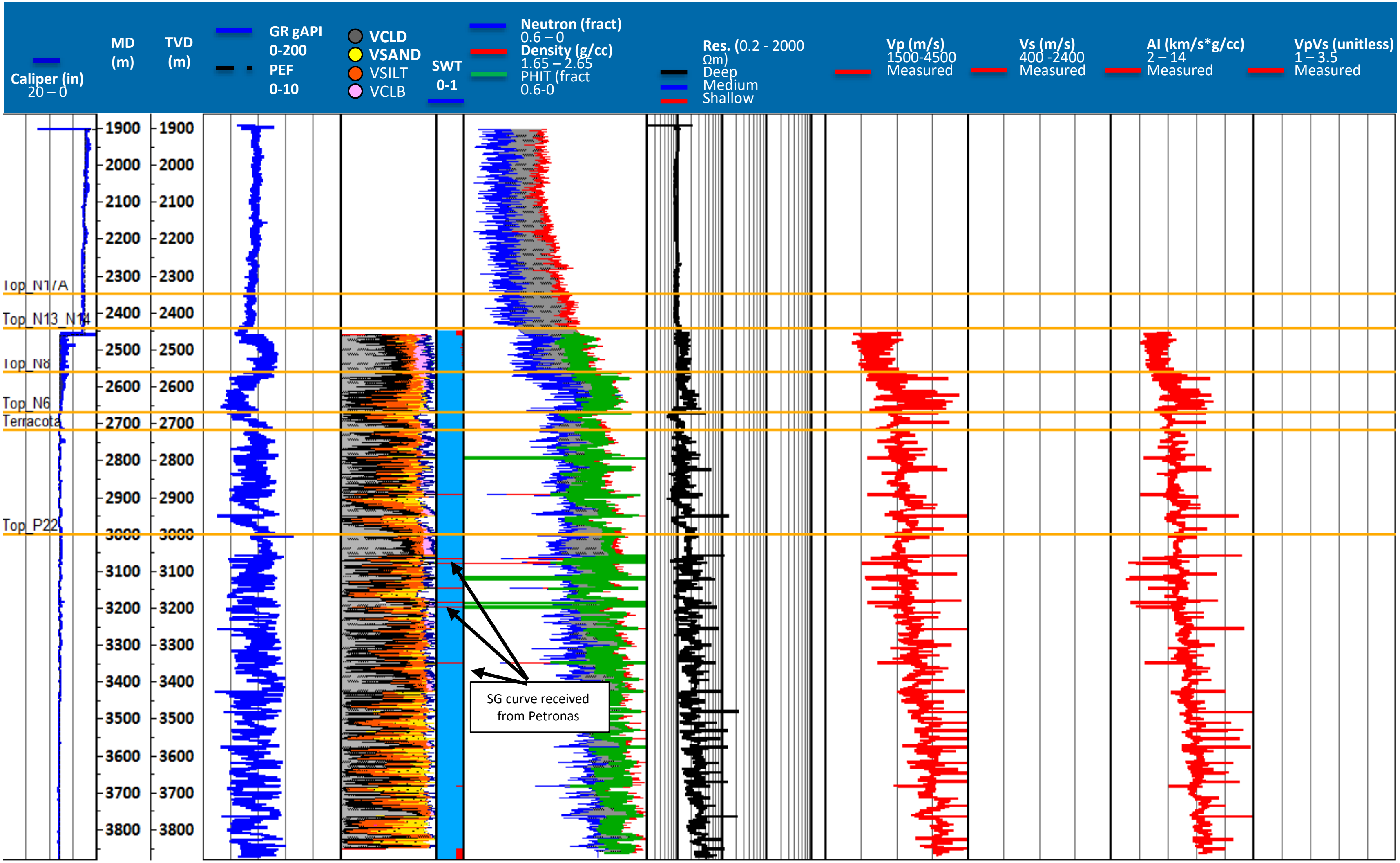
Hydrocarbon properties used in substitution have been obtained from PVT analysis performed on samples of the Spaoh-1 well:

- Brine salinity: 60,000 ppm
- Gas gravity: 0.68
- Oil Gravity: 52 API
- Gas / Oil ratio: 192 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the sands encountered in Late Oligocene to Early Miocene siliciclastics sections, encompassing the N13_N14, N8, N6, Terracota and P22 markers.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – Bako-1



Additional data includes mud weight data and well reports. Gas saturation was previously interpreted by Petronas in intervals were coal is present.

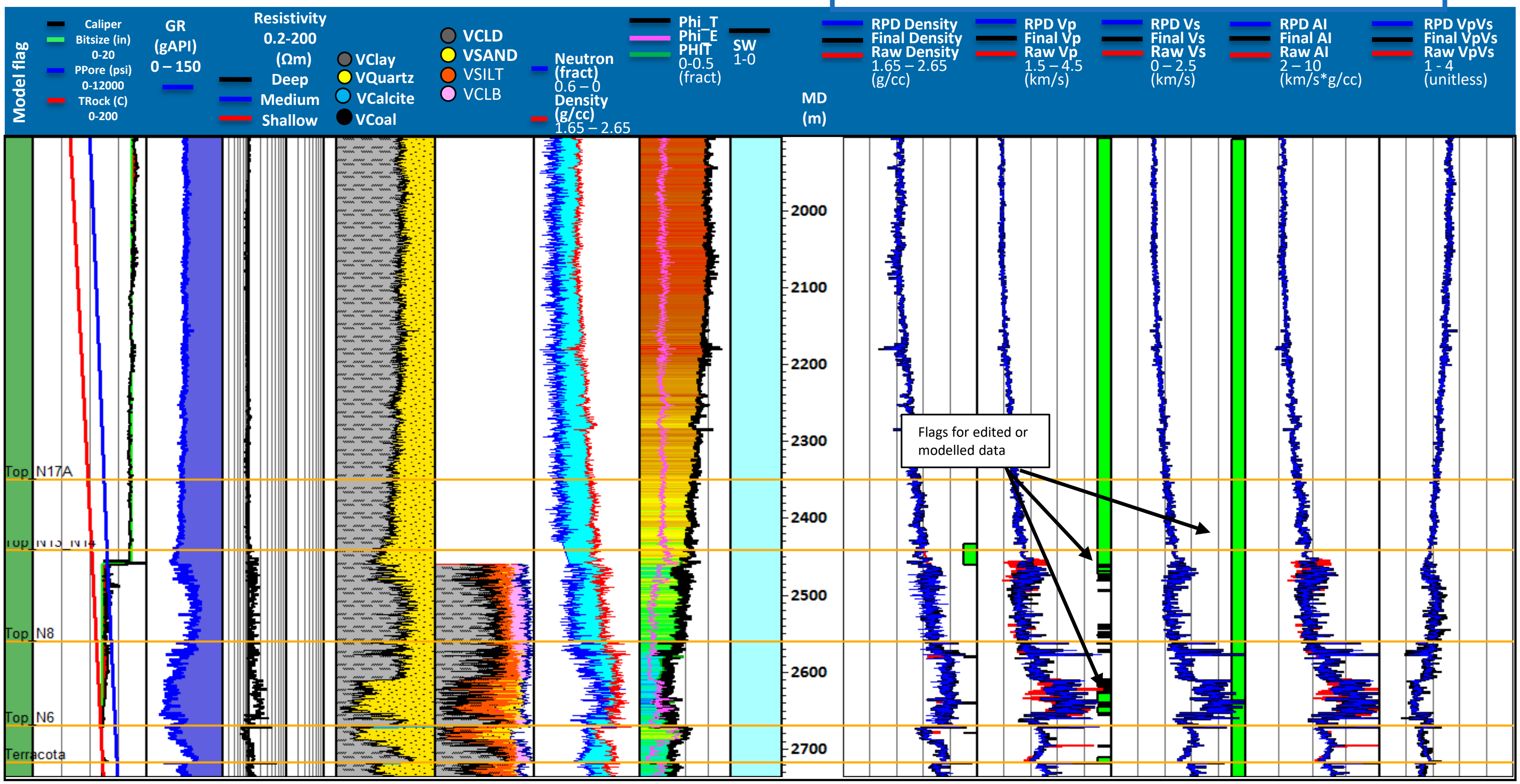
Bako-1 Geophysical Well Log Analysis (GWLA) – Interval from Top of logs to 2700 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Vp was not acquired in the in the 1900-2460 m, and has been estimated using the density log and rock physics modelling. In the 2470-2654 m section, the rock appeared to be highly laminated: the density log seems to capture this heterogeneity but the sonic log appears to be not in gauge. Therefore, Vp was edited in some sections. Vas was not logged in the well and it was entirely modelled.

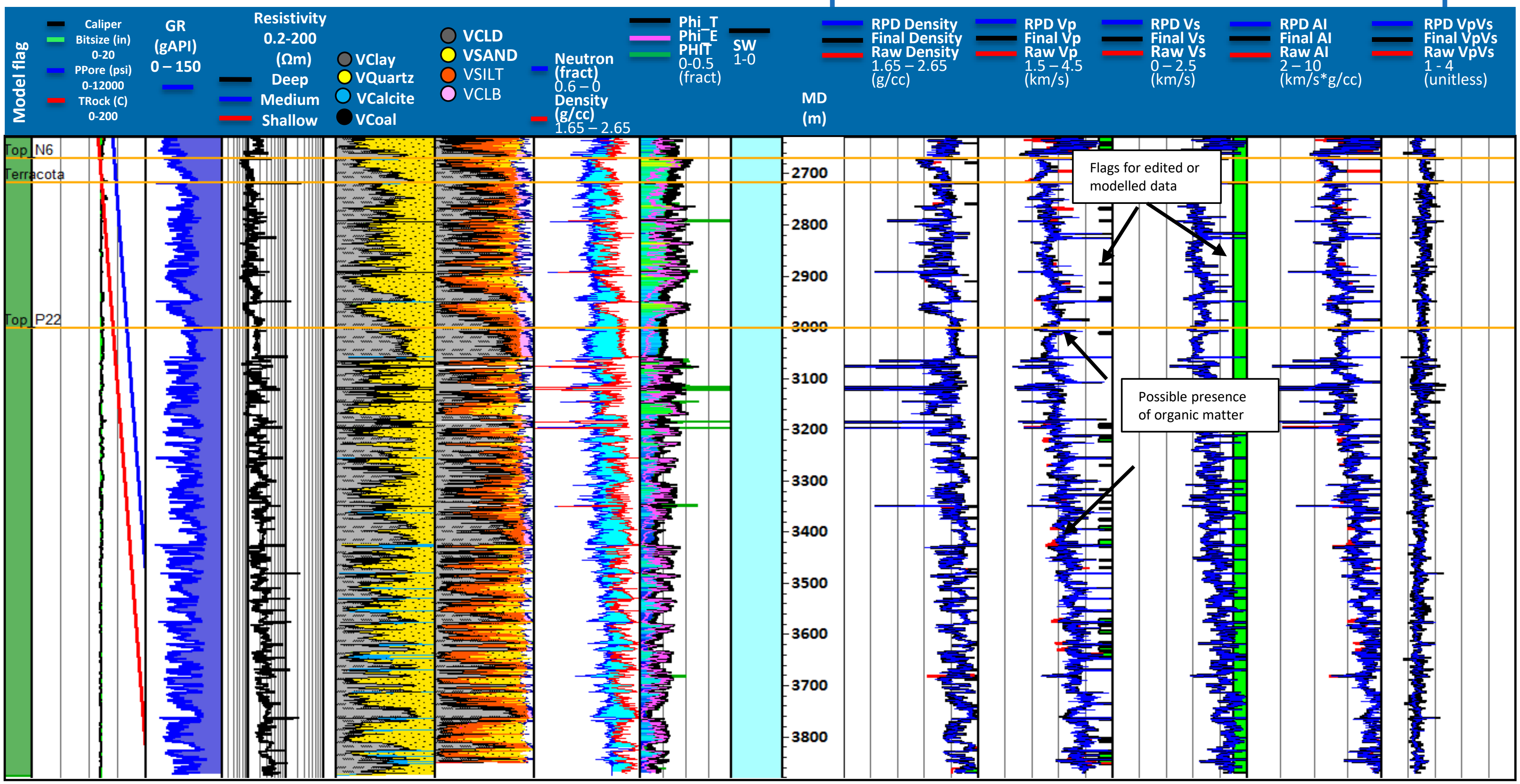
Bako-1 Geophysical Well Log Analysis (GWLA) – Interval from 2700 m to end of logs

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

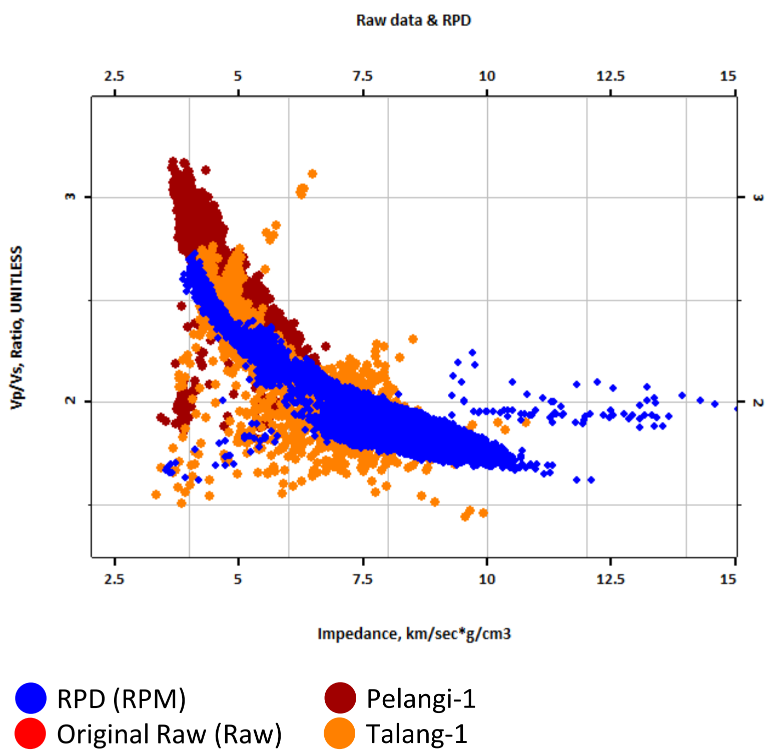


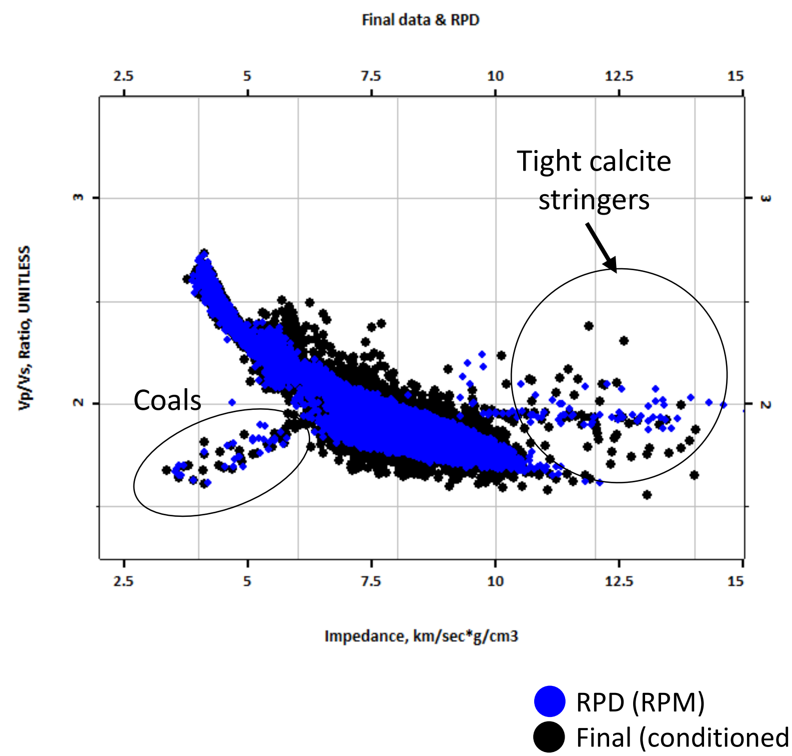
Granular media model (soft sand with variable Coordination Number) was used for all elastic curves prediction (Rhob, Vp and Vs). Elastic logs are of good quality in this section and there is a good correlation between the modelled elastic logs and the measured data, particularly in the siliciclastic facies. Coaly sections were not modelled and the RPM Modelled curve was kept the same as the original raw curve in these sections.

Bako-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the analog wells with similar trends in the elastic data, given the measured shear in Bako-1 is not available

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

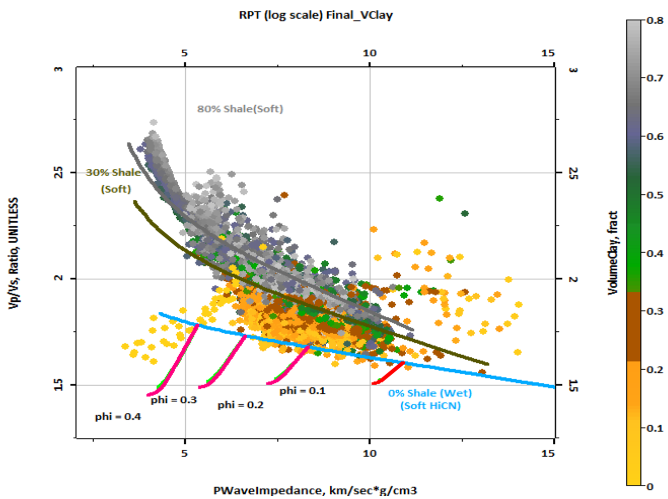


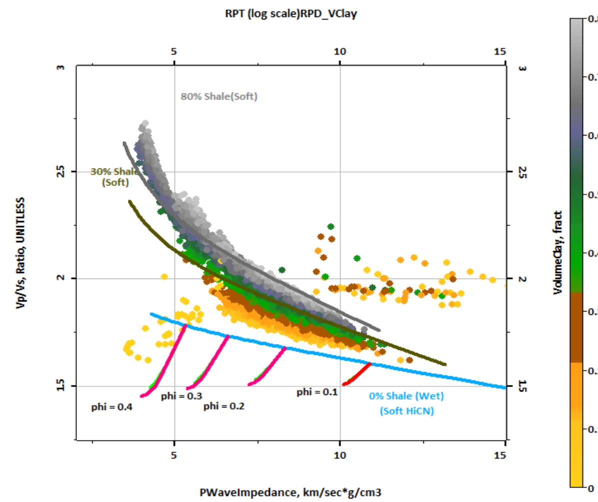


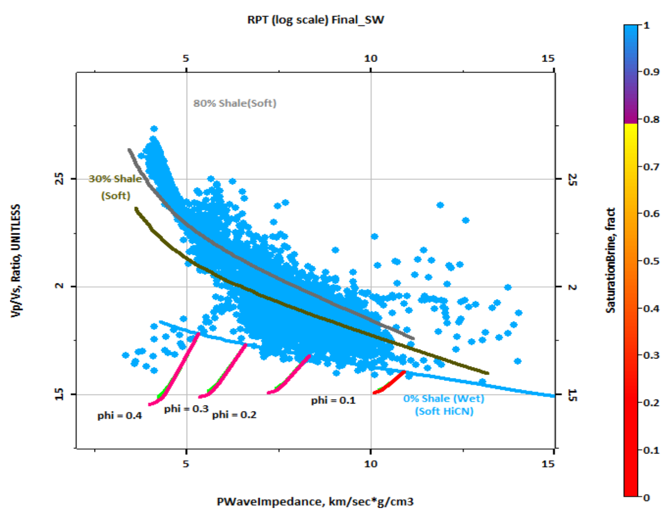
Bako-1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

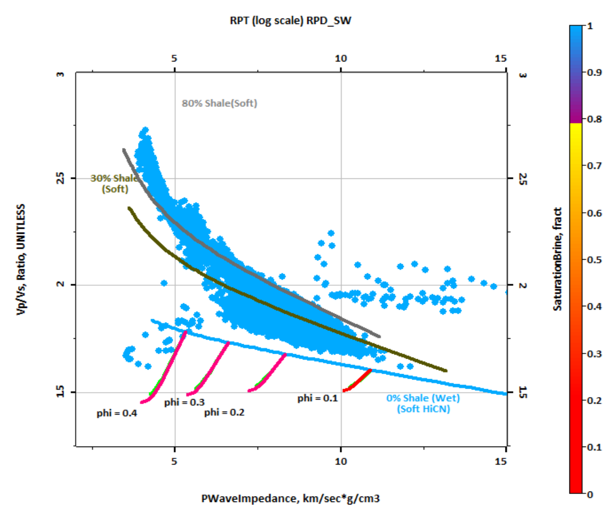
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Bario West-1

Bario West-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair.. Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Vs was heavily edited in the shallower section of the measurement(1018m-1991m).
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with come clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the clean wet sand section(3045-33050m) yielded a formation water salinity of 13000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=1.8 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2000m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- This well behaves very similar to the elastic trend in the southern area of Sabah basin(Samarang wells) where same model was applied.

Fluid properties:

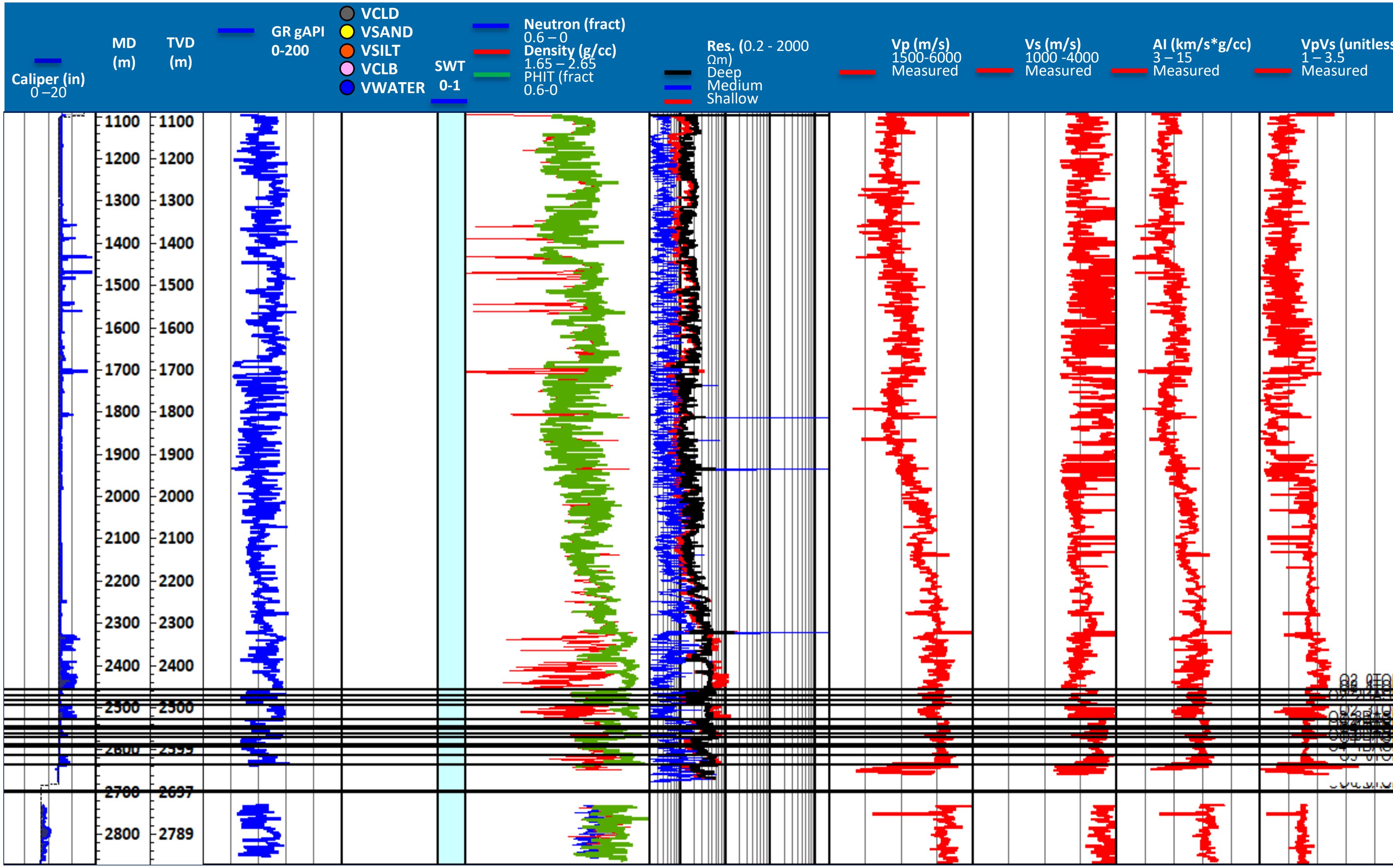
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

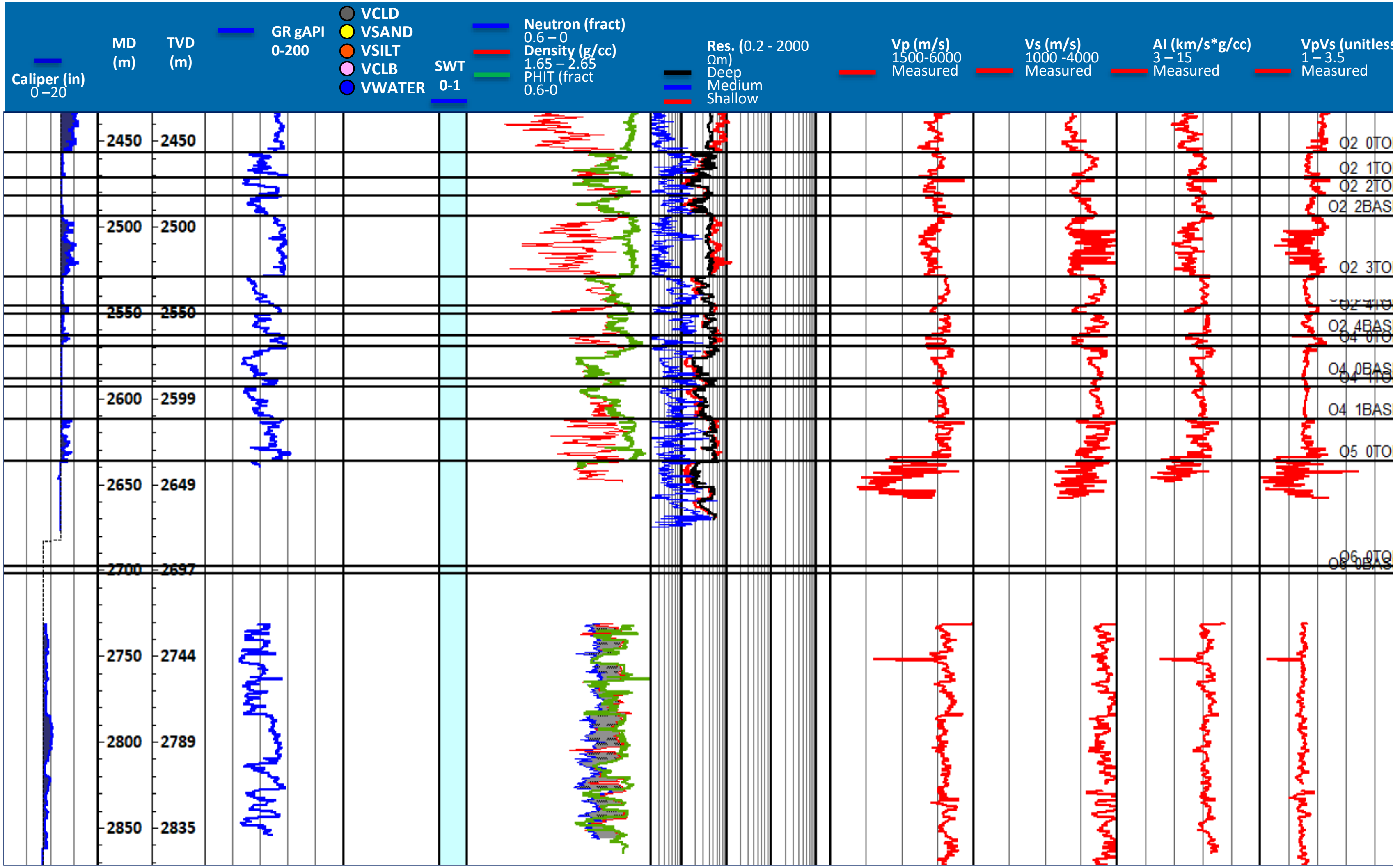
- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- AVA class IV was observed near the H800 gas sands @ 3500m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no noticeable change for the AVO class was observed.

Bario West-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Bario West-1 Input Logs (~2450-2850M)



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

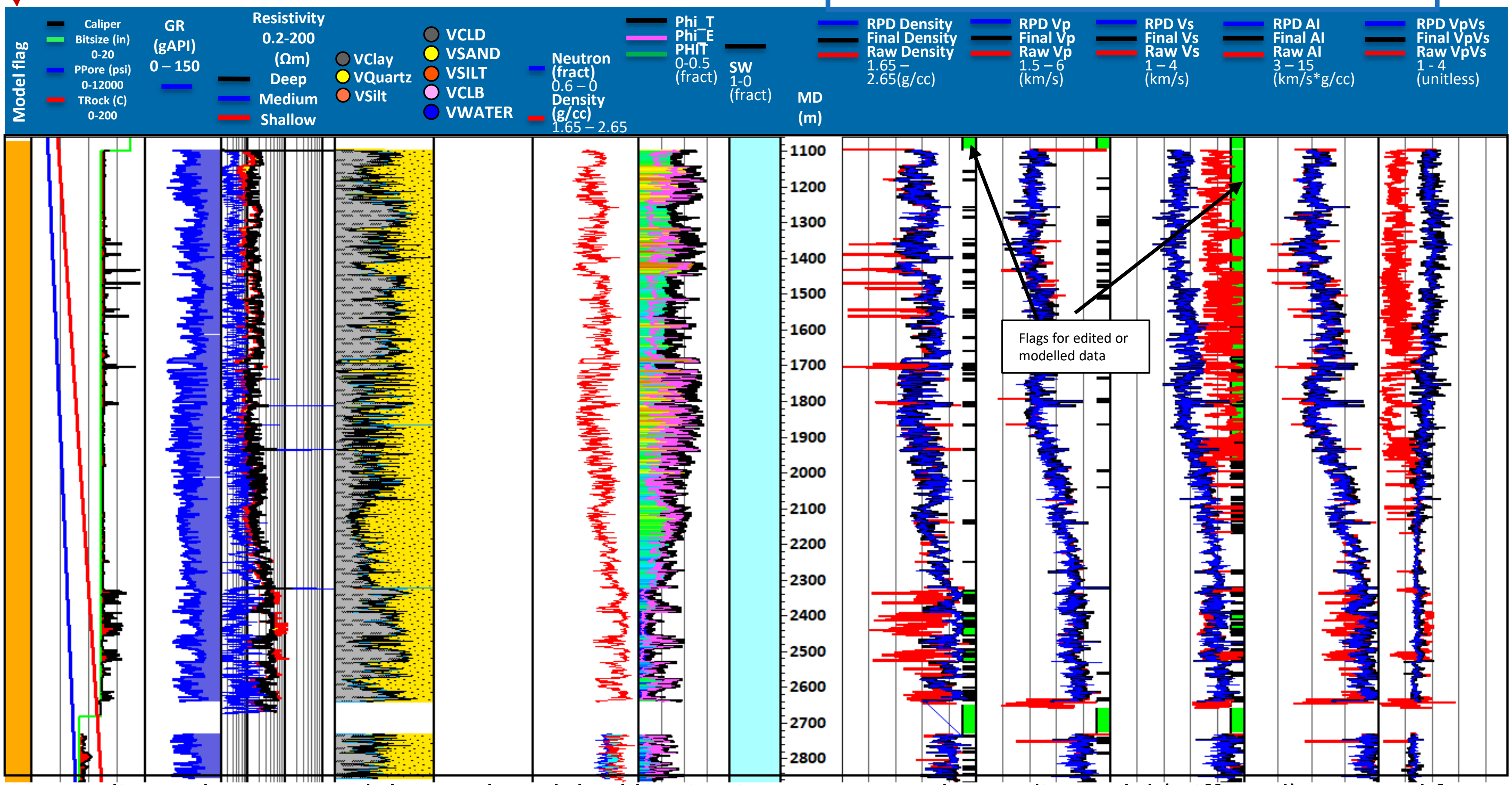
Bario West-1 Geophysical Well Log Analysis (GWLA) Top of elastic logs to 3000m(MD)

model type flag

- Soft rock model
- Stiff rock model

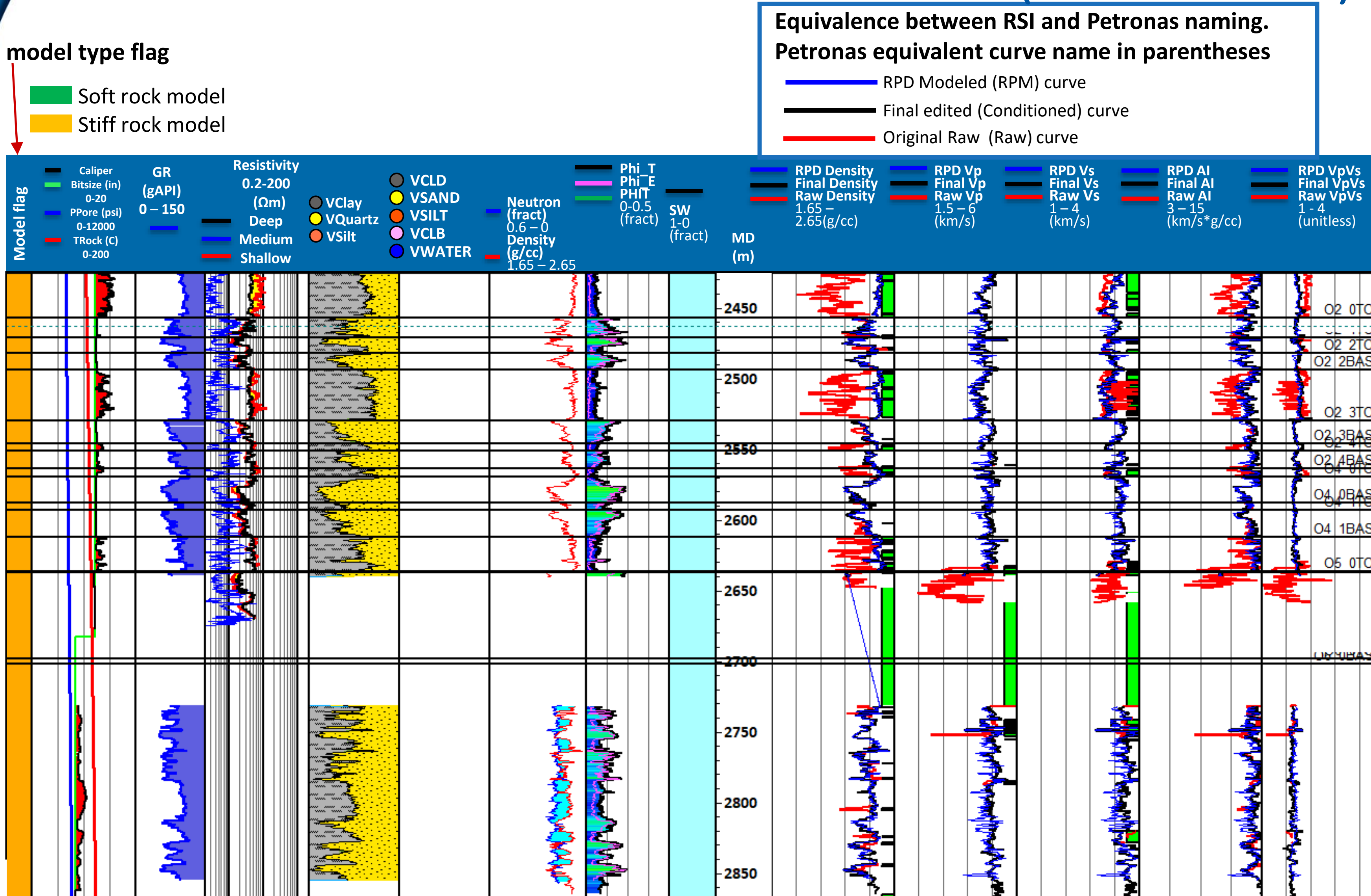
Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Bario West-1 Geophysical Well Log Analysis (GWLA) (~2450-2850M)

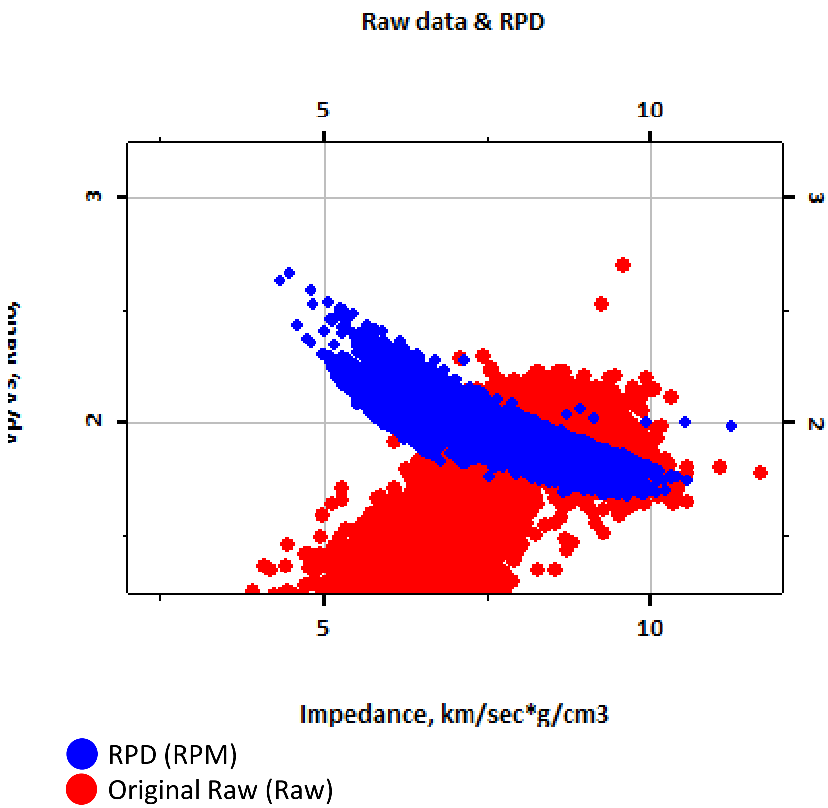


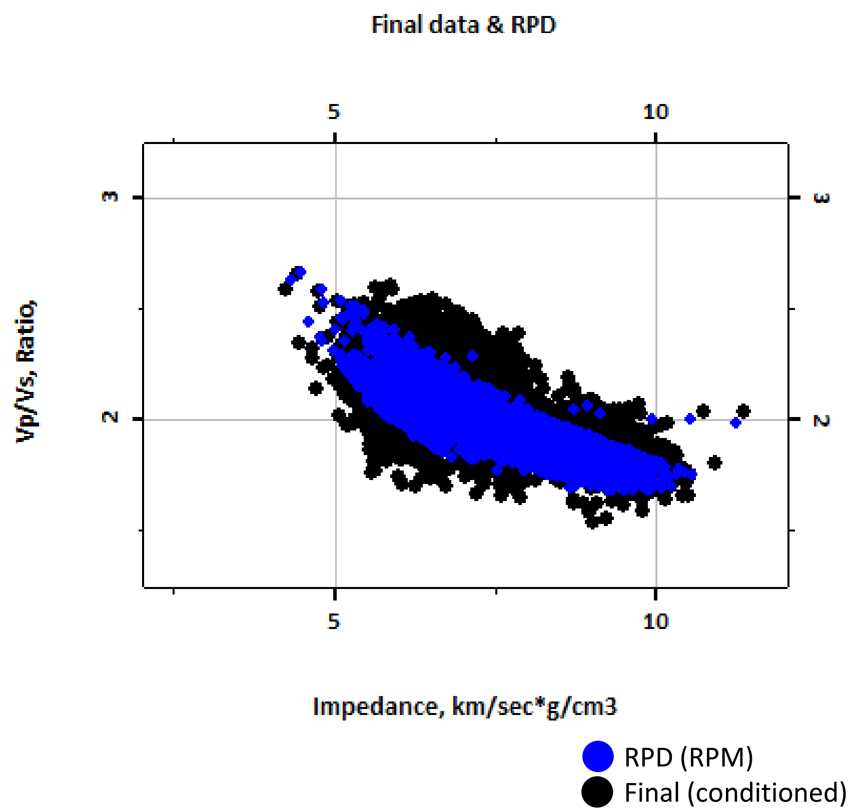
all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Bario West-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

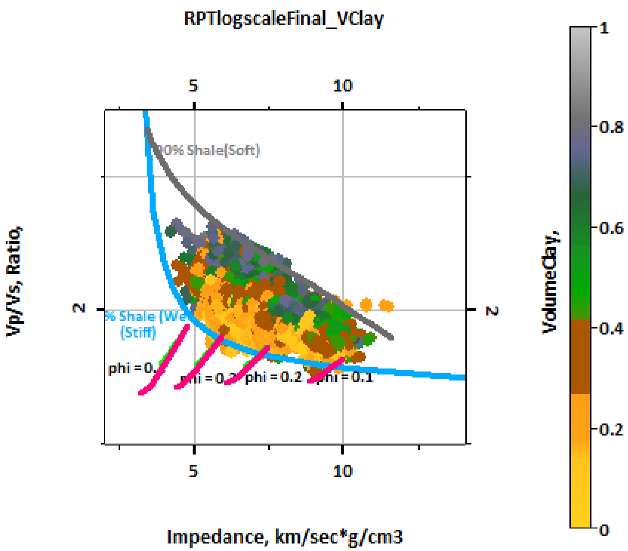


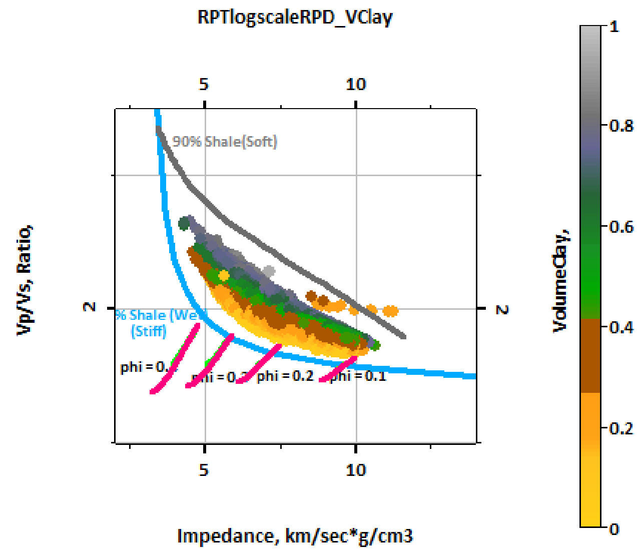


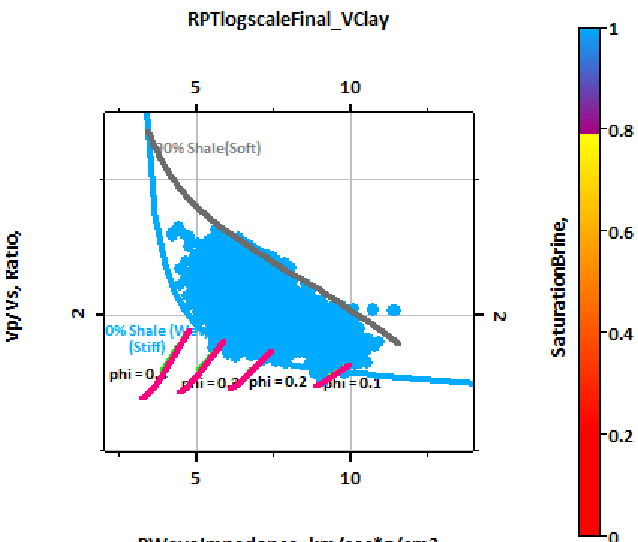
Bario West-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

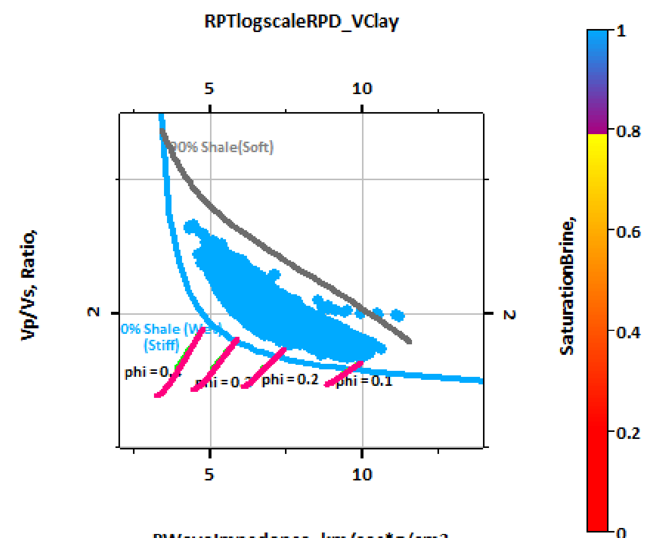
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Baronian_19

Baronian_19 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Invasion correction was applied for the density log in the gas saturated sands and the results were aligned with the porosity provided by Petronas for reference.
- Vs was heavily edited in the shallower section of the measurement(2000m-2150m).
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with some clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well from top to about 3100m(MD) were 100% brine saturated while most of the sands penetrated below that depth were gas saturated with saturation reached to 80% in many intervals especially H790, H800 and H830.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the clean wet sand section(3045-3050m) yielded a formation water salinity of 13000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=1.8 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2000m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

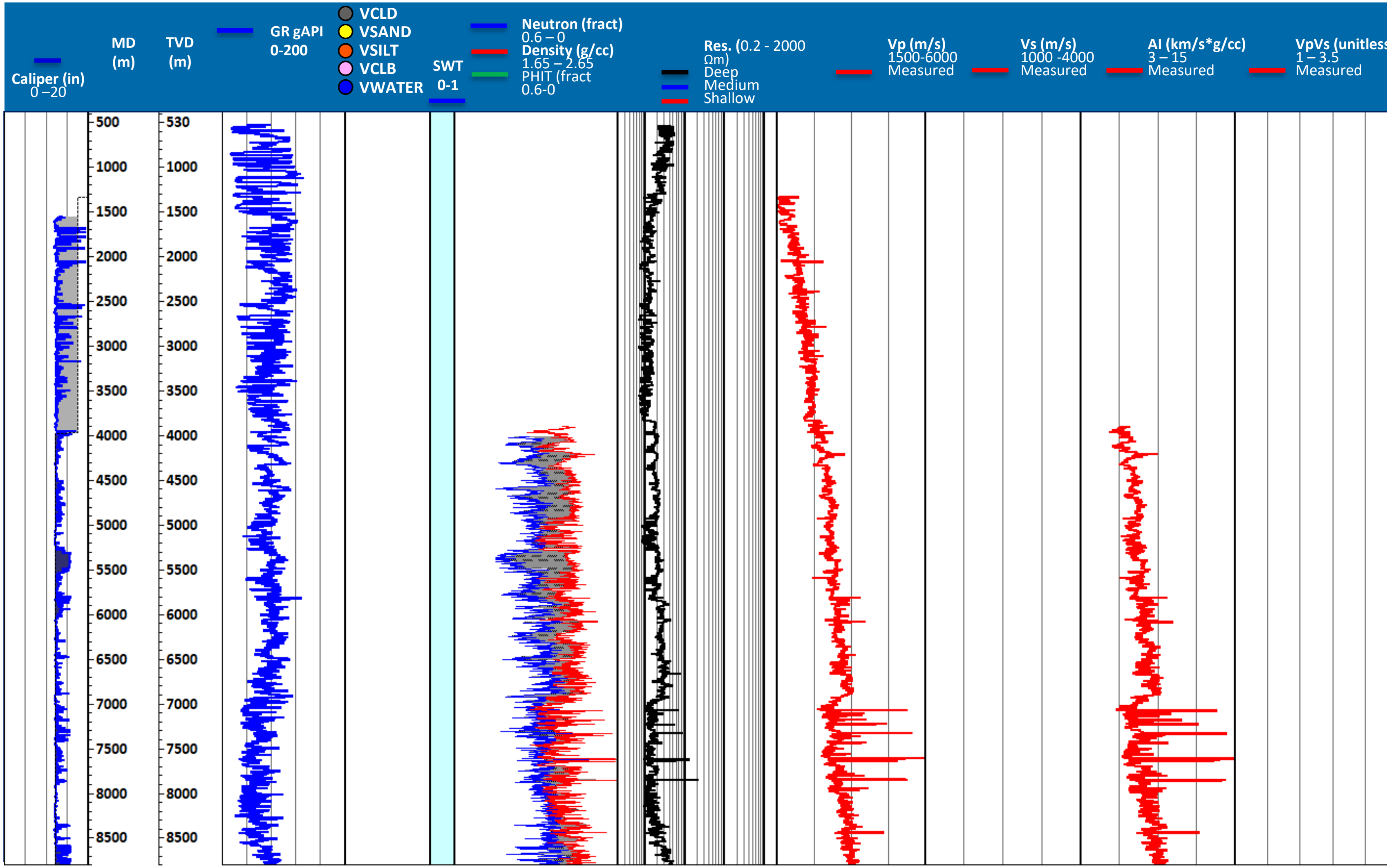
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

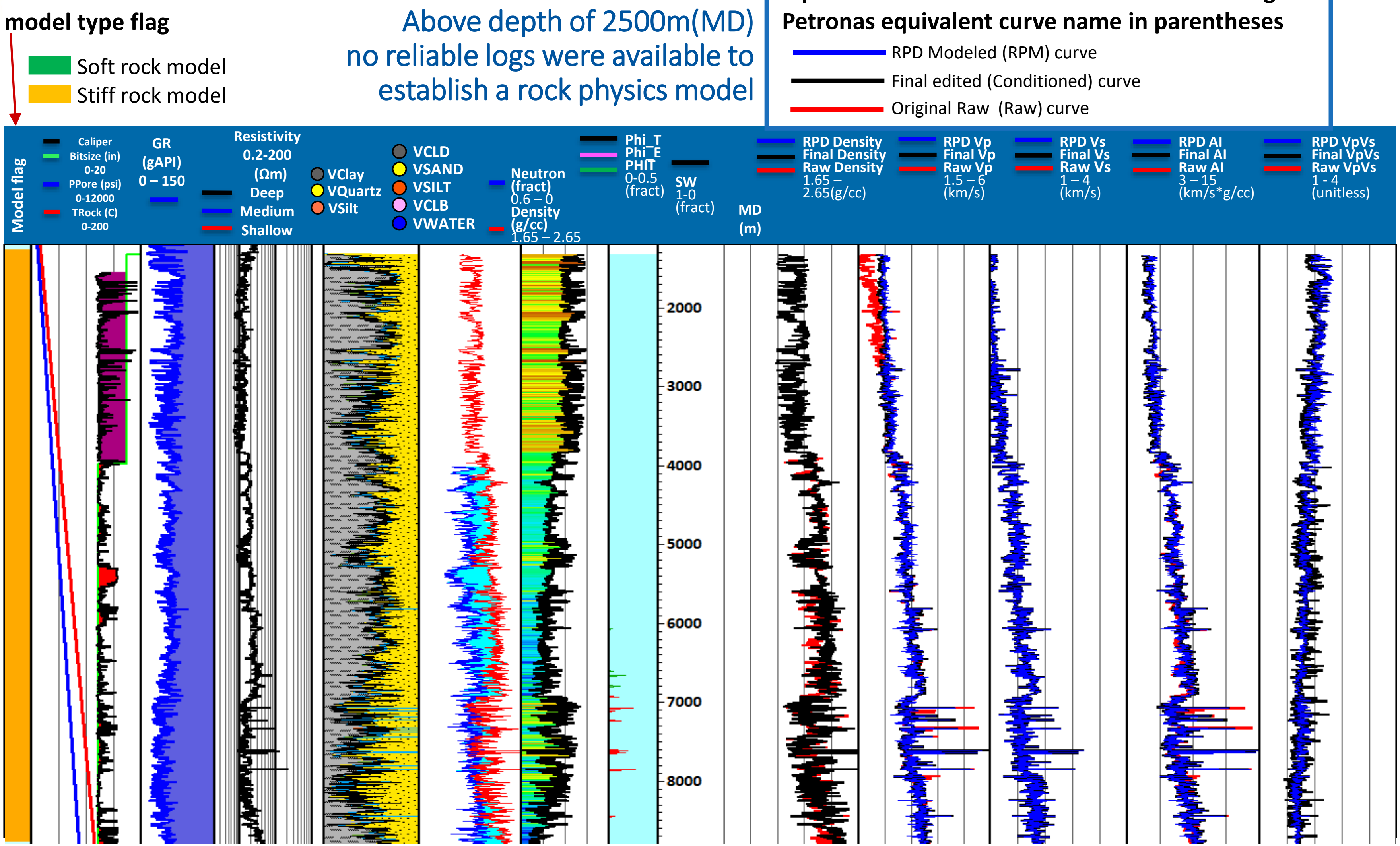
- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.

Baronian_19 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Baronian_19 Geophysical Well Log Analysis (GWLA) Top of elastic logs to TD)

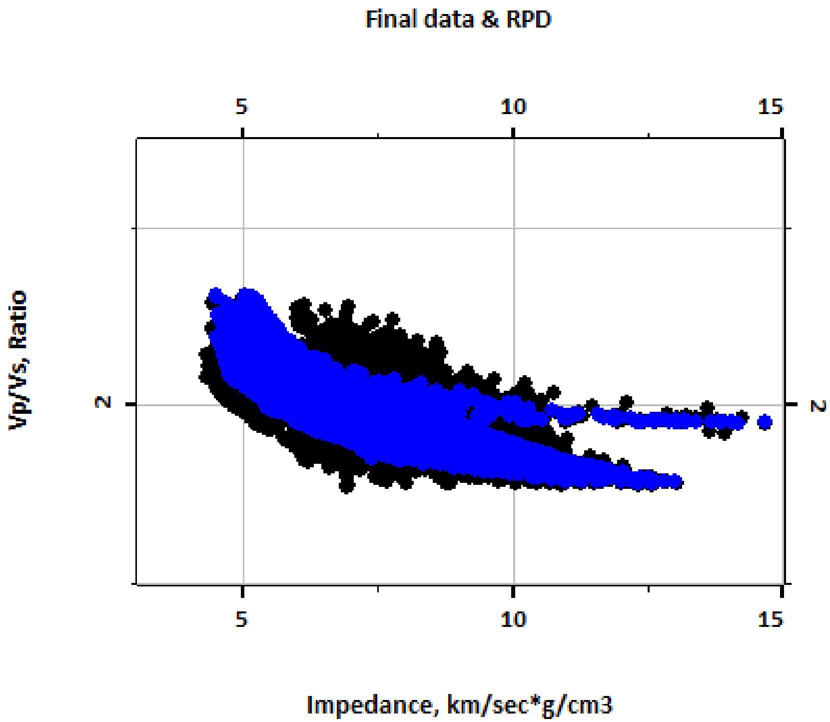


Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

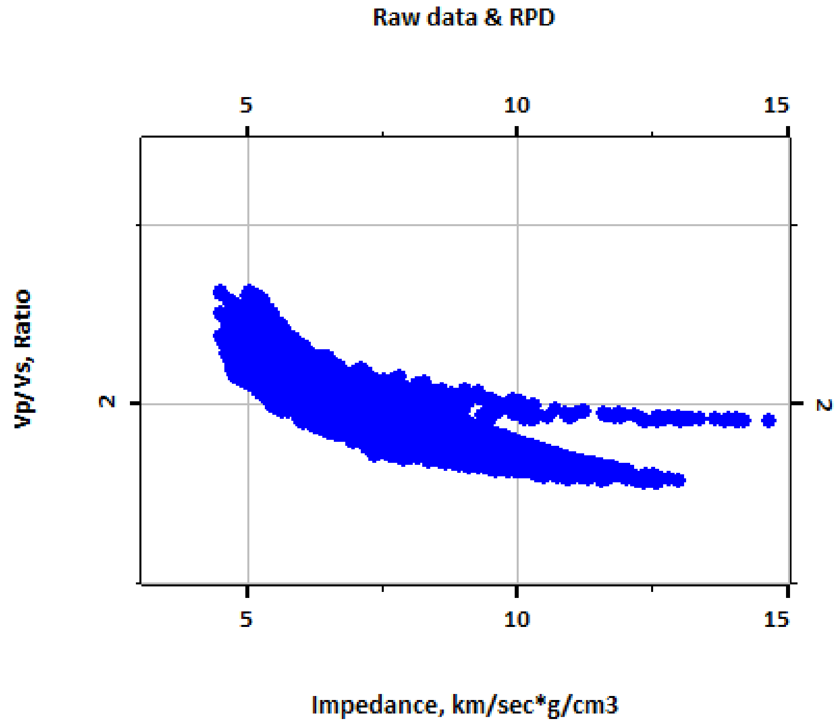
Baronian_19,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)

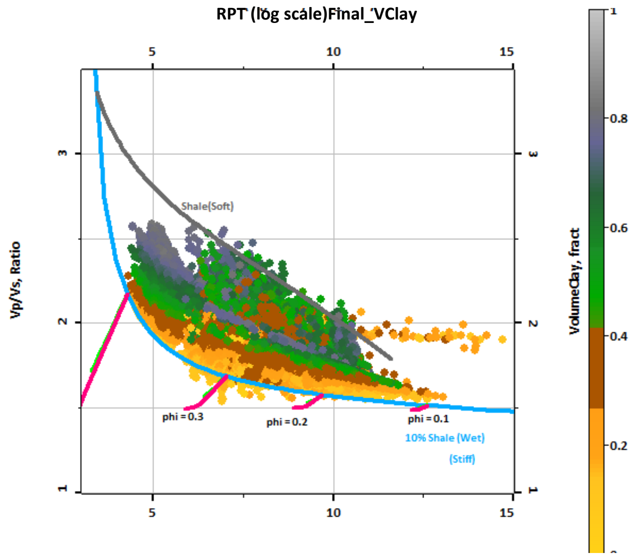


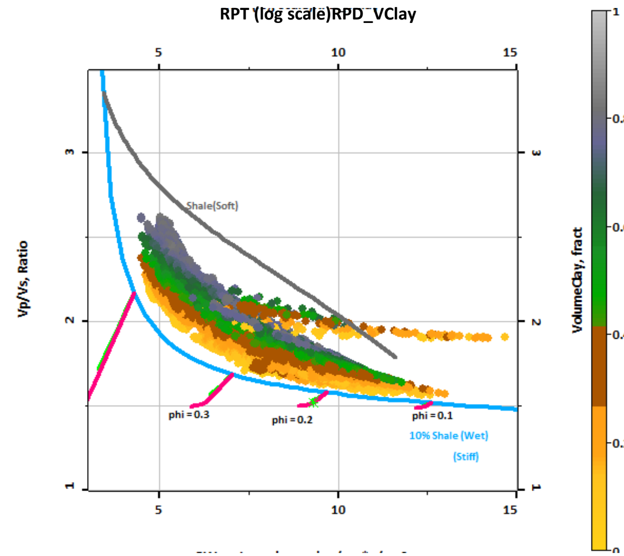
RPD (RPM)
Final (conditioned)

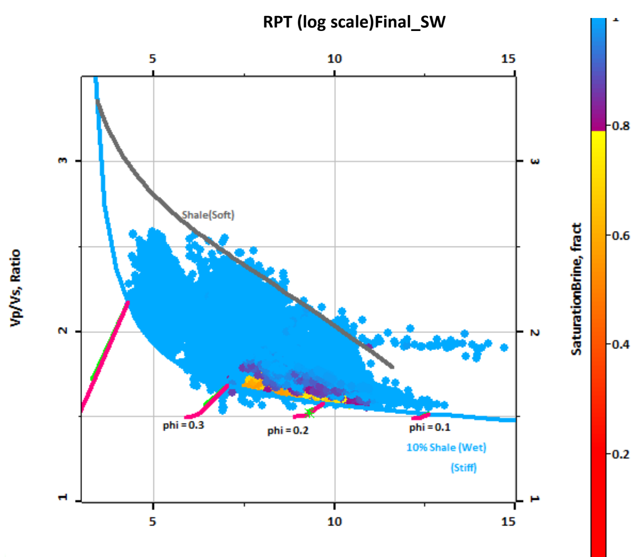
Baronian_19,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

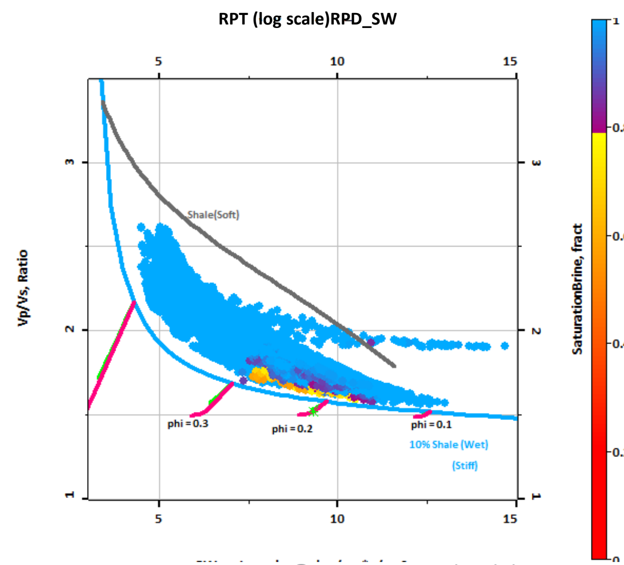
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Baronian_20

Baronian_20 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Density and Vp were heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Missing VS and was calibrated using nearby wells
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well from top bottom were 100% brine saturated.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the clean wet sand section, yielded a formation water salinity of 13000 PPM. Water saturation was calculated using Simandoux's equation with RW=0.12, constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=1.8 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

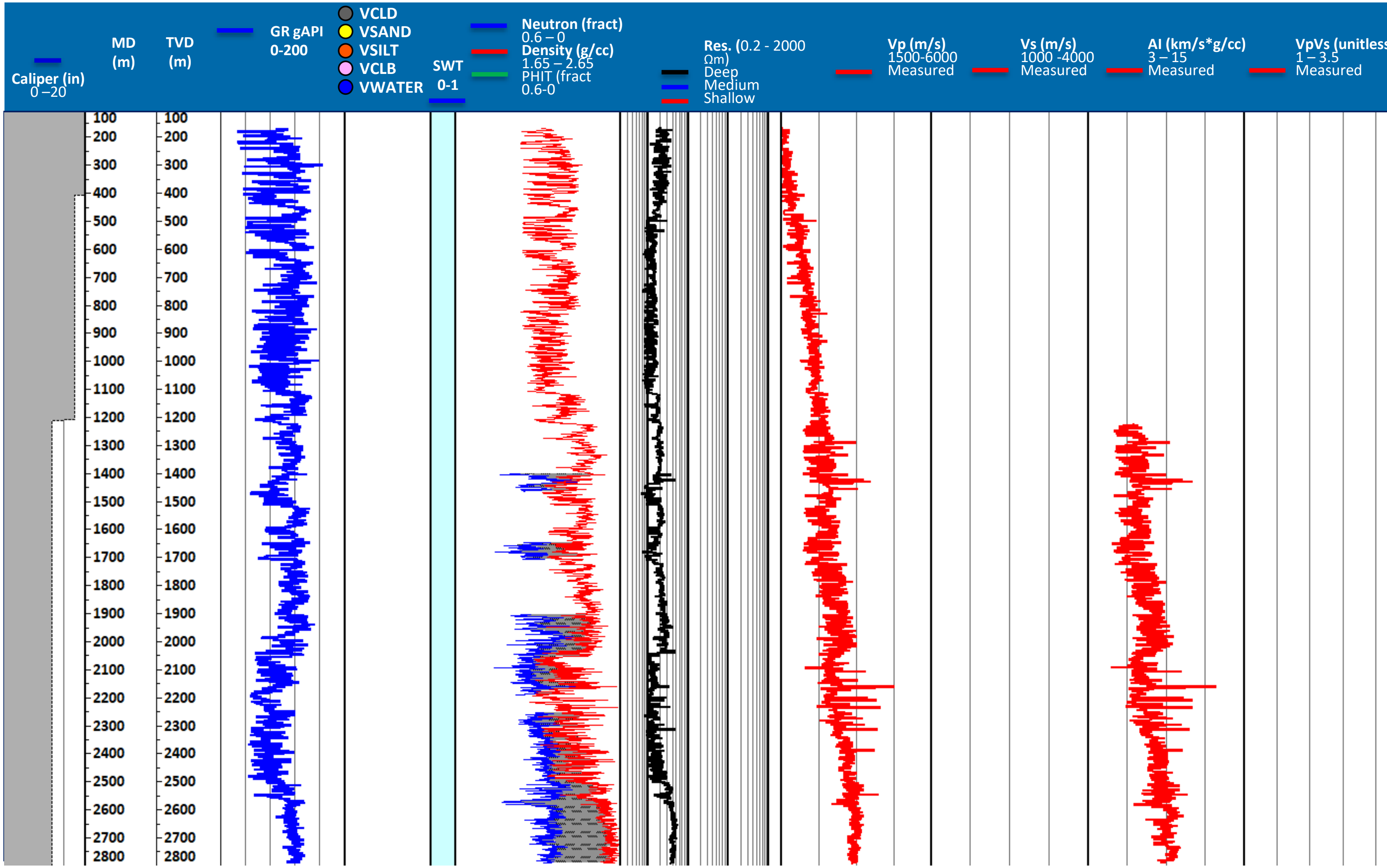
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.

Baronian_20 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Baronian_20 Geophysical Well Log Analysis (GWLA) Top of elastic logs to TD)

model type flag

Soft rock model

Stiff rock model

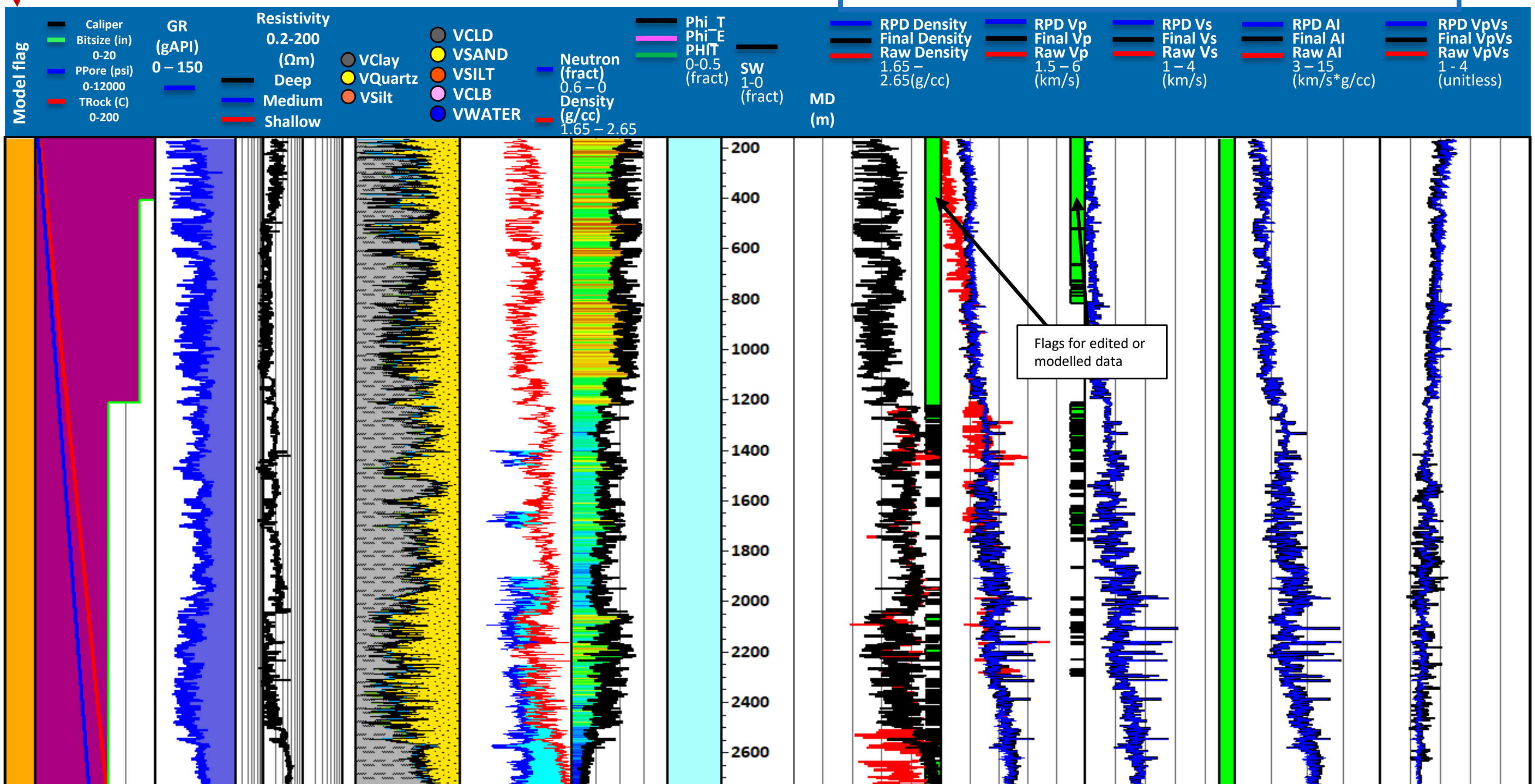
Above depth of 2500m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve

Final edited (Conditioned) curve

Original Raw (Raw) curve

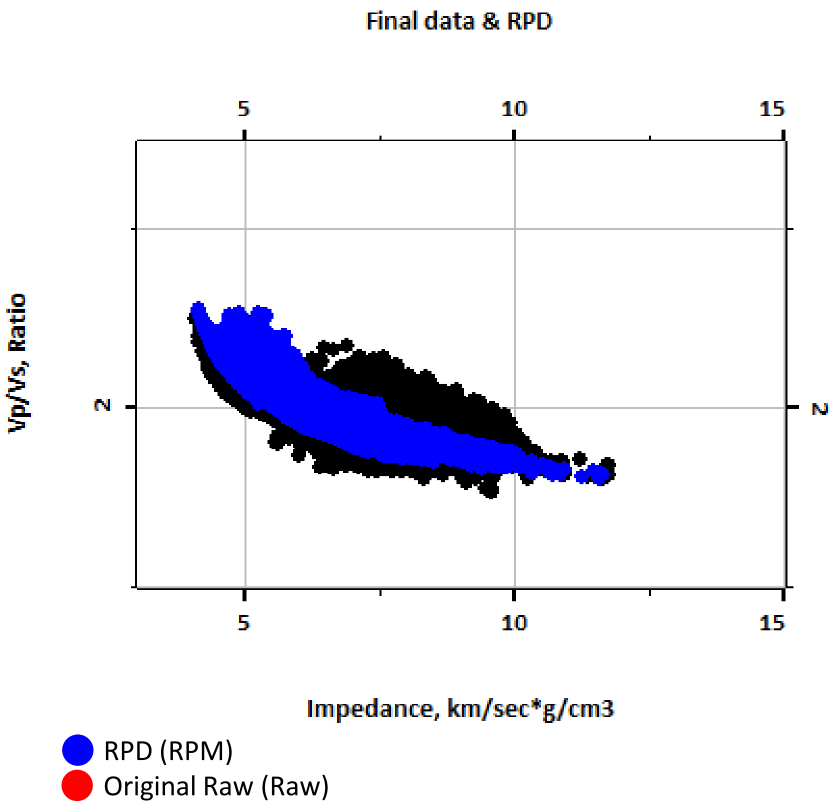


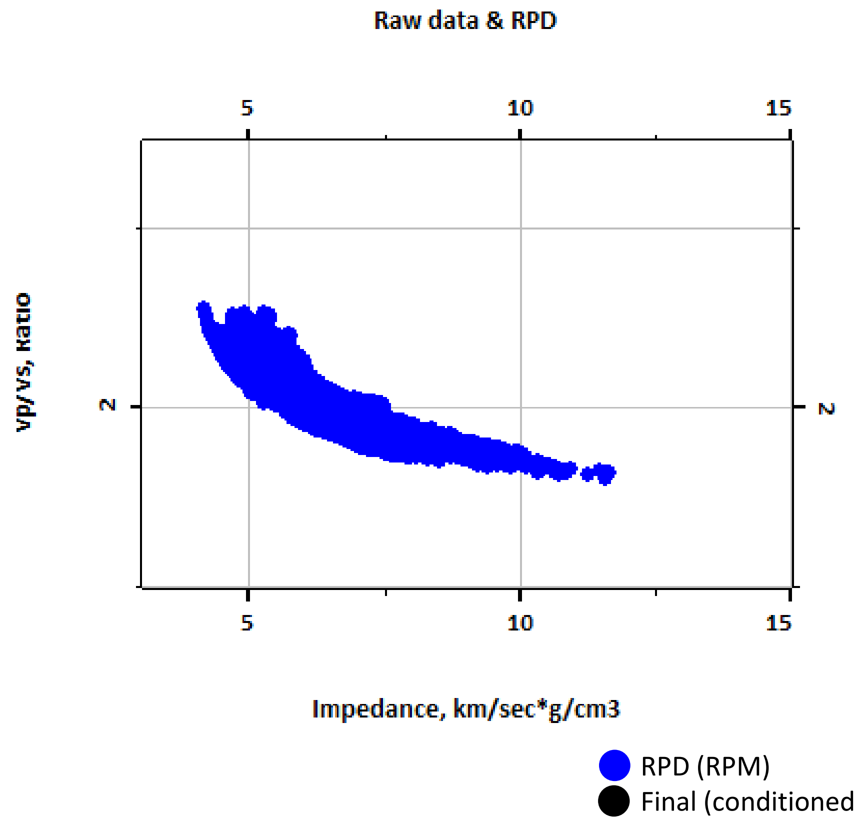
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Baronian_20,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

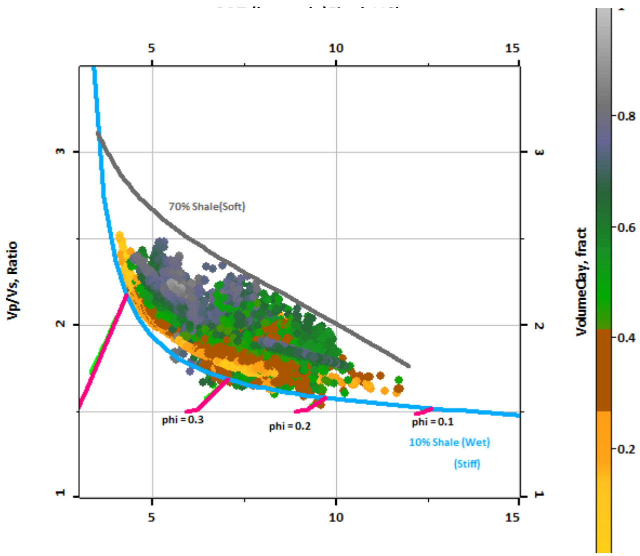


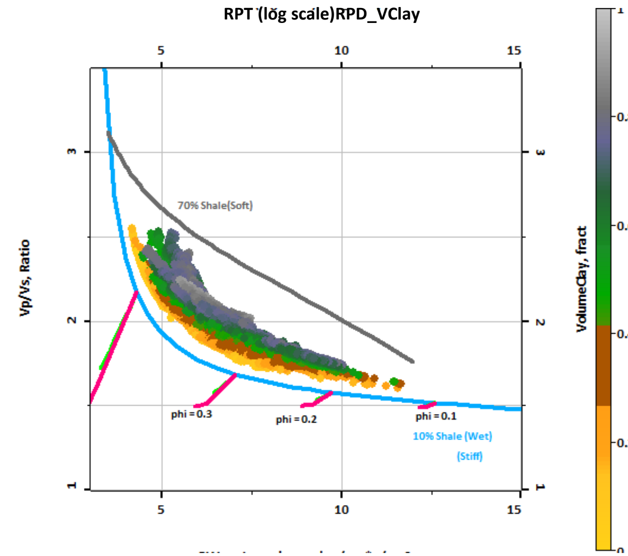


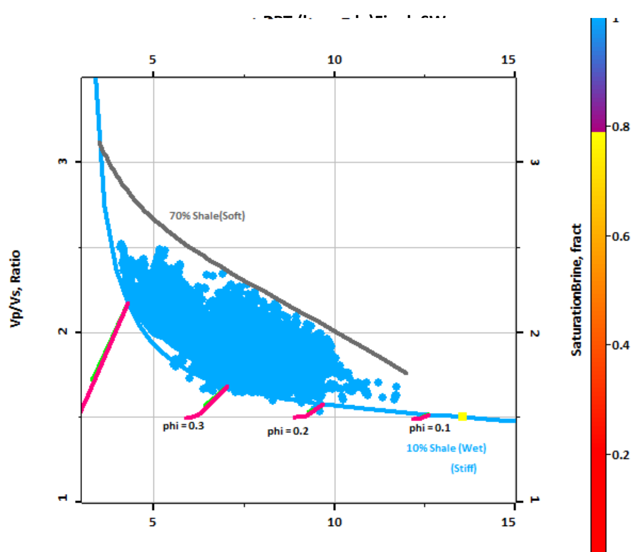
Baronian_20,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

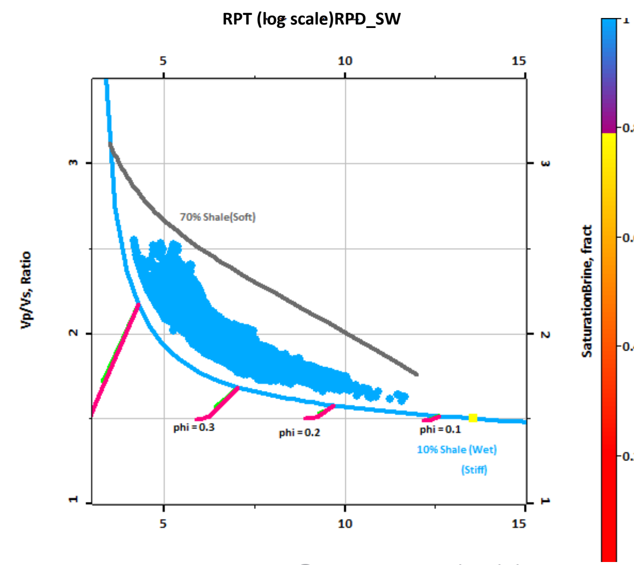
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Betty_3

Betty_3 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Invasion correction was applied for the density log in the gas saturated sands.
- Vp was heavily edited in the shallower section of the measurement(above 700m).
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with some clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well from top to about 2450m(MD) were 100% brine saturated while most of the sands penetrated below that depth were gas saturated with saturation reached to 55% in some intervals.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. yielded a formation water salinity of 14000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.73 and Saturation exponent (n)=1.6.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

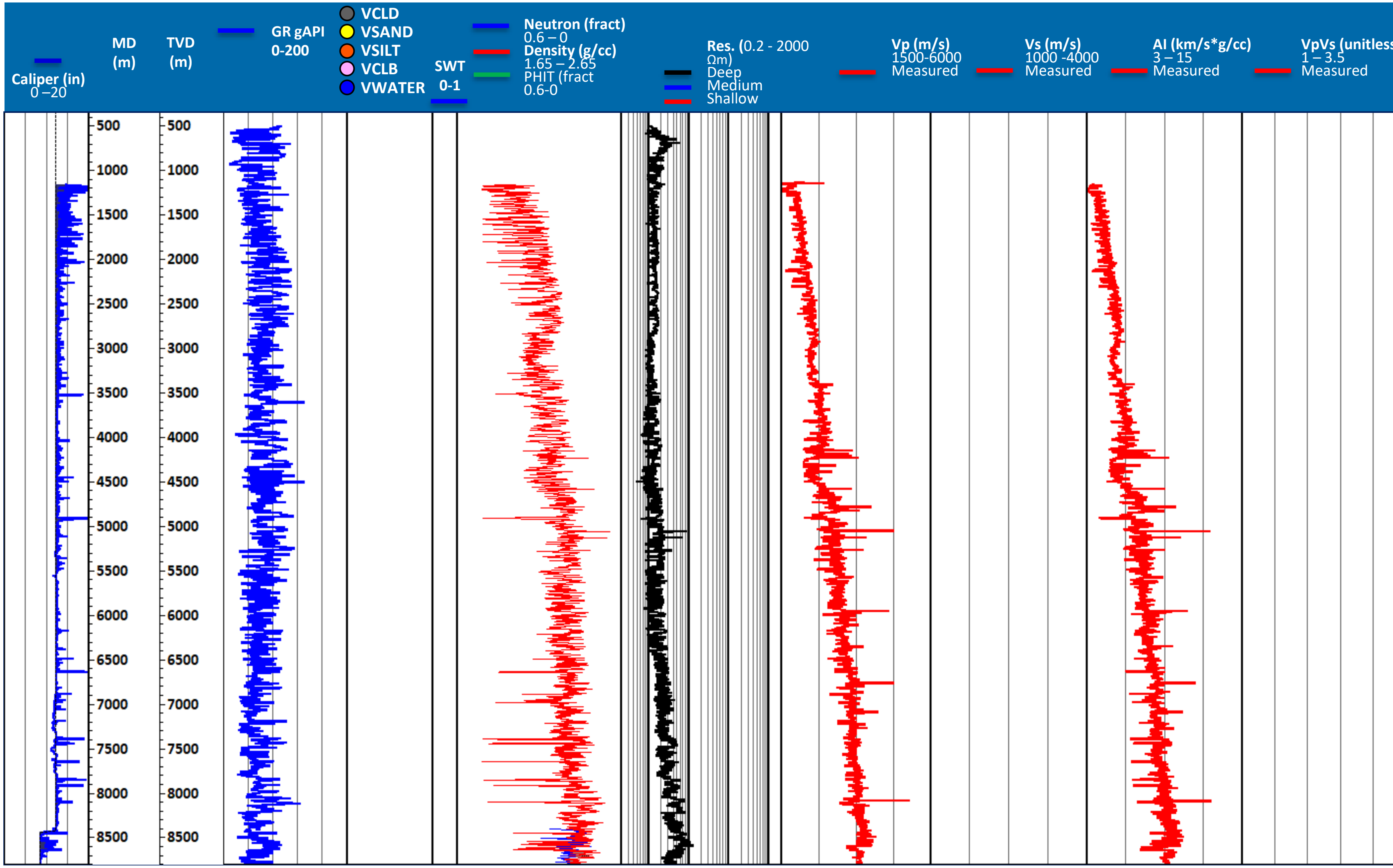
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 14000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.

Betty_3 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Betty_3 Geophysical Well Log Analysis (GWLA) Top of elastic logs to TD)

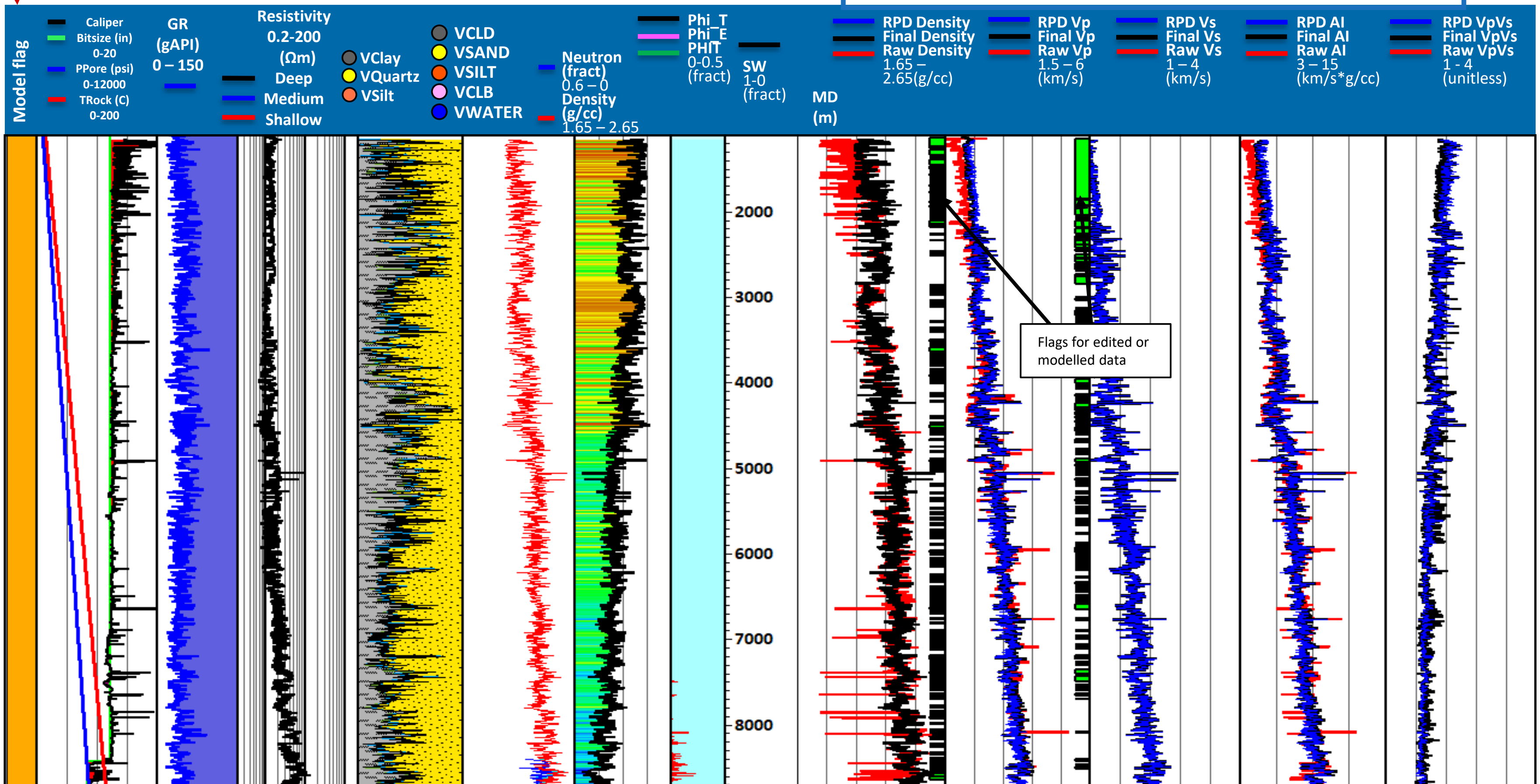
Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

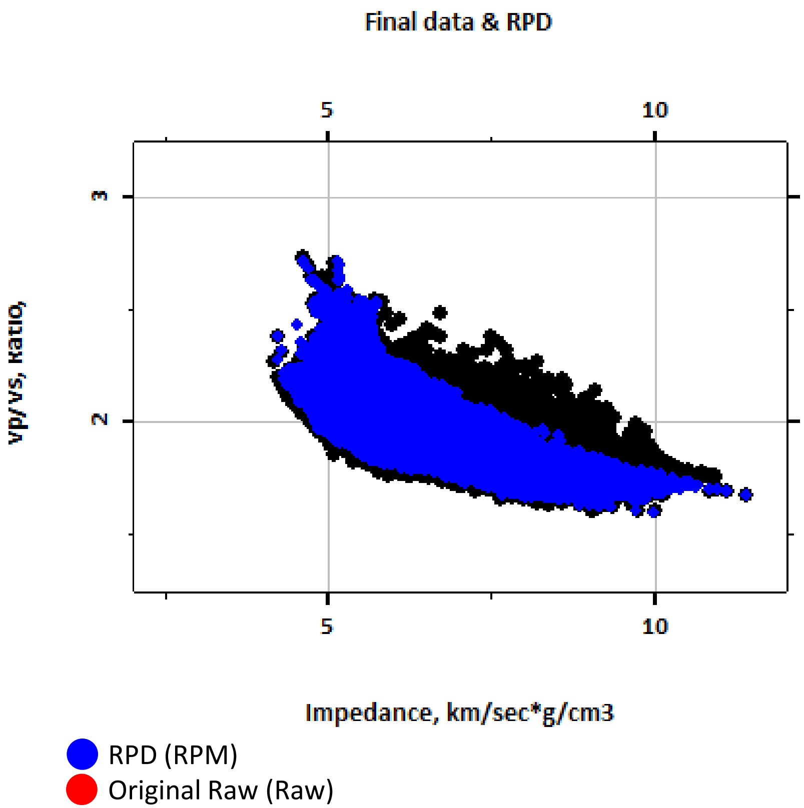
Above depth of 700m(MD) no reliable logs were available to establish a rock physics model



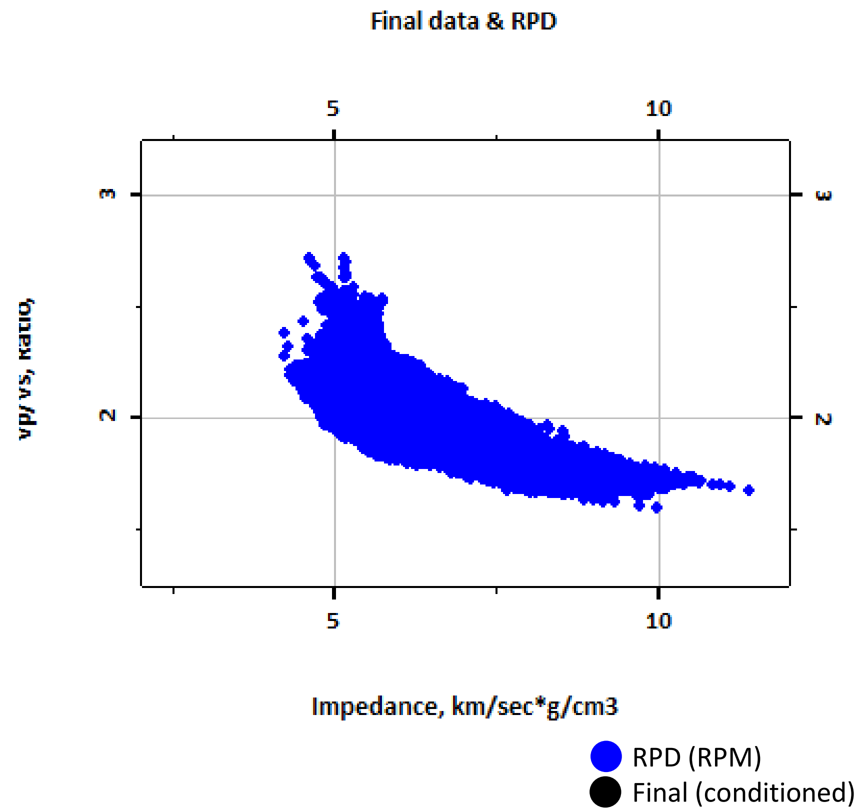
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Betty_3,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data (Missing original VS).



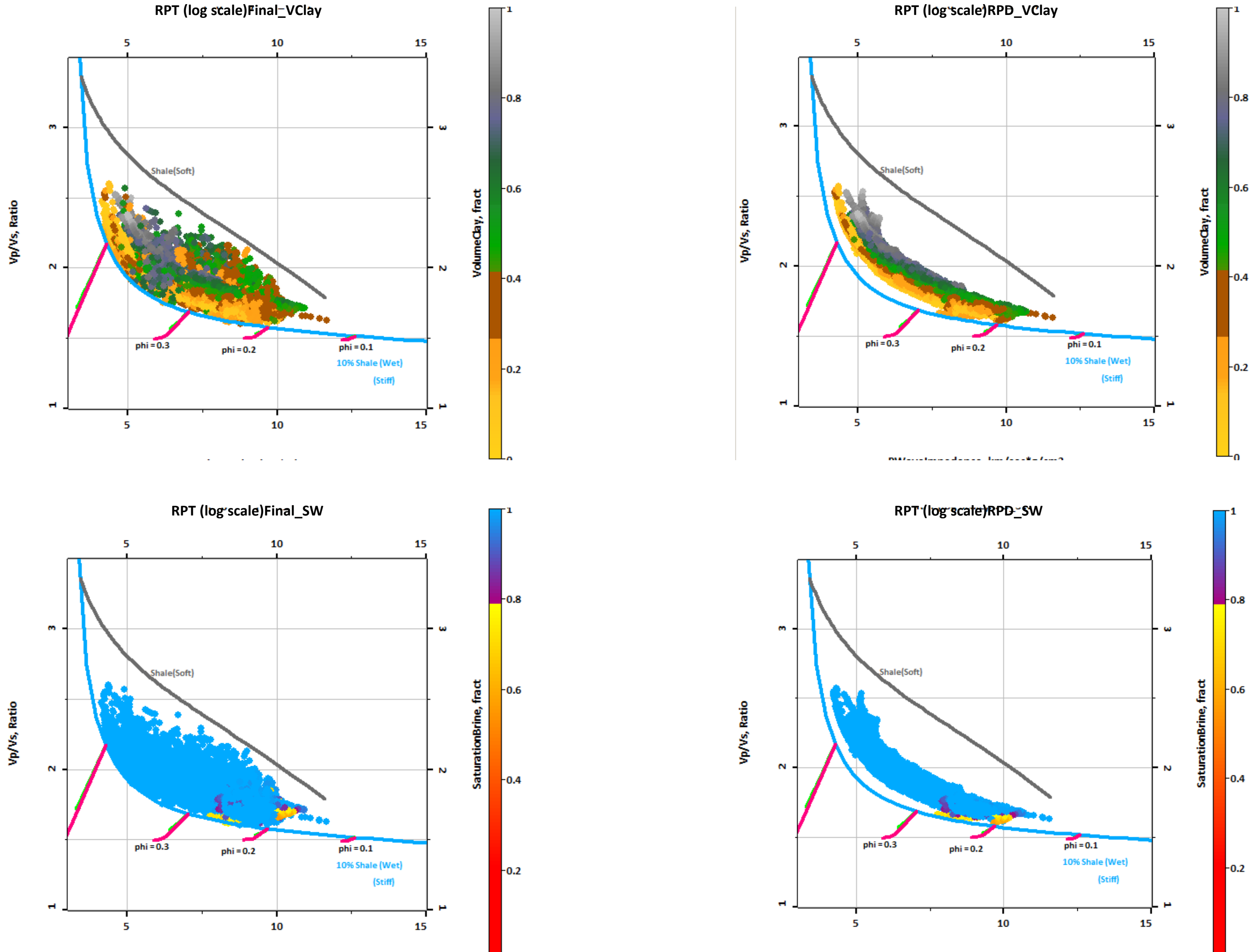
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



Betty_3,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2000m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- This well behaves very similar to the elastic trend in the southern area of Sabah basin(Samarang wells) where same model was applied.

Fluid properties:

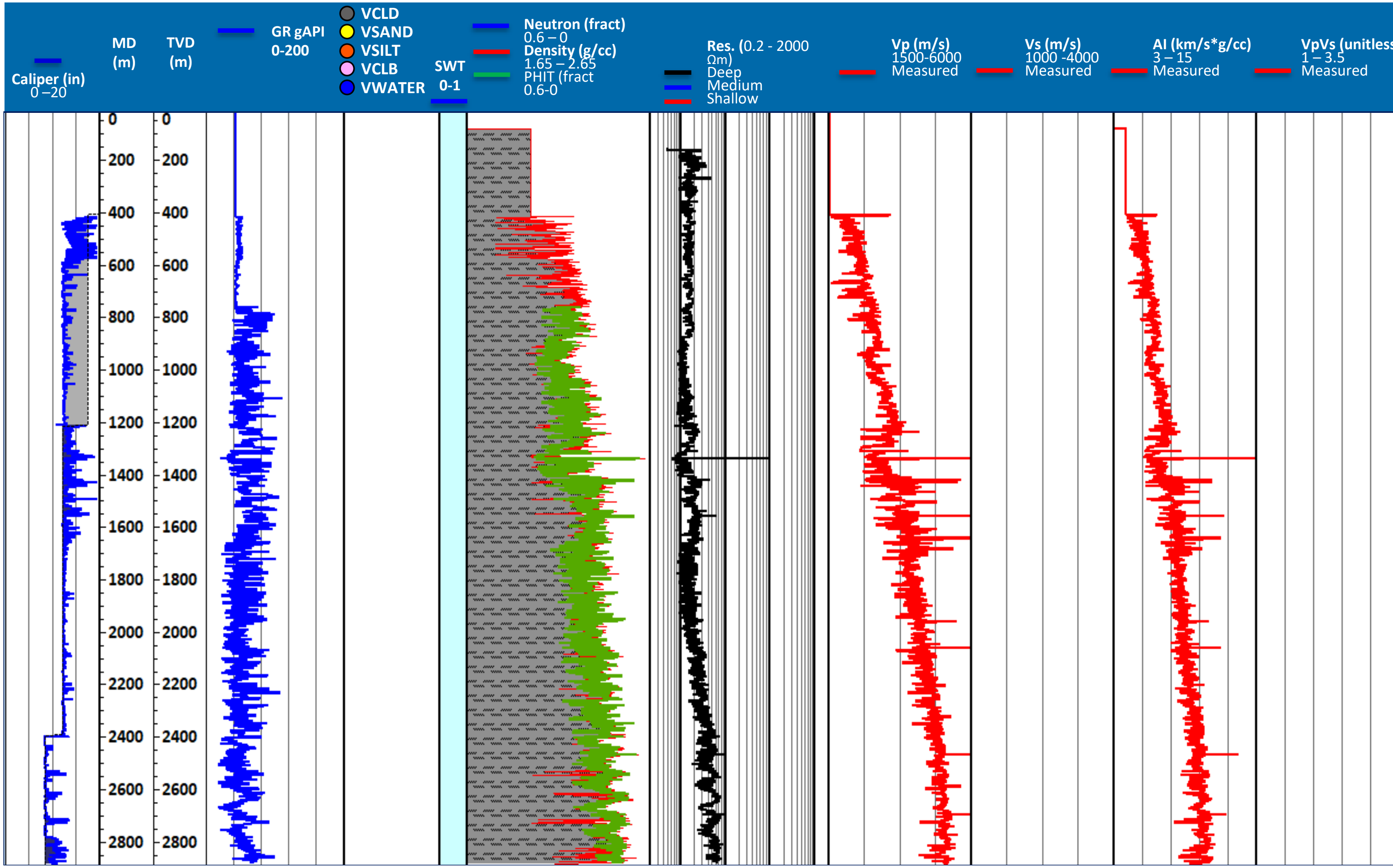
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- AVA class IV was observed near the H800 gas sands @ 3500m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no noticeable change for the AVO class was observed.

Betty-4 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Betty-4 Geophysical Well Log Analysis (GWLA) Top of elastic logs to 3000m(MD)

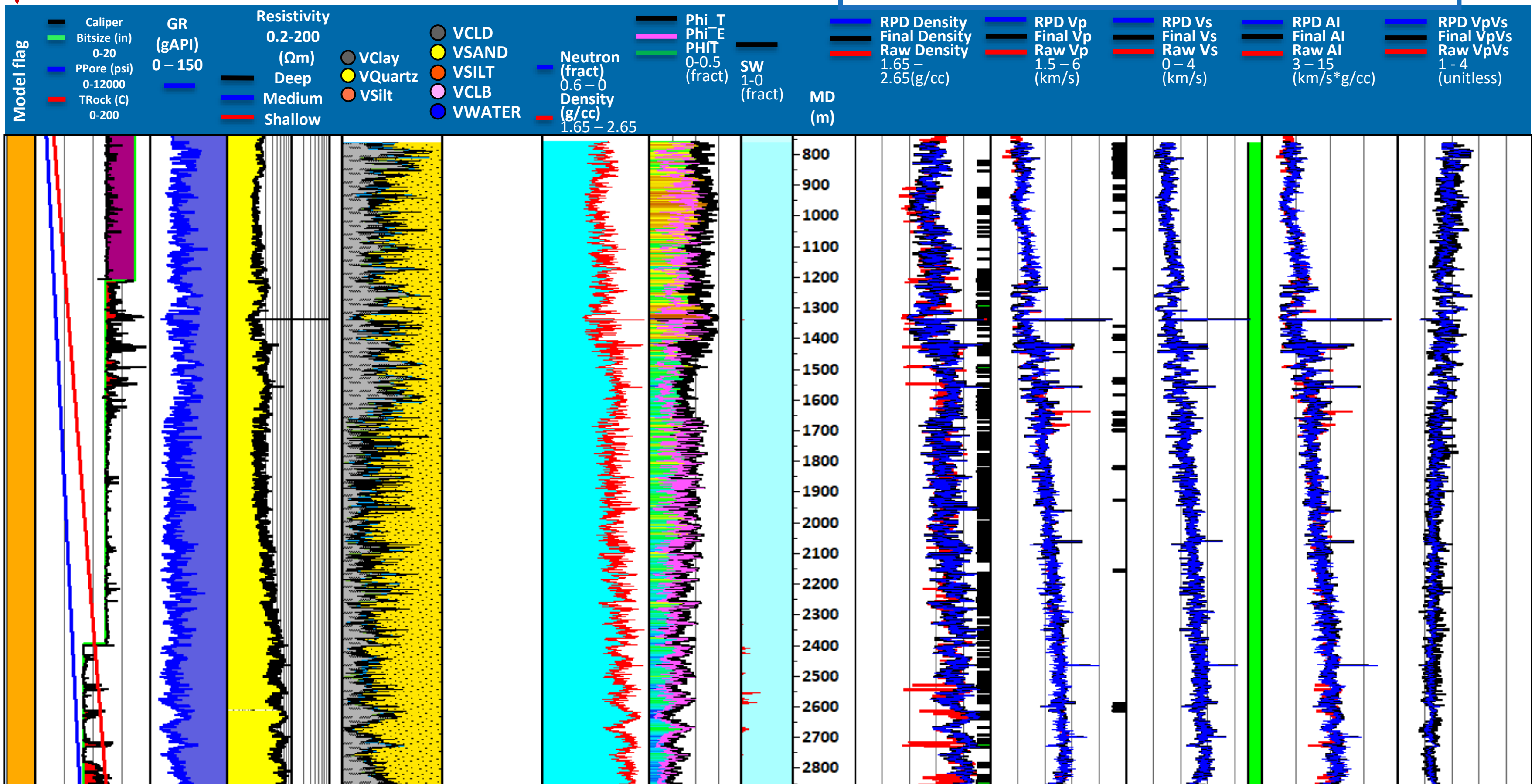
Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

Above depth of 2000m(MD) no reliable logs were available to establish a rock physics model

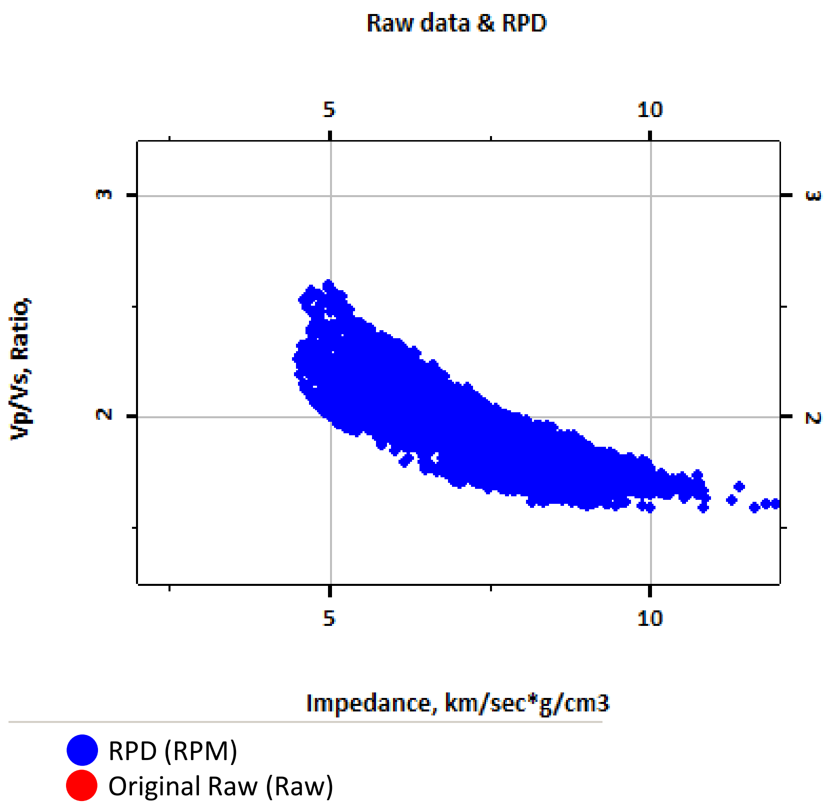


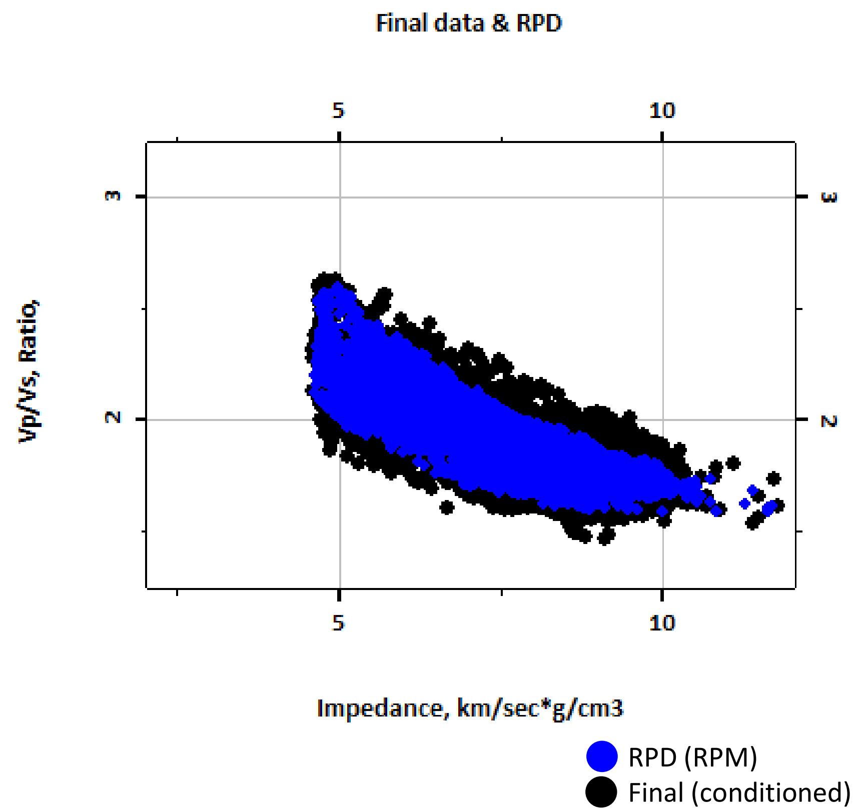
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Betty-4,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

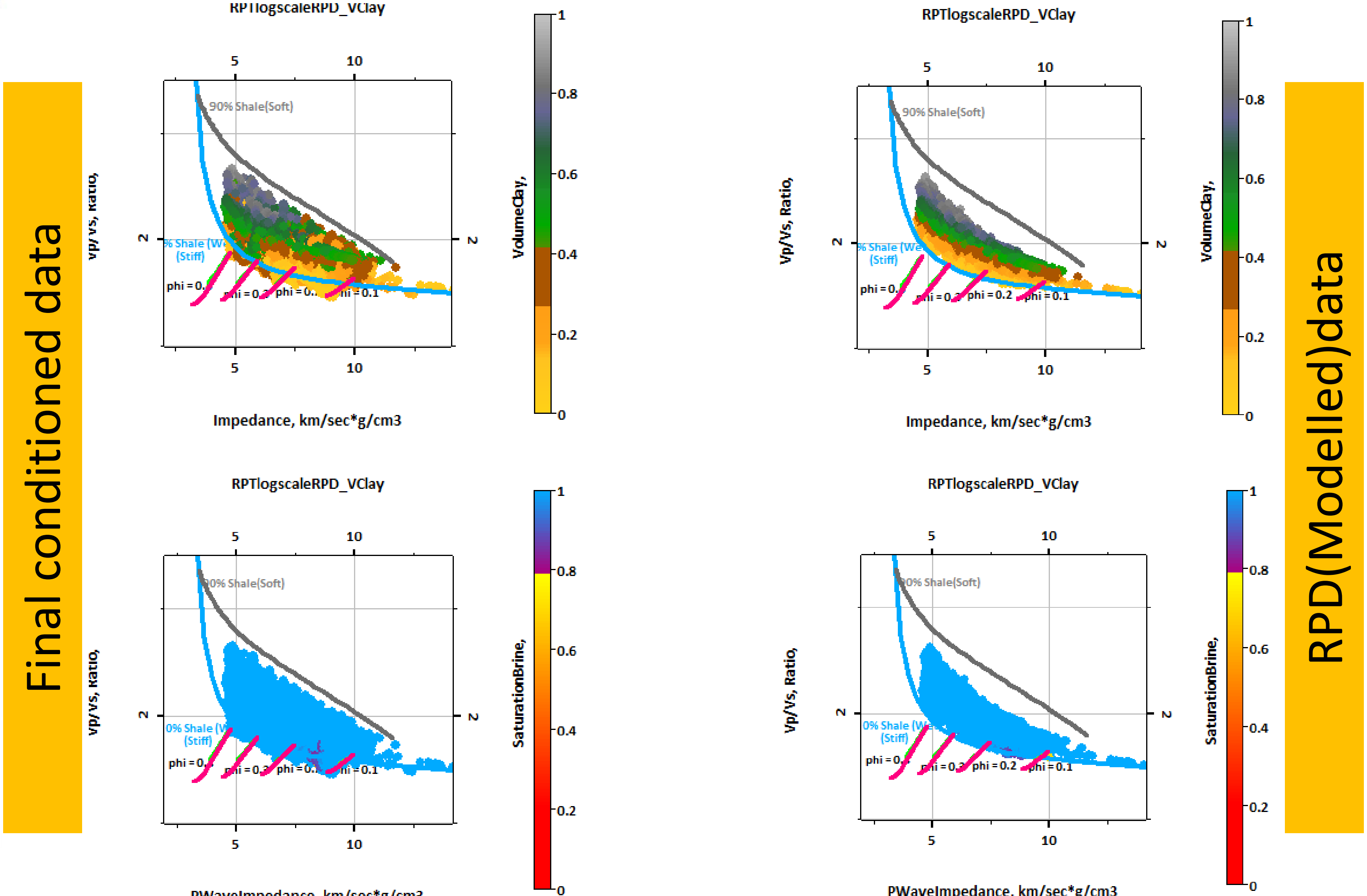
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.





Betty-4,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.



Betty Timur-1

Betty_Timur-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Invasion correction was applied for the density log in the gas saturated sands and the results were aligned with the porosity provided by Petronas for reference.
- Vs was heavily edited in the shallower section of the measurement(2000m-2150m).
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with come clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well from top to about 3100m(MD) were 100% brine saturated while most of the sands penetrated below that depth were gas saturated with saturation reached to 80% in many intervals especially H790, H800 and H830.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the clean wet sand section(3045-33050m) yielded a formation water salinity of 13000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=1.8 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2000m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

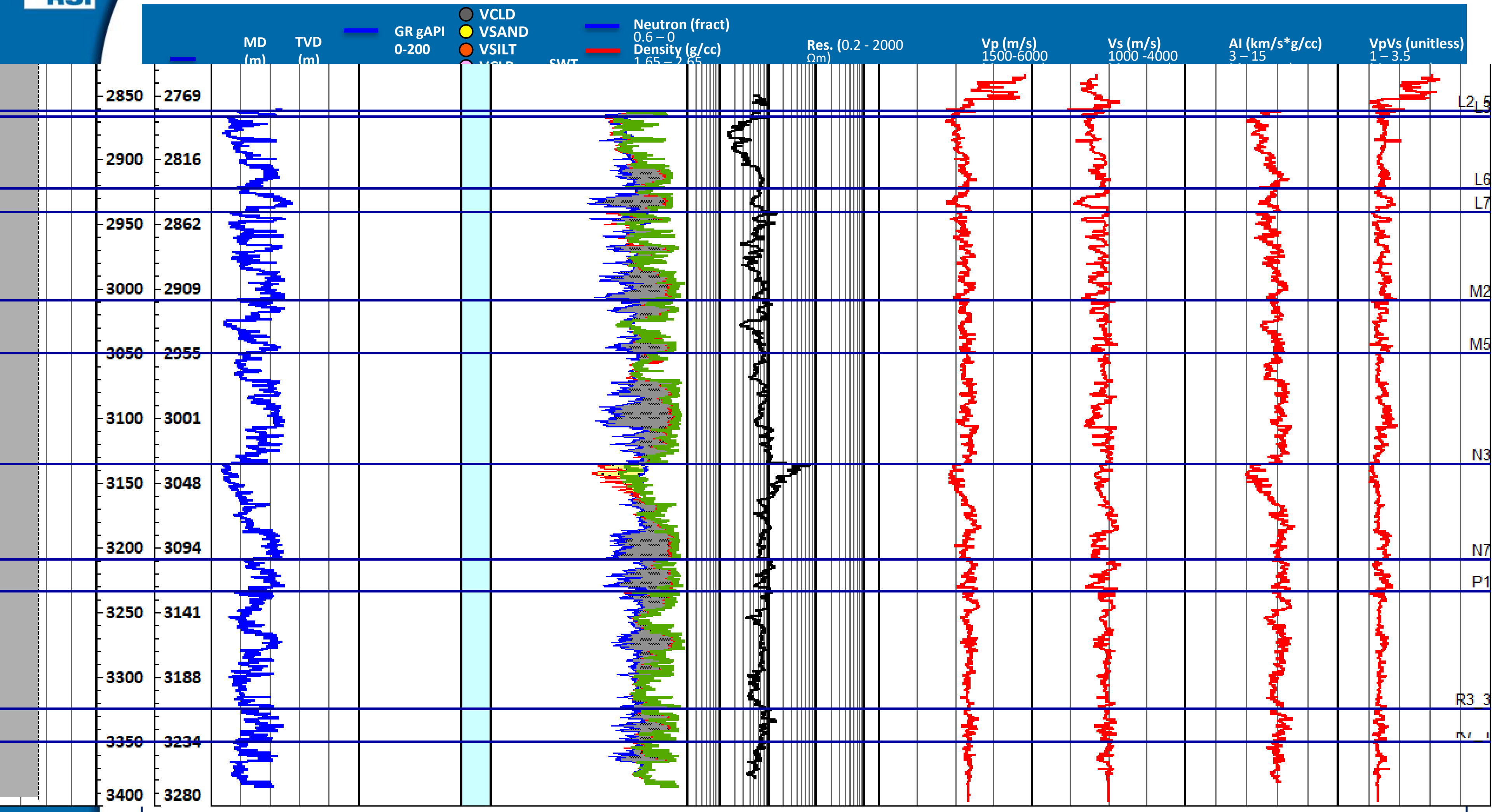
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- AVA class IV was observed near the H800 gas sands @ 3500m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no noticeable change for the AVO class was observed.

Betty_Timur-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Betty_Timur-1 Geophysical Well Log Analysis (GWLA) Top of elastic logs to 3000m(MD)

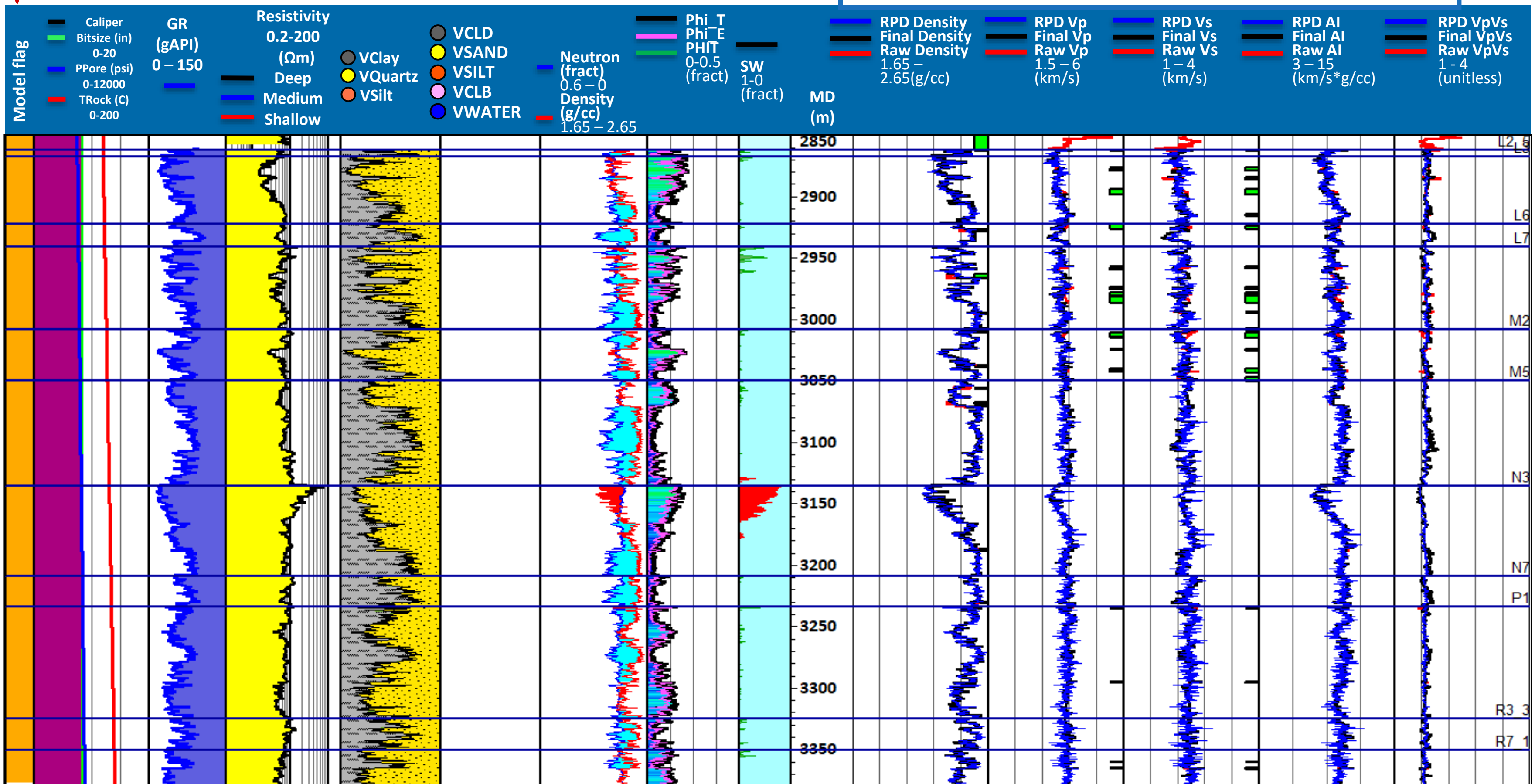
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2000m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

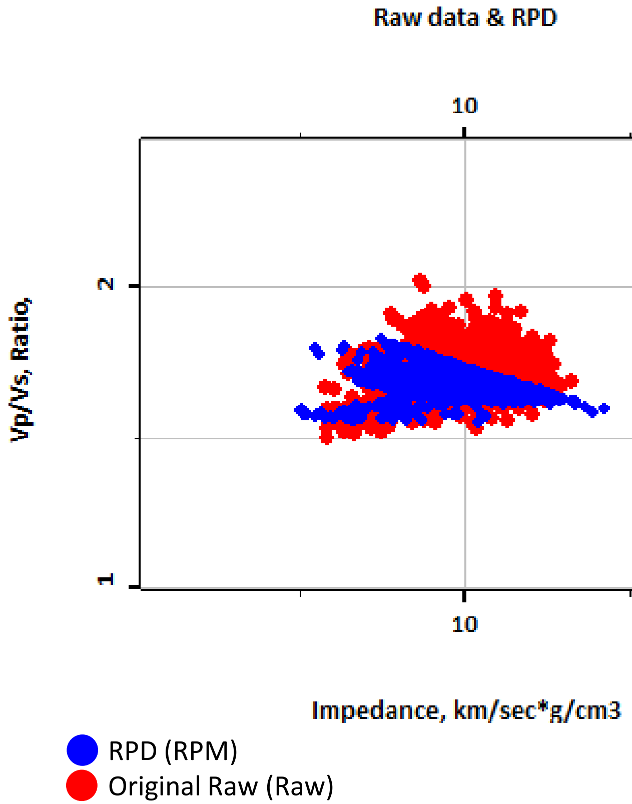


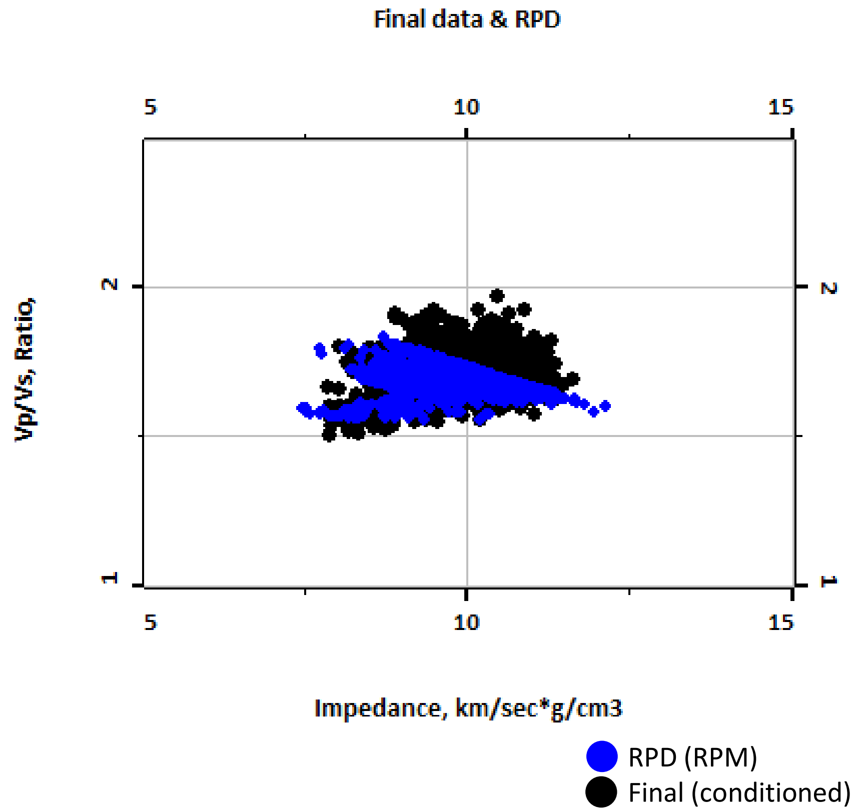
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Betty_Timur-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

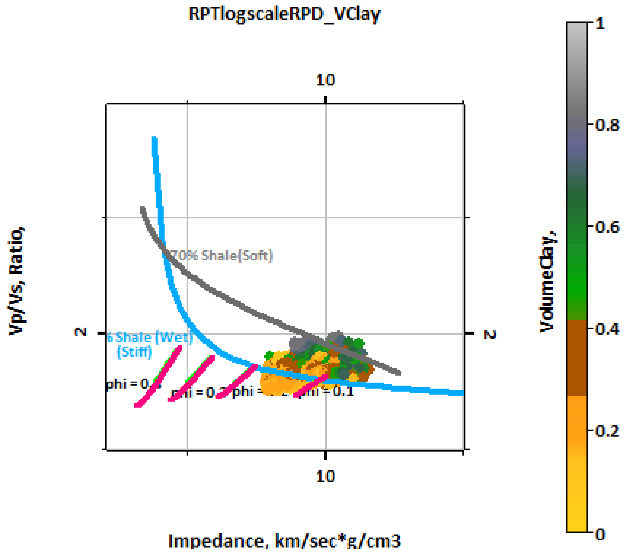


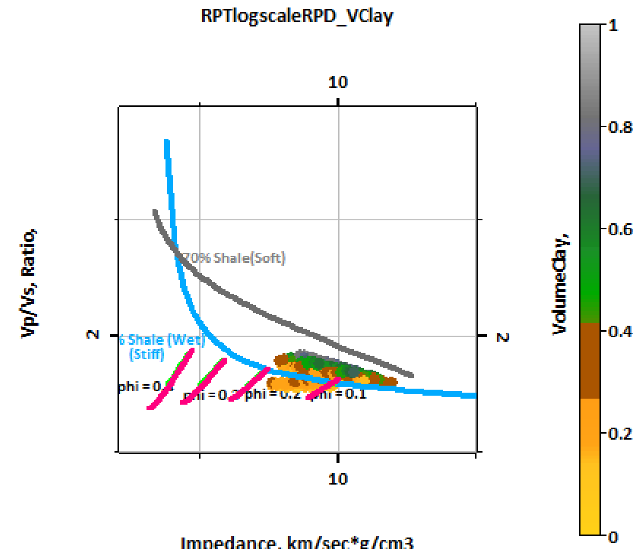


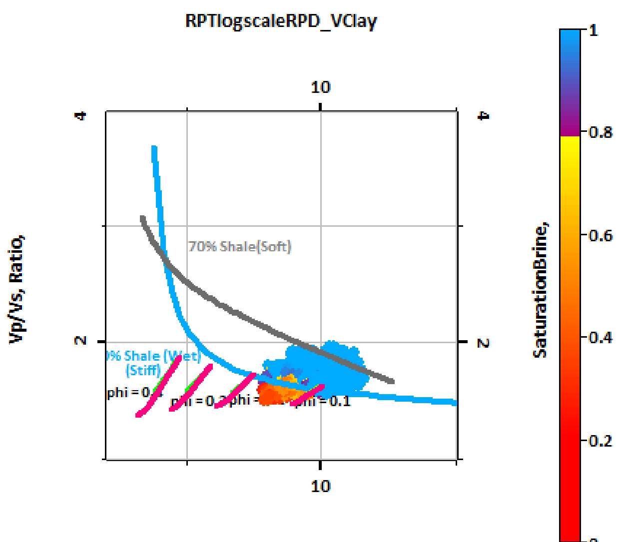
Betty_Timur-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

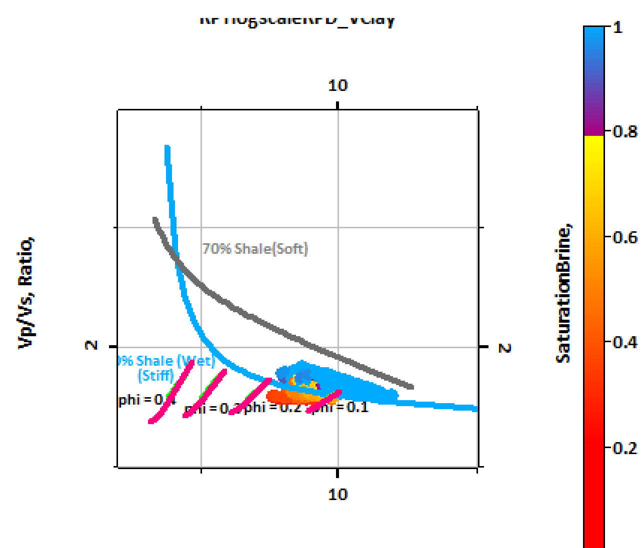
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Bidara-1

Bidara-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is fair. Vs data is unavailable. Most of the well log suite runs in the 2056-3265 m interval.
- Density measurements are of very good quality. Edits were applied only in sections in the vicinity of casing shoes (e.g. 2550 m and 2680 m).
- Vp log quality is fair to poor. Below 2700 m the acoustic log seems to be affected by a remnant depth shift that in conjunction with the effects of overpressure, display a Vp not in sync with the trend displayed by the density log. Resistivity, and NPHI logs were useful tools to validate the character of the acoustic log in various sections. Vp was also affected in the casing shoe locations, particularly in the 2547-2578 m interval, where the Faust relationship was used to predict Vp.
- Vs has been entirely modelled in this well using Granular Media. Two different set of parameters (a "softer" model from Well Top-2860 m and a "stiffer" model from 2860 m- TD) were applied based on the elastic trends observed in the Vp-Rhob space. Nearby wells, particularly Pelangi and empirical Vp-Vs models (e.g. Greenberg-Castagna) also assisted in the Vs modelling parameterization.
- Other logs include, Neutron, Caliper, Deep and Medium resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Particularly, in H210 and in the upper 50 m of H220, the clay interpretation has been refined based on the cuttings and mud log reports. Additionally, Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation in the aforementioned section.
- Gamma Ray has been edited in the 2565-2577 m, 2694-2696 m intervals to account for the locations of the casing shoe. Gamma values tend to decrease at these events implying the presence of less radioactive rocks but it is simply an artifact. Mud log report has assisted in this interpretation.

Reservoir characteristics:

- Bidara-1 is the first deep water well drilled by PETRONAS to explore for deep water hydrocarbon potential in Sarawak and the well was intended to test four-way dip toe-thrust anticlinal structure. The target reservoirs are Late Miocene deep water submarine fan complex turbidite sandstones. The H110, H150 sands and H160, H200 sands equivalent to Sabah deep water Kamunsu and Kinarut sequences at Kikeh oil field are respective secondary and primary targets.
- The well consists of claystones and some thick sandstones, typically silty. The cleanest sands are thin and less developed. The majority of pressure tests attempted below 2700 m were tight and unsuccessful. Thin section analysis performed in samples below 2700 m suggests a consistent presence of kaolinite as an authigenic clay material, that might be a product of feldspar dissolution. These diagenetic effects could explain the poor reservoir conditions observed in the rocks below H180, and that has translated into the elastic characteristics of this section.

Volume of hydrocarbons:

- Several sands in the well has been interpreted as gas bearing, particularly in thin events in H120, H140, H180, H190, H210, and H220. In one of the H120 sands the gas saturation was interpreted as high as 50%, but in general it has been interpreted with values lower than 15% in the majority of the interpreted sands.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=1.89 based on the client's petrophysical report. Two different salinities were used to interpret Sw: Rw=0.15 ohmm @ 120 F (26,000 ppm) above H180, and 0.11 ohmm @ 185 F (23,000 ppm) below this marker.

** Depths referred in this report are MD.

Bidara-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and three different rock physics models were considered, based primarily in pore pressure regimes and elastic properties:

  1. Both clay-rich and sand facies are soft in a normal pressure regime.

  2. Claystone dominated section. Pore pressure builds-up to 0.61 psi/ft (overpressured).

  3. Both, clay-rich and non-clay facies appears to be more compacted, and tight. Vp and Rhob describes a different trend compared to sections above. The majority of pressure tests attempted below 2700 m were unsuccessful (tight) implying poor reservoir properties as a consequence of the tightness of the rock. Furthermore, seismic sections found in reports exhibit strong seismic events (high impedance contrasts) below H160.

- In the two shallowest rock physics models considered, the Soft sediment model proved to be the best predictor for both sands and shales, whereas in the more compacted, high impedance interval (below 2700 m) a higher set of coordination numbers were required for both facies. Vs was modelled considering two different parameterisation sets, guided by nearby wells and Vp-Vs empirical models.

- Rock physics templates (RPT's) displayed on the crossplots represent averages of the different rock physics modelling parameterisation applied in this well.

Fluid properties:

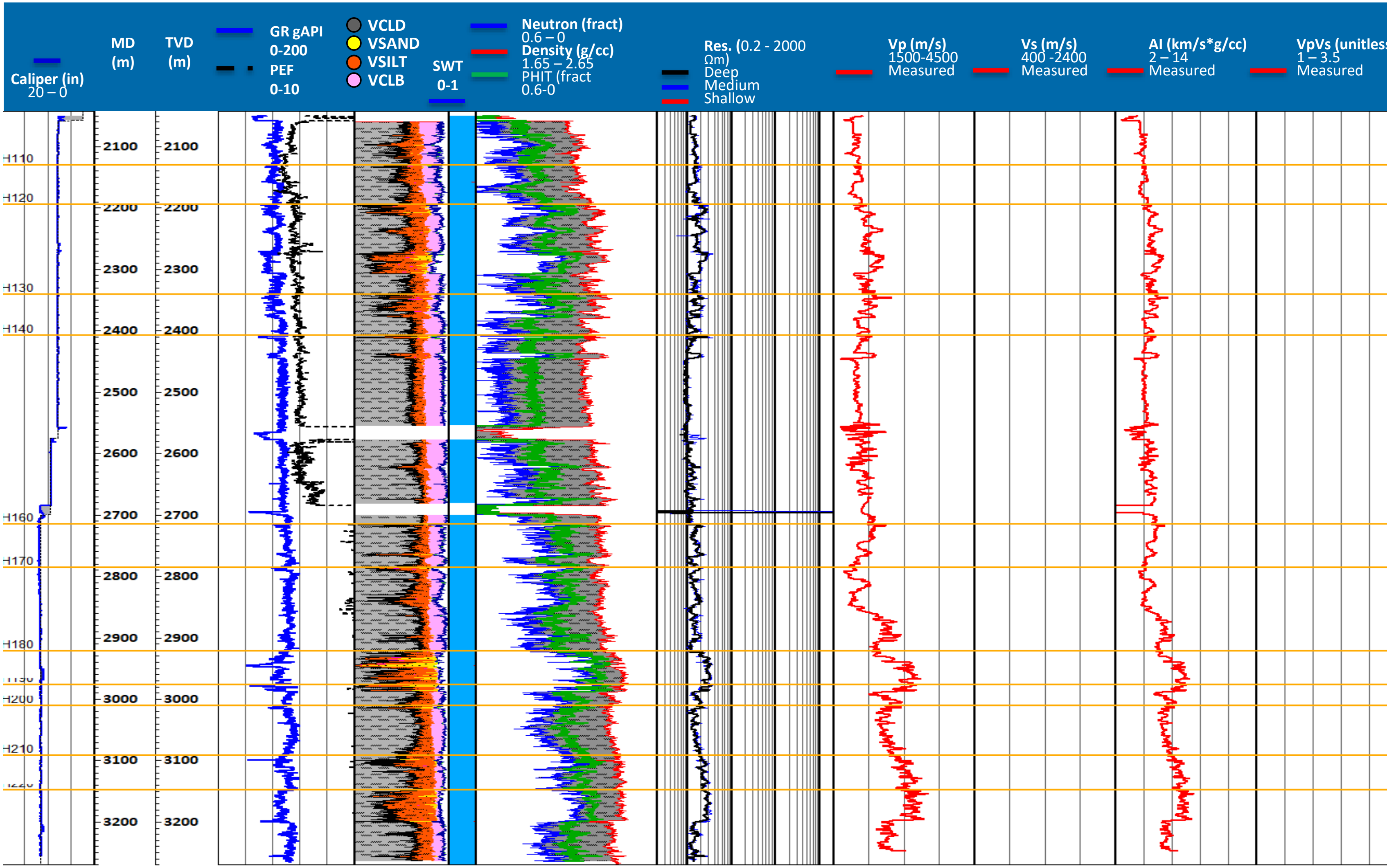
Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken in the well, particularly the gas properties. Oil properties have been taken from nearby Jelawat-1. Main parameters used in this modelling are:

- Brine salinity: 23,000 ppm
- Gas gravity: 0.62 (PVT report)
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene Cycle V sands.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – Bidara-1



Additional data includes mud weight data, pressure data, petrography and well reports.

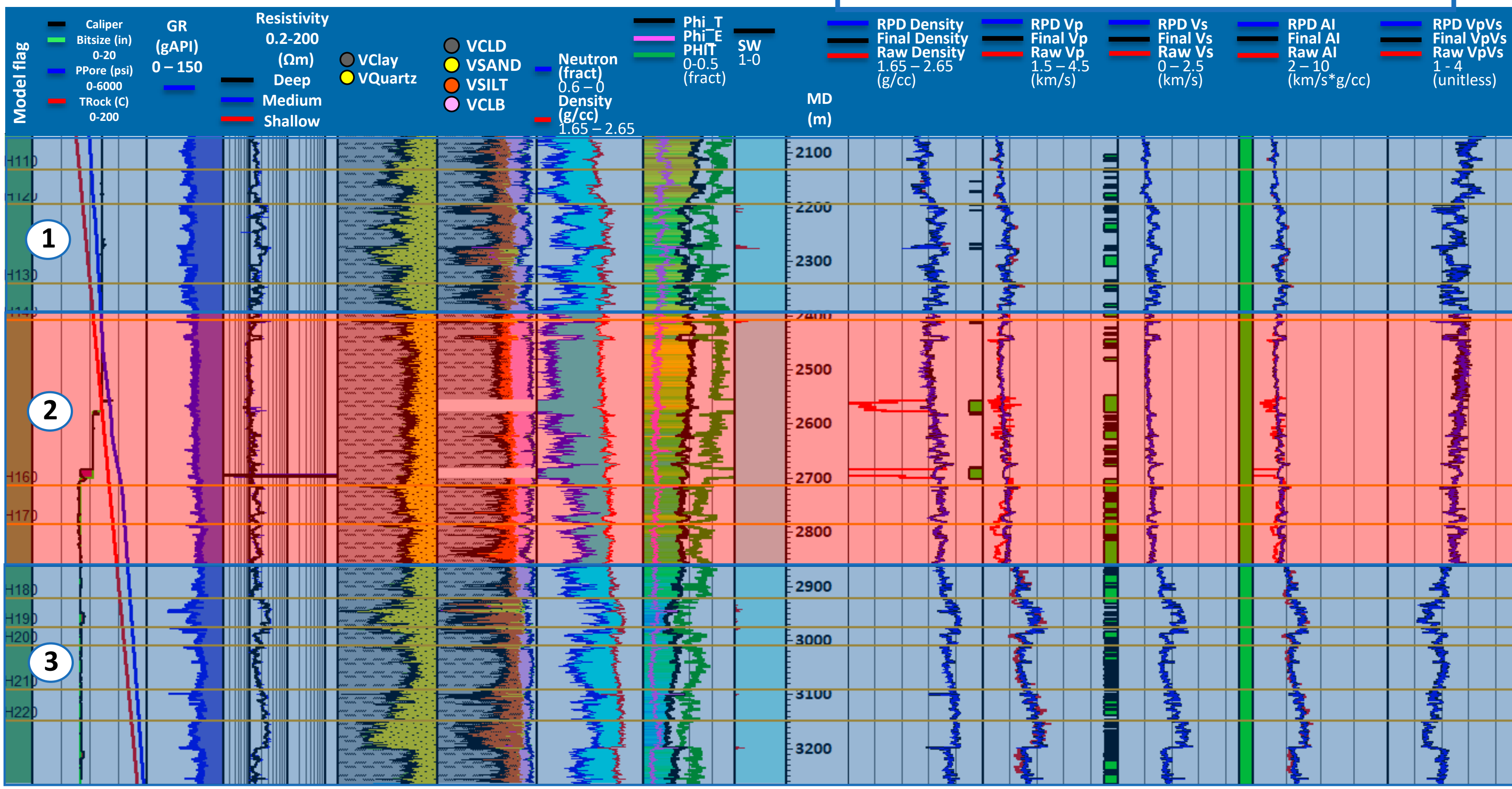
Bidara-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to Bottom

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Unconsolidated rock model
- Stiff rock model



Three different rock physics models were considered and applied in this well, based primarily in pore pressure regimes and elastic properties:

1. Both clay-rich and sand facies are soft in a normal pressure regime.
2. Claystone dominated section. Pore pressure builds-up to 0.61 psi/ft (overpressured) Slightly softer elastic responses compared to section 1.
3. Both, clay-rich and non-clay facies are compacted, and tight, suggesting a “stiffer” model. Vp and Rhob describes a different trend compared to the overlying sections.

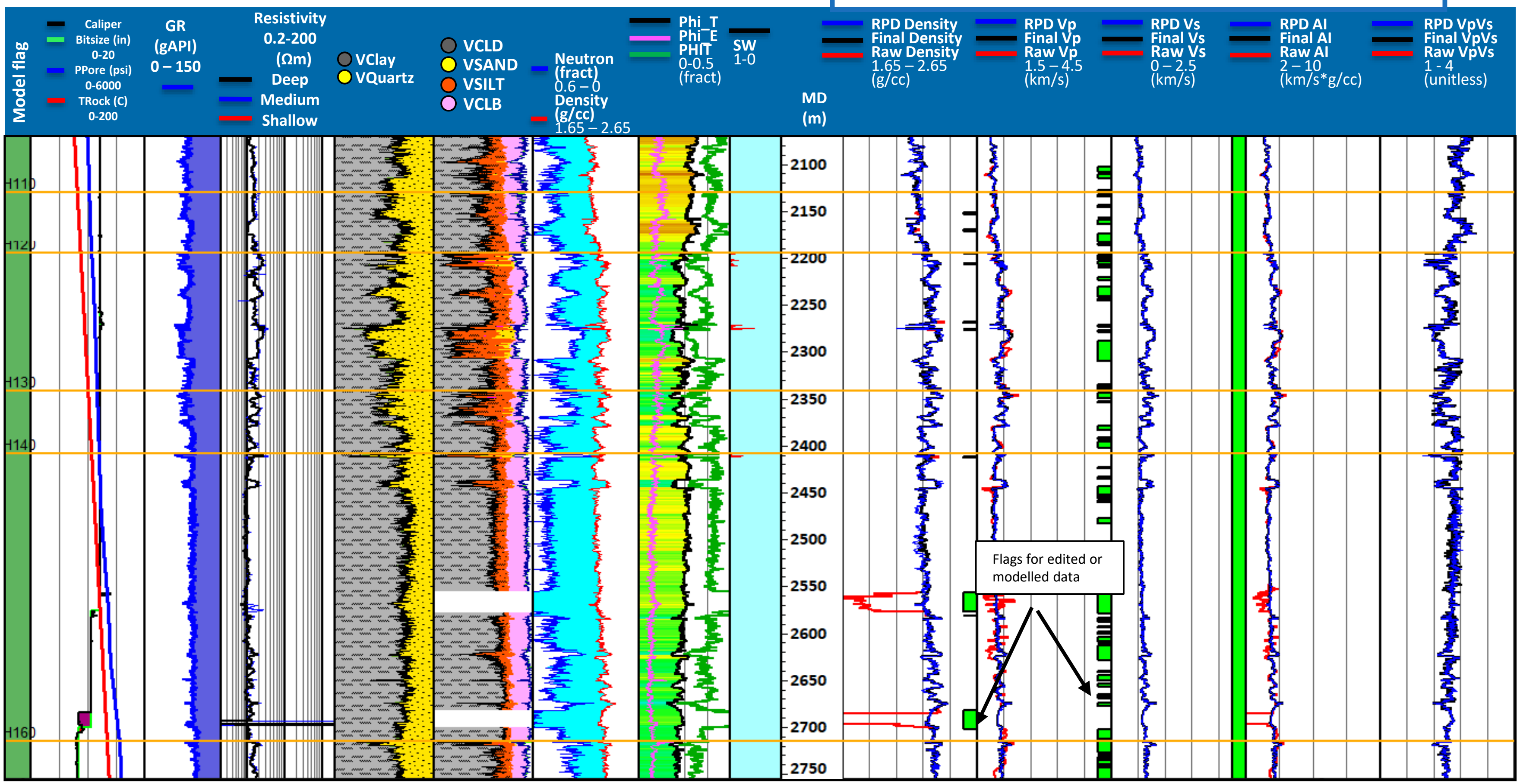
Bidara-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to 2750 m

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Unconsolidated rock model
- Stiff rock model



Density has been estimated in the vicinity of 2550 m and 2680 m, due to casing shoe locations. In the 2547-2578 m interval, Vp was also affected by the borehole conditions, therefore it was edited using the Faust relationship and then used as input to edit density via rock physics modelling. Vs has been entirely modelled in the well.

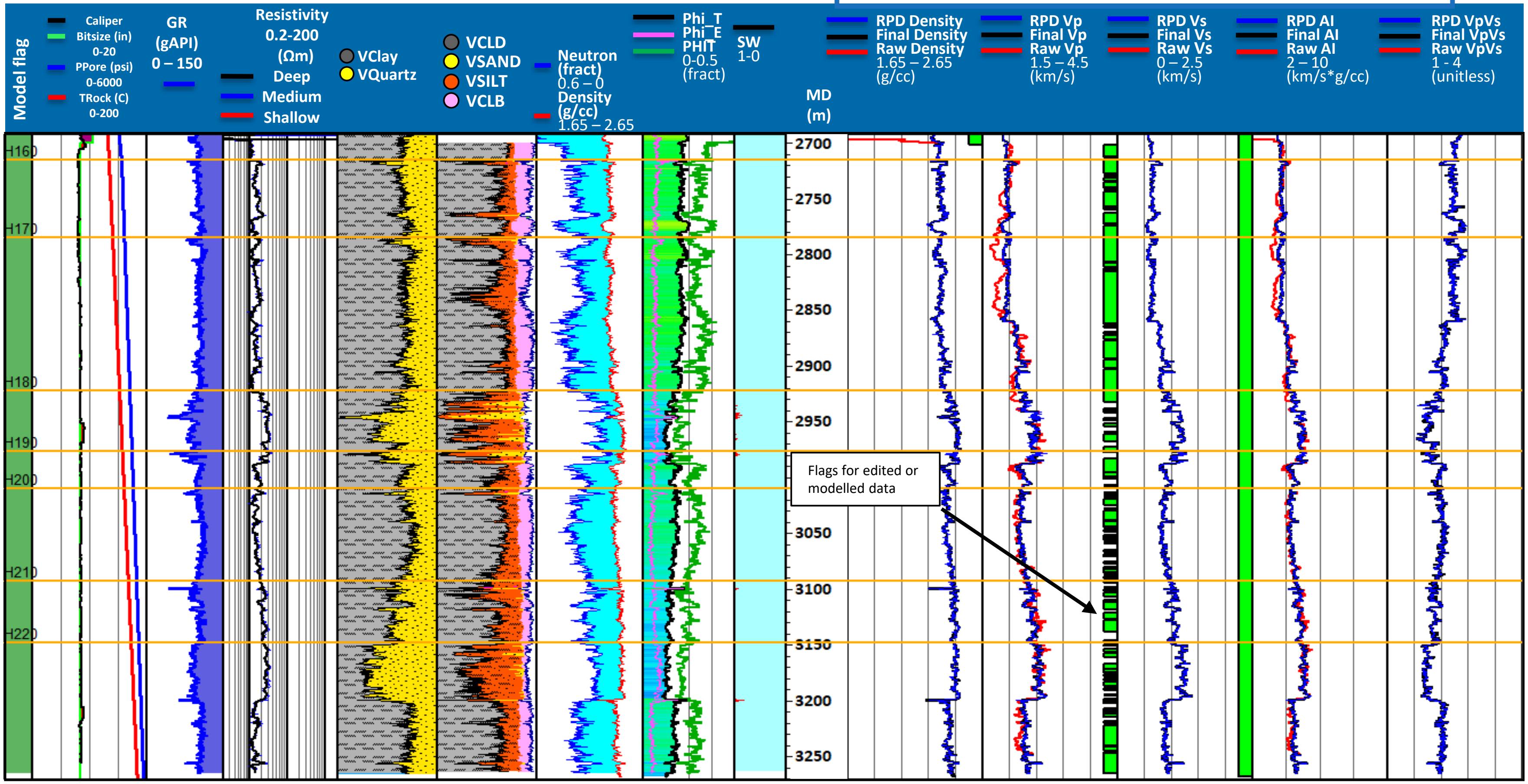
Bidara-1 Geophysical Well Log Analysis (GWLA) – Interval from 2700 m to Bottom

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Unconsolidated rock model
- Stiff rock model

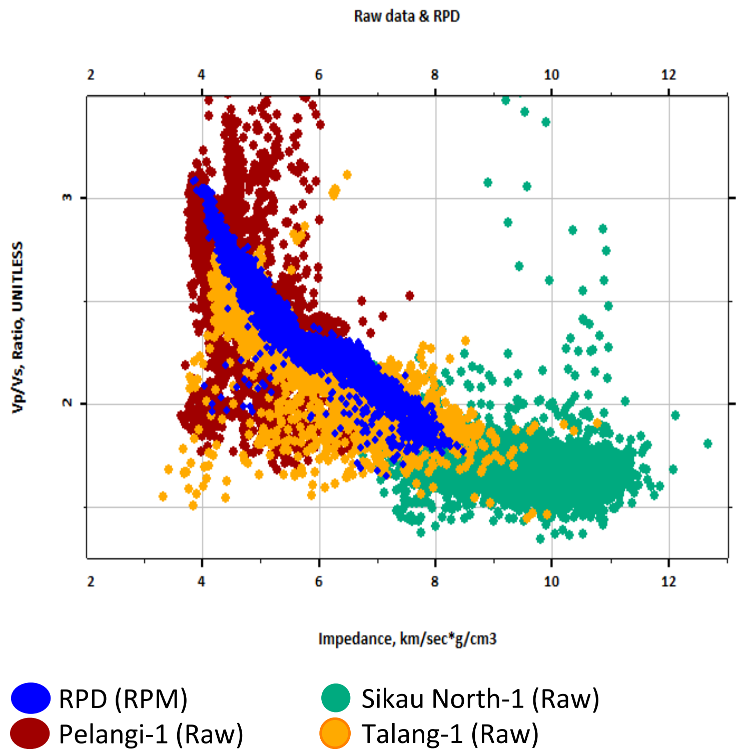


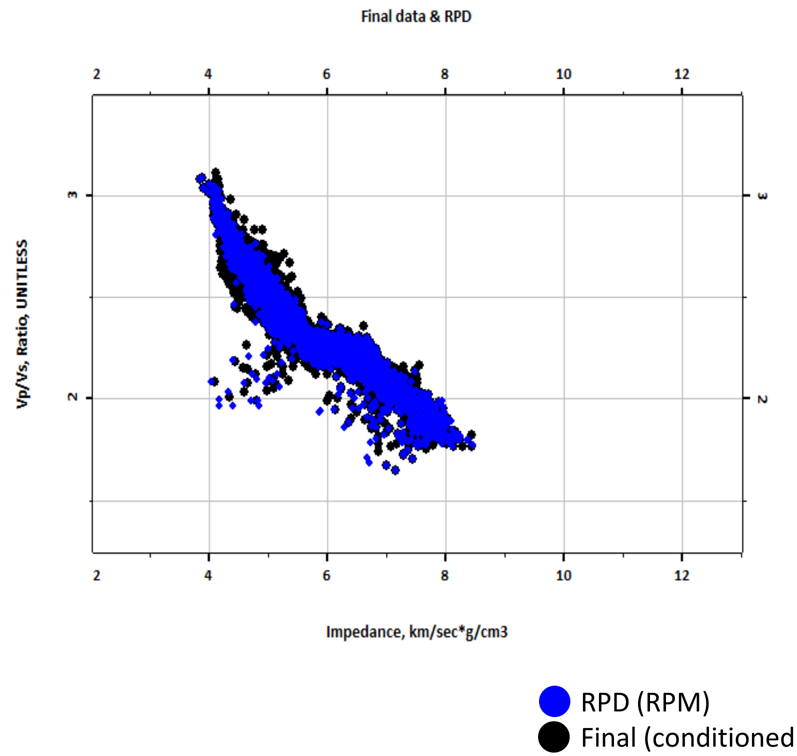
This section seems to be overpressured with a pore pressure gradient that could surpass the 0.62 psi/ft. Both, sands and shales, are harder compared to shallower sections, and sands tighter with poorer reservoir properties, particularly below H180. In the 2750- 2920 m section, the Vp appears to be off trend, probably attributed to the overpressure effect that has impacted Vp more than the rest of the logs. A distinct rock physics model was used in this section compared to the one applied in the "stiffer" rocks below 2850 m.

Bidara-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data, along with elastic data from analog wells with similar trends in the elastic space.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.





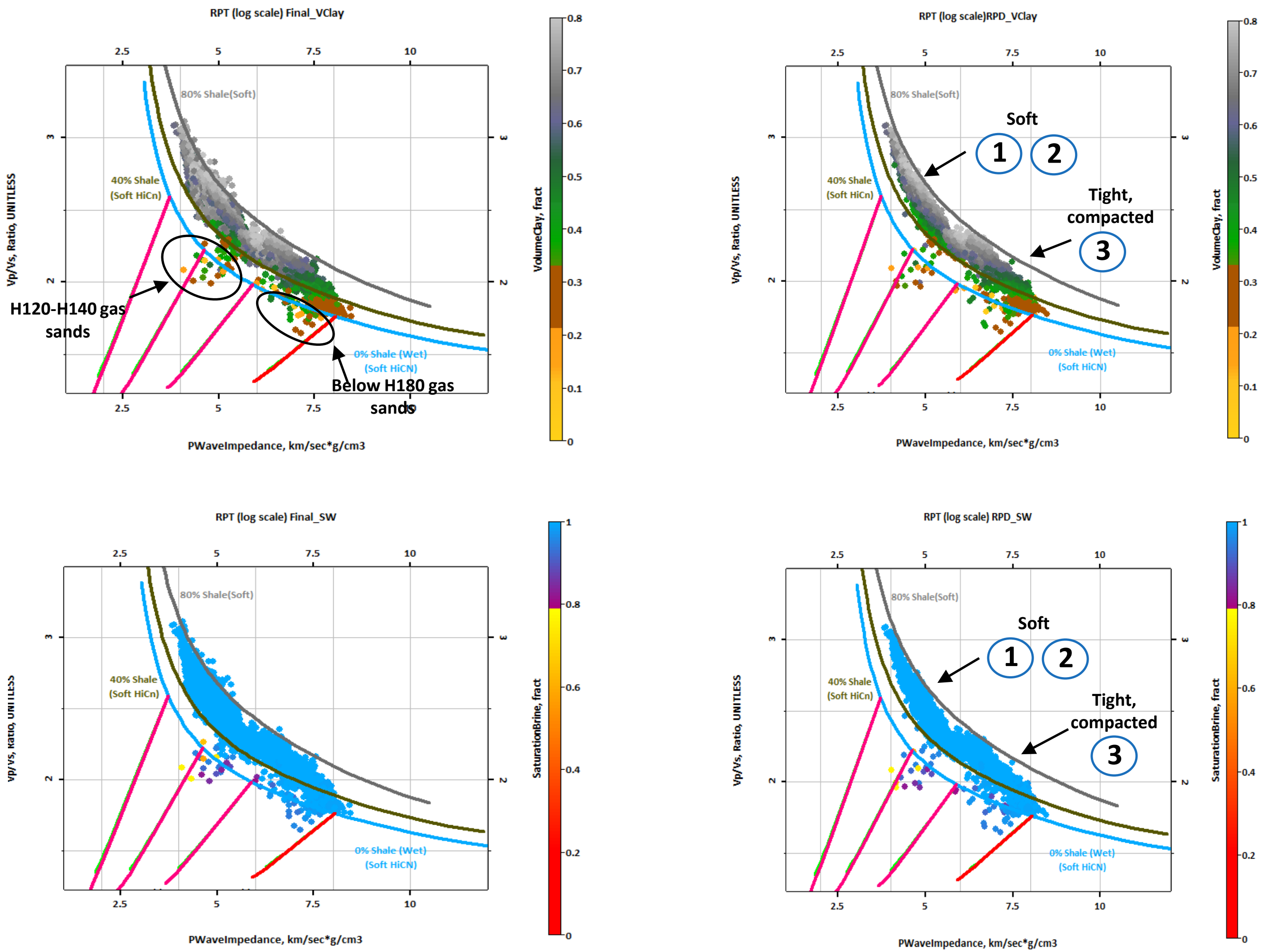
Bidara-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

Rock Physics Models

1. Soft facies, normal pressure
2. Soft facies, overpressured
3. Tight, compacted, overpressured

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Buah Naga-1

Buah Naga-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality and availability is fair. Some logs (gamma, resistivity) extend from 1280 m (below Seabed). Elastic logs, with the exception of Vp, extend from around 1914 m to 2053 m , but reliable data starts at 1922 m.
- Density measurements are of fair quality. Both, density and Vp are highly affected by borehole conditions in the 1982-2010 m section.
- Vp has not being acquired from 2032 to 2053 m.
- Vs has been acquired in small sections within the limestone reservoir (e.g. 1978-1981 m; 1985-1992 m; 2004-2034 m)
- Other logs include, Neutron, Caliper, Deep and Flushed Zone resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method. In localized zones, the density/neutron approach assisted the interpretation.

Reservoir characteristics:

- The well consists of a 55m thick claystone lying on top of a limestone that extends from 1977 m towards the TD (2061 m). There are no cutting returns to the surface in a considerable section of the carbonate. A karstified zone within the carbonate was observed at the top, approximately in the 1980-2010 m interval, based on the well log responses and the drilling mud loss in this section. The carbonate is high porosity (30% average porosity) but was interpreted as water wet and no shows were reported.

Volume of hydrocarbons:

- No prospective reservoir was encountered in the well, and the limestone observed in the 1976-2050 m section was interpreted as water wet based on logs and pressure gradient data

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were taken from the well report, which assumes this information based on data from other wells in the area: Rw=0.12 Ohmm @ 95F (45,000 ppm), with a=1, m=2, and n=2.

Buah Naga-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in clay-rich and an Intermediate Stiff Sediment Model with a variable Coordination Number with depth was more suitable in the non-clay rich facies. These models have been used to edit the Vp and Rhob data where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock physics modelling (RPM) stage of the project. Vs data was modelled using Granular Media.

Fluid properties:

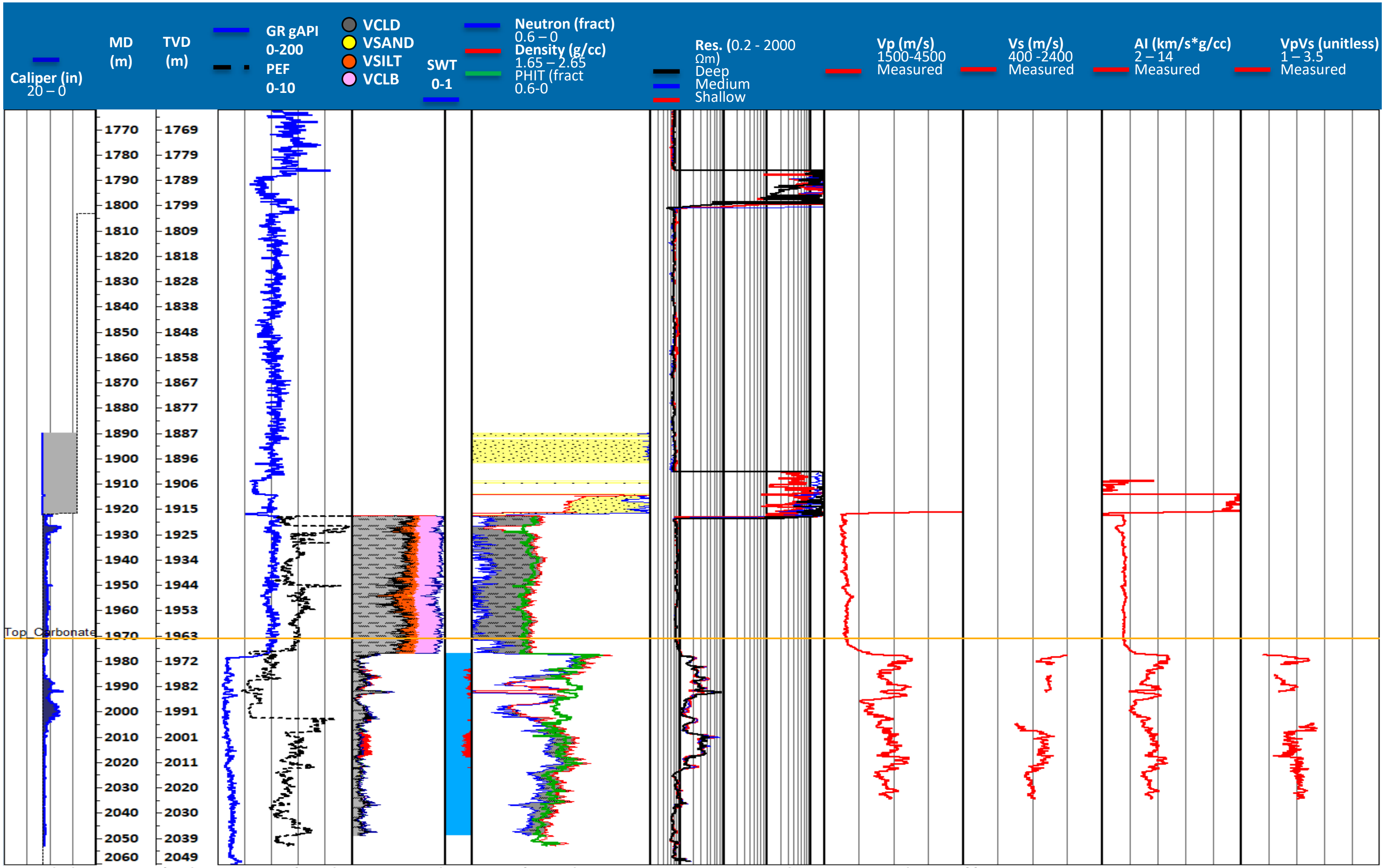
Hydrocarbon properties used in substitution have been obtained from PVT analysis performed on samples of the Spaoh-1 well:

- Brine salinity: 45,000 ppm
- Gas gravity: 0.68
- Oil Gravity: 52 API
- Gas / Oil ratio: 192 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Lower Miocene carbonate section only.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – Buah Naga-1



Additional data includes mud weight data, pressure data, and well reports.

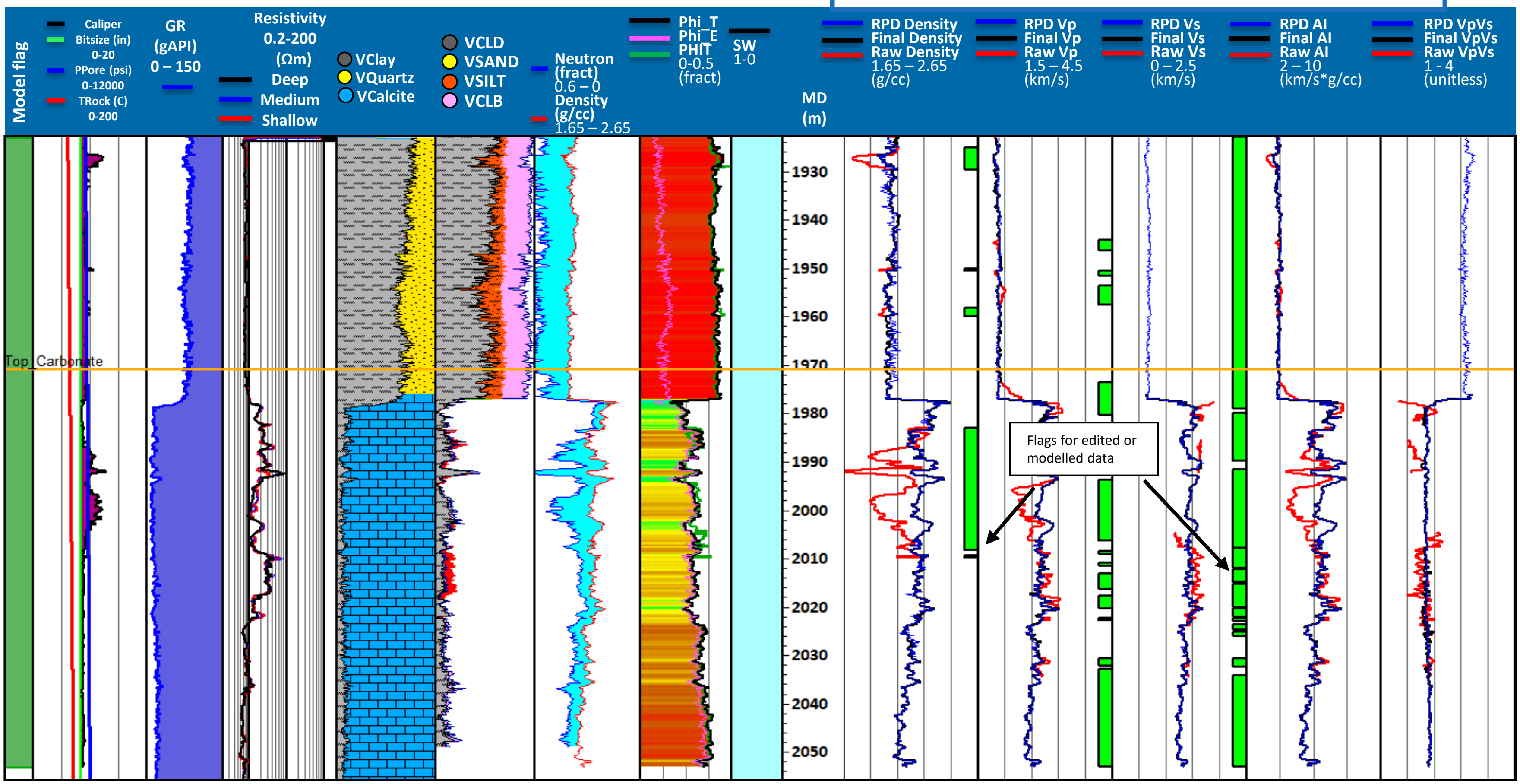
Buah Naga-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to Bottom

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

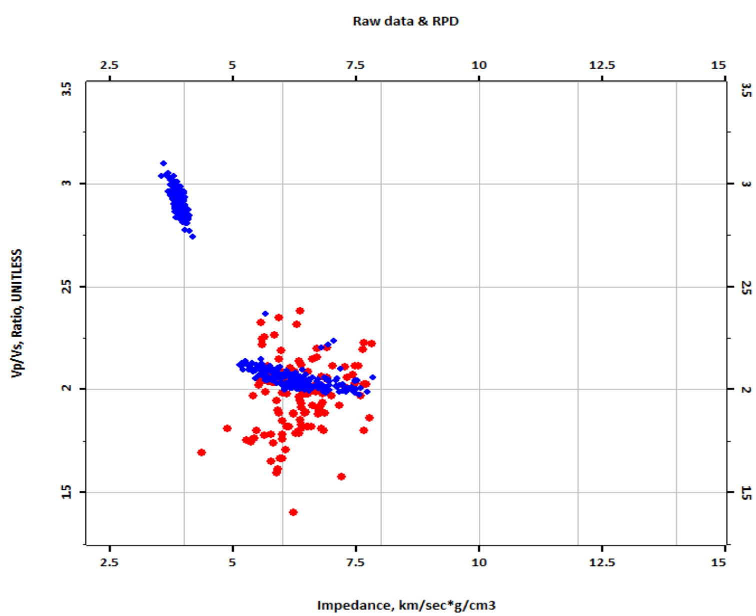
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Density and velocity readings are affected by the presence of karst (1985-2010 m), producing an enhancement of the borehole size affecting the elastic measurements. Vp was corrected in this interval using Faust relationship and density was subsequently estimated using Vp and rock physics modelling. Vp was estimated in the 2030-2050 m section to extend the log towards the end of the well. Vs was acquired only in small sections within the limestone reservoir and when required, was replaced by a modelled one using Granular Media.

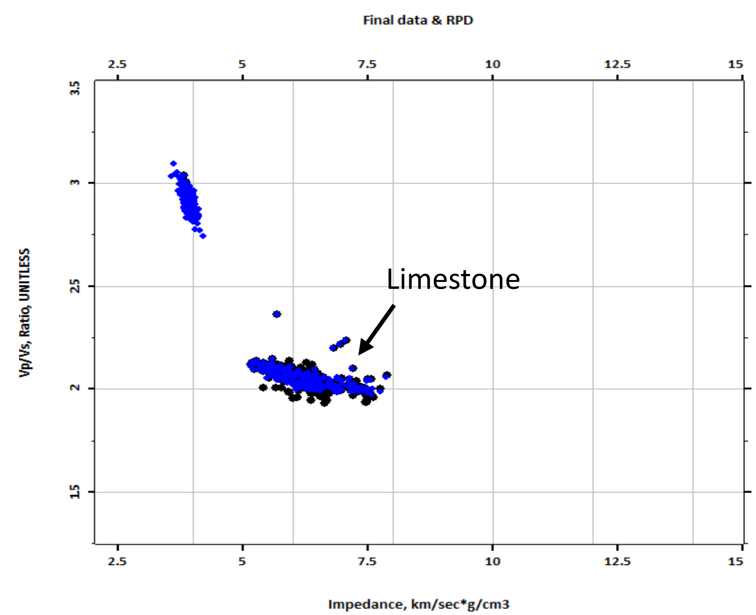
Buah Naga-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing only the RPD model estimated elastic variables.



- RPD (RPM)
- Original Raw (Raw)

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

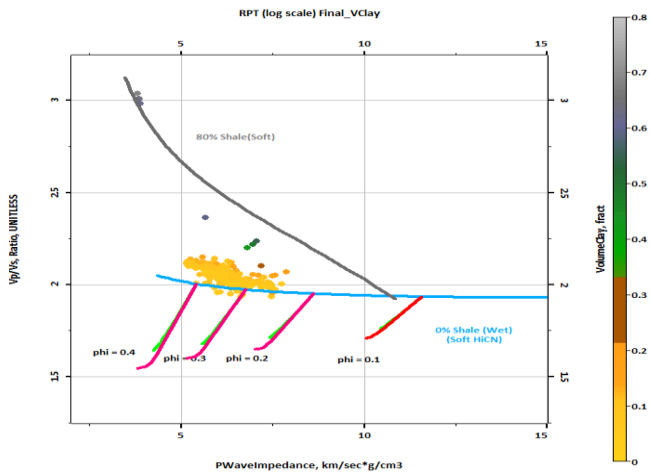


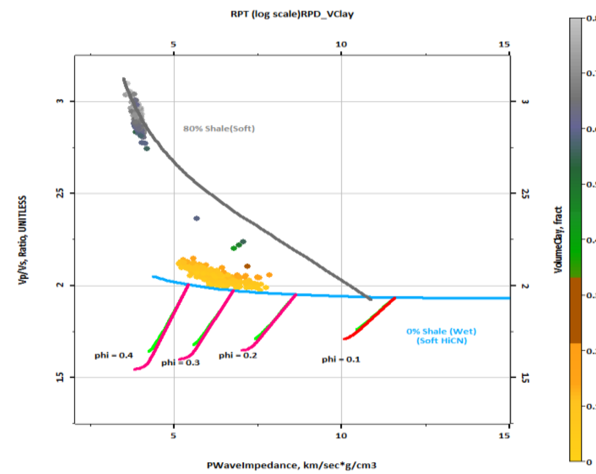
- RPD (RPM)
- Final (conditioned)

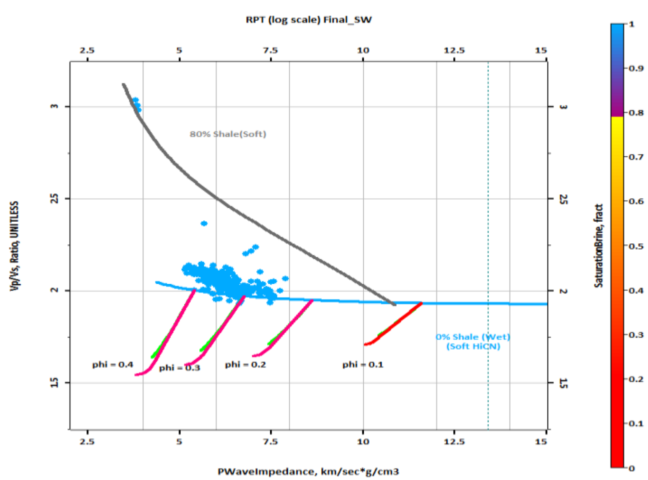
Buah Naga-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

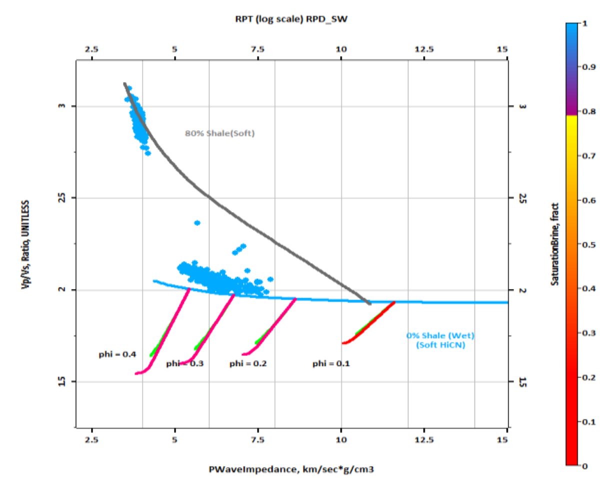
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Bukoh-1

Bukoh-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited near the casing depth(3470-3540m) using the RPD due to bad measurement.
- Vs was edited in some intervals in the section (3000-3250m)using the RPD in order to have consistent VpVs ratio results.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Intra cycle II and I sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with decreasing porosity towards the base of the section.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section the clean wet sand section(3150-3300m) yielded a formation water salinity of 39000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2900m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Krief model was used to replace the VS data where it looks unreliable.

Fluid properties:

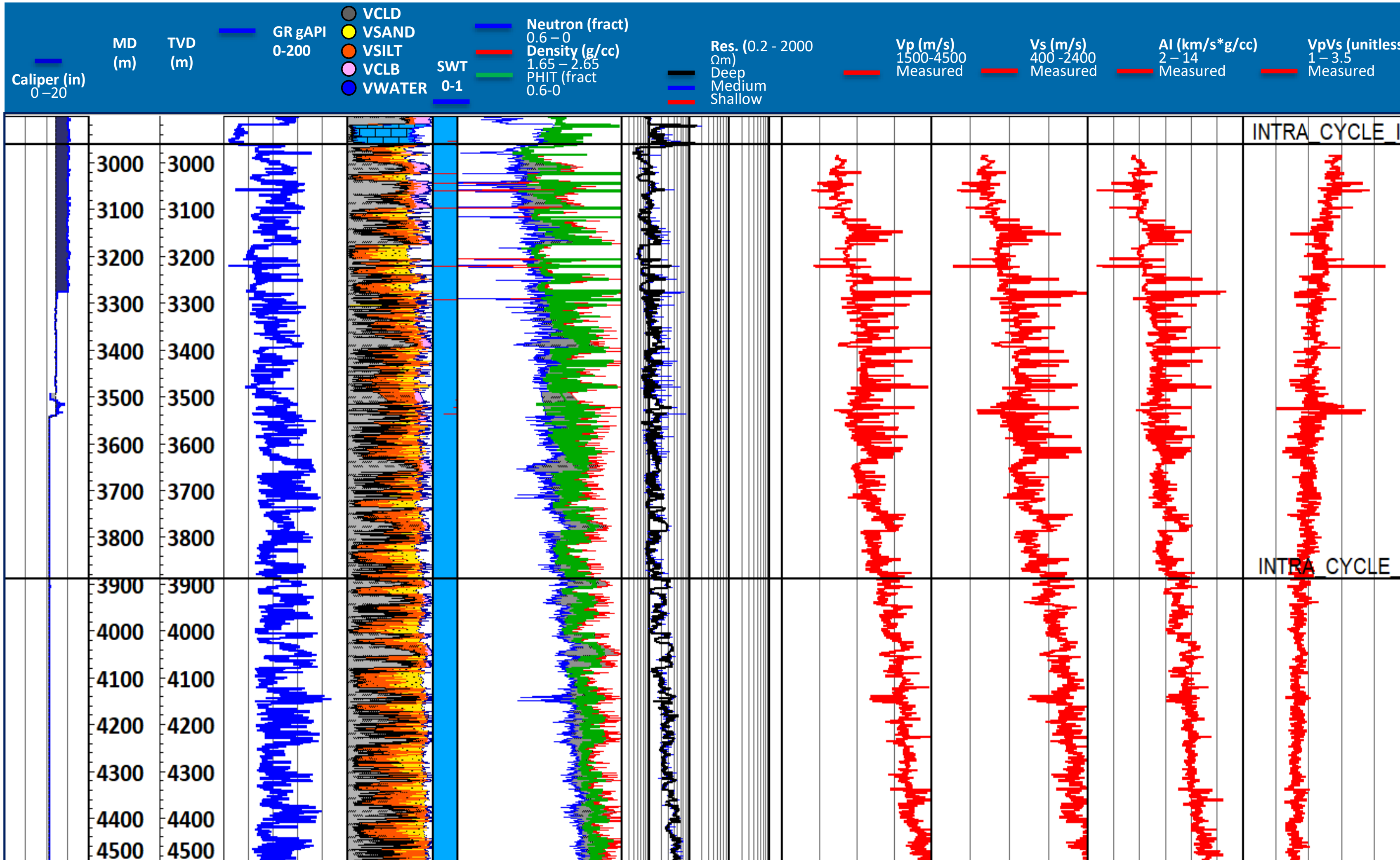
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 39000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of Intra cycle I and II using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class IV was observed near a good porosity sand @ 3400m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) no significant change for the AVA class could be noticed.
- AVA class III was observed near a lower porosity sand @ 4075m for all hydrocarbon cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no significant change for the AVA class could be noticed.

Bukoh-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Bukoh-1 Geophysical Well Log Analysis (GWLA) – Interval Of Intra Cycle II

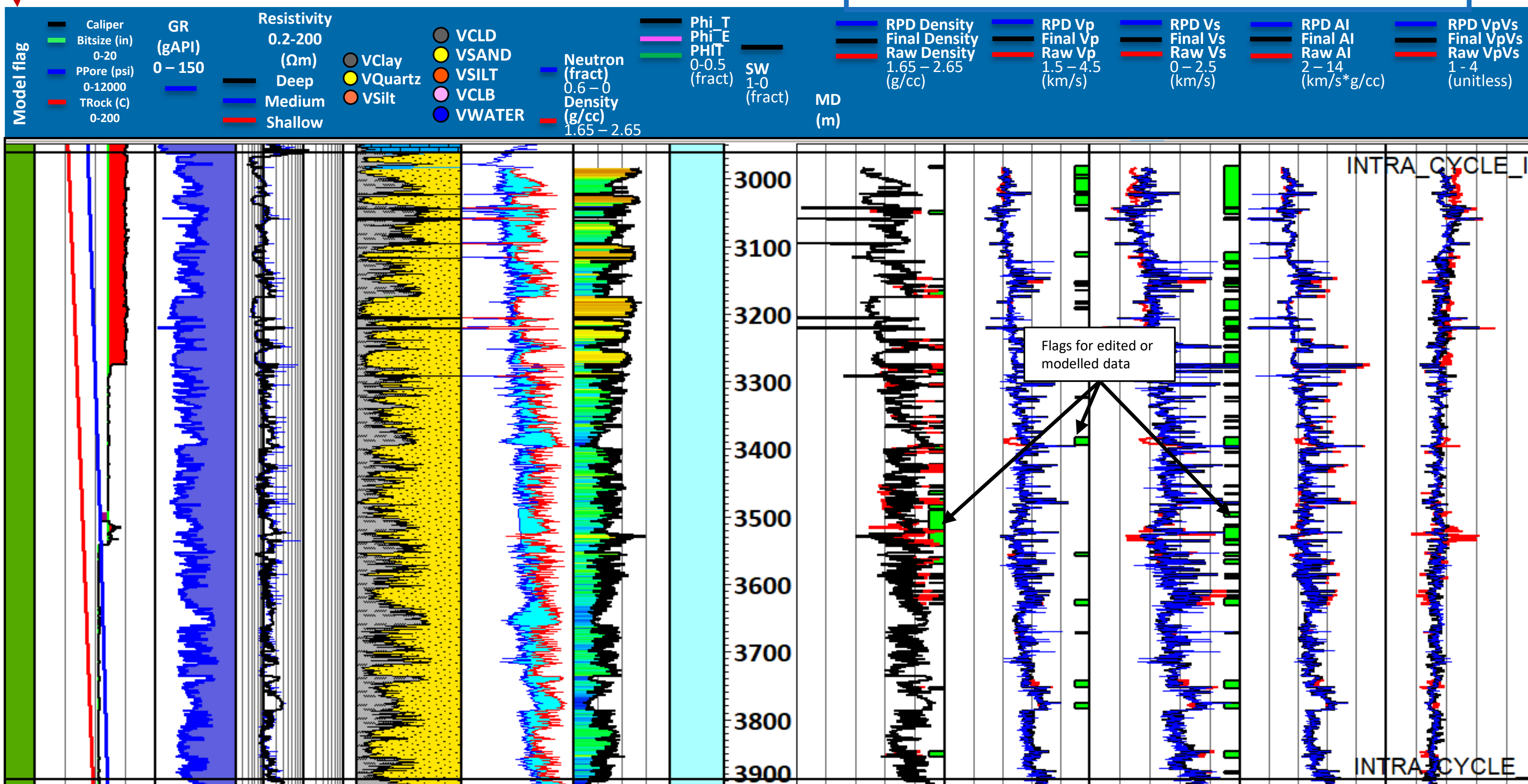
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2900m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Bukoh-1 Geophysical Well Log Analysis (GWLA) – Interval Of Intra Cycle I

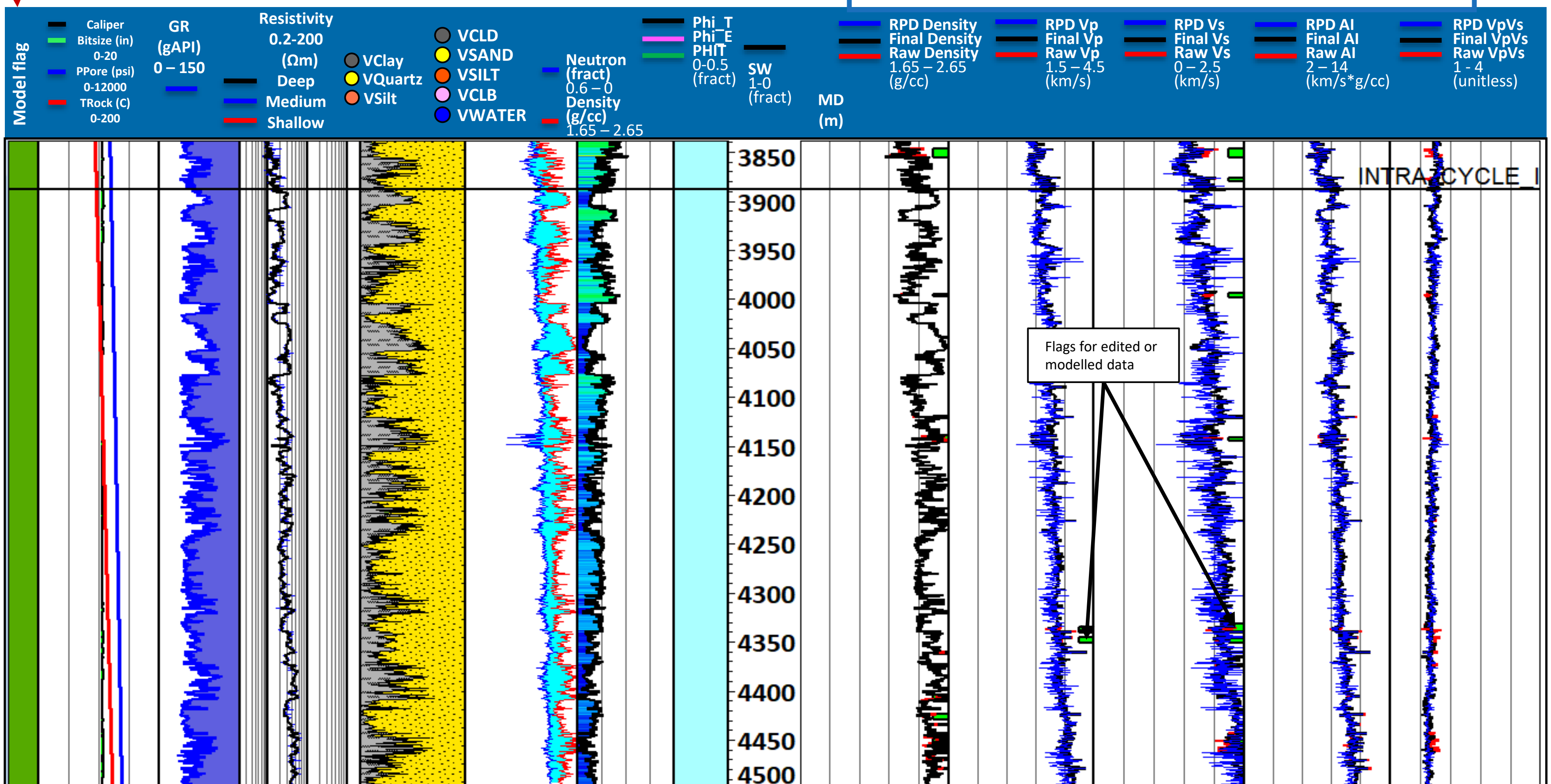
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2900m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

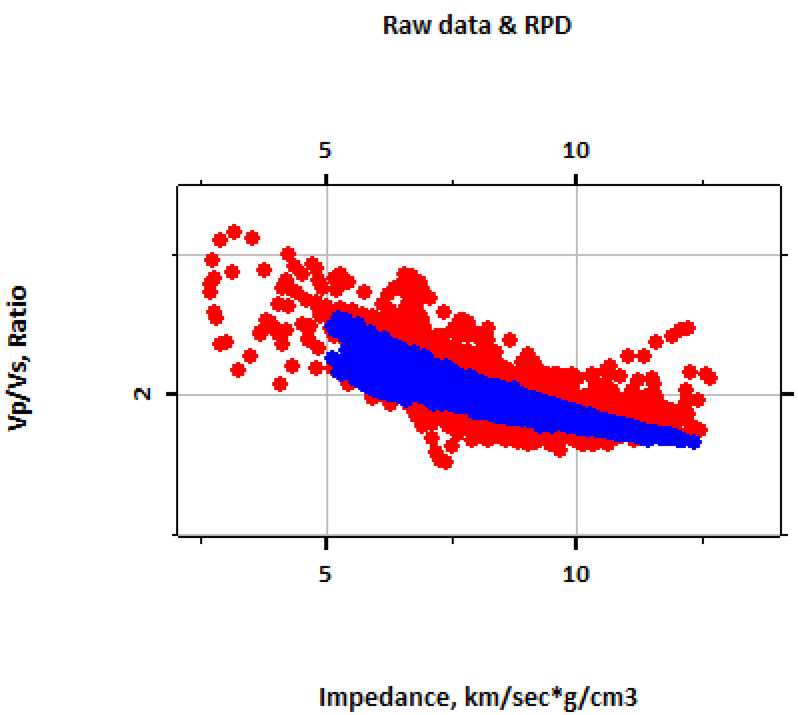
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

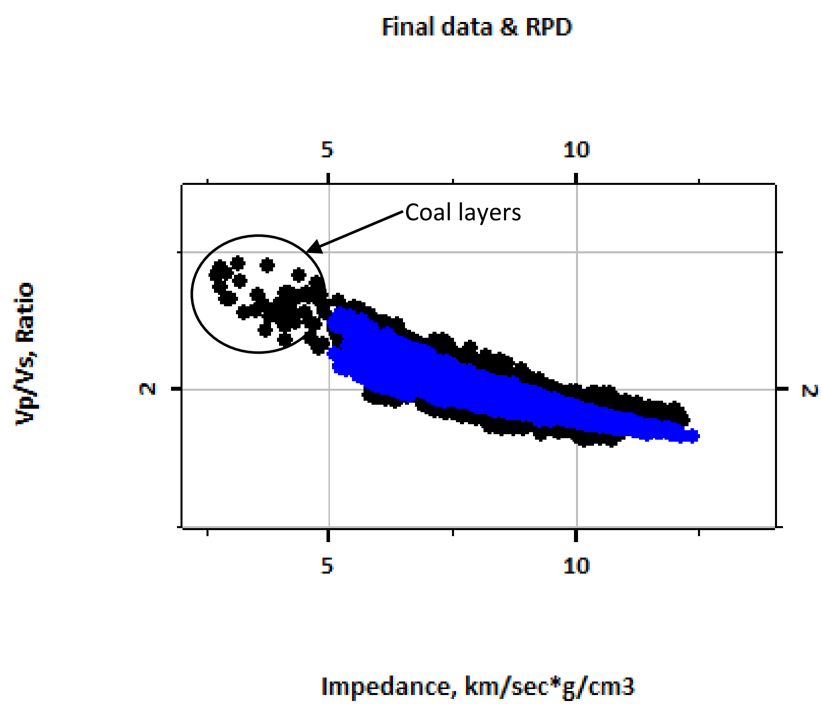
Bukoh-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.



RPD (RPM)
Original Raw (Raw)

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

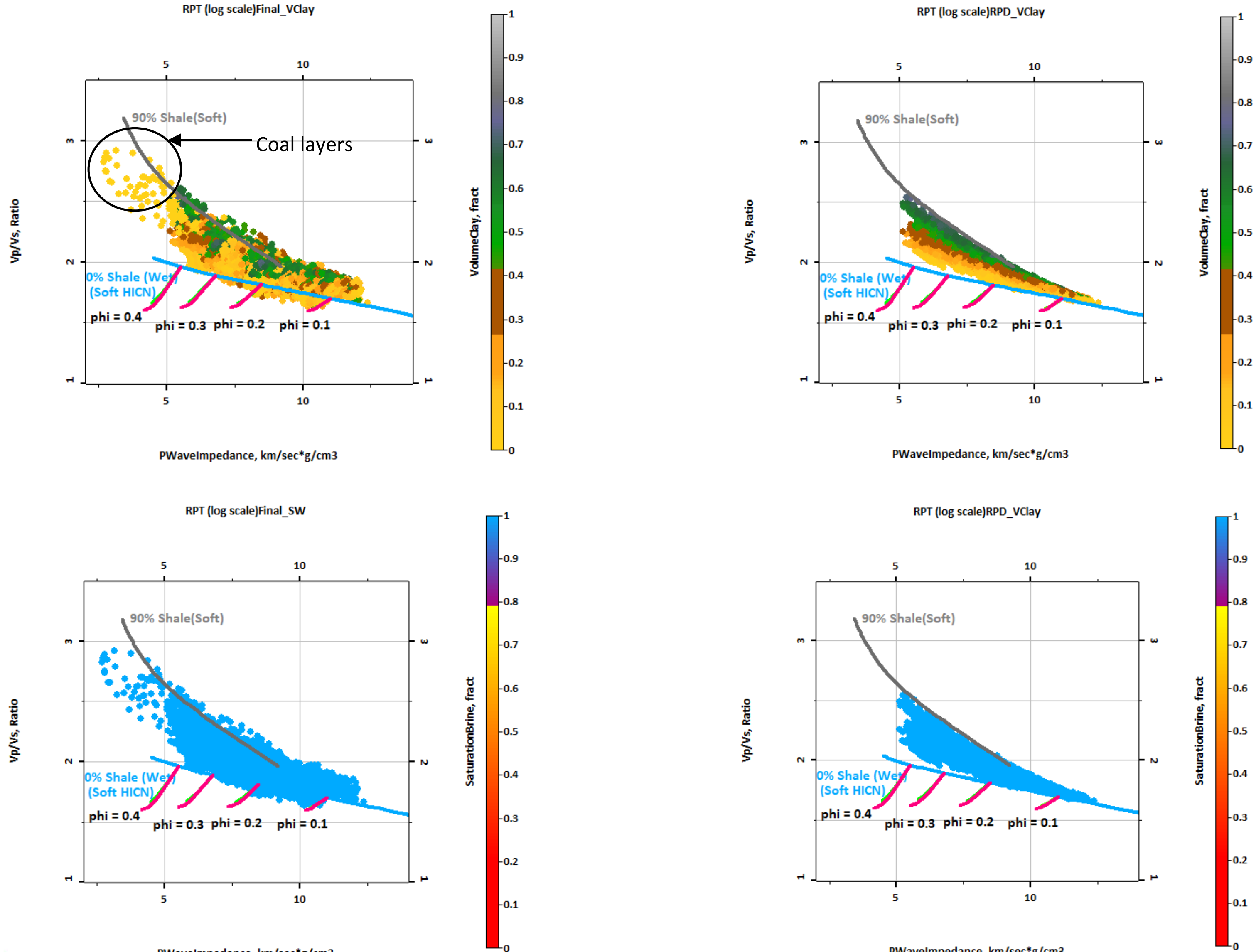


RPD (RPM)
Final (conditioned)

Bukoh-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

D8-1

D8-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is variable between the logs. The density log looks heavily damaged and bad density reads are associated to the presence of borehole rugosity as it evidenced where there is caliper log availability. Most of the well log suites run from 150 m to 2280 m **.
- Density measurements are of good quality in general. Minor edits were applied in shallower intervals.
- Vp log quality is good to poor. Enough data was found to be of enough quality so a rock physics diagnostics could be performed and a model could be selected for further editing and estimation of the different logs. considered good, and suffers from low frequency content. As a measure of the quality of the sonic log, an estimate was calculated using a modified Faust model, giving excellent correlation with compressional data. This is an indication that the sonic data is of fair to good quality.
- Shear data was not measured in this well.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The primary objective of D8-1 well was to test the subzone between the Pcs.38 and Pcs145 markers. In this interval sand bodies develop with fair thickness. Best reservoir sands show average thickness of 20 meters and porosity values from 12 % to 14 %.

Volume of hydrocarbons:

- No hydrocarbons were logged in well D8-1. Petrophysical interpretation shows 100% water saturated sands.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=2. Water resistivity used to interpret Sw: Rw=0.17 ohmm @ 187 F (14,000 ppm).

** Depths referred in this report are MD.

D8-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clay rich and sand facies. Several intervals were selected, where it was believed the presence of good measured density and compressional velocity data.
- Editions and estimation were performed mainly using granular media unconsolidated rock physics model. In some intervals, especially in the upper section above the gap present at around 700 m, Faust model was used to estimate the compressional velocities as the compressional velocity log proved to be inconsistent with the rock physics model. Density measurements were also bad in this upper interval.
- Shear velocities were estimated using the unconsolidated model. Data from other wells (ROMPIN-1) where superposed to check the validity of the prediction. Although ROMPIN-1 is not close to D8-1 (is the closest well with reliable shear information), shear data from this well was used as reference. The shear velocity logs of both wells, show to follow the same trend.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken in a near by well (SPAOH-1), particularly the gas properties. Average values were taken from nearby wells for oil properties. Main parameters used in this modelling are:

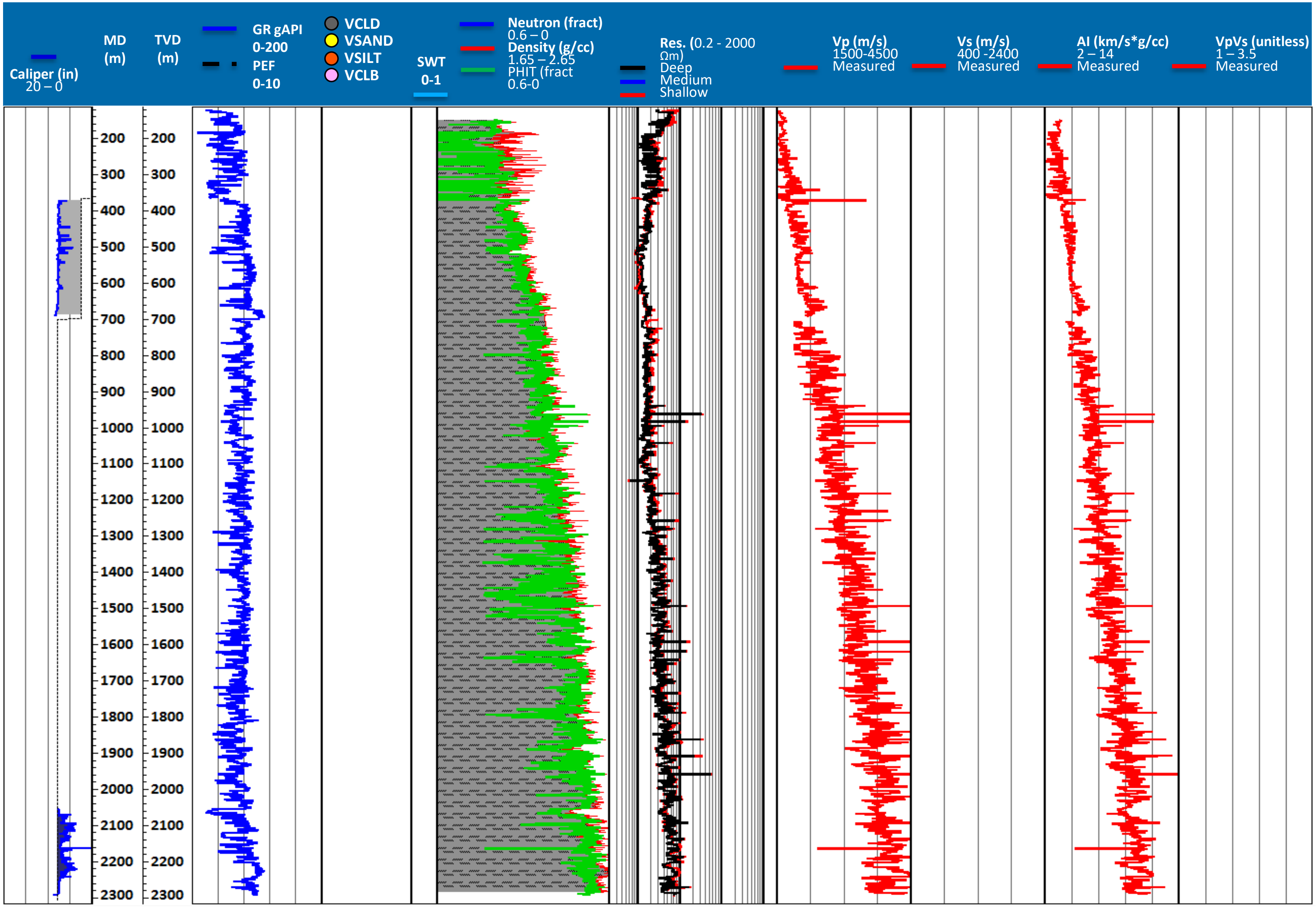
- Brine salinity: 14,000 ppm (Calculated from Picket analysis)
- Gas gravity: 0.9 (Value selected based on nearby data)
- Oil Gravity: 39 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in sands appearing in the subzone between Po3.79 and Phc88 markers of the well. Targeted was the sand at 2060 m of this section. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Gassmann and Brie models.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As in the selected example, the sand package at 2060m (Gas bearing sand in Cycle II) was gas substituted allowing the Water saturation to be reduced to 20%. Porosity was preserved for this exercise. This exercise showed lower values for VpVs ratio and lower values for Acoustic Impedance compared to the wet case.

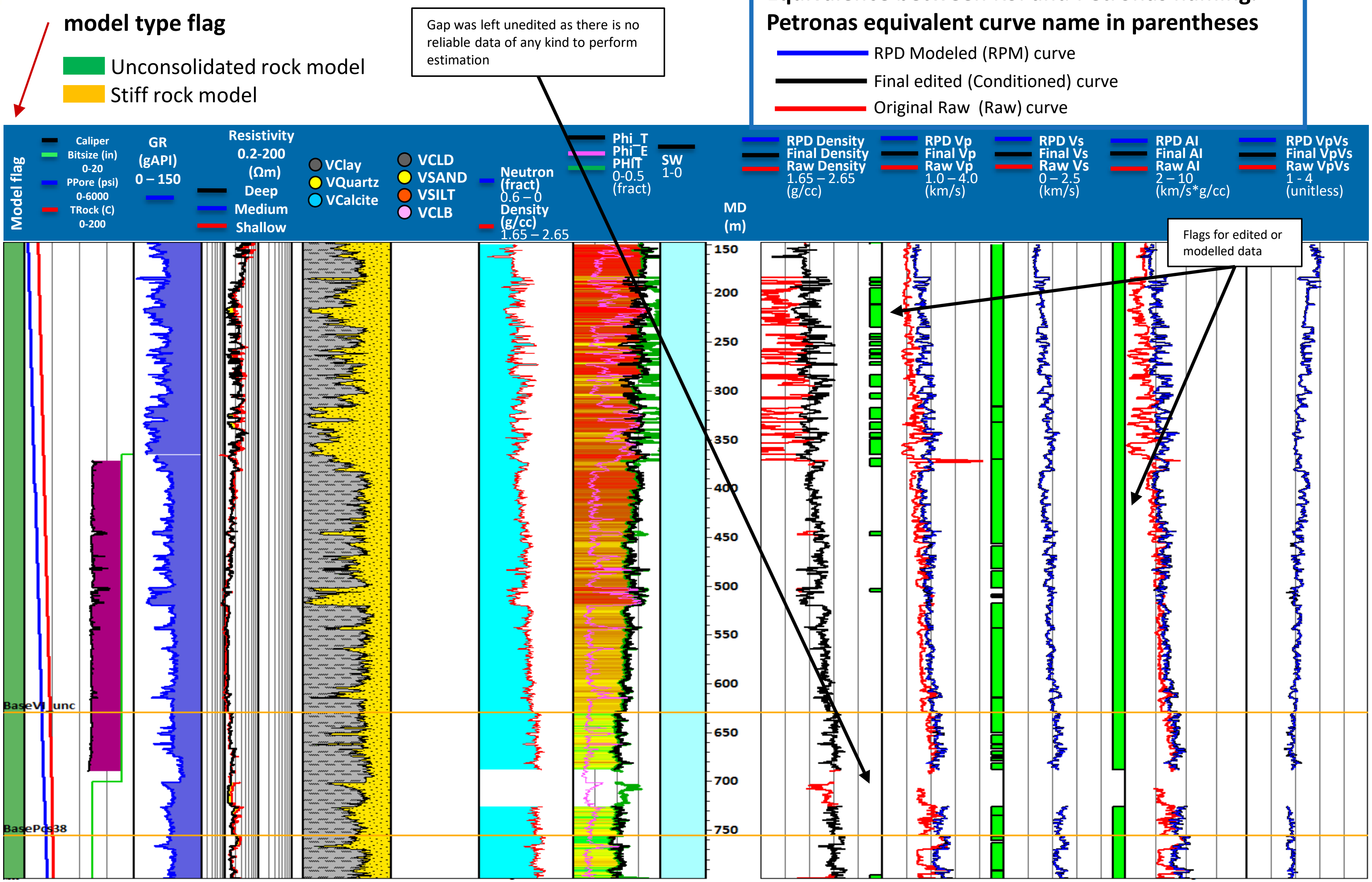
** Depths referred in this report are MD.

Input Logs – D8-1



Additional data includes mud weight data, pressure data, petrography and well reports.

D8-1 Geophysical Well Log Analysis (GWLA) – Interval from 150 to 750 m



Compressional velocity was considered to be reading consistently low in this interval. A modified Faust model was used where the density was of very bad quality. Elastic logs in the gap section at 700 m were left unedited given there is no data available.

D8-1 Geophysical Well Log Analysis (GWLA) – Interval from 150 to 750 m

model type flag

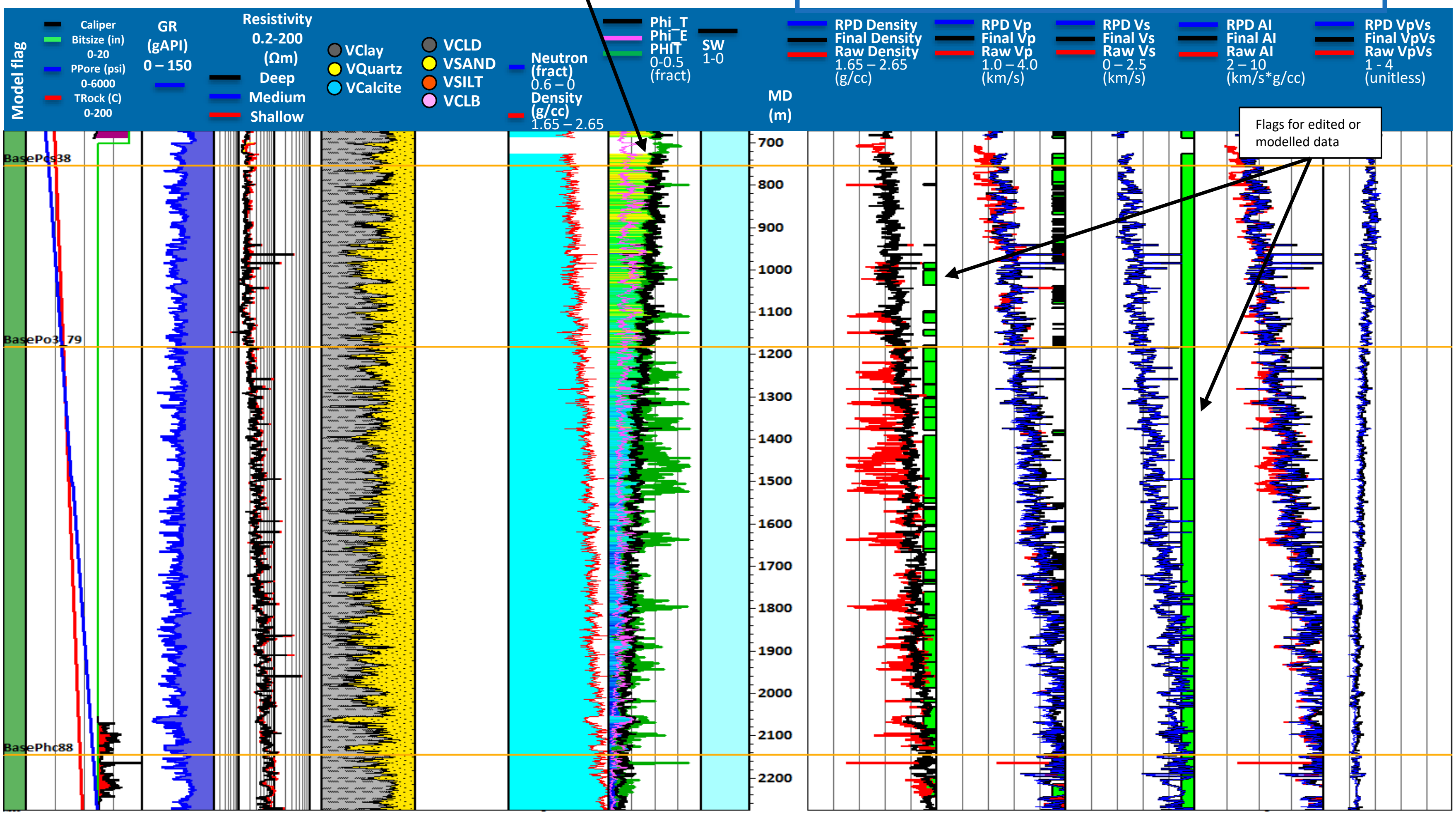
Unconsolidated rock model

Stiff rock model

Gap was left unedited as there is no reliable data of any kind to perform estimation

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

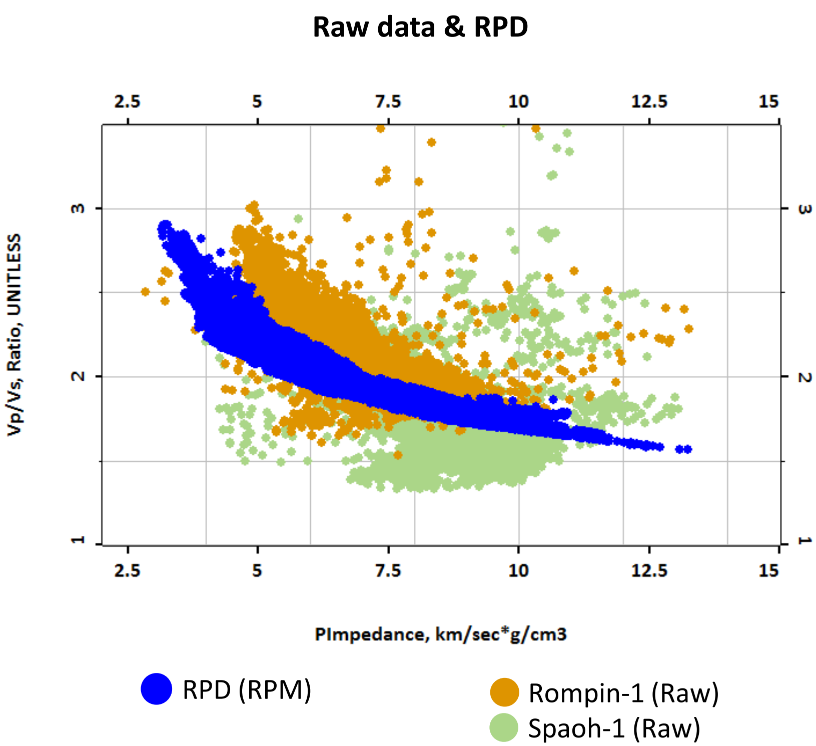


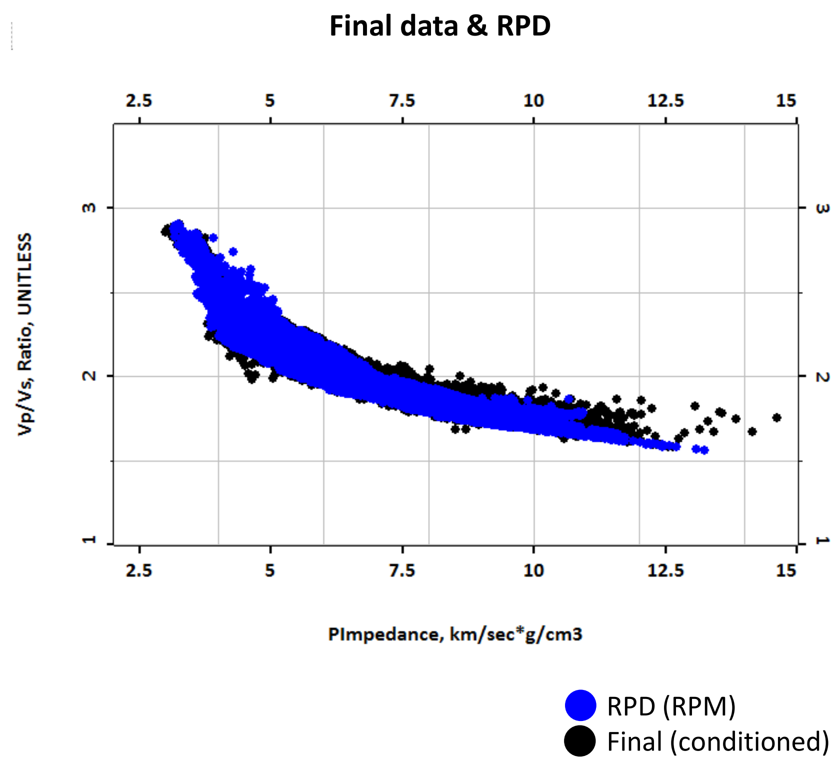
In this section the quality of elastic logs improves, however the density log is heavily affected by borehole rugosity. Elastic logs in the gap section at 700 m were left unedited given there is no data available.

D8-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data, along with elastic data from other wells. Rompin-1 and Spaoh-1 wells are not close to D8-1, although they are the closest ones. Data id plotter for reference only.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

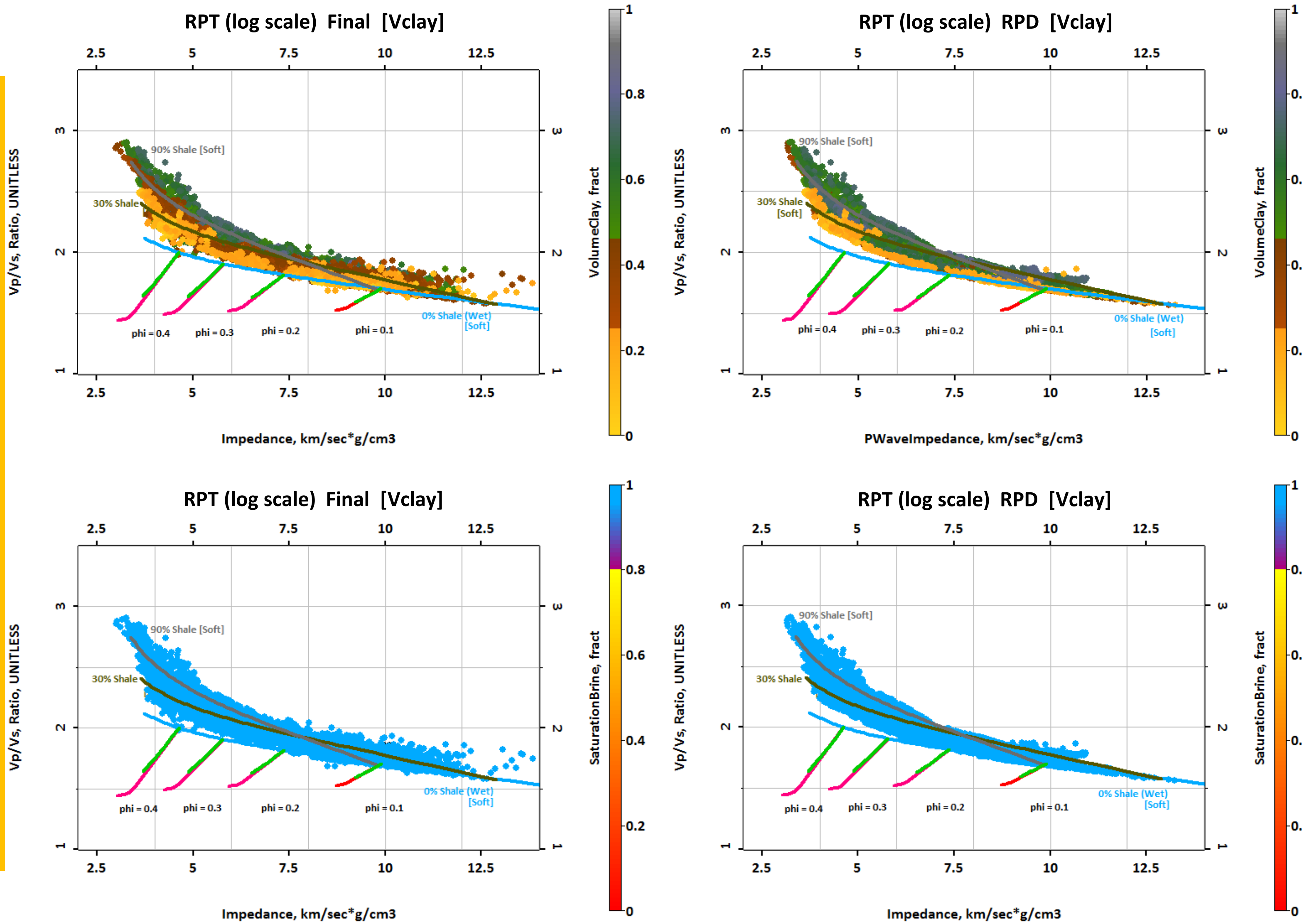




D8-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Dayung-1

Dayung-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was not for this well. The interval covered with the log suite was too short(600-800m), full elastic logs were available in the whole interval with good quality.
- Vs was edited in the gas sand section due to low resolution when compared to density and VS.
- Vp and Vs were edited in some intervals in the well due to flat or lazy readings using the RPD in order to have consistent VpVs ratio results and normal relationship between quartz rich and clay rich sediments.
- Density in the gas sand interval was corrected for invasion.
- Other logs include Gamma, SP, Caliper, Deep resistivity and Neutron which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method except in the interval(685-700) where Neutron/Density was used in combination was Gamma ray.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sand(cycle VI). The sand section penetrated in the well was a blocky sand interval grading to siltstone or claystone in some interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were tight and 100% brine saturated except the blocky sand in cycle VI where the gas saturation was about30-40% in average .

Water saturation (Sw):

- Water salinity obtained from water sample test in well Nuang-1 was used and reflected RW of about 0.175phmm @ 123 degF. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (based on regional area knowledge).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(620m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- S-wave velocity was calibrated also using Greenberg-Castagna relationship which produced a matched results to the one obtained using the RPD(soft model) .

Fluid properties:

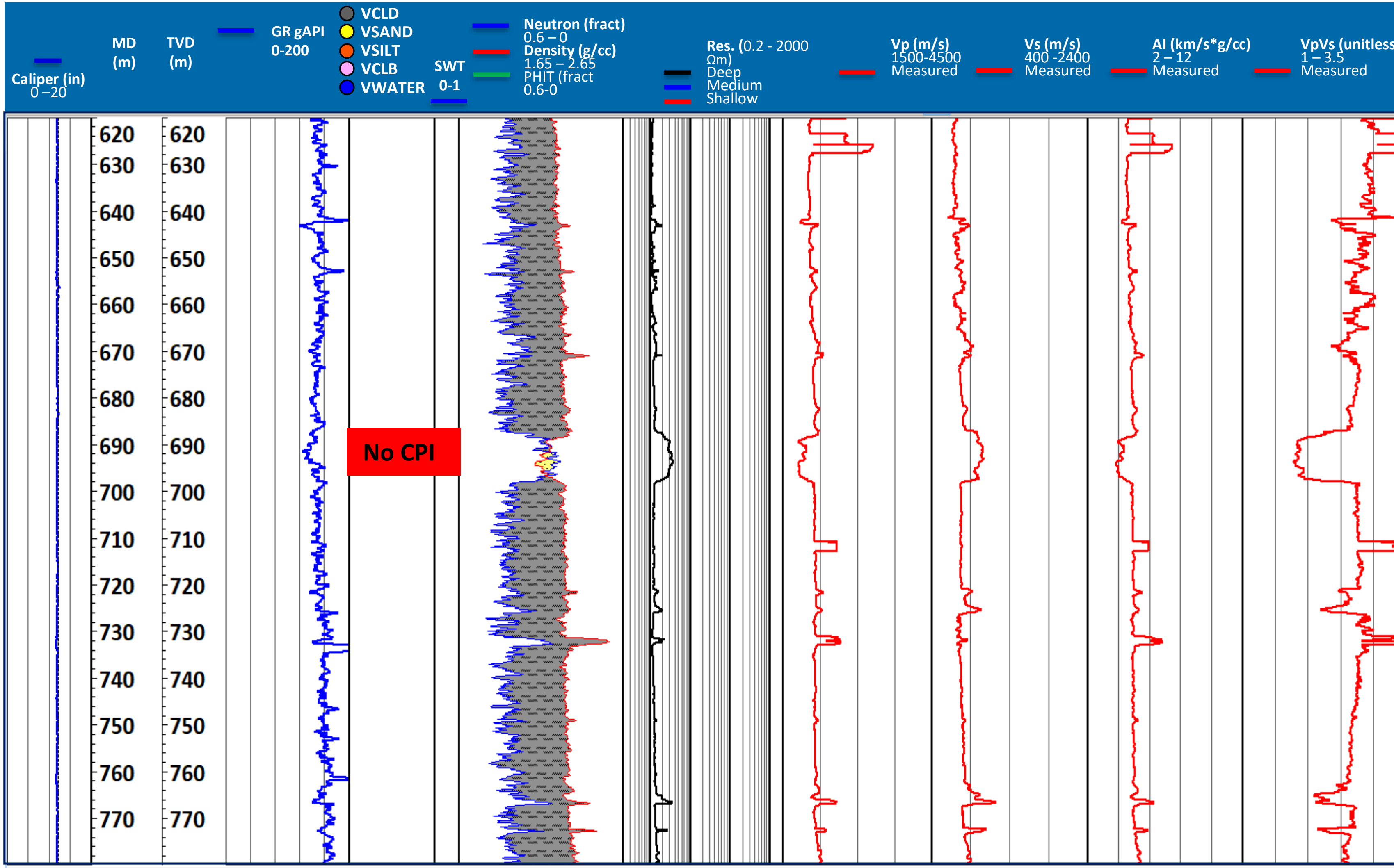
Fluid properties used in substitution have been assumed based PVT results from a nearby well(Nuang-1). Main parameters used in this modeling are:

- Brine salinity: 21500 ppm[Pickett plot]
- Gas gravity: 0.86[assumed]
- Oil Gravity: 38.1 API[assumed]
- Gas / Oil ratio: 263 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sand(cycle VI) using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class III was observed near the top of a low impedance blocky gas saturated sand @686m for all the hydrocarbon cases while the wet case can not be discriminated from the background shale cloud at the insitu reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) the oil and wet scenarios started to show class II AVO response with no change to the gas case.

Dayung-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions(Final geological report).

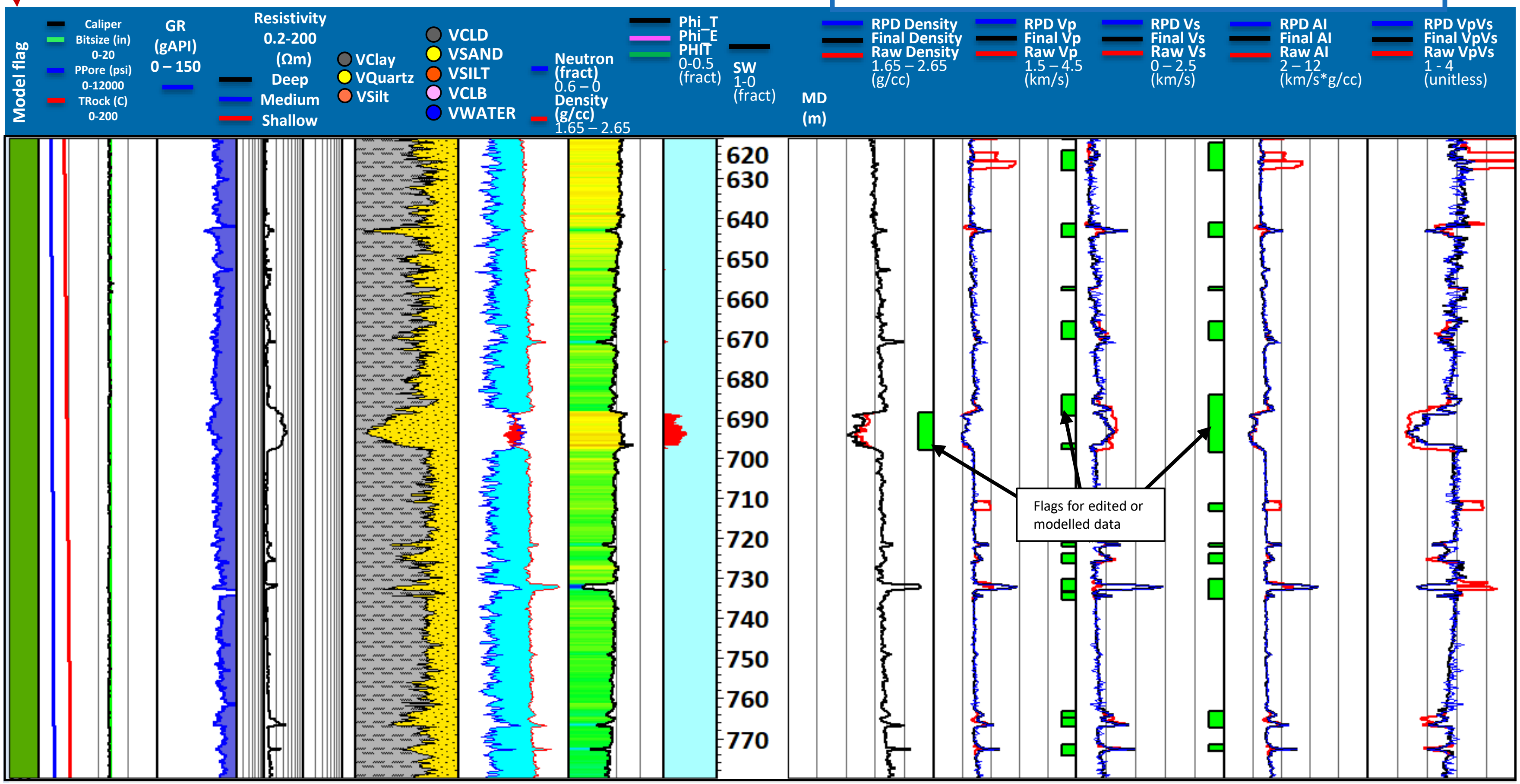
Dayung-1 Geophysical Well Log Analysis (GWLA) – All Well Interval

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

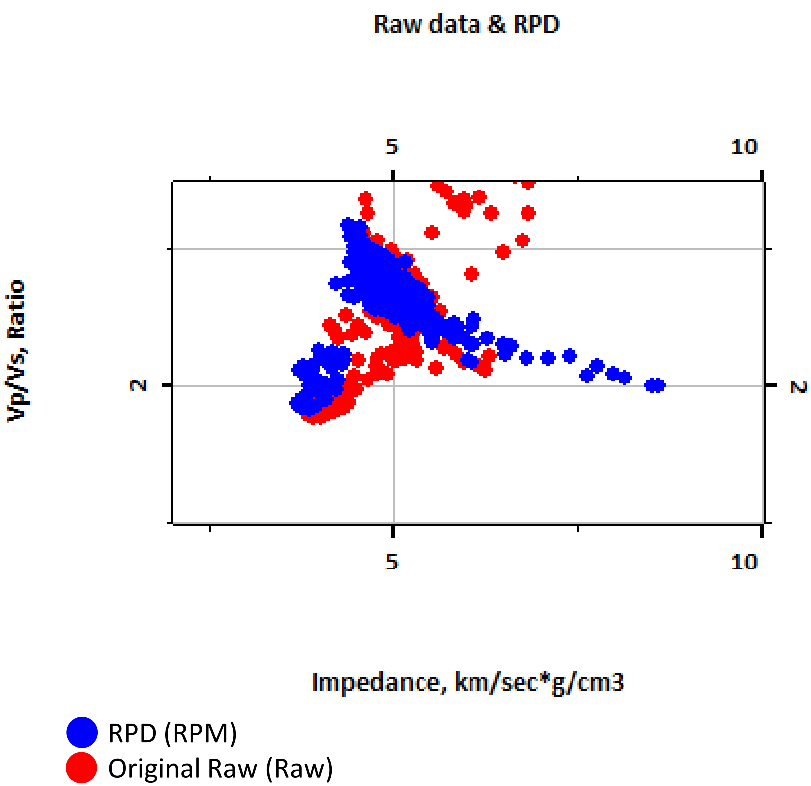


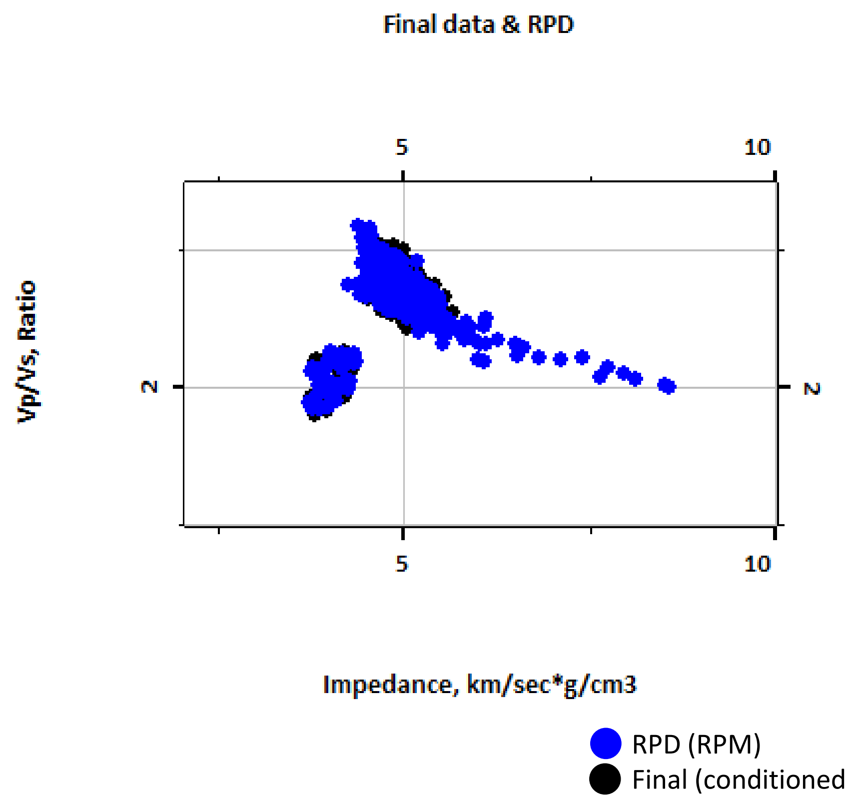
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Dayung-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

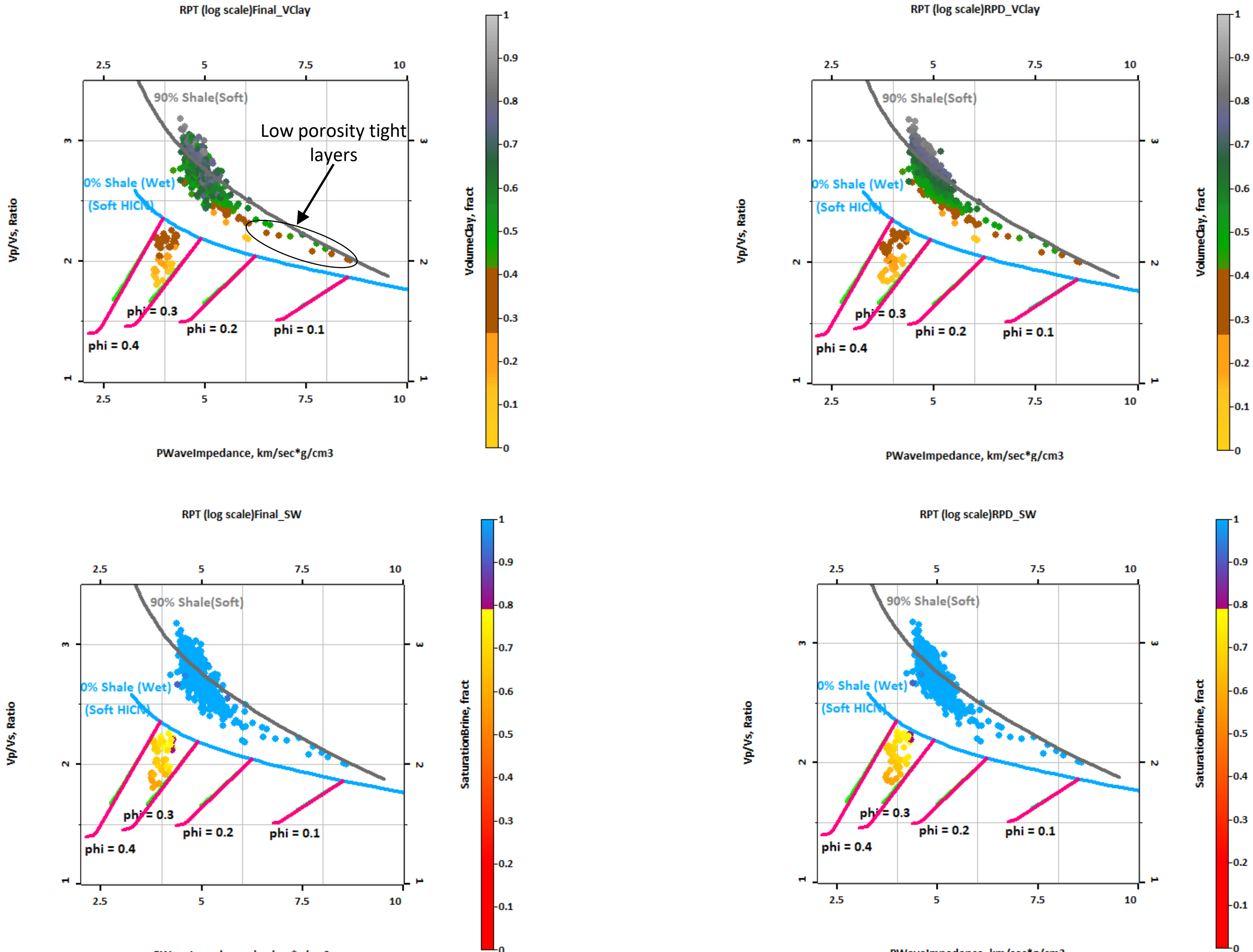




Dayung-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Empurau-1

Empurau-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited near the casing depth(3360-3520m) using the RPD due to bad measurement.
- Vs was heavily edited in many intervals in the well due to flat or lazy readings especially below 3500m and in the section(2500-32900m)using the RPD in order to have consistent VpVs ratio results and normal relationship between quartz rich and clay rich sediments.
- The hole encountered a sudden over-pressure section starting around 3450m MD causing sudden drop in the velocity, density and resistivity readings.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the SB7, SB6 and SB5 sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with blocky shape intercalated with claystone layers.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated except some minor hydrocarbon saturation found around 3245m and 3320m MD where the gas saturation reached to 40%.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section the clean wet sand section(2500-2600m) yielded a formation water salinity of 29000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2250m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- The hole encountered a sudden over-pressure section starting around 3450m MD causing sudden drop in the P-wave velocity, density and resistivity readings while the S-wave velocity was lazy and flat, so it was corrected using the calibrated model best match with the measured data where it was reliable.

Fluid properties:

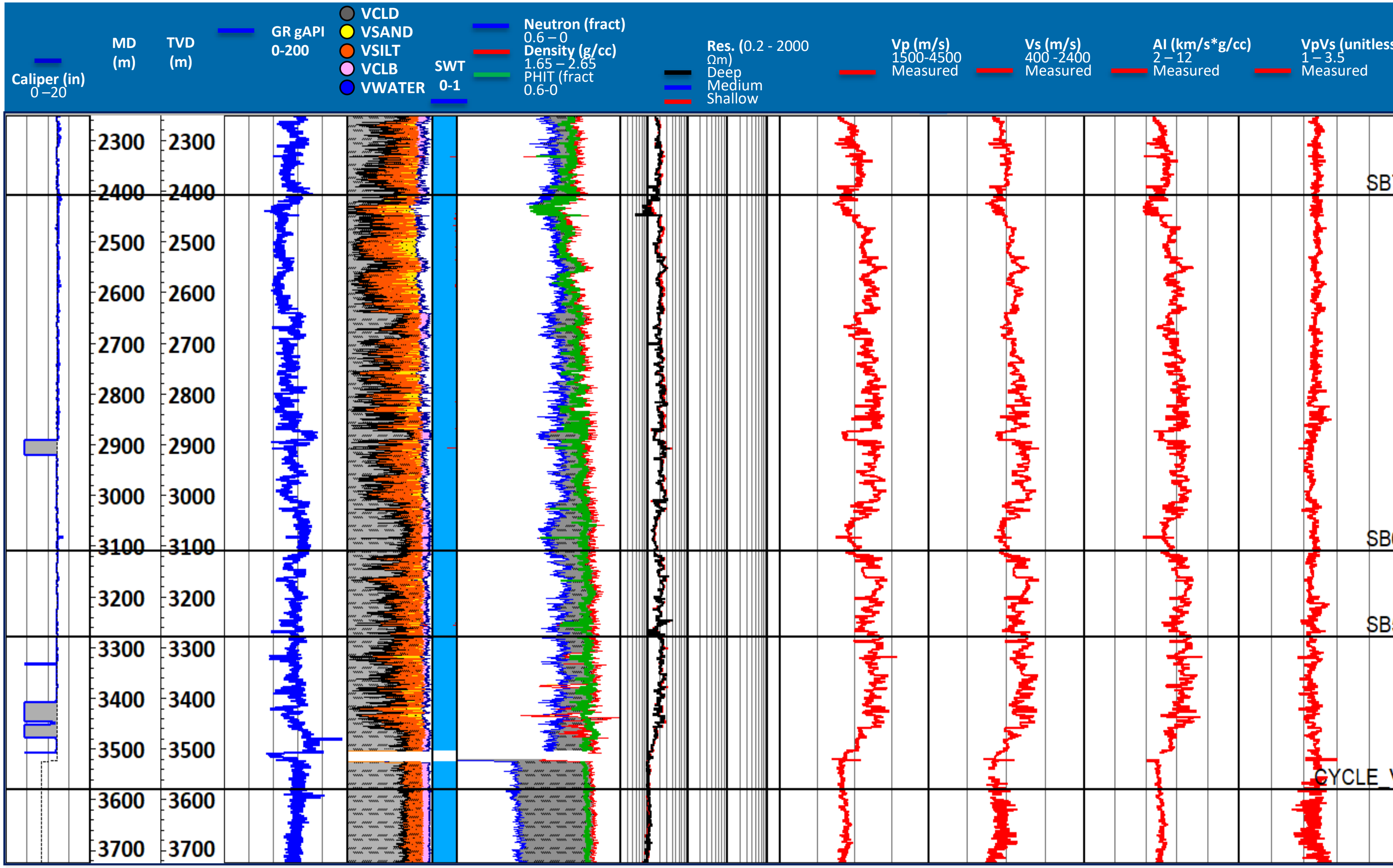
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 29000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of SB7, SB6 and SB5 using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class IV was observed near the top of a good blocky sand @ 2560m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no significant change for the AVA class could be noticed.

Empurau-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Empurau-1 Geophysical Well Log Analysis (GWLA) – Interval Of SB7

model type flag

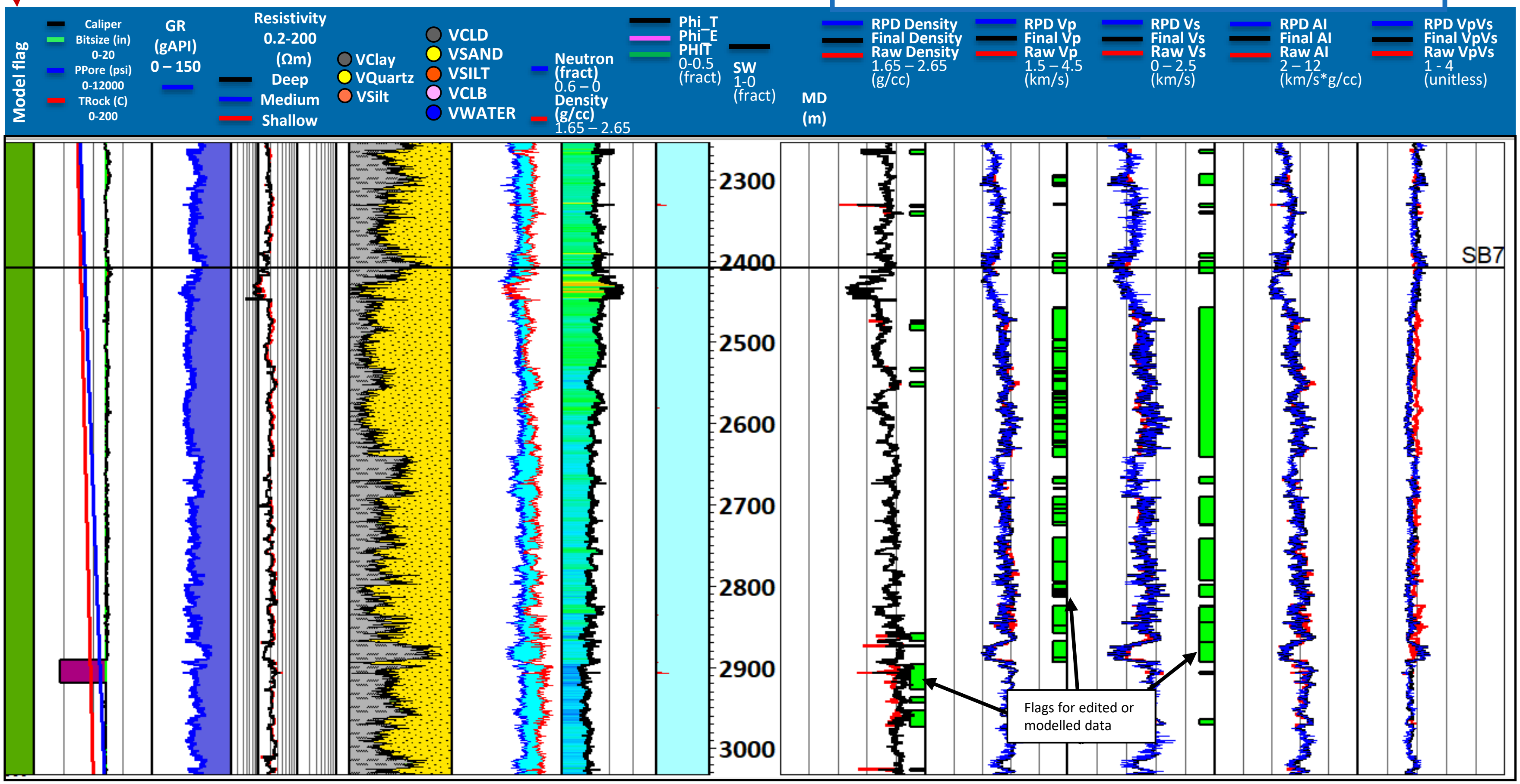
Soft rock model

Stiff rock model

Above depth of 2250m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Empurau-1 Geophysical Well Log Analysis (GWLA) – Interval Of SB6-Cycle V

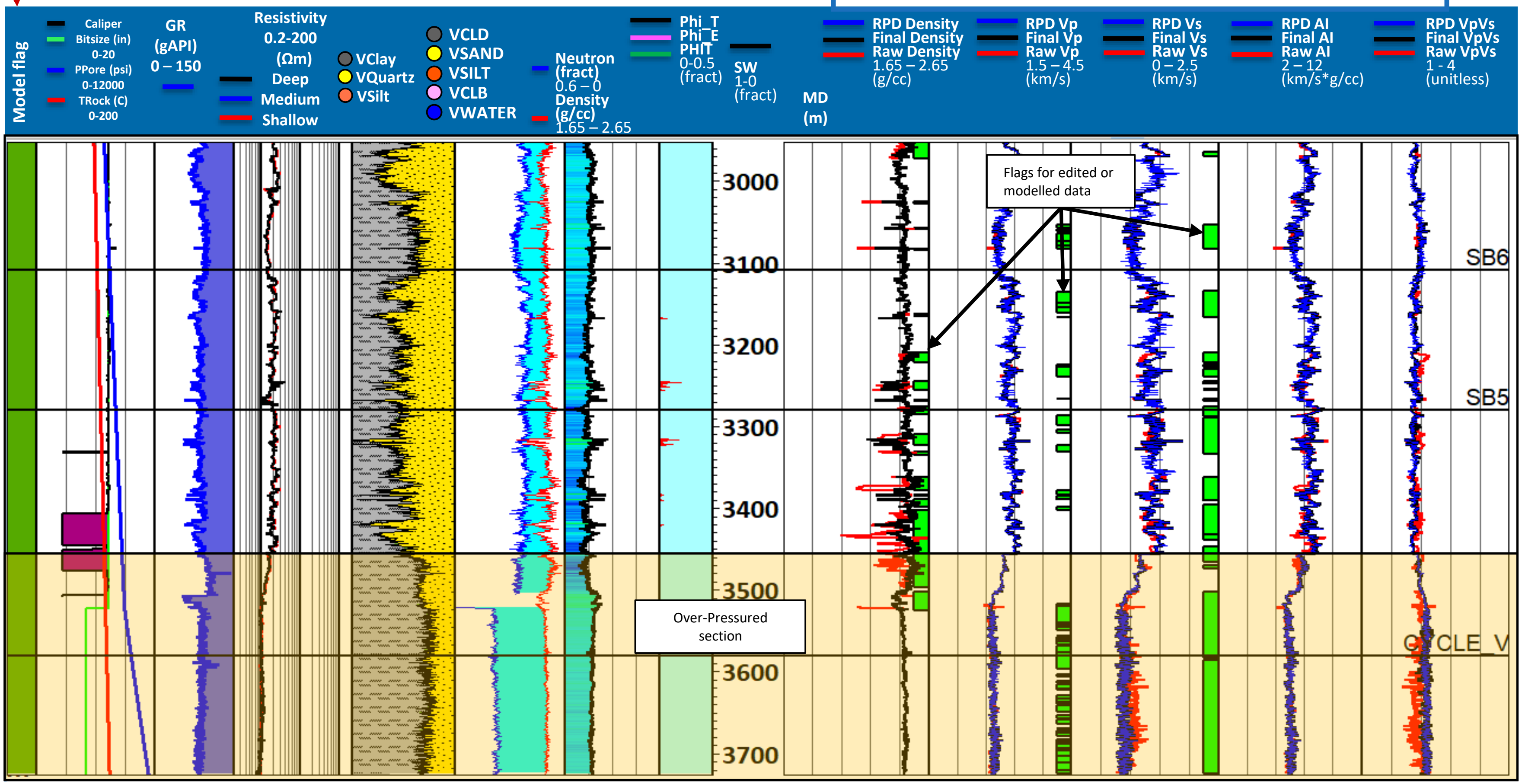
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2250m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

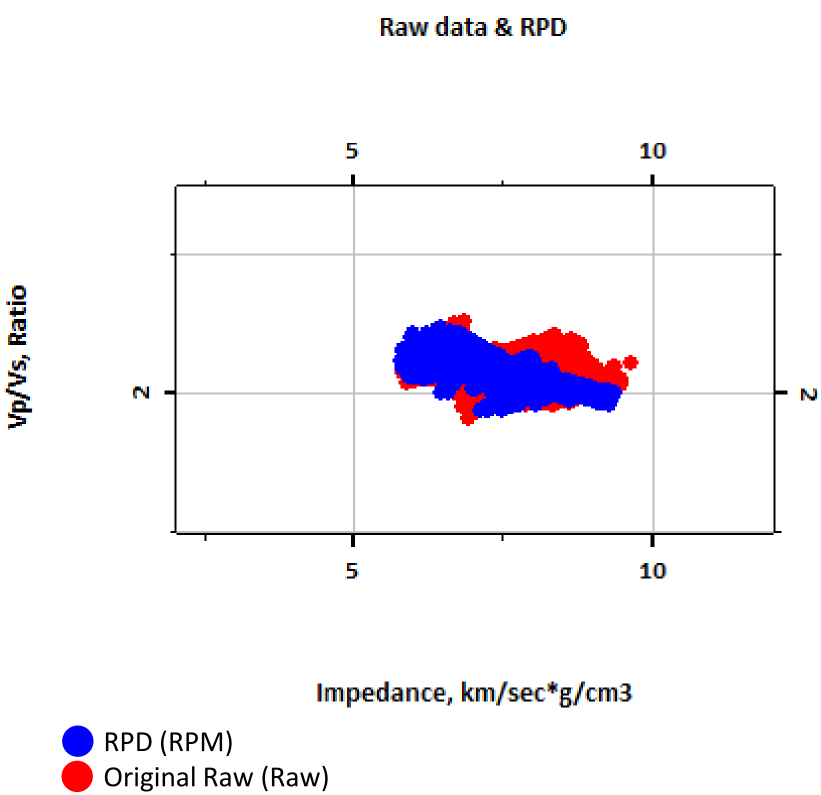


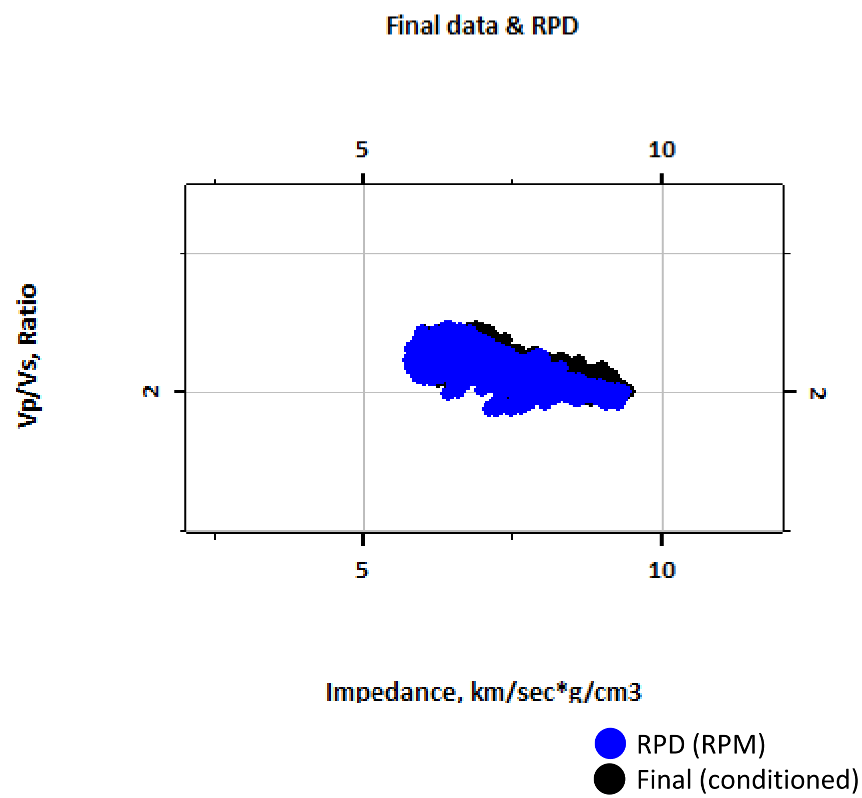
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Empurau-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

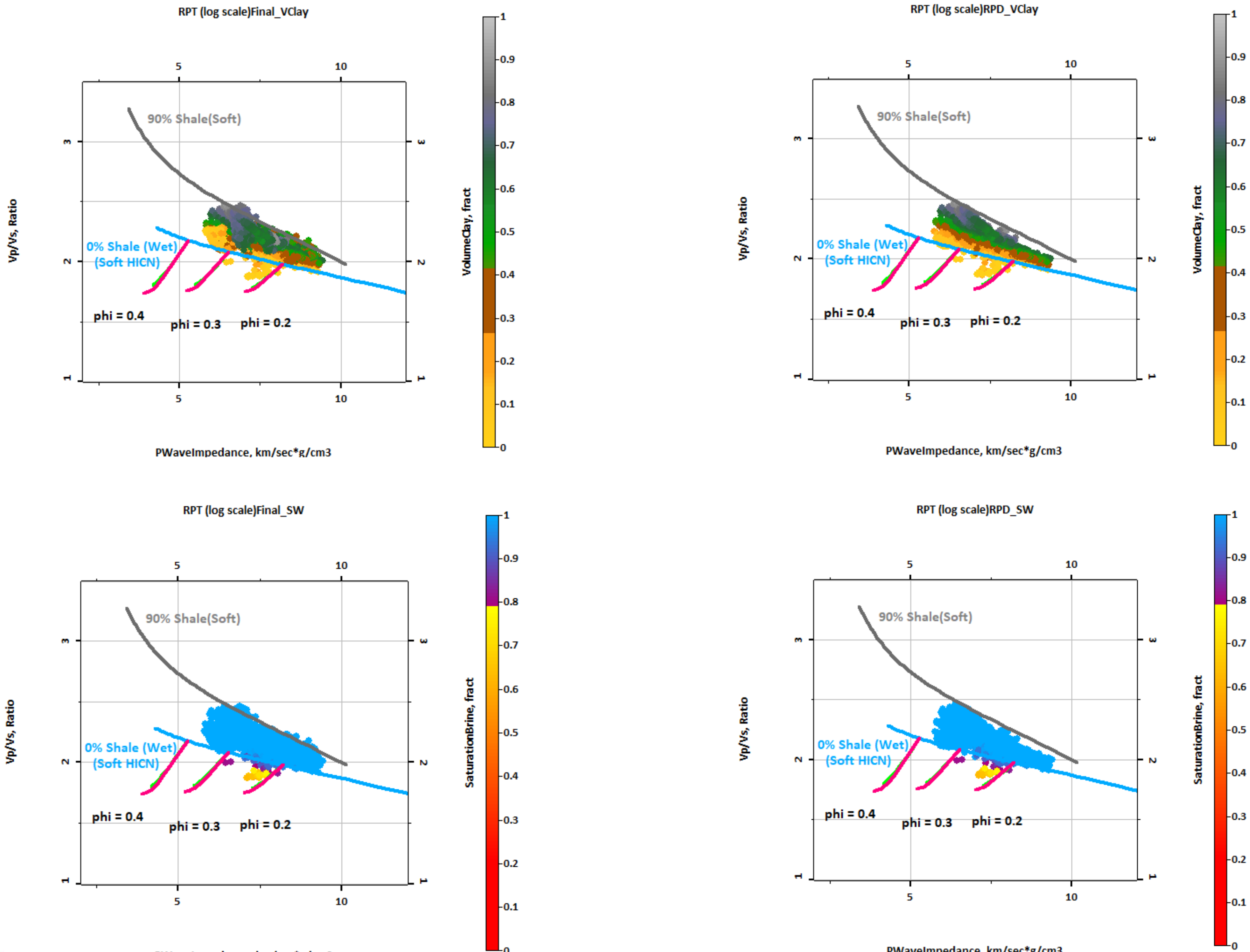




Empurau-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

G10-1

G10-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality and availability is poor. Due to the severe deterioration of the wellbore, the well has been abandoned. The quality of the elastic logs and the logs availability have been impacted by the borehole conditions. Various density gaps were observed, particularly in the 12.25- 8 inch hole transition, and in a 450 m section within the 17.5 inch hole.
- Elastic logs were only sanitized in the 1528-4248 m section. The borehole conditions in the shallower section (182-1528 m) was very poor and due to the presence of the aforementioned gaps in the density log and the poor borehole conditions observed, the elastic logs were not edited in this interval. 600 m of elastic logs in the limestone section has been sanitized to provide enough data for modelling purposes.
- Logs still show some remnant depth shift. Most of the depth shift has been accounted for on the density and sonic logs using GR as a reference. Resistivity seem to be also not in gauge with the rest of the logs at some intervals but this was not tackled during the current work.
- Density and thus porosity, was highly affected by the borehole conditions in the 2120-4000 m siliciclastic section, and the original data was almost fully substituted with the estimated density data in this interval. The original density measurements produce unrealistically high porosity values that yield low Sw curves in the client provided data. The size of some washout intervals reaches more than 3 inches, considerably higher than the depth of investigation of the density tool (~1 inch). Density was finally edited using Vp and porosity trend information from nearby wells that display similar acoustic characteristics, such as Talang, Mulu, and Lanjak. Vp has also been edited at a few zones often showing off trend responses, possibly impacted by the borehole conditions.
- Vs has not been acquired in the well and was fully modelled using Granular Media and guided by Vs trends observed from acoustic analogue wells.
- Other logs include, Caliper, and Deep resistivity. Neutron was only available in the 3810-4250 m section.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method, due to the absence of the neutron log in the majority of the well.

Reservoir characteristics:

- The well consists of 1932 m of reefal limestone of Mid-Miocene to Pliocene age on top of a Miocene sequence which is characterized by a siliciclastic sequence accompanied by tight limestones with variable thickness. In the M1_M2 sequence (2136-3350 m) sands are poorly developed and have been interpreted as silty, with average porosities of 25%. Below 3350 m, sands are more mature, thicker, but more compacted, with porosities close to 18%.
- The thick reefal limestone is characterized by good overall reservoir properties, with porosities above 26% in average. Different textural characteristics have been reported within this section where packstone - wackstone seems to be the dominant facies. Moreover, some heterogeneity is observed in the elastic logs within the limestone section that could be associated to textural differences.

Volume of hydrocarbons:

- The well has been interpreted as wet and no gas shows have been reported during drilling. Water saturation curve provided by the client seems to be highly affected by the poor borehole conditions encountered in the well.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters and water formation resistivity were taken from the well's quantitative log analysis report: Rw=0.083 Ohmm @ 177.8F (33,000 ppm), with a=1, m=2, and n=2.

Rock physics diagnostics (RPD):

- This was performed only in the 1528-4248 m section due to the various gaps observed in the density logs and the poor quality of the logs in the shallower section of the wellbore. Data in the elastic space indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in clay-rich and an Intermediate Stiff Sediment Model with a variable Coordination Number with depth was more suitable in the non-clay rich facies. These models have been used to edit the Vp and Rhob data where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock physics modelling (RPM) stage of the project. Vs data was entirely modelled in this well and it was estimated using Granular Media.

Fluid properties:

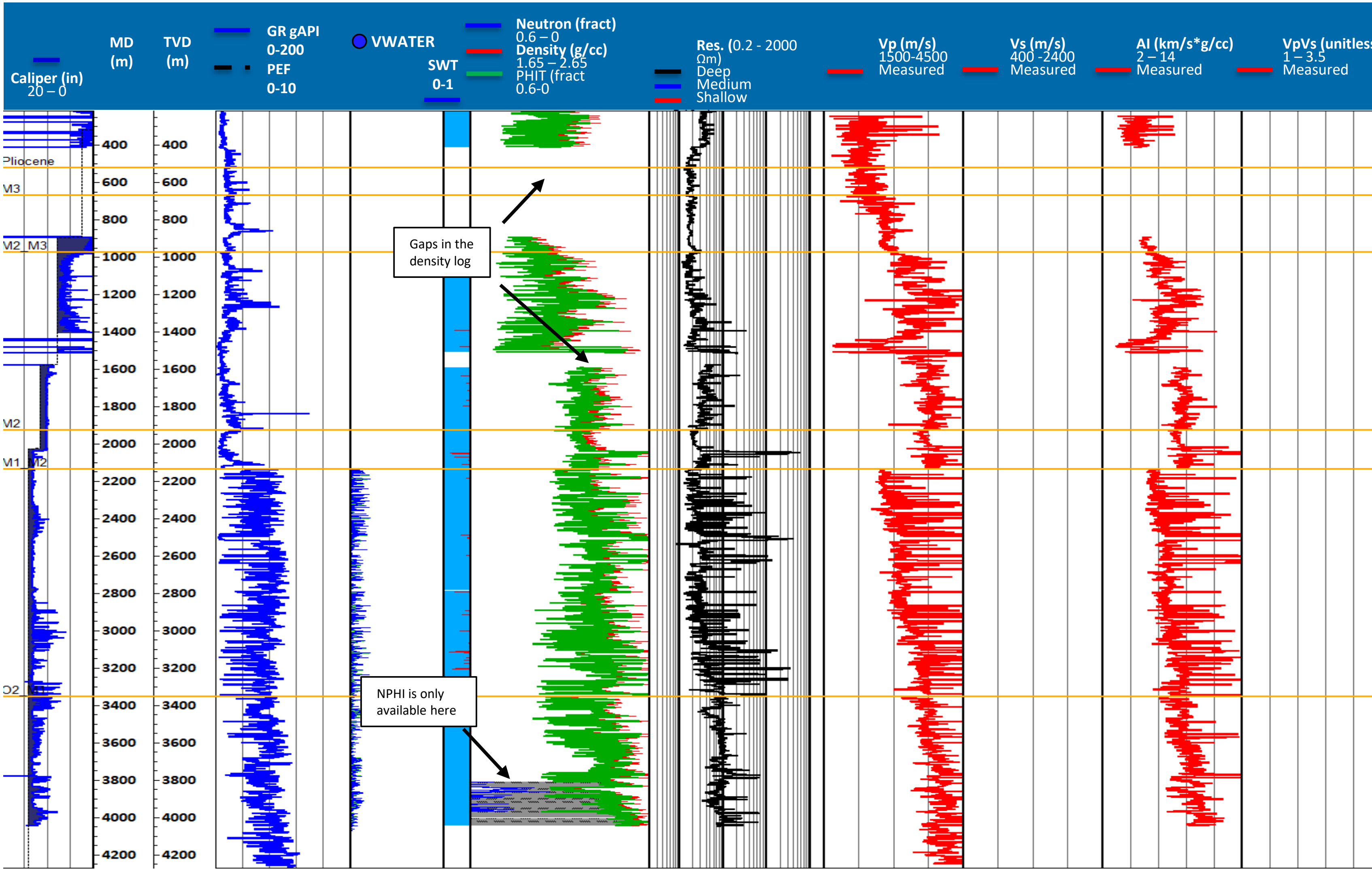
Hydrocarbon properties used in substitution have been obtained from PVT analysis performed on samples of the Spaoh-1 well:

- Brine salinity: 33,000 ppm
- Gas gravity: 0.68
- Oil Gravity: 52 API
- Gas / Oil ratio: 192 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Pliocene-Miocene section. Modelling parameterization is different for both, the reefal limestone and the siliciclastic sequence; therefore, two different rockAVO modelling projects will be delivered for this well.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – G10-1



Additional data includes mud weight data, completion log, quantitative well log analysis and biostratigraphy reports. SW data received from Petronas seem to be highly affected by the poor borehole conditions

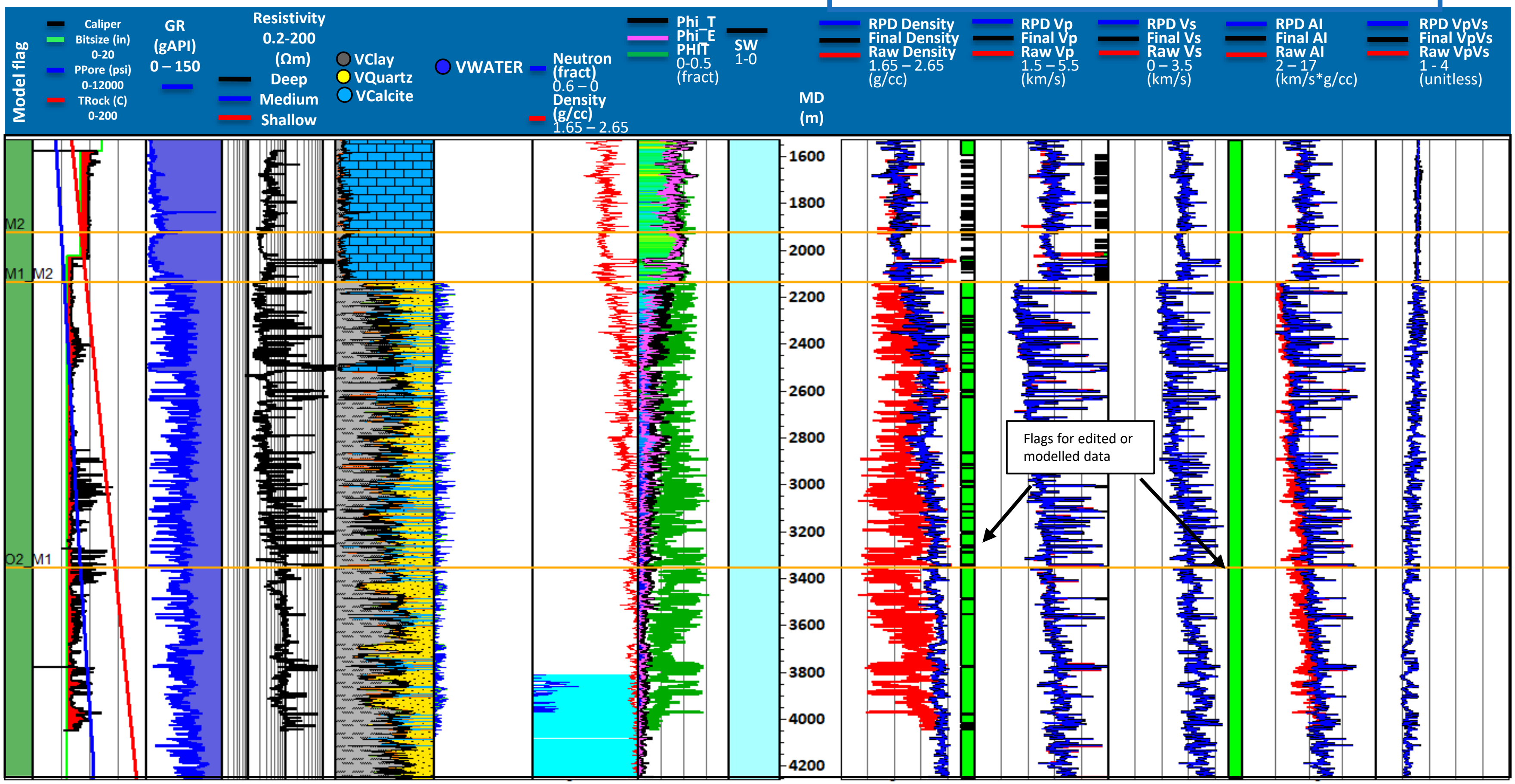
G10-1 Geophysical Well Log Analysis (GWLA) – Interval from 1530-4230 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Data quality and availability is poor. Due to the severe deterioration of the wellbore, the well has been abandoned. The quality of the elastic logs and the logs availability have been impacted by the borehole conditions. Particularly below 2800 m, the borehole enlargement can be as high as 3 inches, considerably higher than the depth of investigation of some of the logging tools, impacting the quality of the elastic measurements.

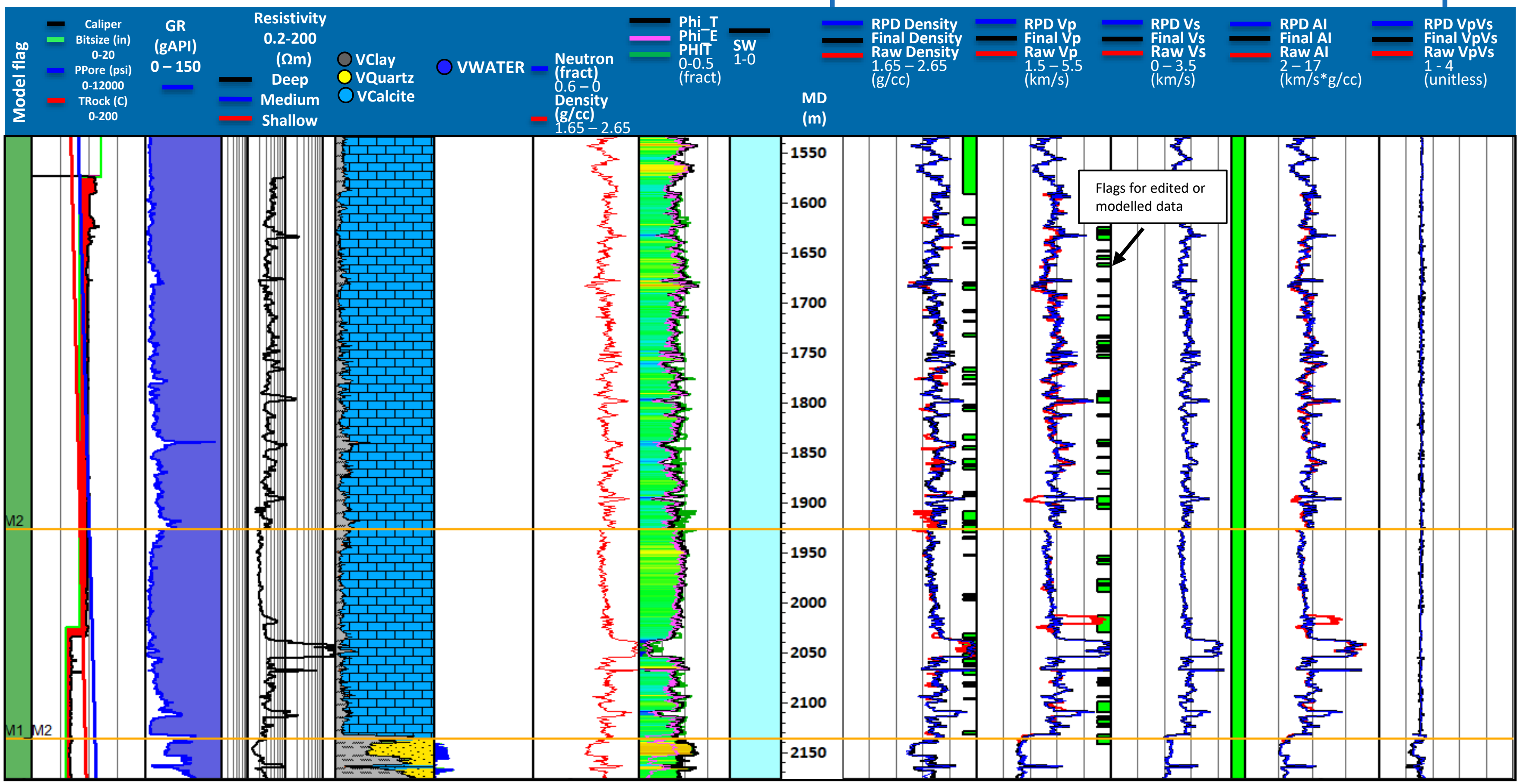
G10-1 Geophysical Well Log Analysis (GWLA) – Interval from 1530 -2170 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



In the reefal limestone section, the wellbore is more competent and the elastic logs are less affected by borehole conditions compared to deeper sections in the well. Good reservoir properties were encountered in this section where packstone – wackstone facies seems to be the most frequent facies. Density log has been estimated above 1600 m in this section due the 12.25-8.5 inches borehole transition.

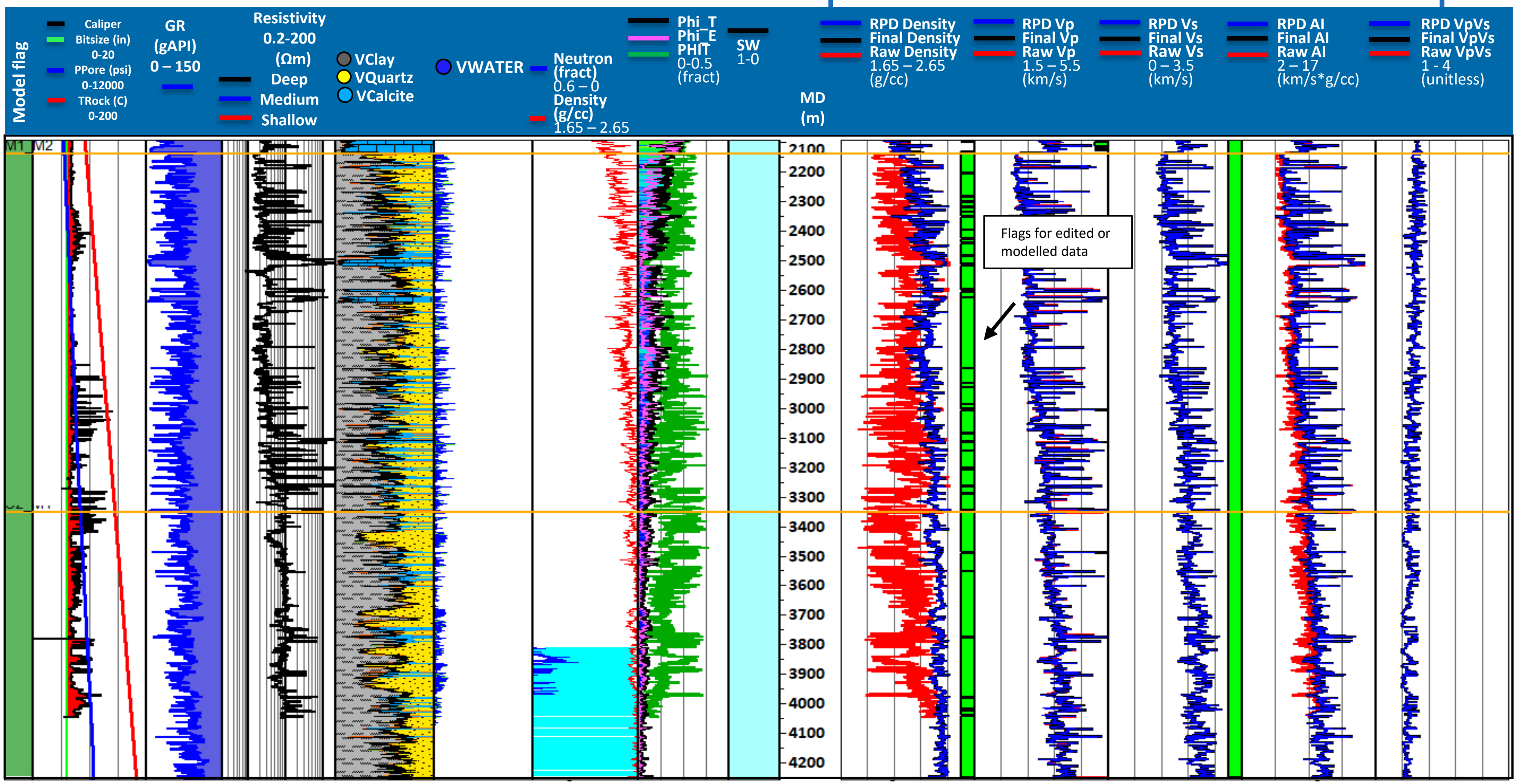
G10-1 Geophysical Well Log Analysis (GWLA) – Interval from 2100 -4248 m

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Unconsolidated rock model
- Stiff rock model

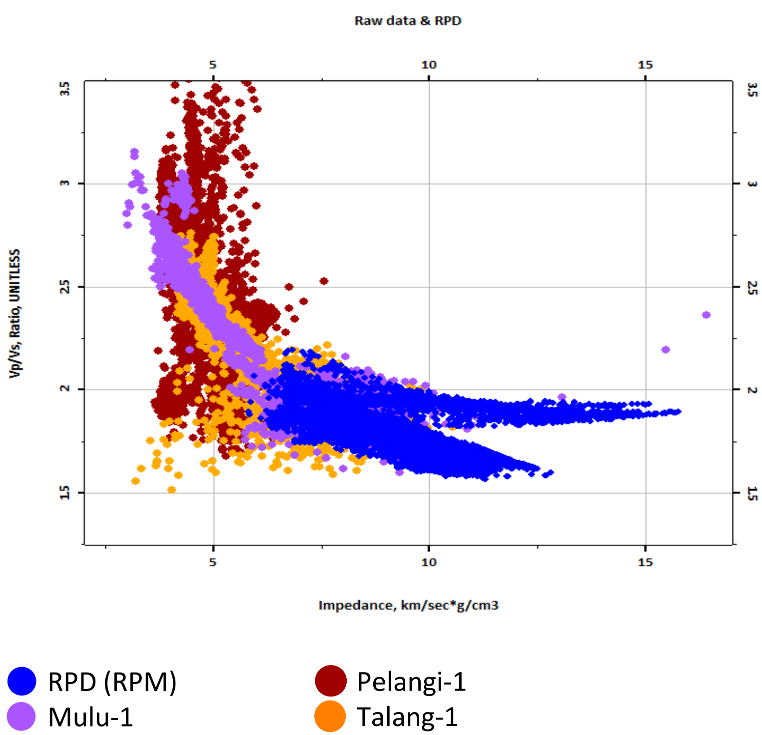


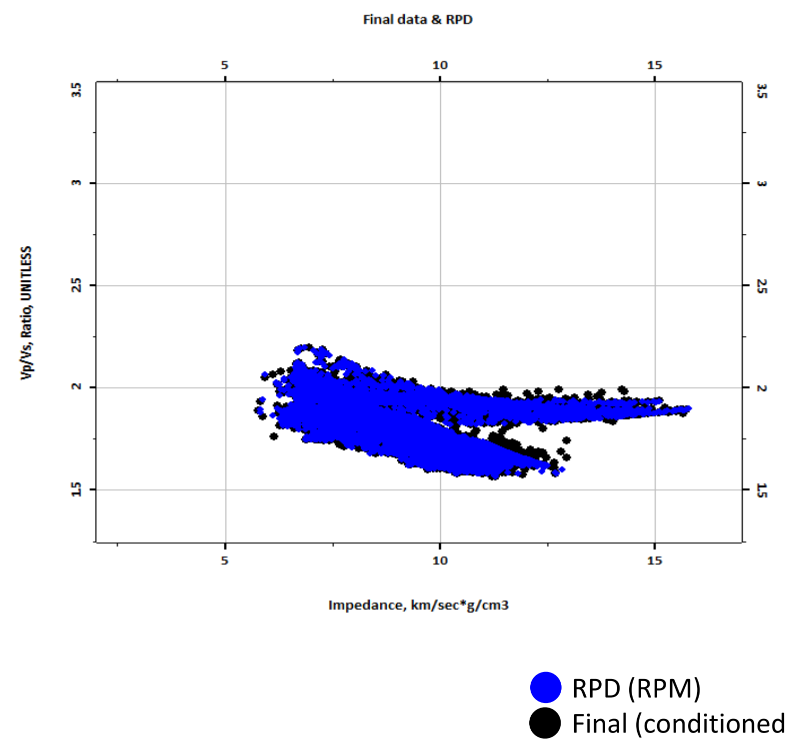
Due to the poor borehole conditions the elastic logs are considerably affected in most of the section displayed. Below 4040 m, the density log was not available and it was estimated using rock physics models. Granular media model (soft sand with variable Coordination Number with depth) was used for all elastic curves prediction (Rhob, Vp and Vs). Vs was not acquired in the well and thus was fully estimated. Sands seem to be more developed in the O2_M1 sequence but tighter.

G10-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data. Full Well

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the analog wells with similar trends in the elastic data, given the measured shear in G10-1 is not available

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

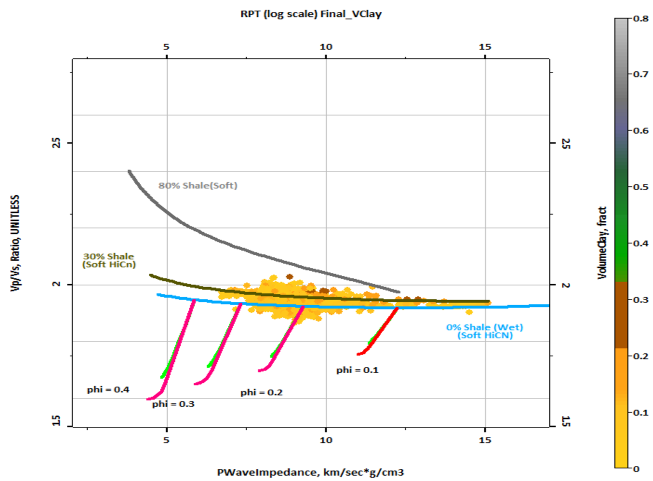


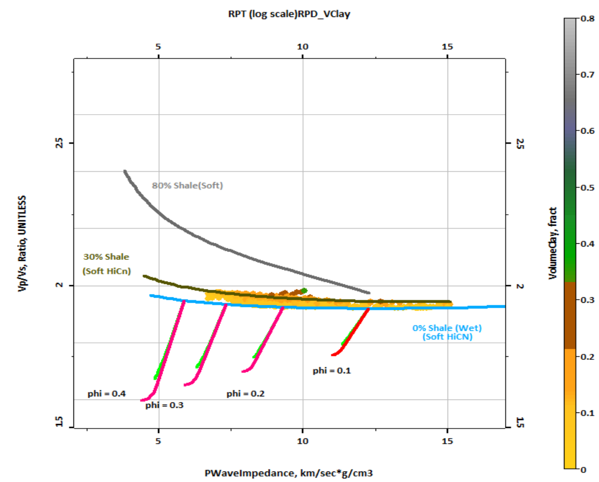


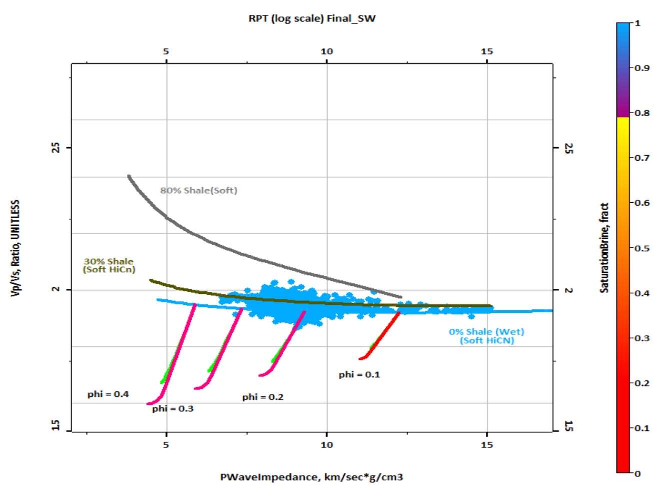
G10-1,Rock Physics Diagnostics (RPD) Rock Physics Models, 1520-2126 m

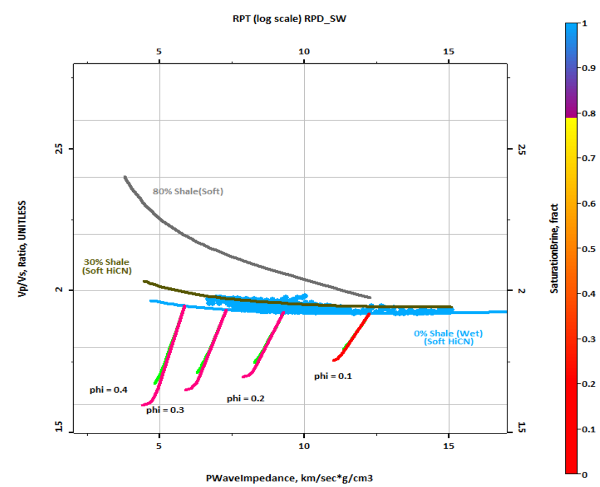
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data







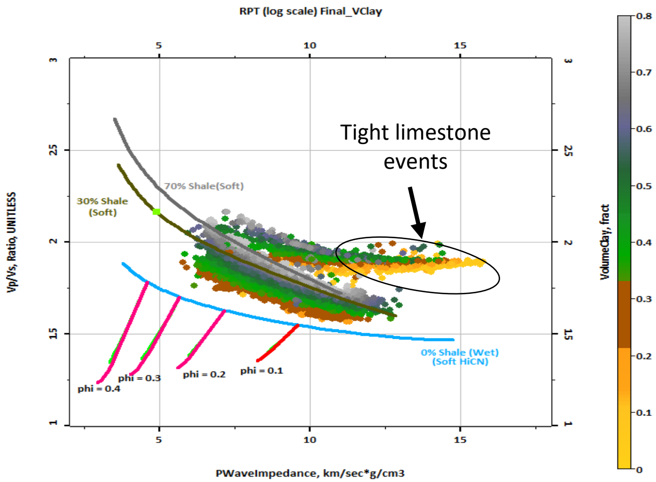


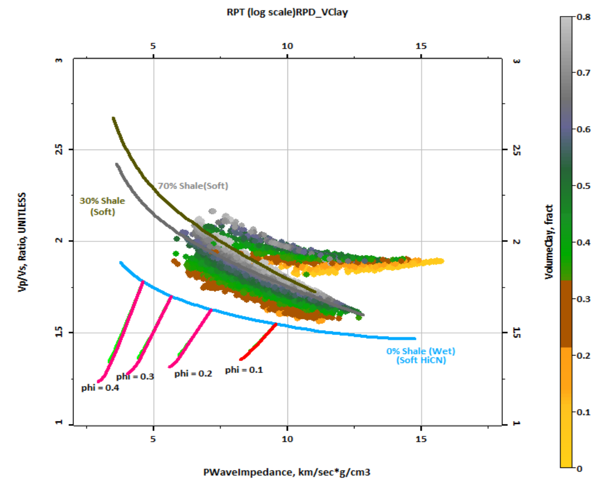
RPD(Modelled)data

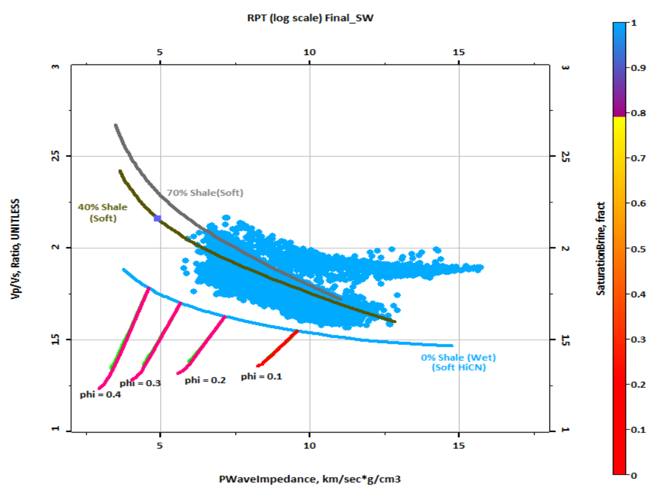
G10-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, 2126-4248 m

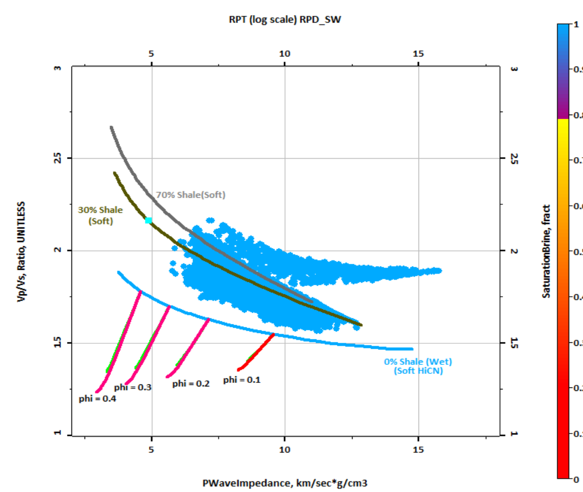
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Gambang-1

Gambang-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is poor to fair. The density log is heavily affected by borehole rugosity in especially in the deepest section of the well. Although borehole rugosity is pervasive in the whole well, it is in the deepest sections of the well that density seems to be affected the most. This becomes evident as the density log is more correlatable with the GR log in the shallower part of the well, i.e., there are consistent responses for the density and gamma ray log in this section.
- Vp log quality is considered fair to good, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies. The editions are necessary to avoid extreme noisy points in Ai vs VpVs space.
- Vs was not measured in this well and it was completely estimated using rock physics model.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities, and Photoelectric factor. Well Gambang-1 included a lot of core data that was helpful in the calibration of the different rock model responses.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The primary objective of Gambang-1 well was to test the 4R-2/3 prospect, constituted by cycle V, IV and III, containing interbedded sands and shales;
- There is a fairly thick sand development at 1500 m, with porosity values of 24% and greater. Below 1600 m there is presence of thinner sand bodies with somewhat reduced porosity values observed to be in the range from 15% to 20%. This set of sands does not seem to be economically attractive.

Volume of hydrocarbons:

- No hydrocarbon content was interpreted in this well, except for some thin sands in the deepest part of the well below 1700m, in the cycle III interval. The well was plugged and abandoned and was catalogued as a dry well.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=2. Water resistivity used to interpret Sw: Rw=0.1 ohmm @ 157 F (30,000 ppm).

** Depths referred in this report are MD.

Gambang-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies.

Fluid properties:

There is no data availability from nearby wells, hydrocarbon properties used in fluid substitution have been taken from values reported in wells from the area. Main parameters used in this modelling are:

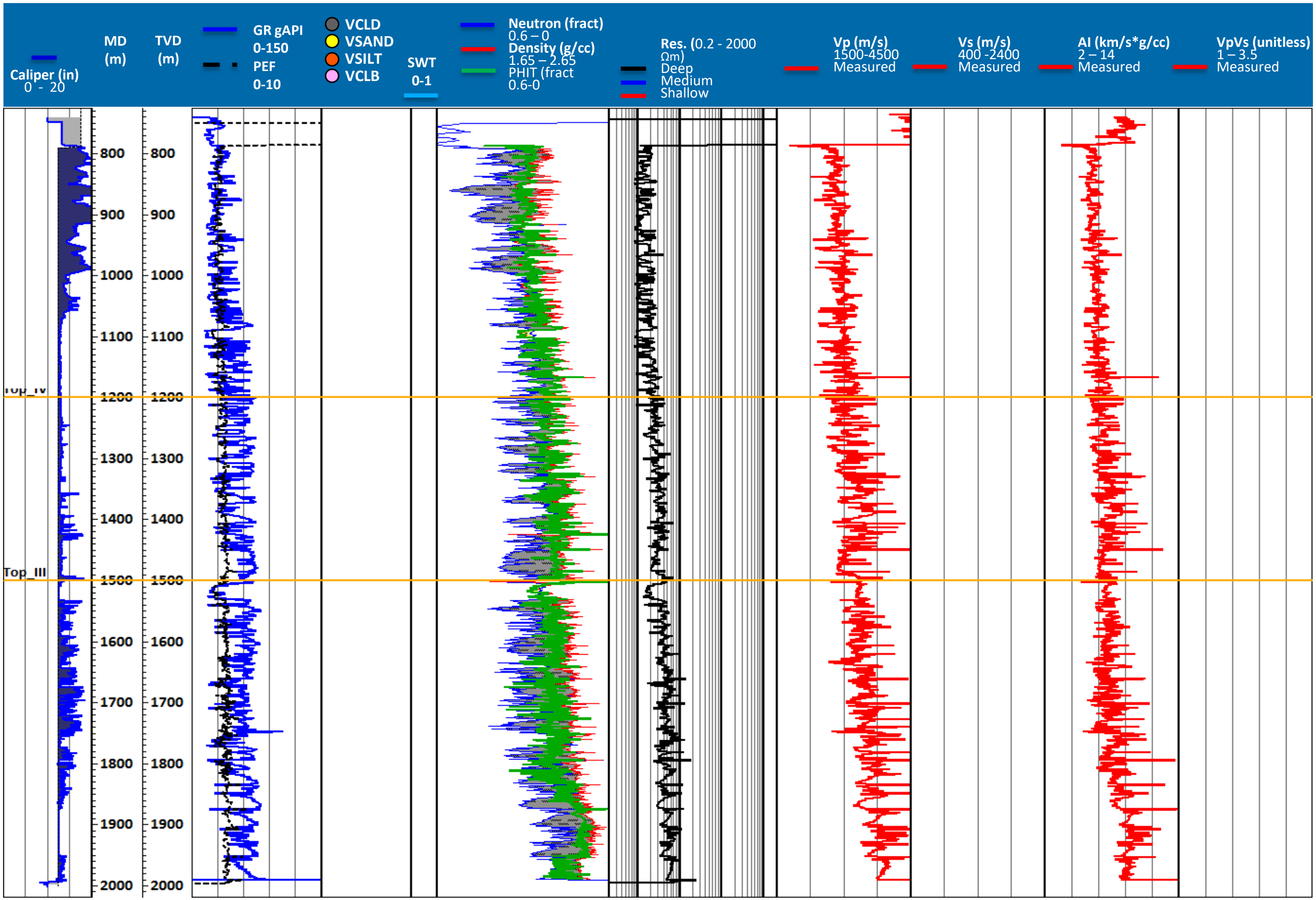
- Brine salinity: 30,000 ppm
- Gas gravity: 0.85 (common value for the area)
- Oil Gravity: 40 API (common value for the area)
- Gas / Oil ratio: 194 (L/L) (common value for the area)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in the well developed sand appearing in cycle III. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Gassmann and Brie models.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As in the selected example, the sand package at 2060m (Water bearing sand in Cycle II) was gas substituted allowing the Water saturation to be reduced to 20%. Porosity was preserved for this exercise. This exercise showed lower values for VpVs ratio and lower values for Acoustic Impedance compared to the wet case.

** Depths referred in this report are MD.

Input Logs – Gambang-1



Additional data includes mud weight data, pressure data, petrography, basic core analysis and well reports.

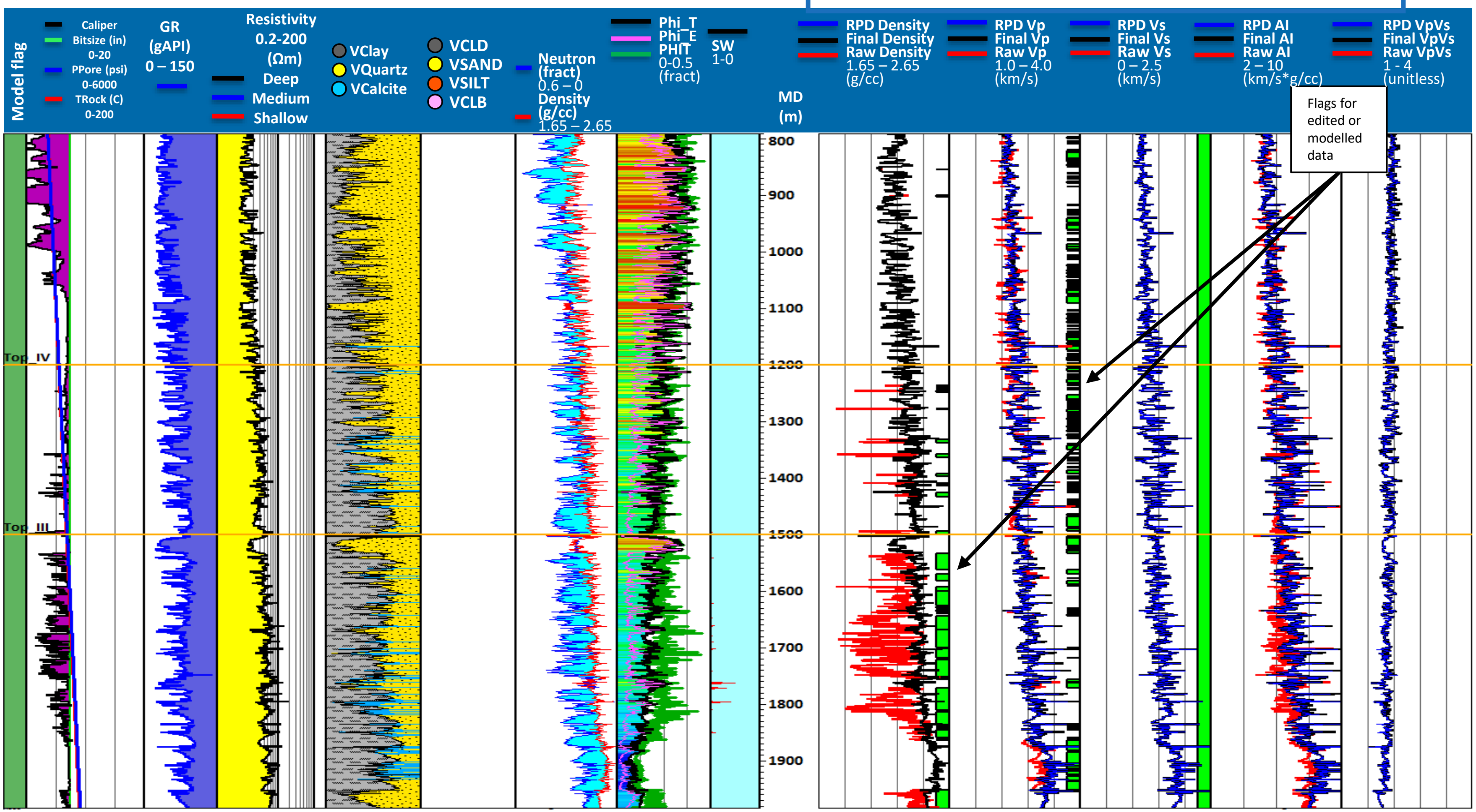
Gambang-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m

model type flag

- Unconsolidated rock model (green)
- Stiff rock model (orange)

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve (blue)
- Final edited (Conditioned) curve (black)
- Original Raw (Raw) curve (red)

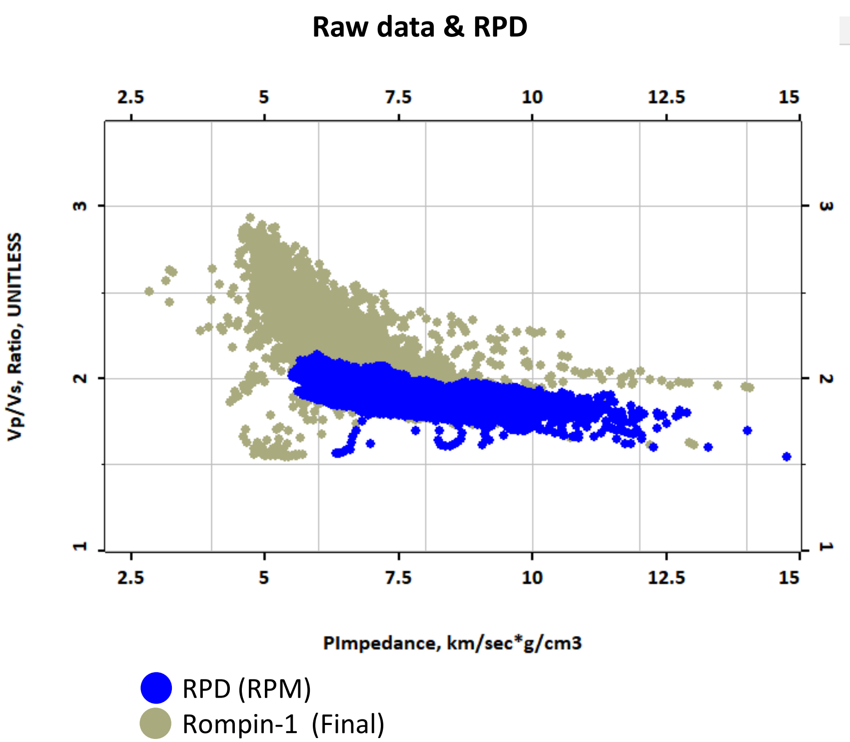


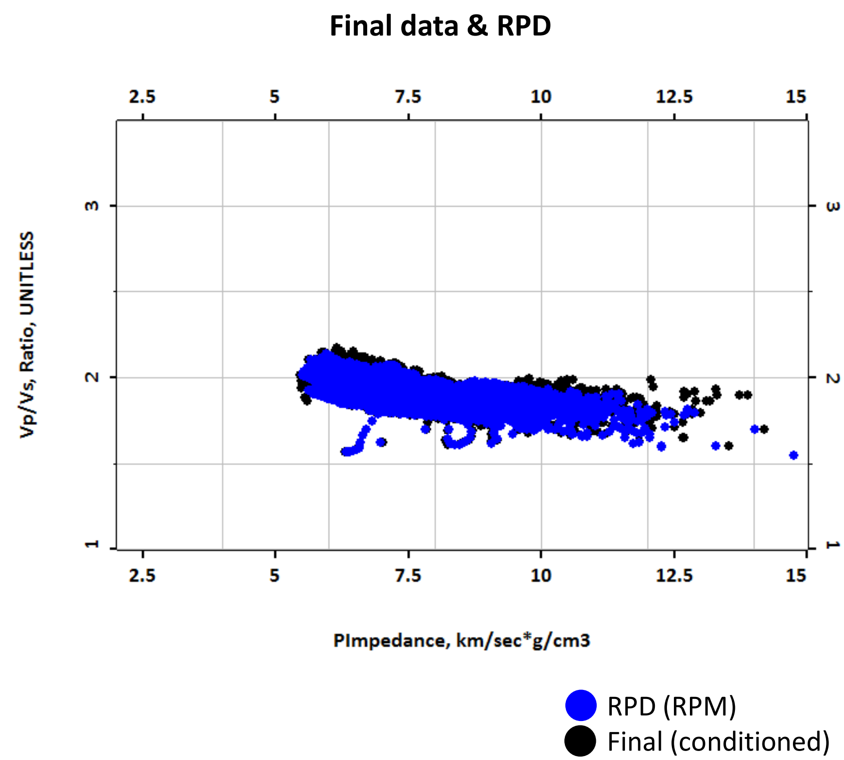
Results for well Gambang-1. Density in mostly affected by borehole conditions. Vp was edited just to recover lost frequencies and to avoid noisy representation of points in the AI vs VpVs space. Vs was totally estimated as it was not measured in this well.

Gambang-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables elastic data from wells with reliable shear measured data, in this case well Rompin-1 Final edited data.

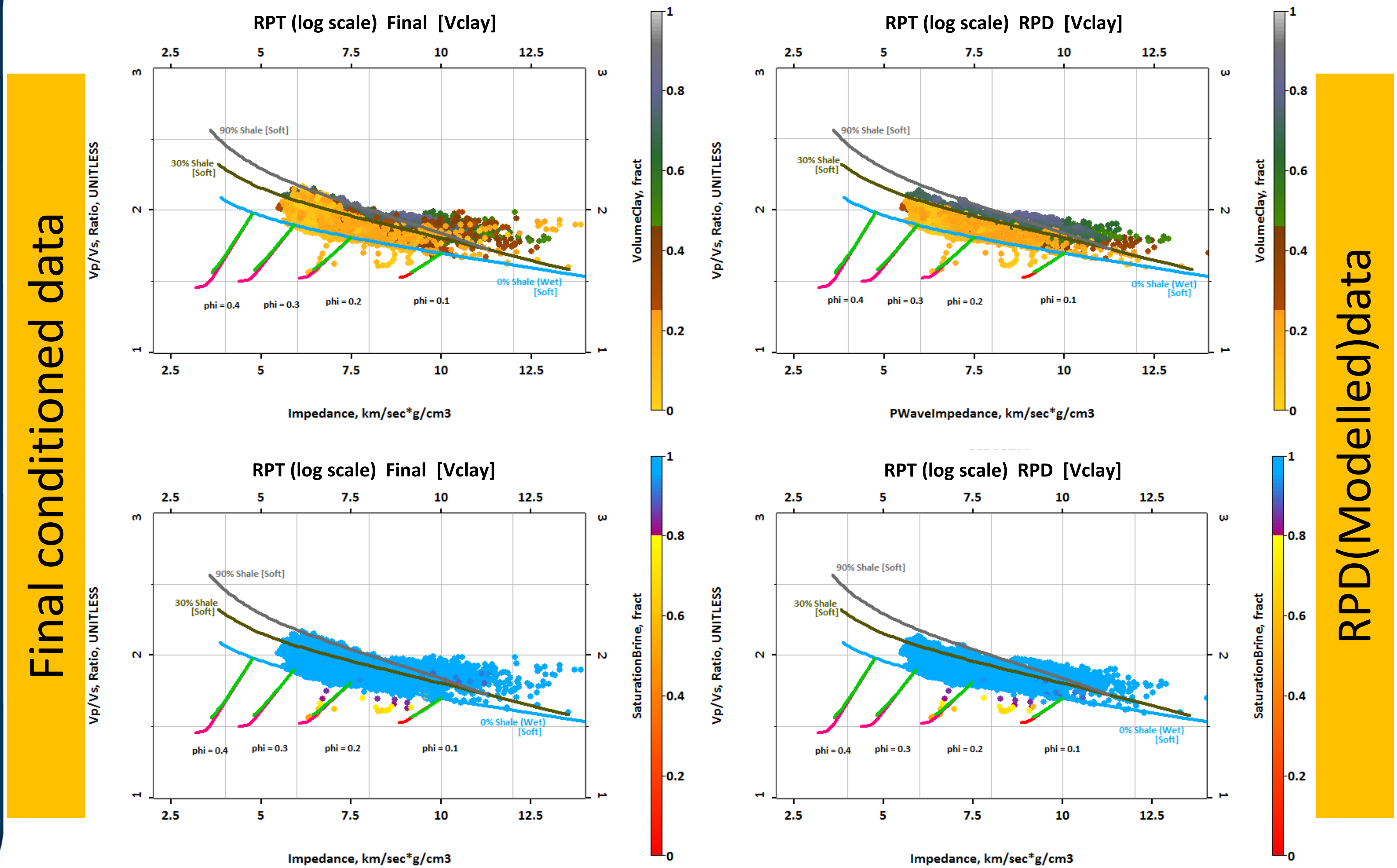
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.





Gambang-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines (soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.



H2-2

H2-2 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is fair, but the data availability is very limited since we have full elastic coverage(RHOB and VP only) for the section(890-1005m) while the VP covers to shallower interval(up to 700m). Client's petrophysical interpretation was not provided for this well.
- Shear wave velocity(VS)was fully modelled in the well using the RPD after the model was carefully calibrated based on the offset well(Nuang-1 and Dayung-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby wells(especially Nuang-1 and Dayung) specifically for the cycle V section, since the carbonate interval and the basement section were never penetrated in the nearby wells.
- Due to the bad hole conditions in some intervals, VP was corrected using the RPD as in the interval(965-990m).
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target was the Miocene carbonate section(cycle IV). These are a blocky lime wackstone/packstone with calcareous shales interbeds.

Volume of hydrocarbons:

- Gas saturation calculated in the carbonate reservoir section of cycle IV was up to 80% near the top of the reservoir while in the basement section there was some low gas saturation that reached to 30-40% .

Water saturation (Sw):

- Water salinity obtained from water sample test in well Nuang-1 was used and reflected RW of about 0.186ohmm @ 145 degF. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 (assumed based on area references).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the full elastic log suite started(700m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for calcite rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Elastic behavior for the well was carefully calibrated with the nearby wells and other wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to Dayung-1 and Nuang-1 wells, so S-wave velocity completely modelled in the well based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells.

Fluid properties:

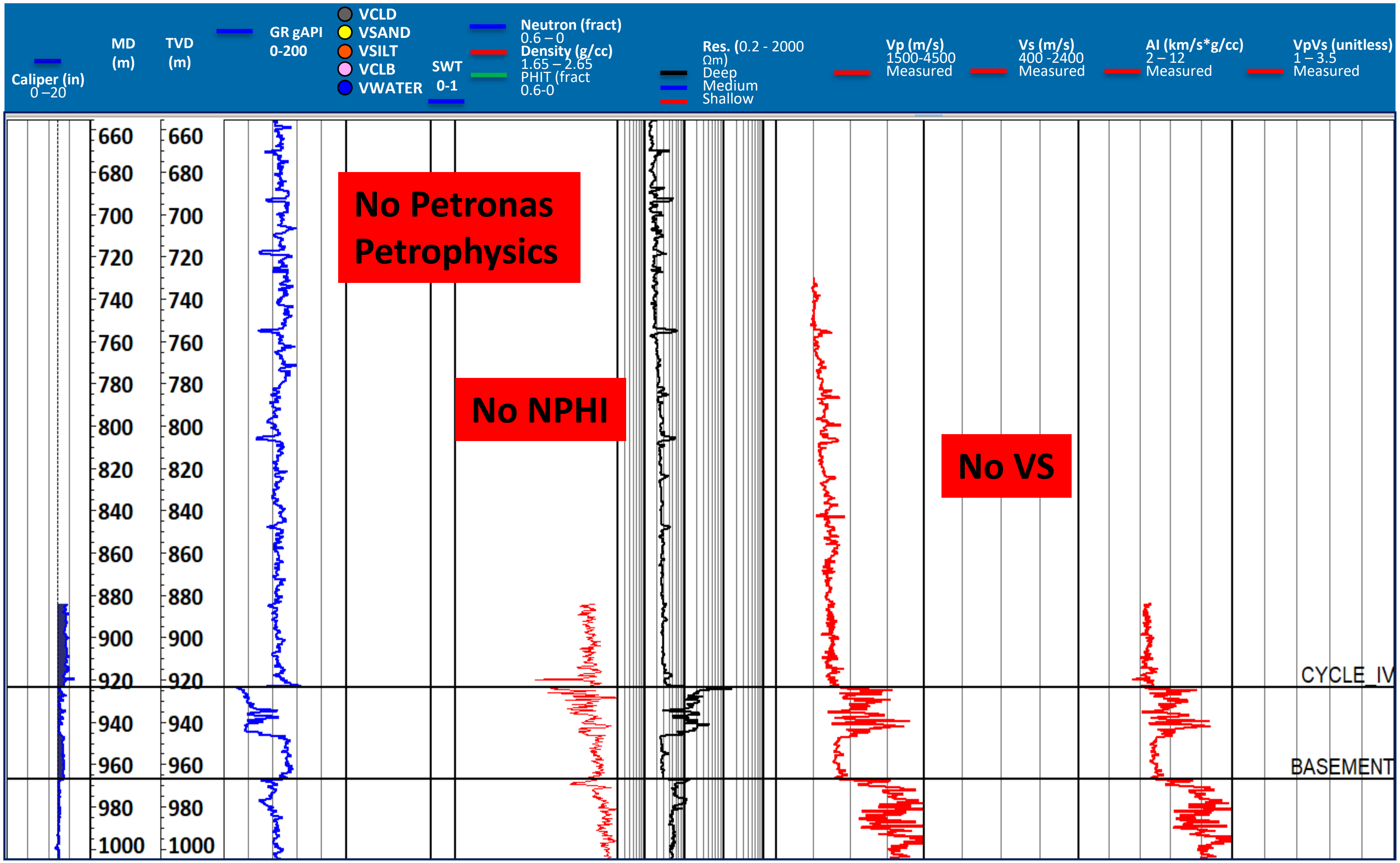
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 17000 ppm
- Gas gravity: 0.86[assumed]
- Oil Gravity: 38.1 API[assumed]
- Gas / Oil ratio: 263 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene carbonates(cycle IV) using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the carbonates top@ 922m for all hydrocarbon cases while class I for the wet case at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) all fluid scenarios behave as class I AVO response.

H2-2 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions(Final geological report).

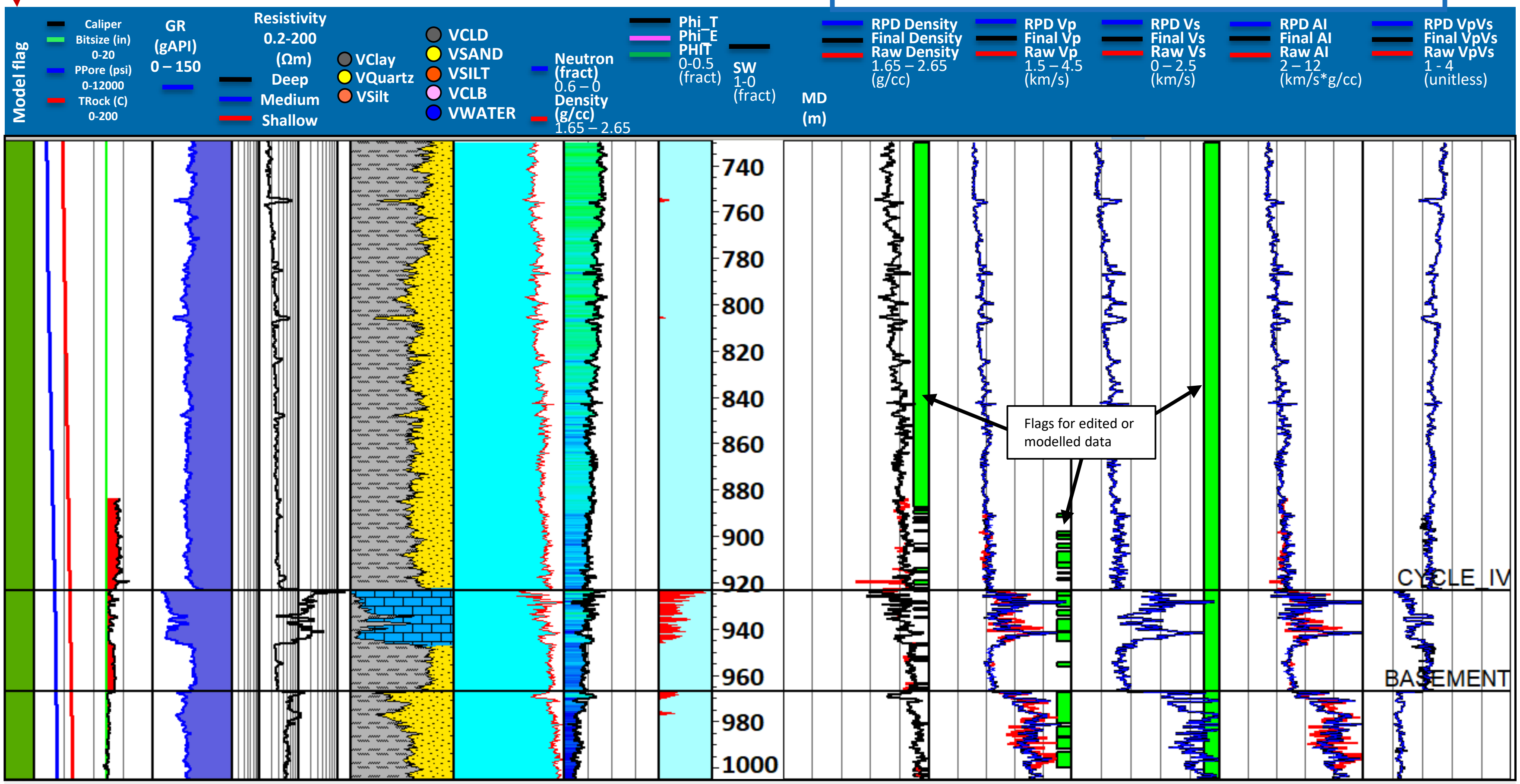
H2-2 Geophysical Well Log Analysis (GWLA) – All Well Interval

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

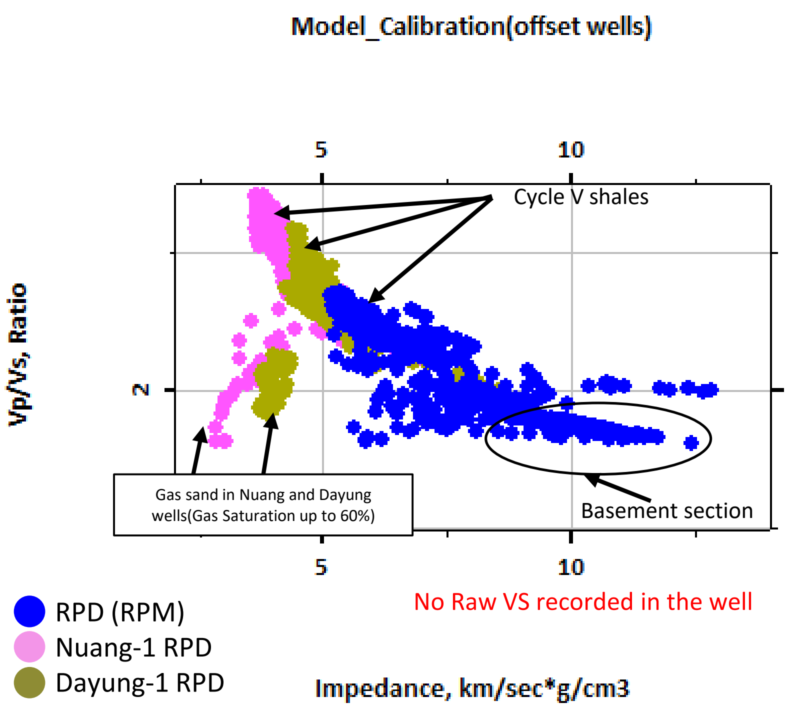


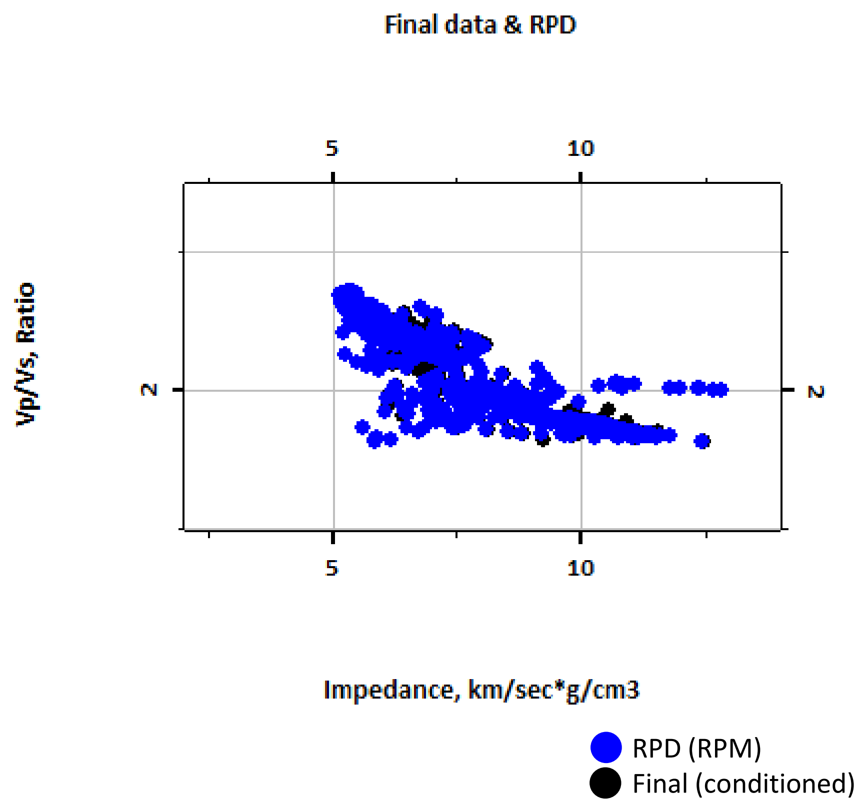
Some edits to the measured data and model calibration is strong. Granular media model (soft model with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean carbonate reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

H2-2,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the H2-2 well RPD with the nearby well Dayung-1 and Nuang-1.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

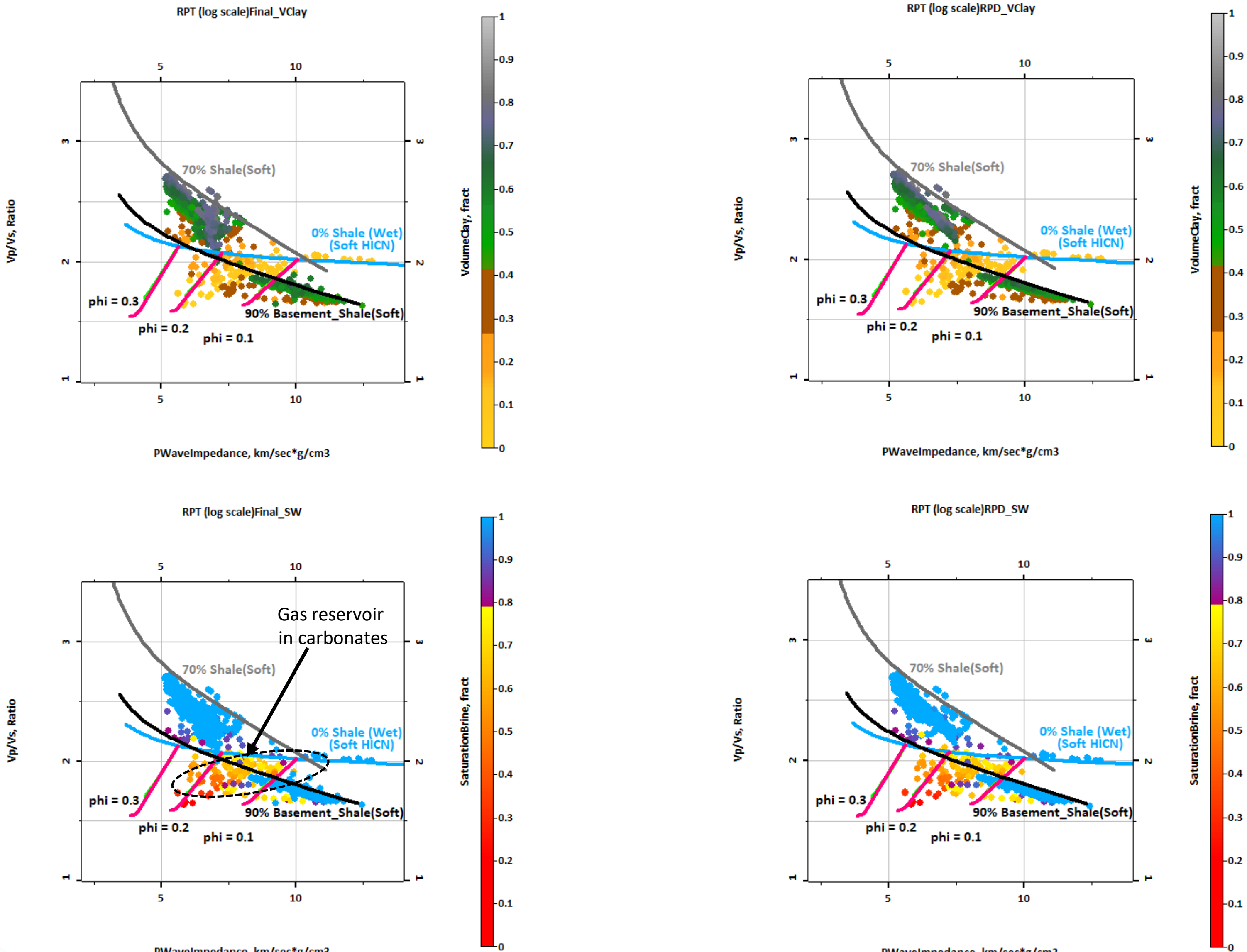




H2-2,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Hibiskus-1

Hibiskus-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is fair but the density and the sonic in some intervals looks very poor and lazy especially near the casing points, but the data availability is good. Client's petrophysical interpretation was not provided for this well except shale volume and porosity. Full elastic logs except VS were available throughout the wellbore covering the interval (1000m-T.D.)
- Shear wave velocity(VS)was fully modelled in the well using the RPD after the model was carefully calibrated based on the offset wells(not very nearby) behaving elastically the same and also using the VP-Rhob relation to predict best model to use. The resulted Vs honors the trend in the nearby wells(Jelawat-1 ST1 and Jemuduk-1 ST1)
- Due to the sever bad hole conditions near the casing points, density and sonic was completely replaced using resistivity via Faust equation to predict the velocity then density was predicted using the RPD based on the calibrated model.
- Vp was also totally replaced with the modelled one in some intervals where it looks lazy and not responding to any lithology variations after carefully calibrated the model with the good measured data present in the well and also in the offset wells to honor the regional trend in the area.
- Other logs include Gamma, SP, Caliper, Deep resistivity and Neutron which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method except in the interval(2250-T.D) where Neutron/Density was used in combination was Gamma ray.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands(Cycles VI and V). These are a series of turbiditic sands with some calcareous cement and less porosity especially the cycle V sands.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine except the blocky sand in cycle V where the gas saturation was about 20-30% in average .

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly the base of the clean sand section of cycle V yielded a formation water salinity of 20700 PPM(which matched with the reported one in the final well report). Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=2.36 (based on special core analysis report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the full elastic log suite started(2200m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Elastic behavior for the well was carefully calibrated with the nearby wells and other wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to Jelawat and Jemuduk wells, so S-wave velocity completely modelled in the well based on the same model which resulted in a matched trend with the calibrated nearby wells and very well behaved model when compared to the modelled results in the other wells.

Fluid properties:

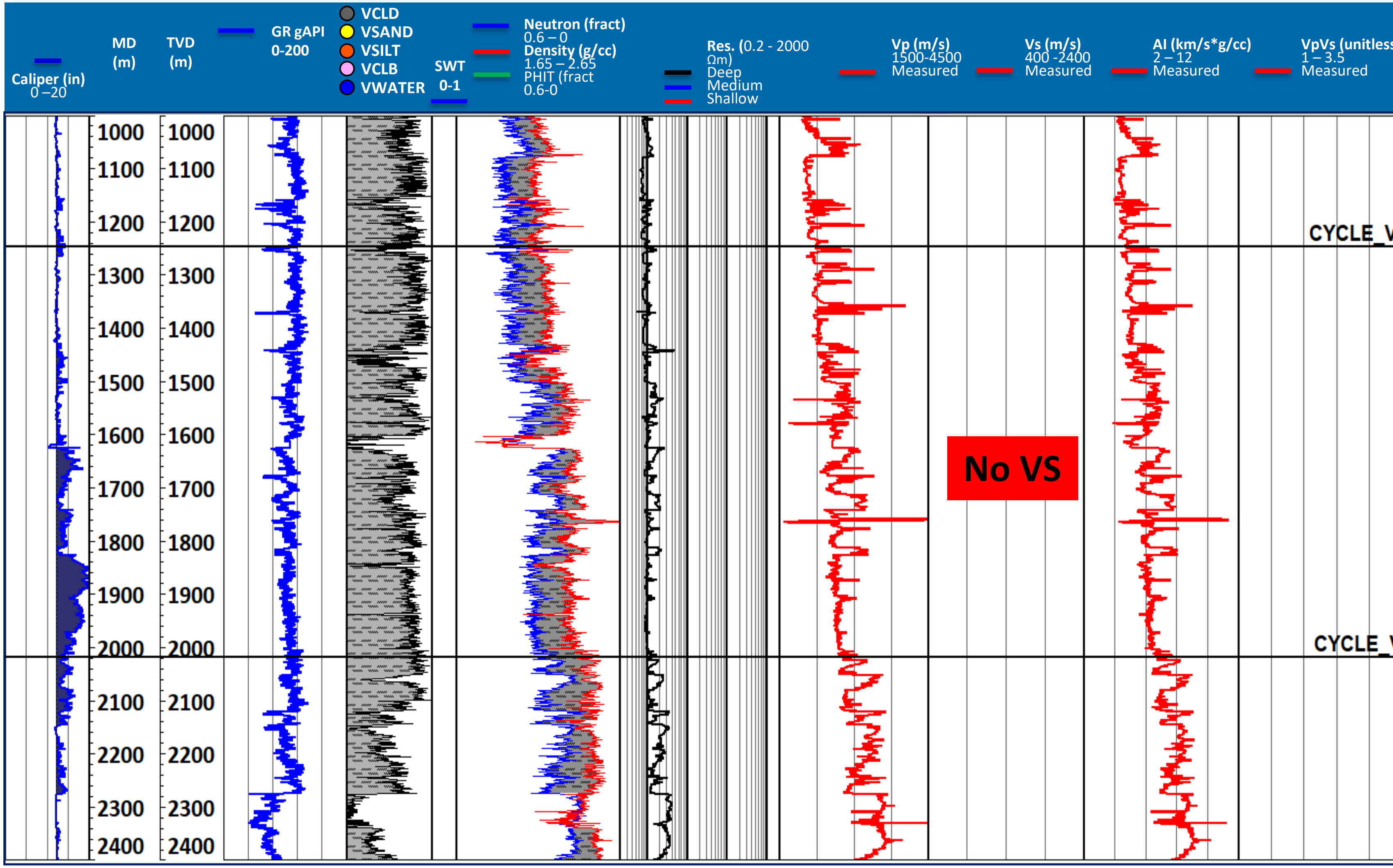
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 20700 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(cycle VI and V) using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class I was observed near the top of a high impedance blocky sand @2280m for the wet case while all the hydrocarbon cases showed class IIP at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) all fluid cases follow class I AVO response.

Hibiskus-1 Input Logs



Additional data includes pressure, temperature data, core and XRD reports and cuttings descriptions(Final geological report).

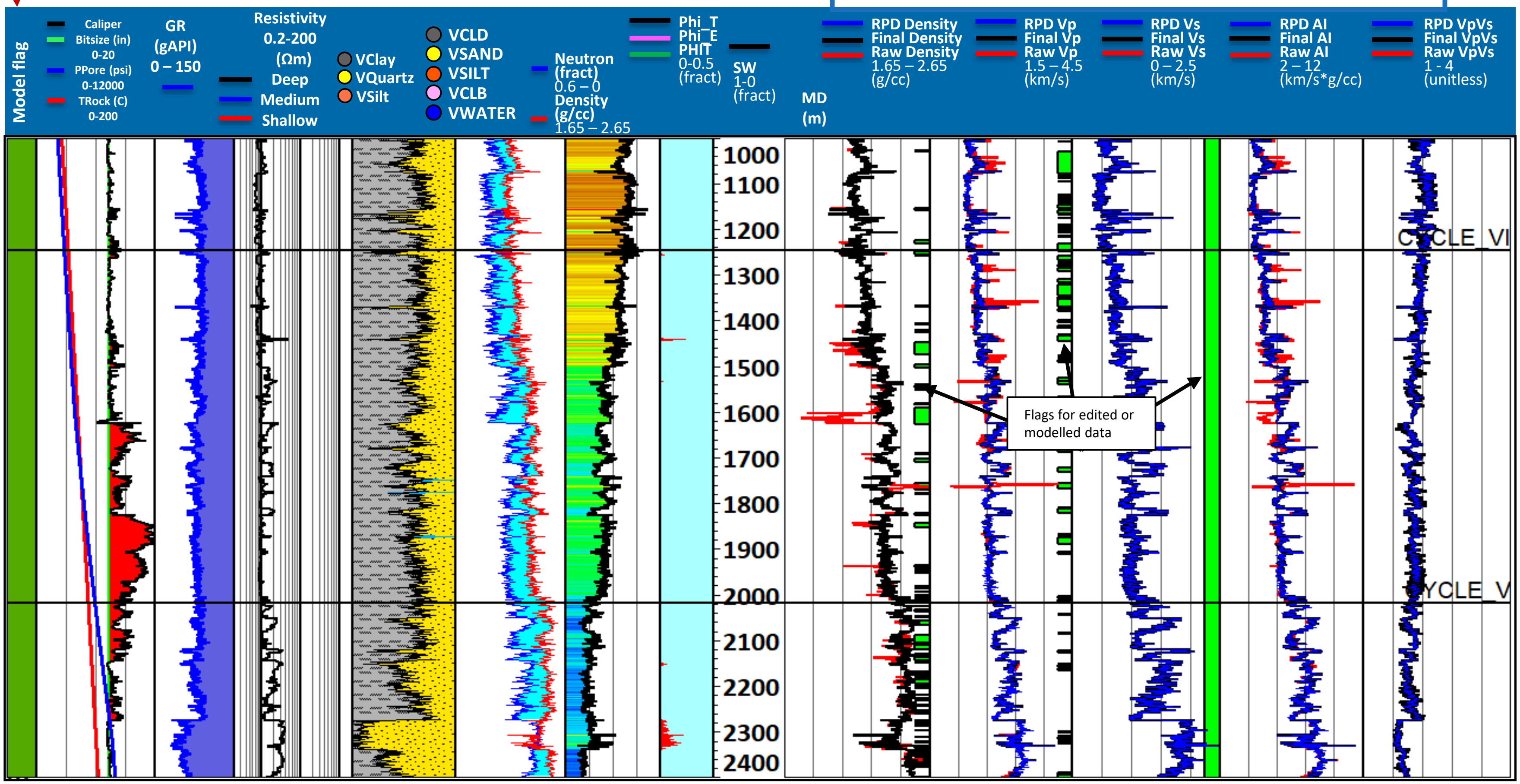
Hibiskus-1 Geophysical Well Log Analysis (GWLA) – All Well Interval

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

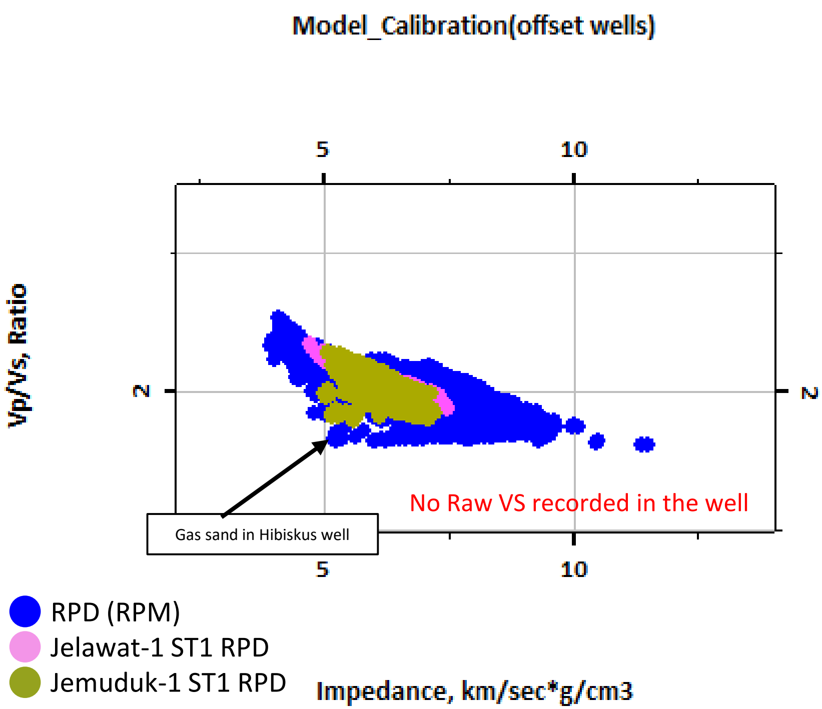
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



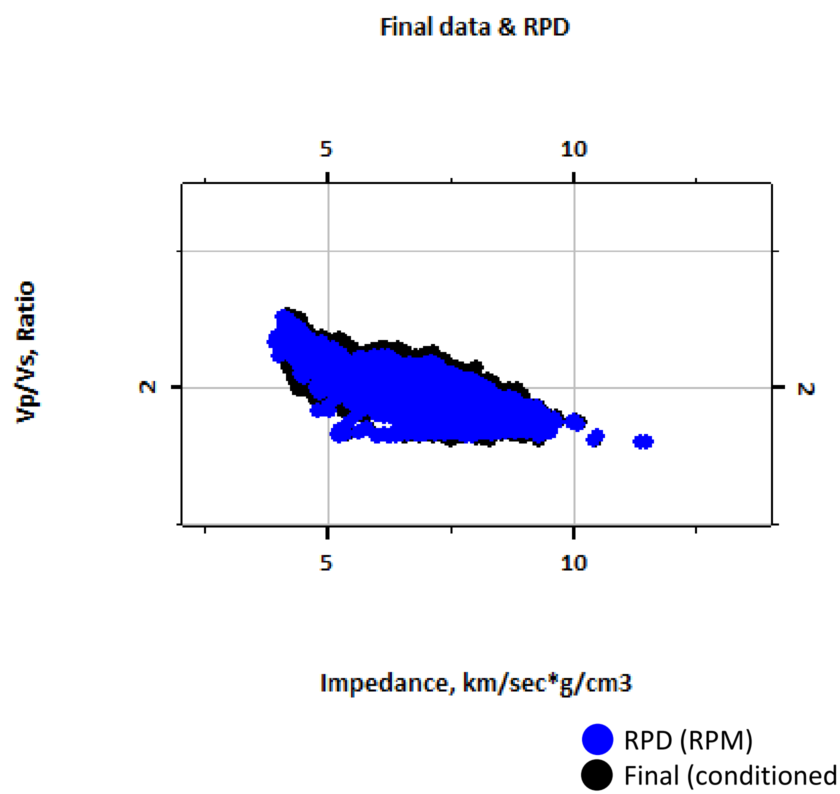
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Hibiskus-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the Hibiskus-1 well RPD with the nearby wells Jemuduk-1 ST1 and Jelawat-1 ST1.



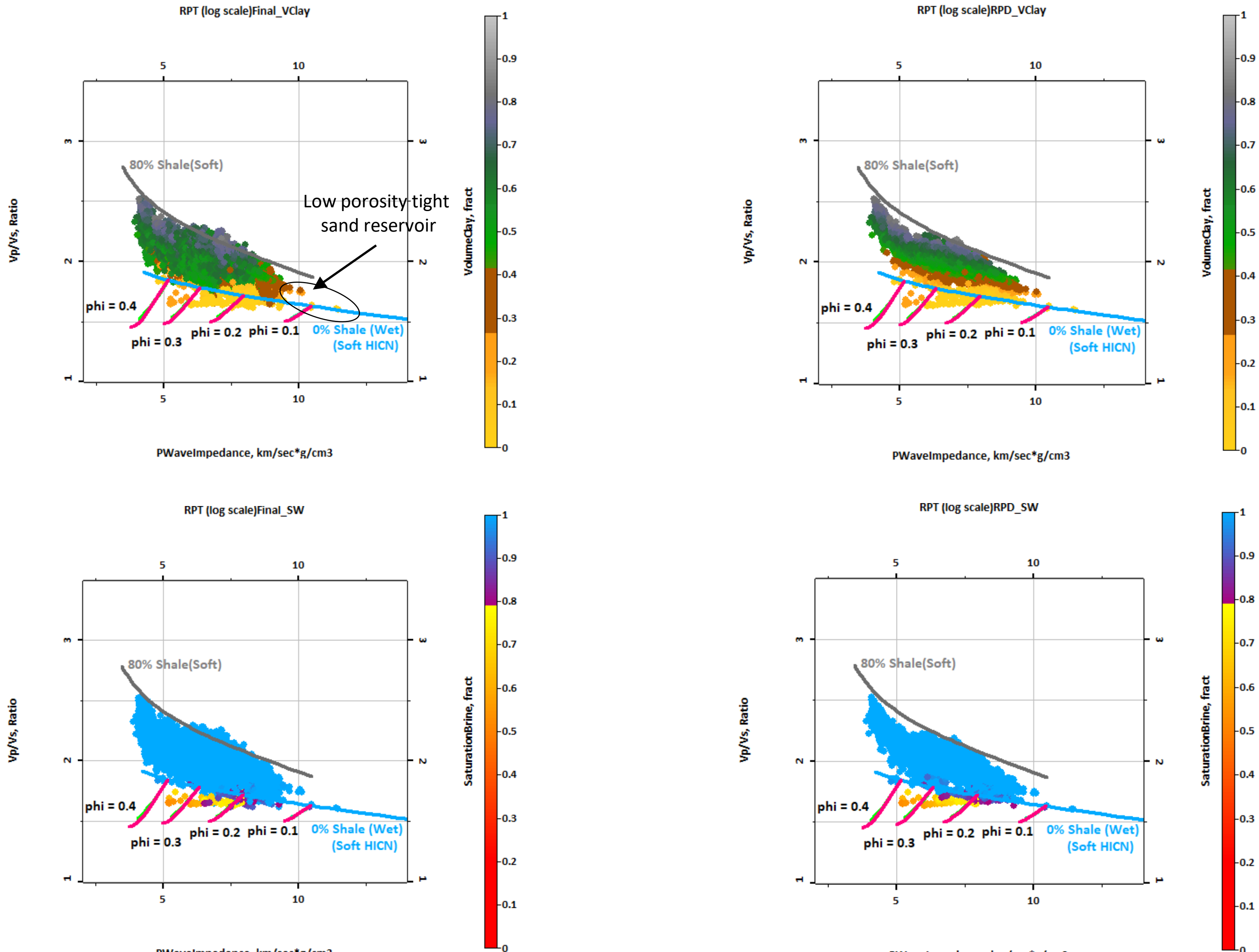
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).



Hibiskus-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

J1-1

J1-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is poor. Density is available only in the carbonate section while compressional velocity is available in the entire well, no shear velocity runs in the well. Client's petrophysical evaluation for the well was not provided. There is a gap in logging, from 1187m-1194m where no logs are present.
- Shear wave velocity(VS)was fully modelled in the entire well interval using the RPD after the model was carefully calibrated mainly in the carbonate section with many offset wells(K5-4, K5-3 and K5-2R) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance in the carbonate section follow the trend of the measured data in the nearby wells.
- In the section(1440-T.D.) the density is fully modelled using the RPD after the model was carefully calibrated with the good measured data in the clastic section.
- Due to the bad hole conditions in some intervals, VP was corrected using the RPD especially in the high gas saturated carbonate interval.
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D except in the logging gap interval.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is a Middle to Late Miocene isolated carbonate platform build-up with porosity ranging from 22-30%, with an average of 27%, including karst pores. Additional clastic reservoirs are present in the lower section of cycle IV below the carbonate section with good porosity as well.

Volume of hydrocarbons:

- Gas saturation calculated in the carbonate reservoir was up to 98% in most of the reservoir section while the best penetrated gas sandstones in the clastic section was about 25-40% gas saturation.

Water saturation (Sw):

- In the Carbonate section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1395m-1401m Rw is 0.18 Ωm, at 184° F NaCl is 13000ppm. Water saturation was calculated using Simandoux's equation.
- In the Clastic section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1430m-1445m Rw is 0.105 Ωm, at 188° F NaCl is 24200ppm. Water saturation was calculated using Simandoux's equation.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the stiff sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clastic and carbonate reservoirs, whereas the soft sediment model proved best in the clay rich lithologies when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed using both K5-4 and K5-3 as reference wells.
- To model the shear velocity in the shallower and deeper clastic sections the elastic behavior for the well was carefully calibrated with the nearby wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to K5-4 well, so S-wave velocity completely modelled in that interval based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells(K5-4 and K5-3) except the extra clastic section that was not penetrated in anyone of the reference wells.

Fluid properties:

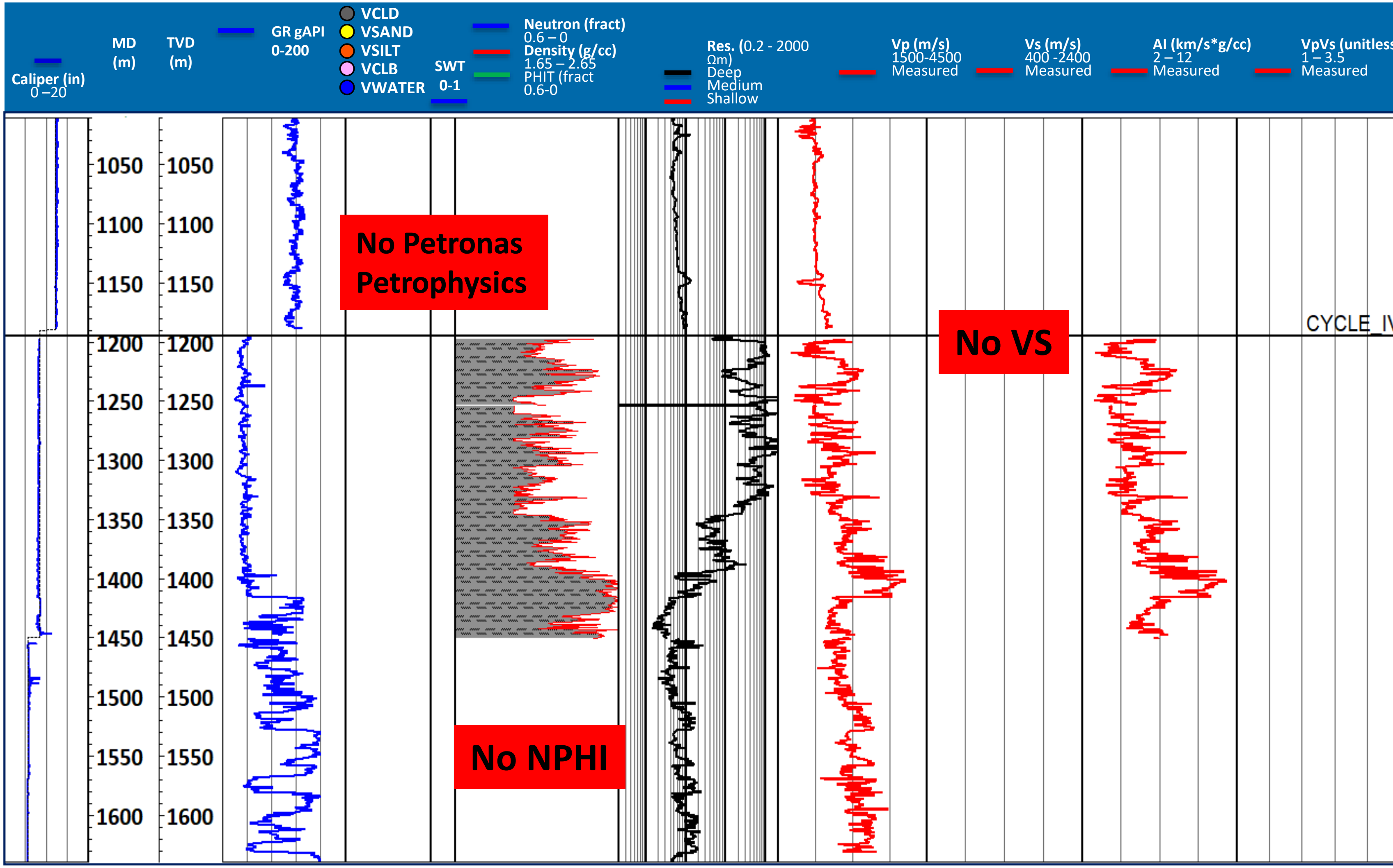
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 13000-24200 ppm
- Gas gravity: 0.886[assumed]
- Oil Gravity: 40 API[assumed]
- Gas / Oil ratio: 50 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene carbonates and the deeper clastic reservoirs using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- In the carbonate section AVA class IV was observed near the gas saturated carbonates top@ 1193m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.
- In the clastic section also AVA class IV was observed near the gas sandstone@ 1563m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.

J1-1 Input Logs



Additional data includes pressure, temperature data and some cuttings descriptions(Final geological report).

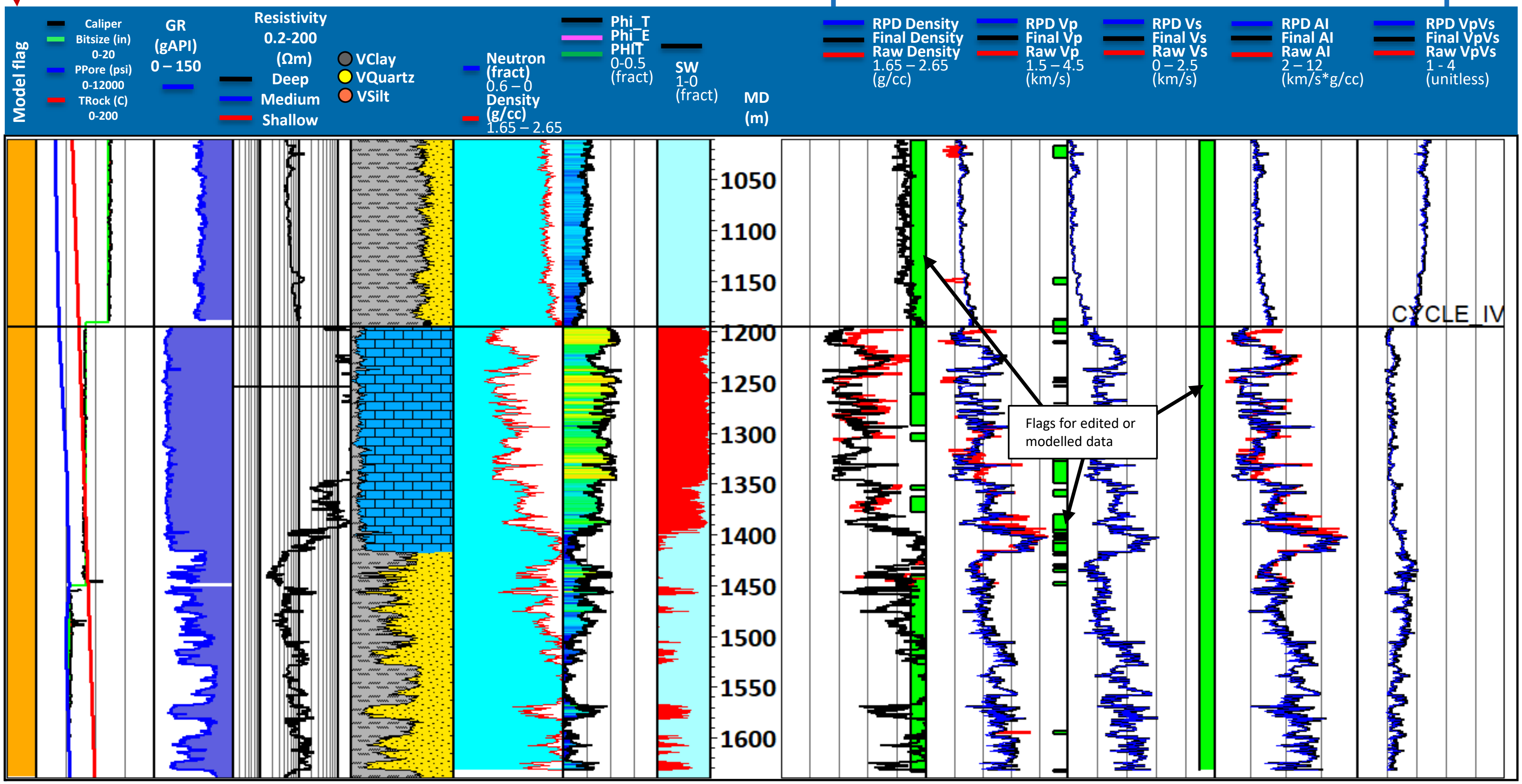
J1-1 Geophysical Well Log Analysis (GWLA) – (All Available Data Set)

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

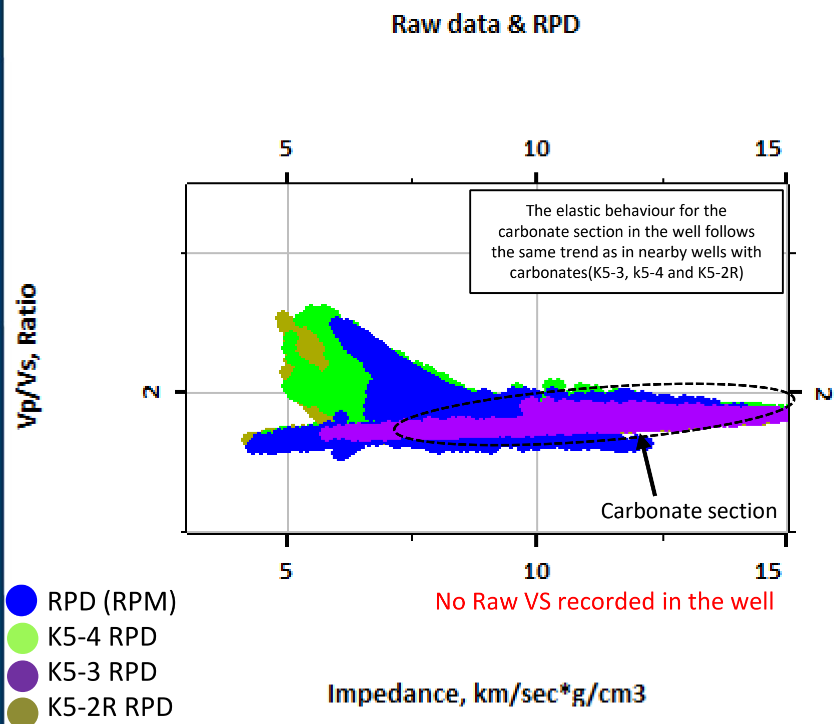
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



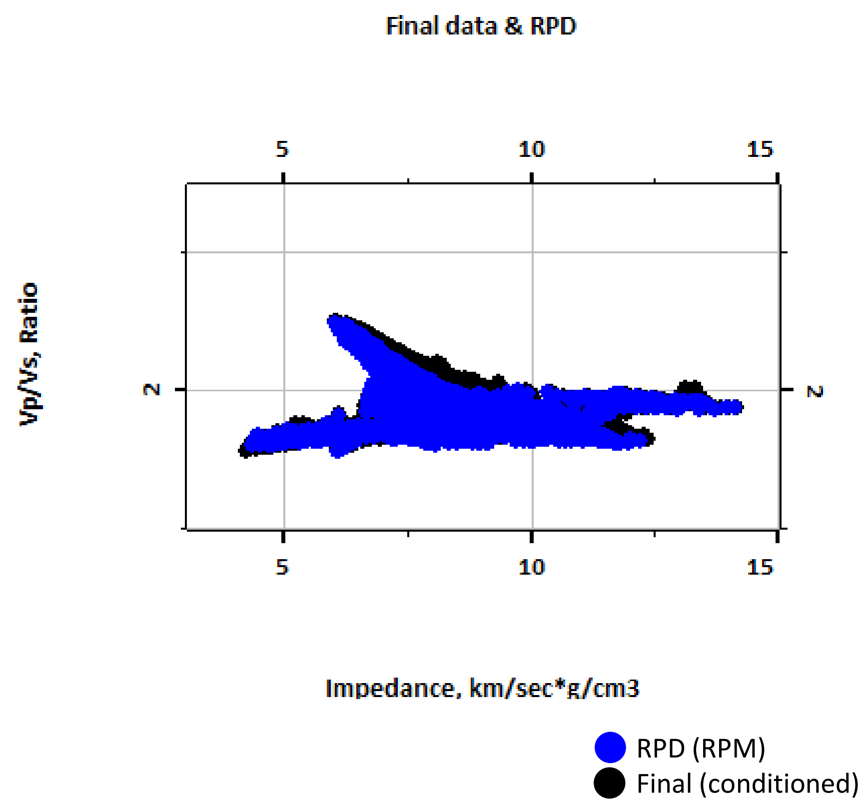
Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data in the well and in the nearby reference wells especially in the carbonate section (K5-4, K5-3 and K5-2R)

J1-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the J1-1 well RPD with the nearby wells K5-2R, K5-3(carbonate section) and K5-4.



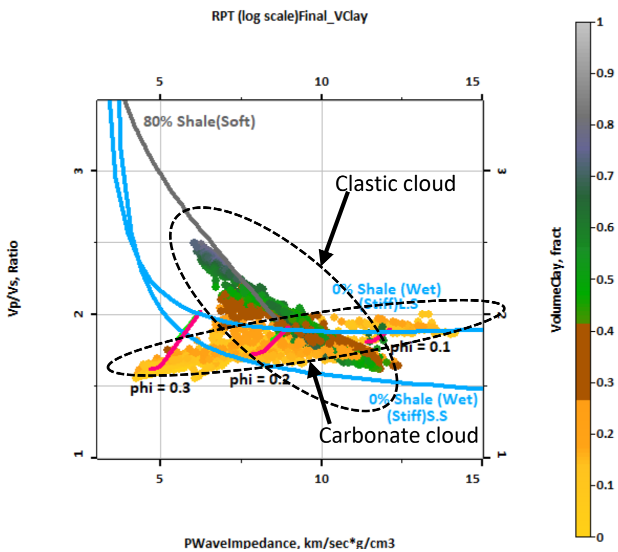
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

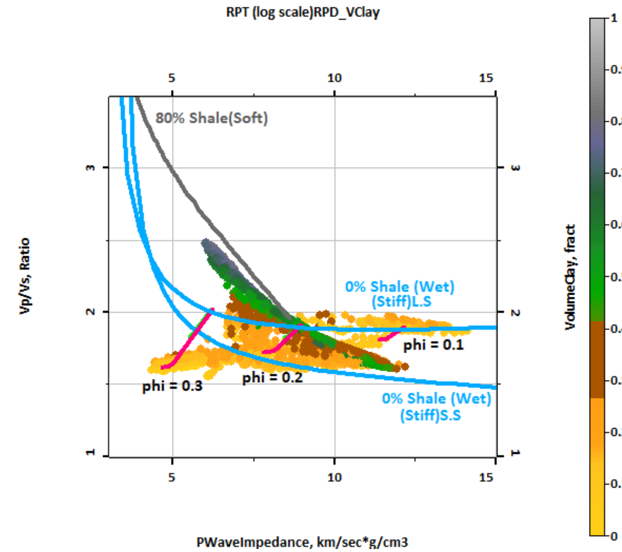


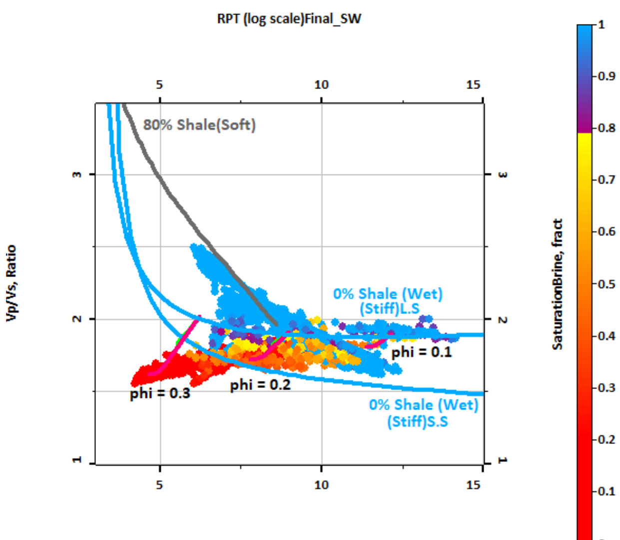
J1-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

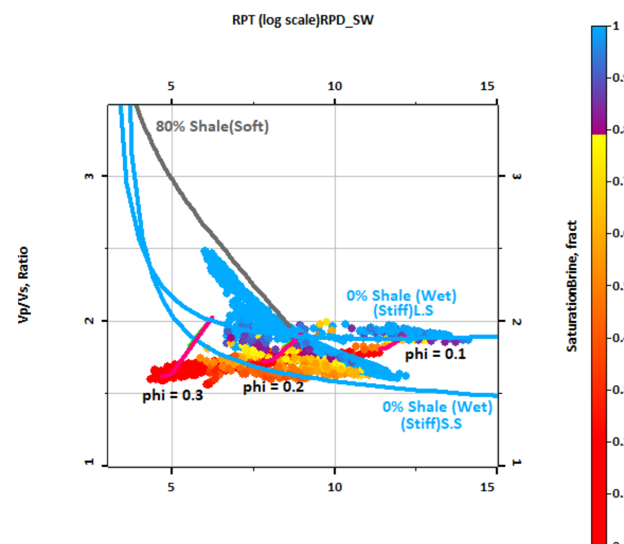
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff sediment models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

J5-1

J5-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is poor. Density and compressional velocity are available throughout the well interval while no shear velocity runs in the well. Some Client's petrophysical evaluation results were provided for the well as a reference also some QI results.The elastic data above 450m were unreliable to estrablish a rock physics model.
- Shear wave velocity(VS)was fully modelled in the entire well interval using the RPD after the model was carefully calibrated mainly in the carbonate section with many offset wells(J1-1 and K5-4) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance in the carbonate section follow the trend of the measured data in the nearby wells.
- In cycle V Dayung well was used to calibrate the model.
- In the section(1500-1900m) the density was heavily edited using the RPD due to the bad hole conditions.
- Due to the bad hole conditions in some intervals, VP was corrected using the RPD especially in the high gas saturated carbonate interval.
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D except in the logging gap interval.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is a Middle to Late Miocene isolated carbonate platform build-up with porosity ranging from 23-29%, with an average of 25%, including karst pores. Additional clastic reservoirs are present in the shallow cycle V and the deeper cycles III and II.

Volume of hydrocarbons:

- Gas saturation calculated in the carbonate reservoir was up to 98% in most of the reservoir section while the best penetrated gas sandstones in the cycle V sands was about 25-40% gas saturation.All sands penetrated in the zones of Cycle II and III were 100% brine saturated

Water saturation (Sw):

- In the Carbonate section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1310-1316m and 1320-1324m Rw is 0.104 Ωm, at 166° F NaCl is 27700ppm. Water saturation was calculated using Simandoux's equation.
- In the Clastic section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1418.5-1424m Rw is 0.072 Ωm, at 178° F NaCl is 39000ppm. Water saturation was calculated using Simandoux's equation.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the stiff sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clastic and carbonate reservoirs, whereas the soft sediment model proved best in the clay rich lithologies when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed using both J1-1 as reference well.
- To model the shear velocity in the shallower and deeper clastic sections the elastic behavior for the well was carefully calibrated with the nearby wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to J1-1 well(except for the cycle V and the basement sections which were not penetrated in the nearby wells), so S-wave velocity completely modelled in that interval based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells(J1-1 and K5-4) except the extra clastic section that was not penetrated in anyone of the reference wells.
- The most nearby well to calibrate the model in the cycle V sand was Dayung-1 well.

Fluid properties:

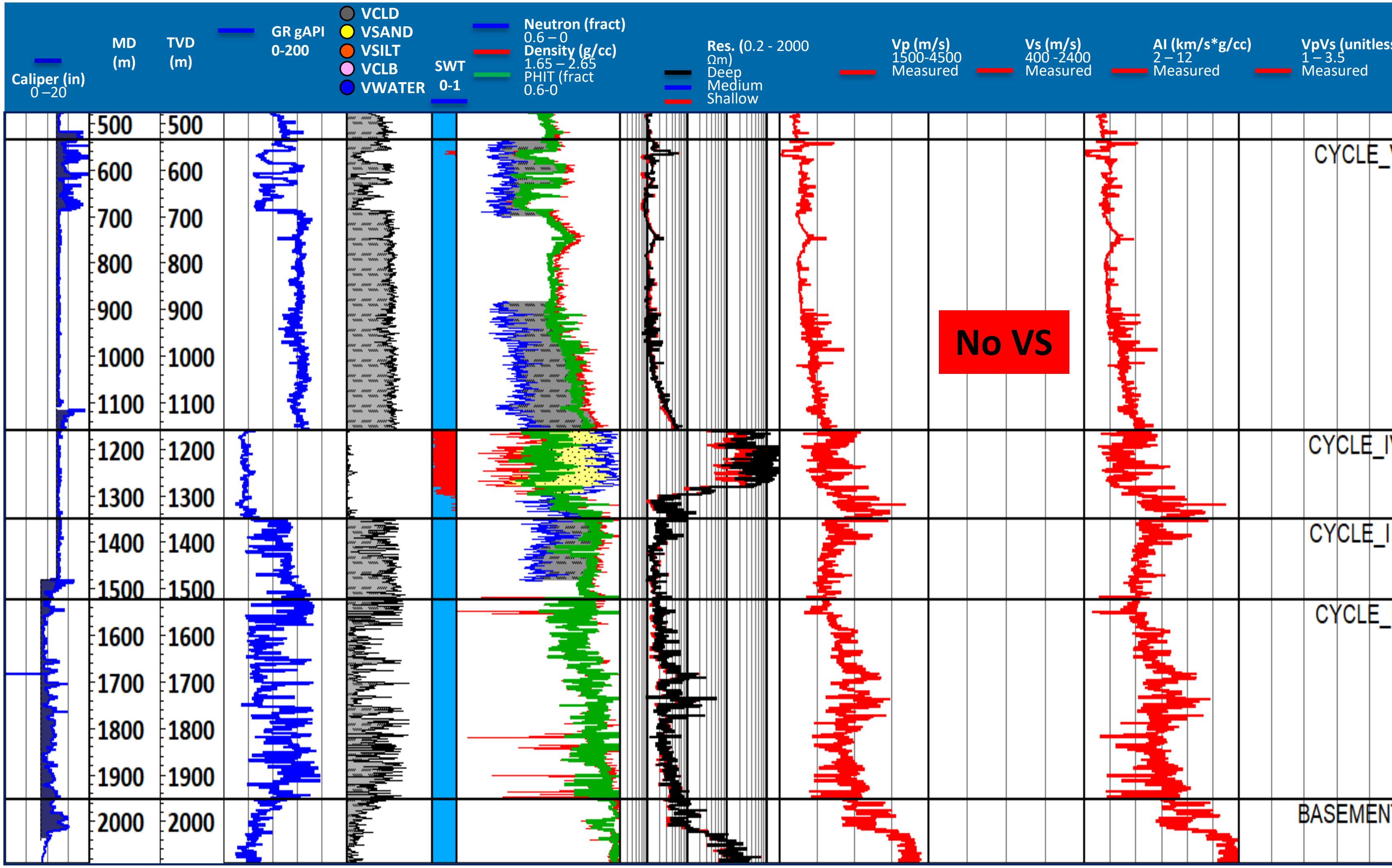
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 27700-39000 ppm
- Gas gravity: 0.886[assumed]
- Oil Gravity: 40 API[assumed]
- Gas / Oil ratio: 50 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene carbonates and the deeper clastic reservoirs(cycles III and II using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- In the carbonate section AVA class II was observed near the gas saturated carbonates top@ 1159m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.
- In the clastic section also AVA class II was observed near the wet sandstone@ 1560m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.

J5-1 Input Logs



Additional data includes pressure, temperature data and some cuttings descriptions(Final geological report),Also internal QI results were provided for reference.

J5-1 Geophysical Well Log Analysis (GWLA) – (Cycles V and IV)

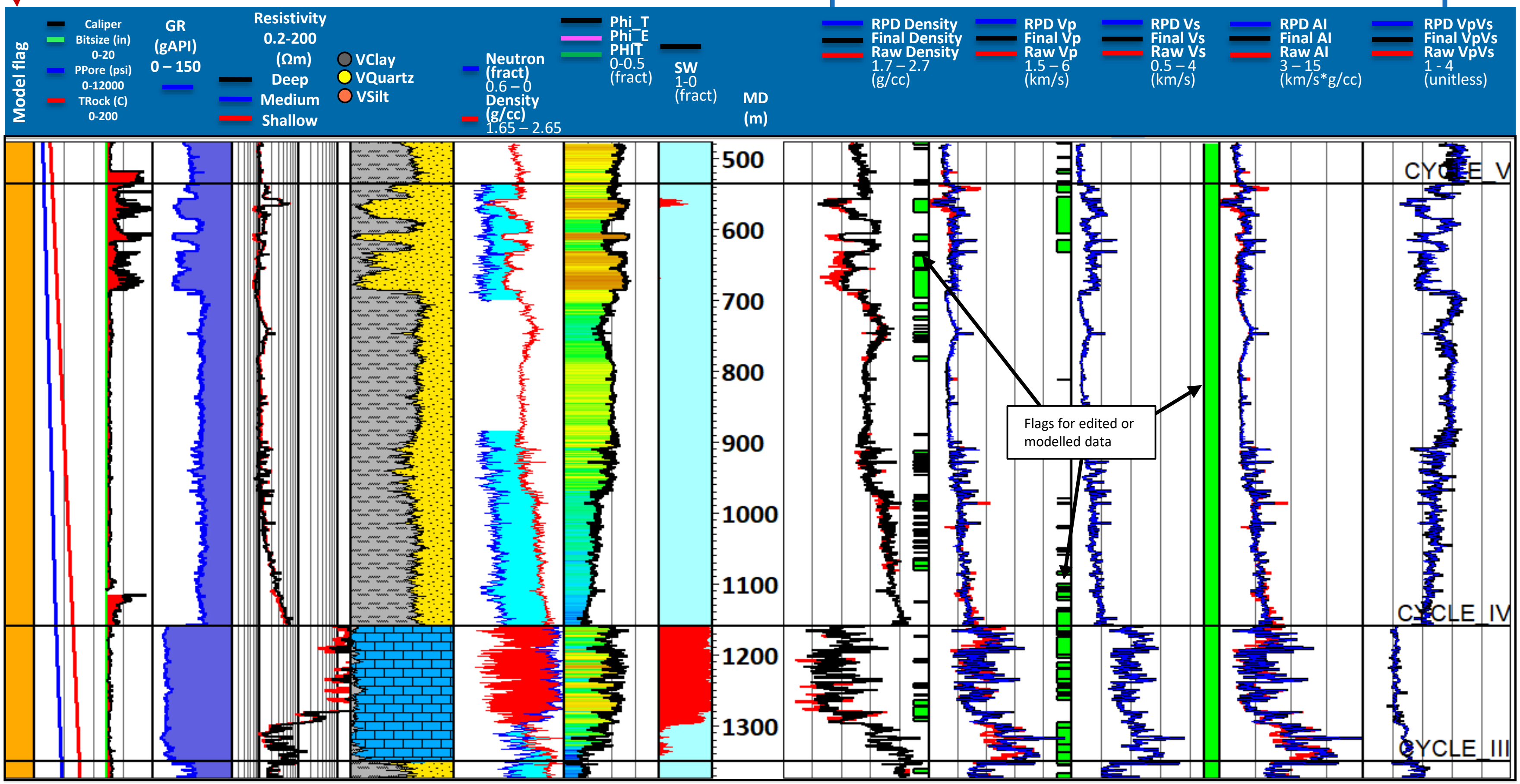
model type flag

Soft rock model
Stiff rock model

Above depth of 450m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve
Final edited (Conditioned) curve
Original Raw (Raw) curve



Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data in the well and in the nearby reference wells used in calibration especially in the carbonate section (J1-1 and K5-4)

J5-1 Geophysical Well Log Analysis (GWLA) – (Cycles III, II and Basement)

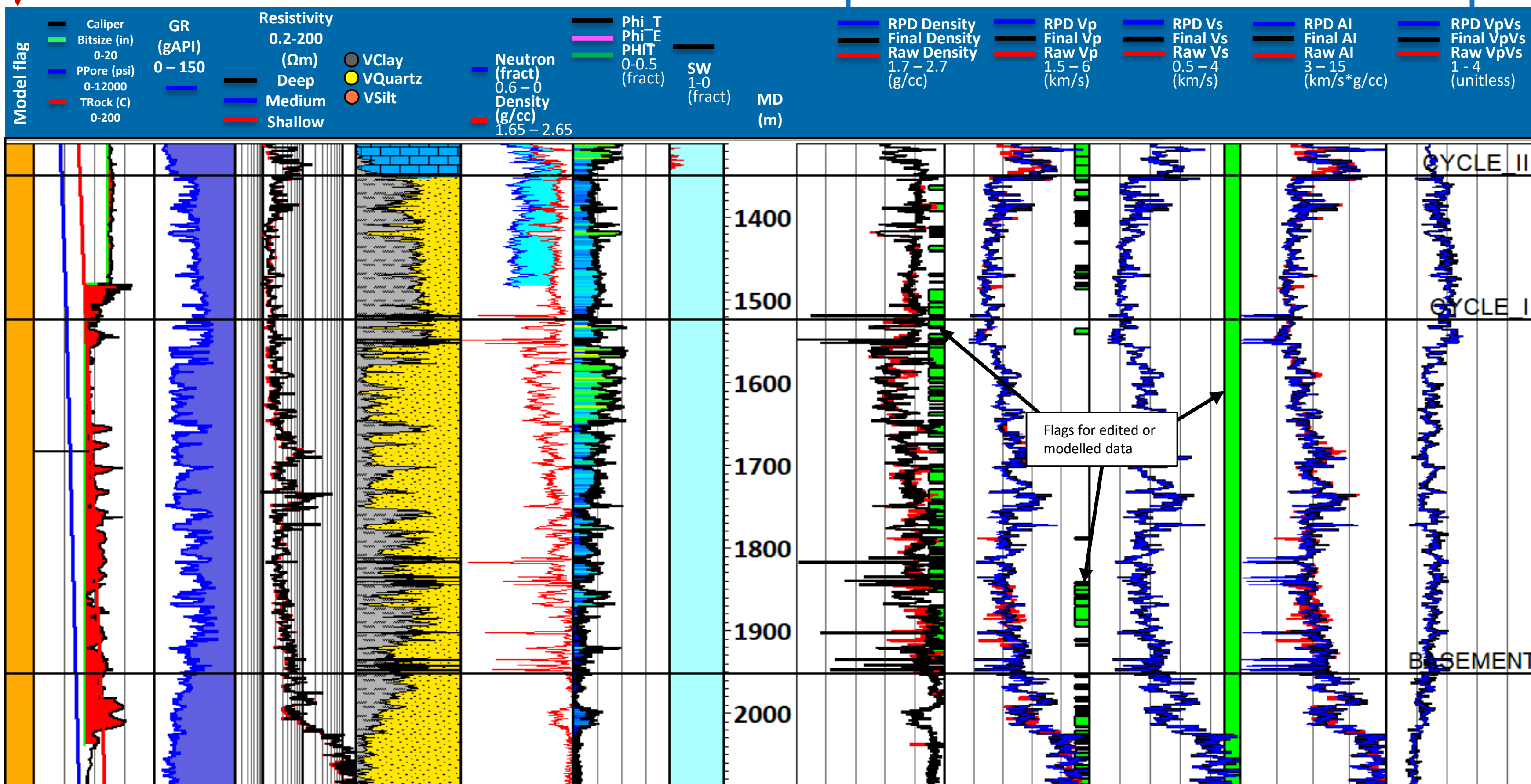
model type flag

- Soft rock model
- Stiff rock model

Above depth of 450m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

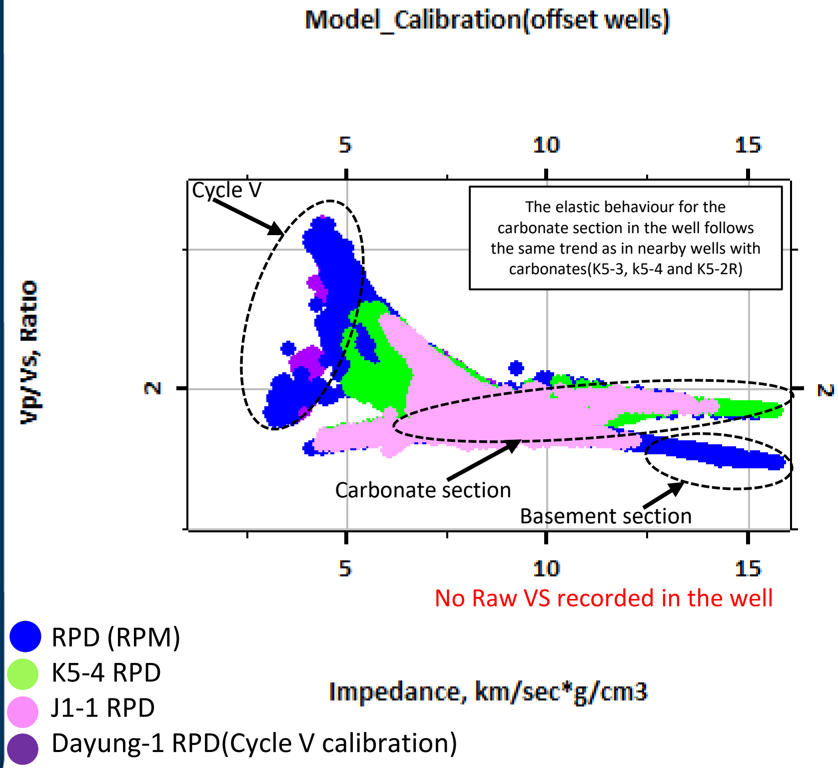
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



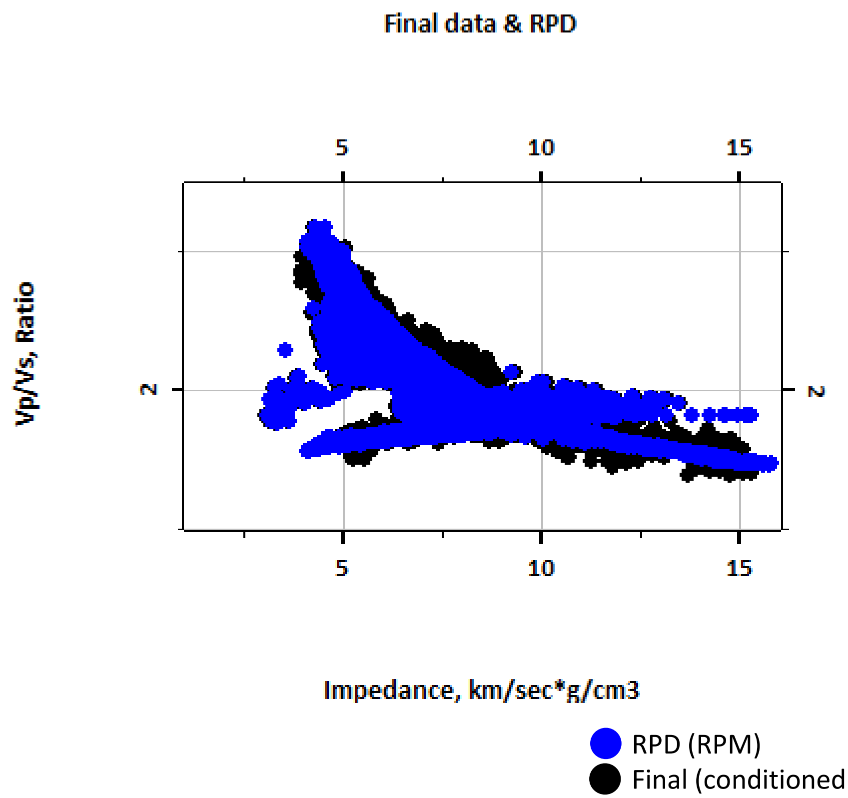
Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data in the well and in the nearby reference wells used in calibration especially in the carbonate section (J1-1 and K5-4)

J5-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the J5-1 well RPD with the nearby wells J1-1, K5-4(carbonate section) and Dayung-1(Cycle V).



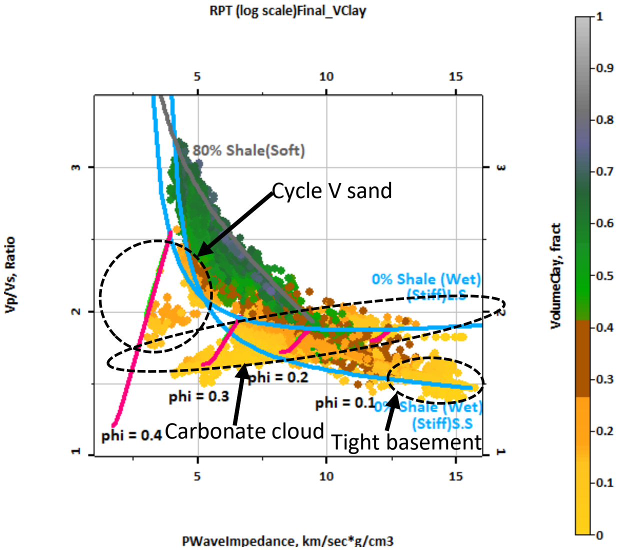
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

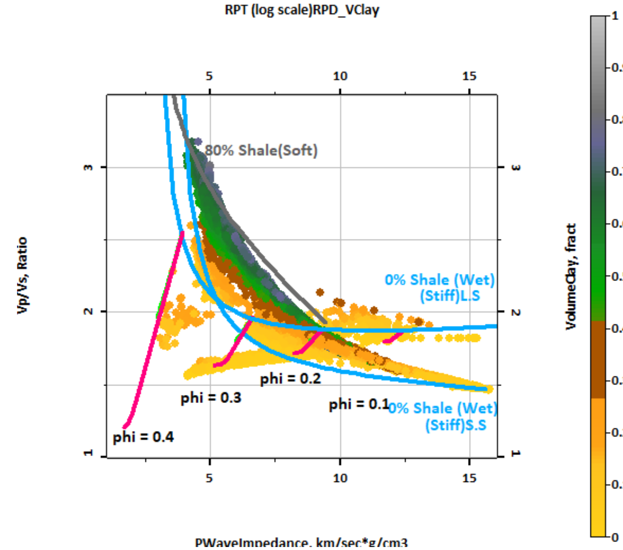


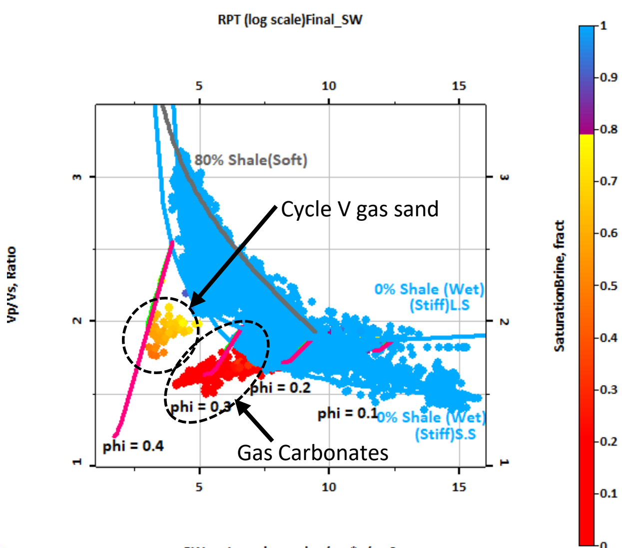
J5-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

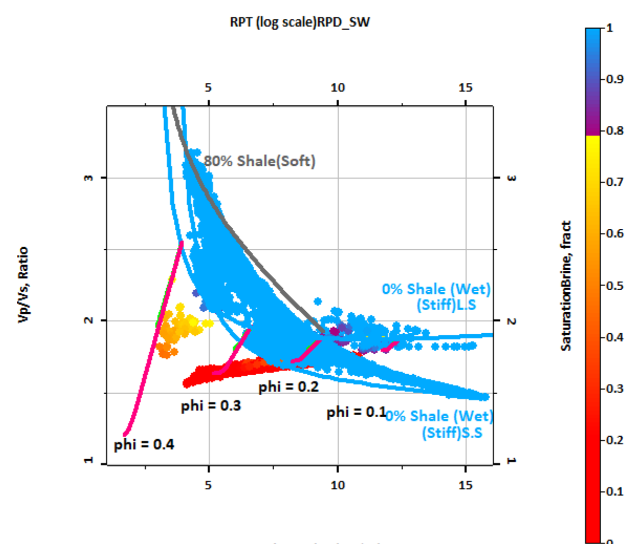
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff sediment models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Jelawat-1ST1

Jelawat-1ST1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited near the casing depth(2980-2015m) using the RPD due to bad measurement.
- Vs and Vp were heavily edited in many intervals in the well due to noisy or lazy readings especially in the section(2200-2500m)using the RPD in order to have a consistent VpVs ratio results and normal relationship between quartz rich and clay rich sediments.
- The hole encountered a local over-pressure zone around 2950m MD causing sudden drop in the velocity, density and resistivity readings.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene RJ1 and RJ2 sands. These are a series of turbiditic tight sands with some calcareous cement, distributed in lobe/channel complexes with blocky shape intercalated with claystone layers.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine .

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section of the clean low porosity wet sand section(3100-3325m) yielded a formation water salinity of 28800 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 (assumed based on the final well report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2200m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- The hole encountered a sudden over-pressure section starting around 2950m MD causing sudden drop in the P and S-wave velocity, density and resistivity readings.

Fluid properties:

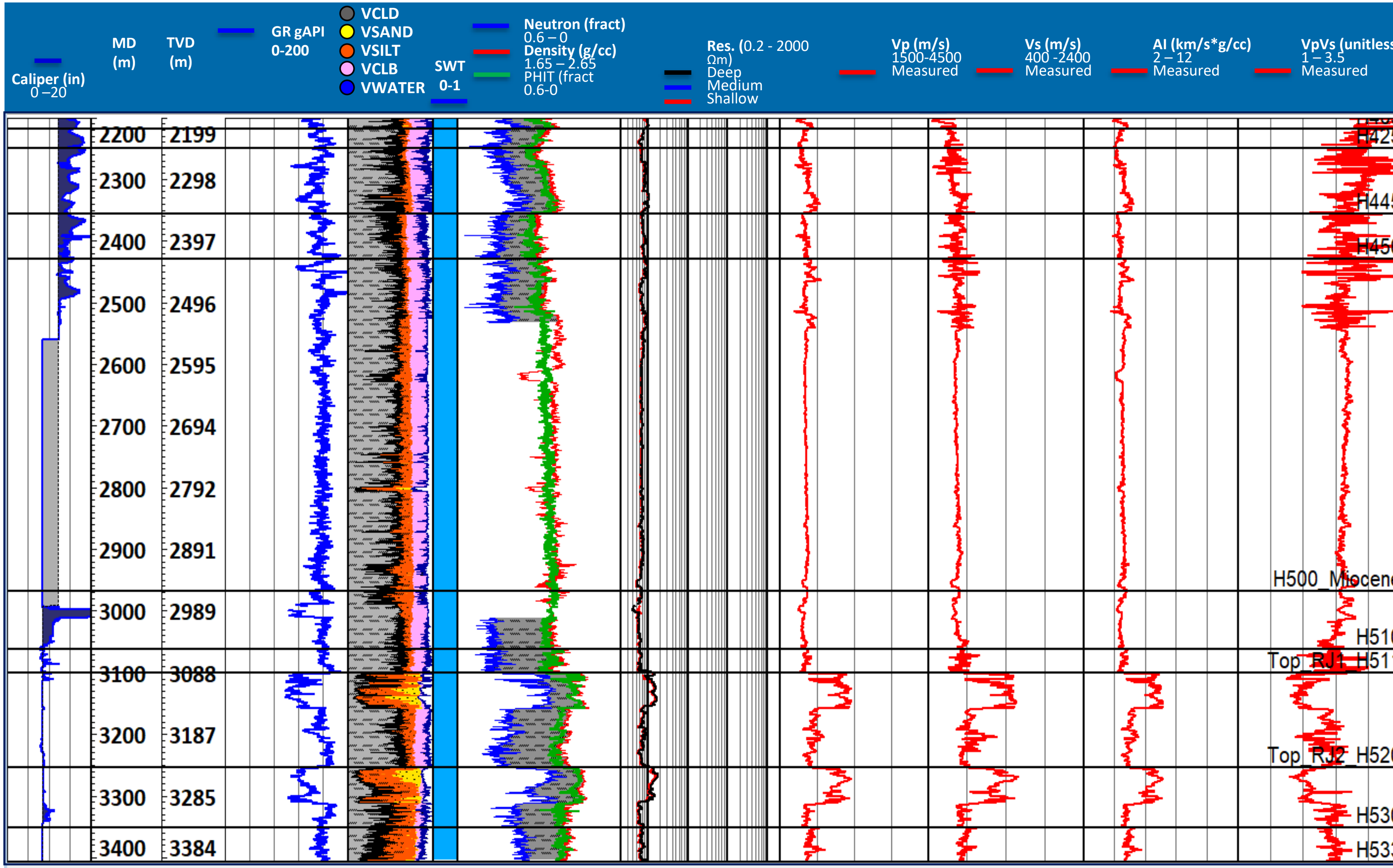
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 28800 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(RJ1 and RJ2) using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the top of a high impedance blocky sand @3105m for the wet case while all the hydrocarbon cases showed class IIP at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no significant change for the AVA class could be noticed.

Jelawat-1ST1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

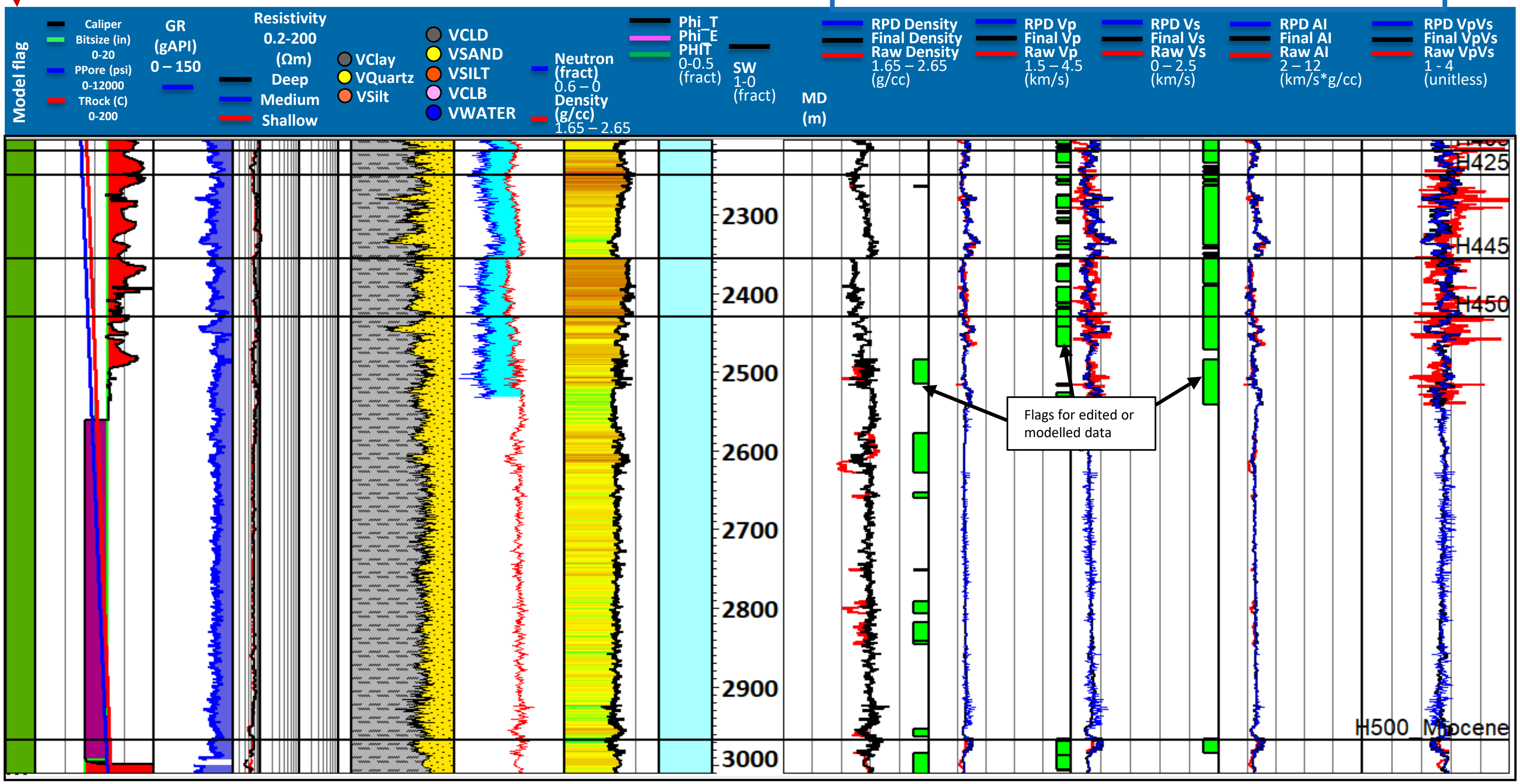
Jelawat-1ST1 Geophysical Well Log Analysis (GWLA) – 12.25” Hole

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

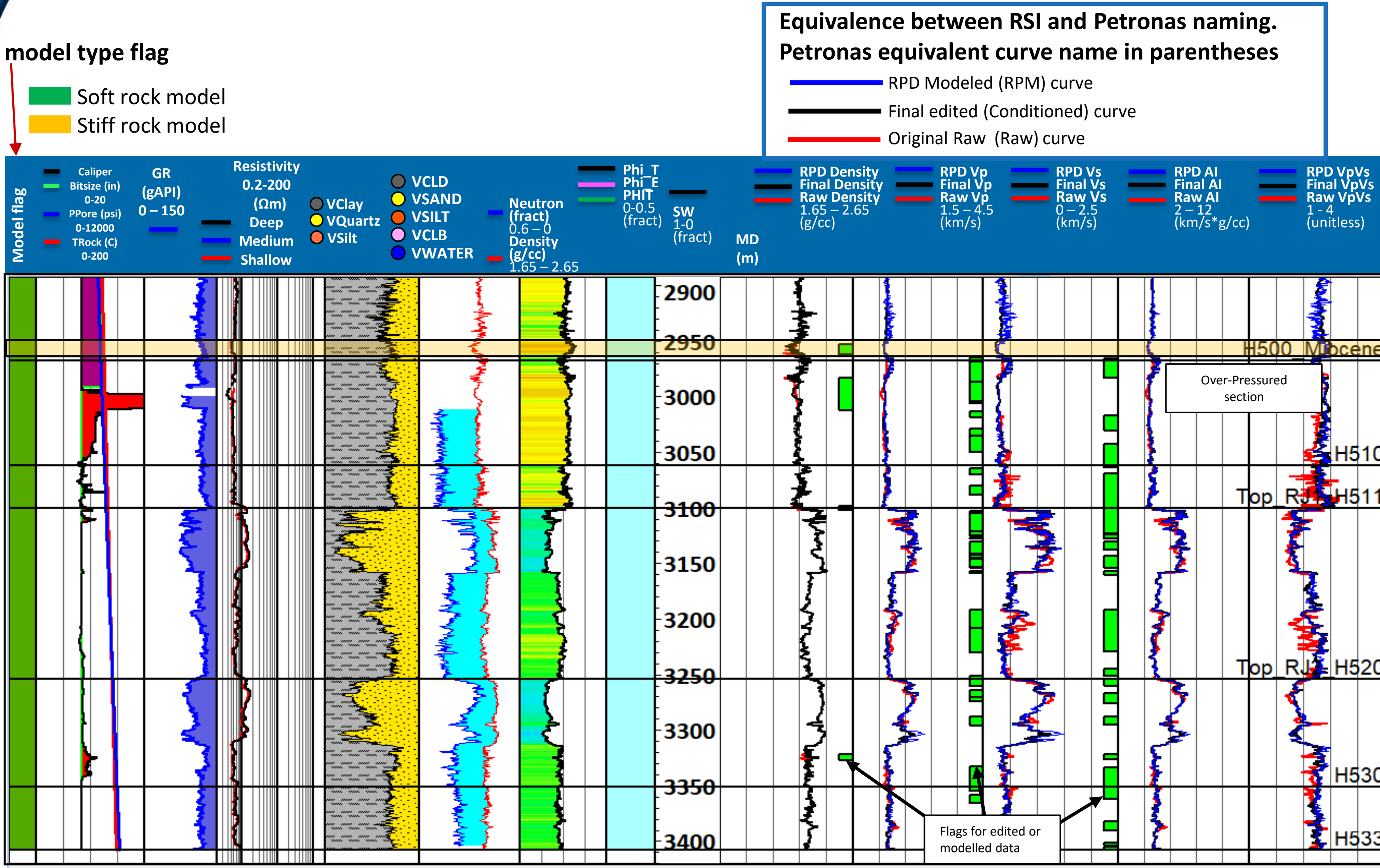
model type flag

- Soft rock model
- Stiff rock model



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

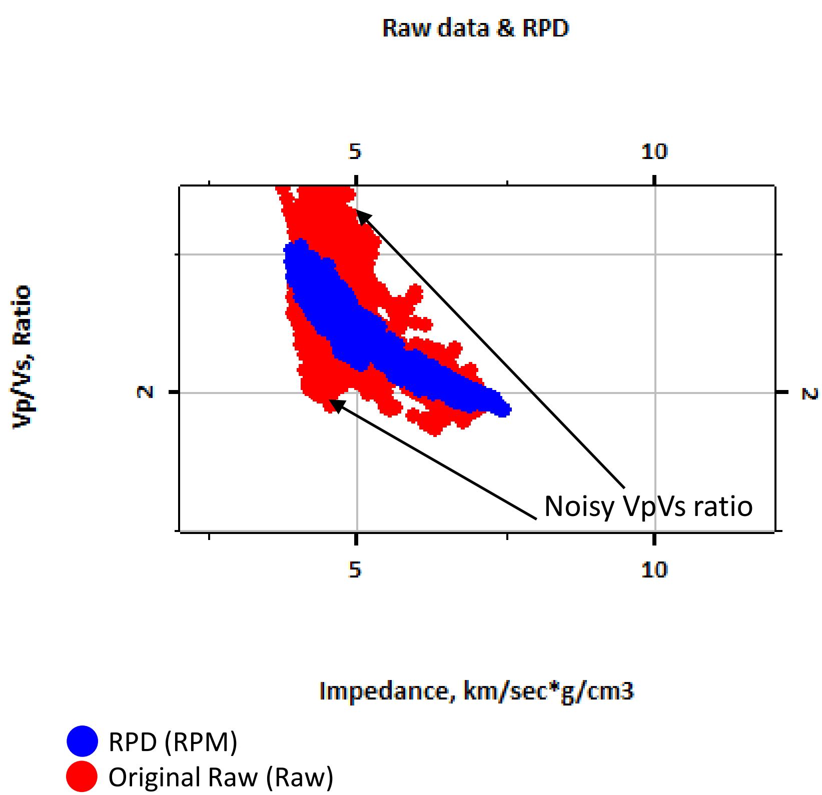
Jelawat-1ST1 Geophysical Well Log Analysis (GWLA) – 8.5” Hole



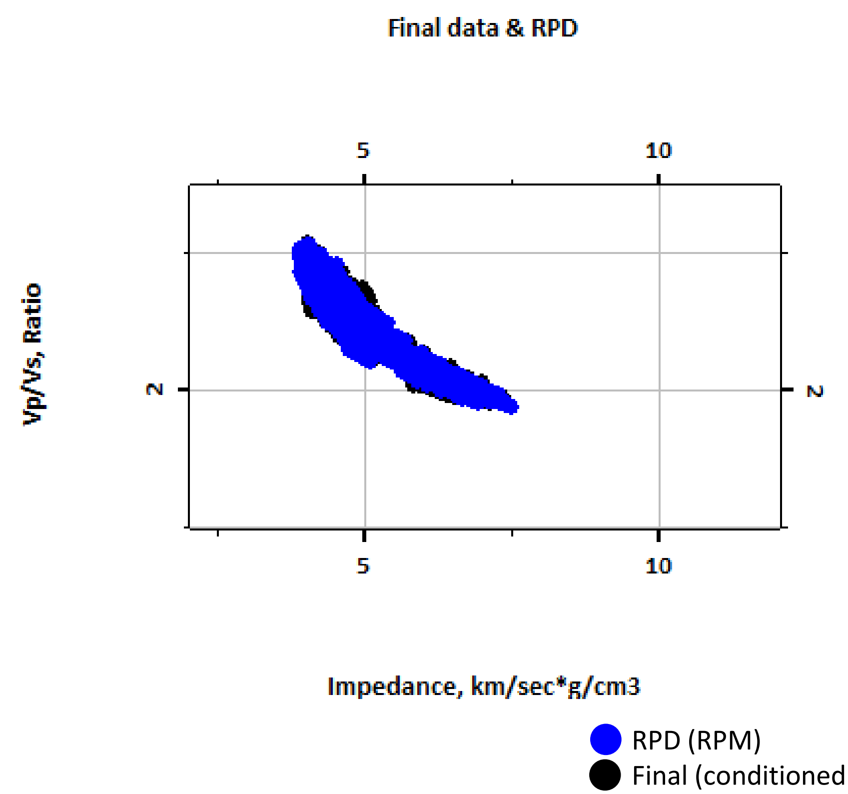
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Jelawat-1ST1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.



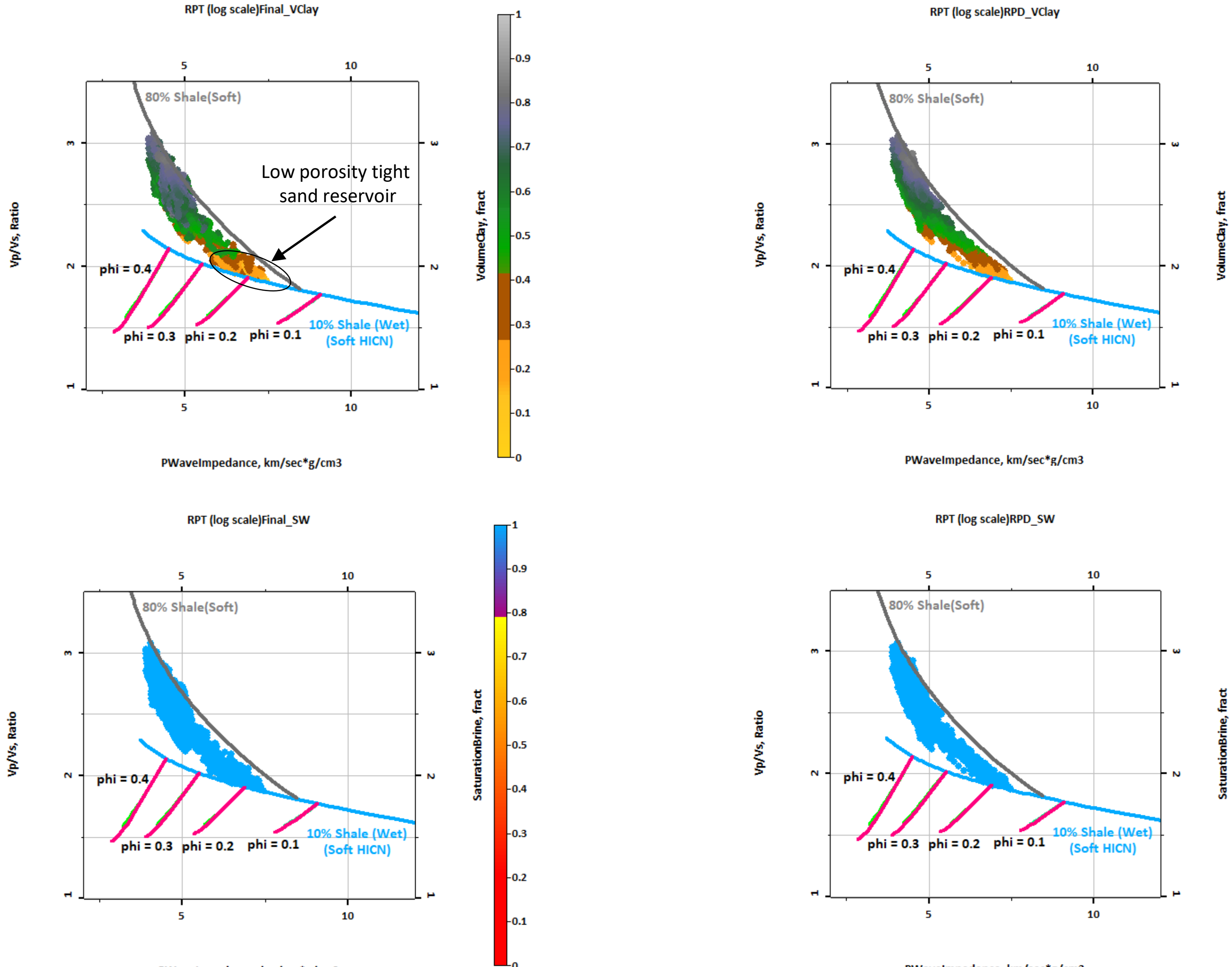
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



Jelawat-1ST1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Jemuduk-1ST1

Jemuduk-1ST1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited near the casing depth(2685-2720m) using the RPD due to bad measurement.
- Vs and Vp were heavily edited in many intervals in the well due to flat or lazy readings especially in the section(1825-2050m)using the RPD in order to have consistent VpVs ratio results and normal relationship between quartz rich and clay rich sediments.
- The hole encountered a sudden over-pressure section starting around 2400m MD causing sudden drop in the velocity, density and resistivity readings.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the cycle VIII and VII sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with blocky shape intercalated with claystone layers.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated except some minor gas saturation found around 2240m MD where the gas saturation reached to 25%.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section of the clean wet sand section(2500-2600m) yielded a formation water salinity of 17000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(1800m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- The hole encountered a sudden over-pressure section starting around 2400m MD causing sudden drop in the P and S-wave velocity, density and resistivity readings.

Fluid properties:

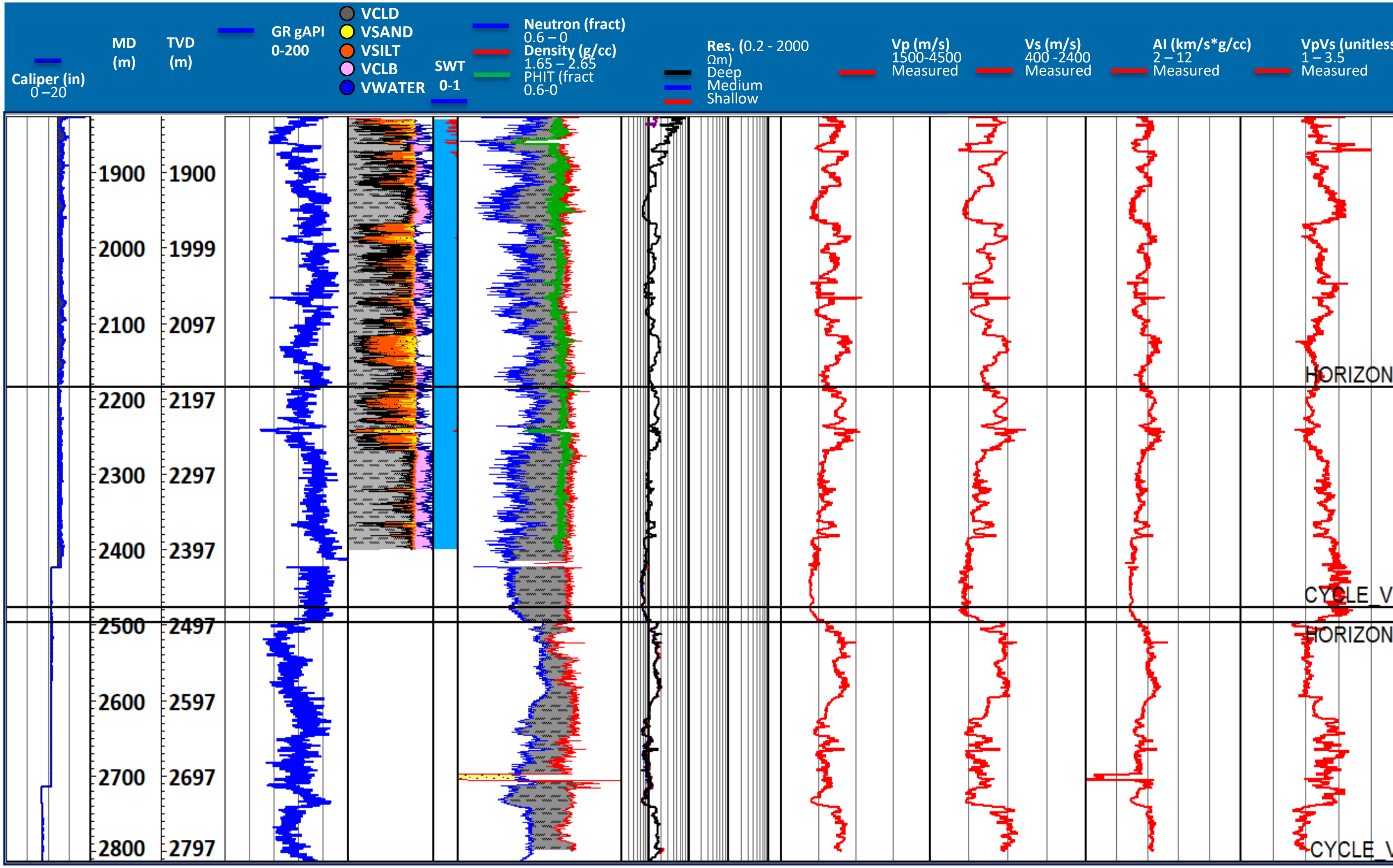
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 17000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of cycle VIII and VII using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the top of a good blocky sand @ 2500m for all fluid cases at in situ reservoir conditions with polarity change in for the hydrocarbon cases.
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) no significant change for the AVA class could be noticed.

Jemuduk-1ST1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

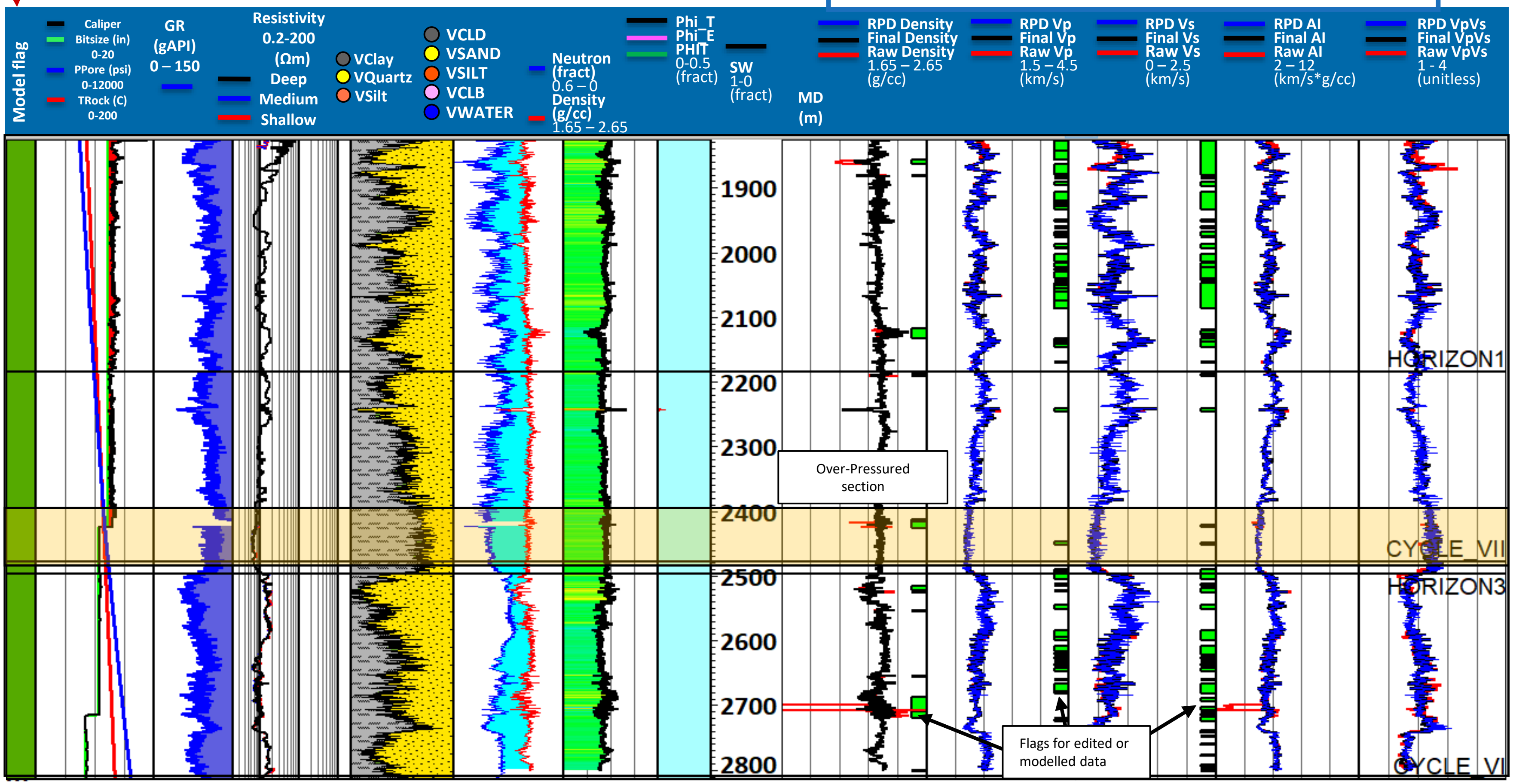
Jemuduk-1ST1 Geophysical Well Log Analysis (GWLA) – Interval with elastic logs

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

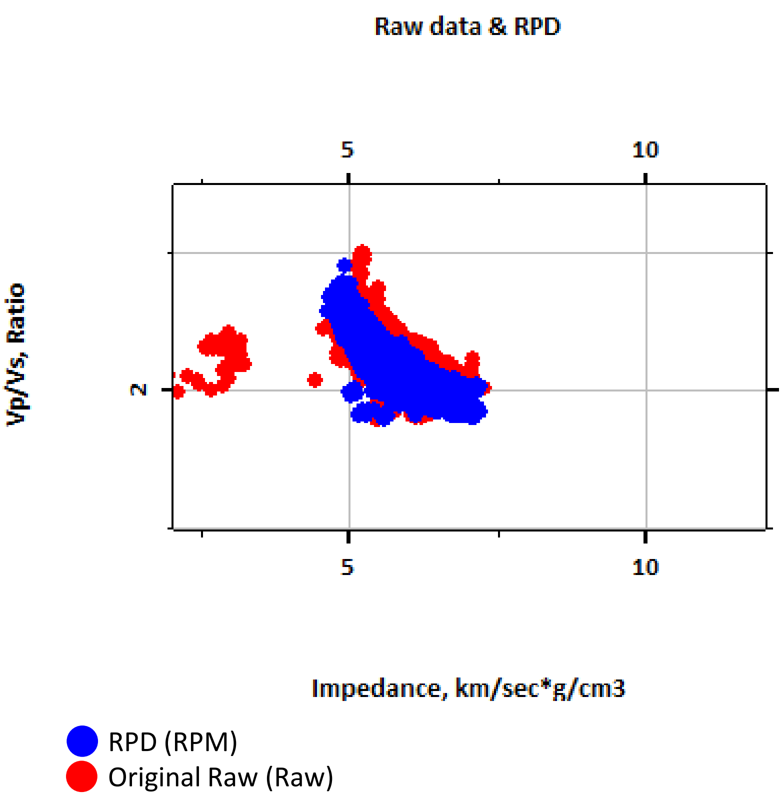
- Soft rock model
- Stiff rock model



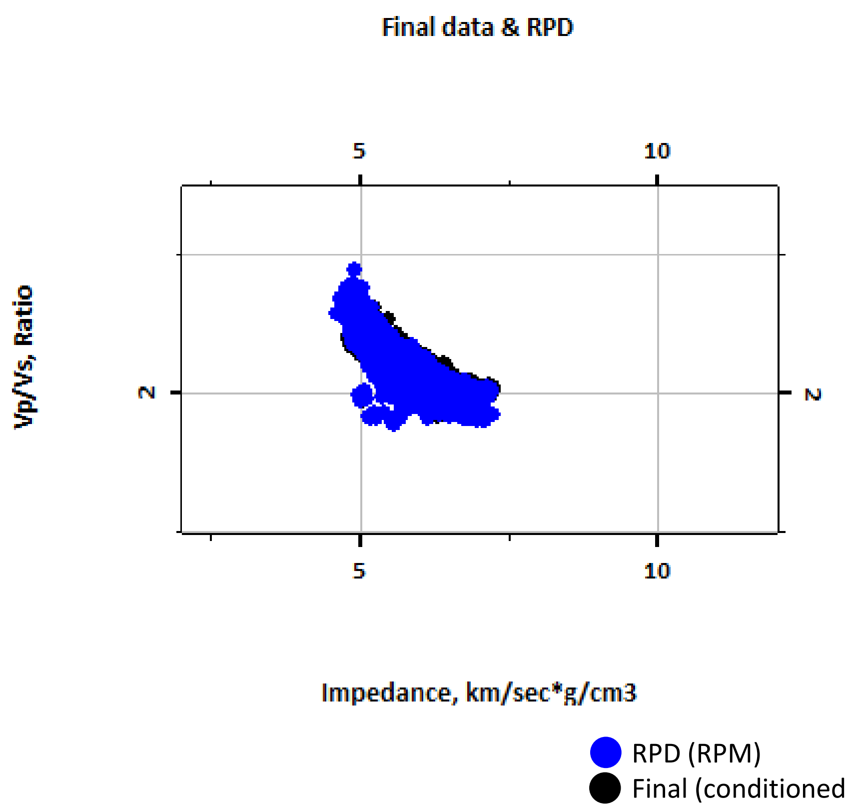
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Jemuduk-1ST1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.



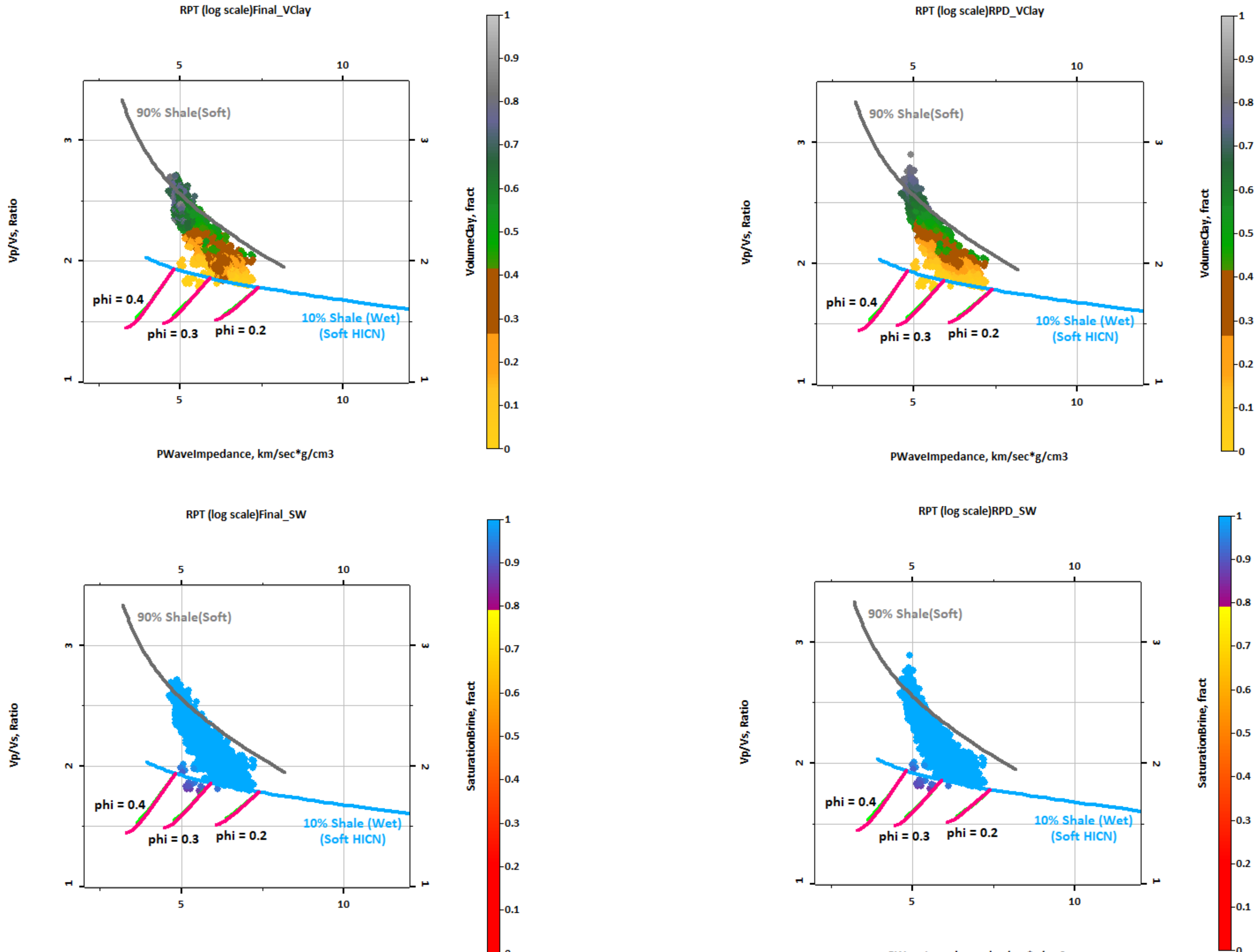
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



Jemuduk-1ST1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

K5-2R1

K5-2R1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is good. Density and compressional velocity are available in the entire well while no shear velocity runs in the well. Client's petrophysical evaluation for the well was not provided. There is a gap in logging, from 1778m-1800m where no logs are present.
- Shear wave velocity(VS)was fully modelled in the entire well interval using the RPD after the model was carefully calibrated based on the offset well(K5-4) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby wells(K5-4 and K5-3).
- In the section(1450-1750m) the Vp is fully replaced by the model given the very slow response when comparing the relationship against depth and against bulk density in surrounding sediments and in other wells. All edits are from the RPD curves
- Due to the bad hole conditions in some intervals, VP and VS was corrected using the RPD especially in the high gas saturated carbonate interval.
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D except in the logging gap interval.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is a Middle to Late Miocene isolated carbonate platform build-up with porosity ranging from 22-35%, with an average of 26%, including karst pores. Additional clastic reservoirs are present in the upper section from 900m-1400m.

Volume of hydrocarbons:

- Gas saturation calculated in the carbonate reservoir was up to 98% near the top of the reservoir while in the all the penetrated sandstones in the clastic section were 100% brine saturated.

Water saturation (Sw):

- In the Carbonate section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 2232m-2237m Rw is 0.169 Ωm, at 250° F NaCl is 11000ppm. Water saturation was calculated using Simandoux's equation.
- In the Clastic section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1043m-1054m Rw is 0.09 Ωm, at 133° F NaCl is 42000ppm. Water saturation was calculated using Simandoux's equation.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the stiff sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clastic and carbonate reservoirs, whereas the soft sediment model proved best in the clay rich lithologies when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed using both K5-4 and K5-3 as reference wells.
- To model the shear velocity in the shallower clastic section the elastic behavior for the well was carefully calibrated with the nearby wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to K5-4 well, so S-wave velocity completely modelled in that interval based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells(K5-4 and K5-3).

Fluid properties:

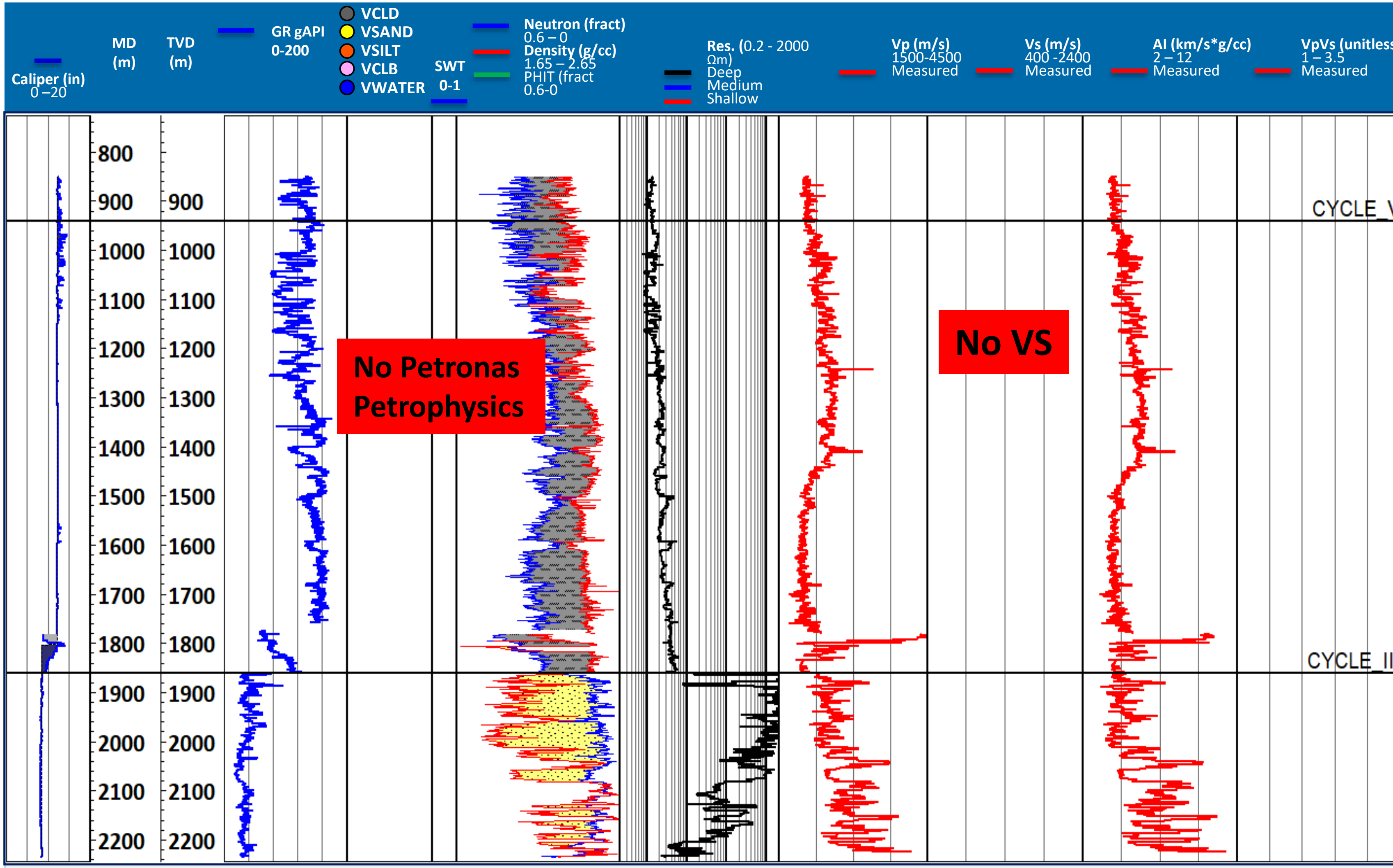
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 11000-42000 ppm
- Gas gravity: 0.886[assumed]
- Oil Gravity: 40 API[assumed]
- Gas / Oil ratio: 50 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene carbonates and the shallower clastic reservoirs using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- In the carbonate section AVA class IV was observed near the gas saturated carbonates top@ 1855m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.
- In the clastic section also AVA class IV was observed near the wet sandstone@ 1040m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay volume) No noticeable changes were observed to the AVA classes.

K5-2R1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions(Final geological report).

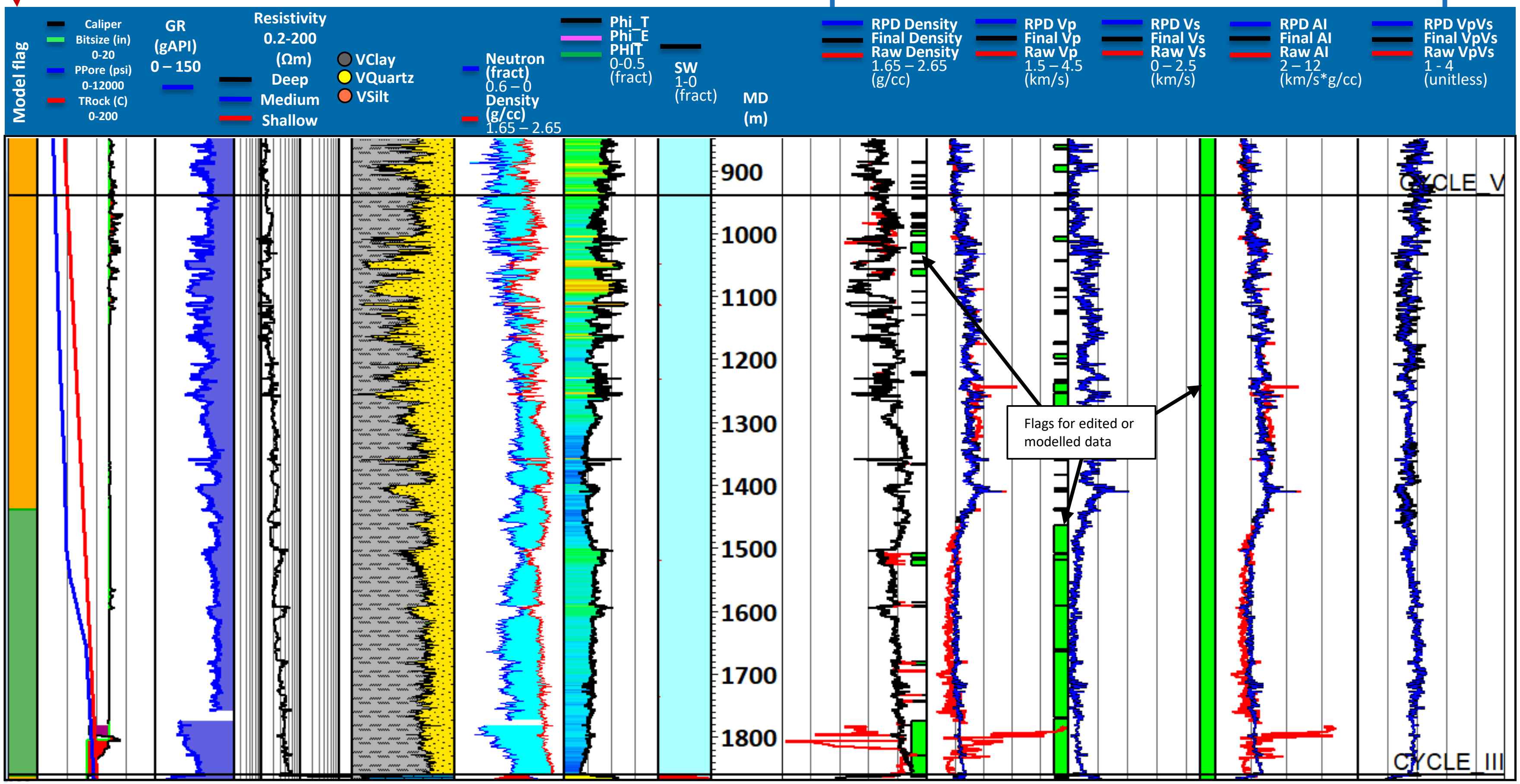
K5-2R1 Geophysical Well Log Analysis (GWLA) – (Clastic Section)

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model



Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data and with the nearby reference well K5-4.

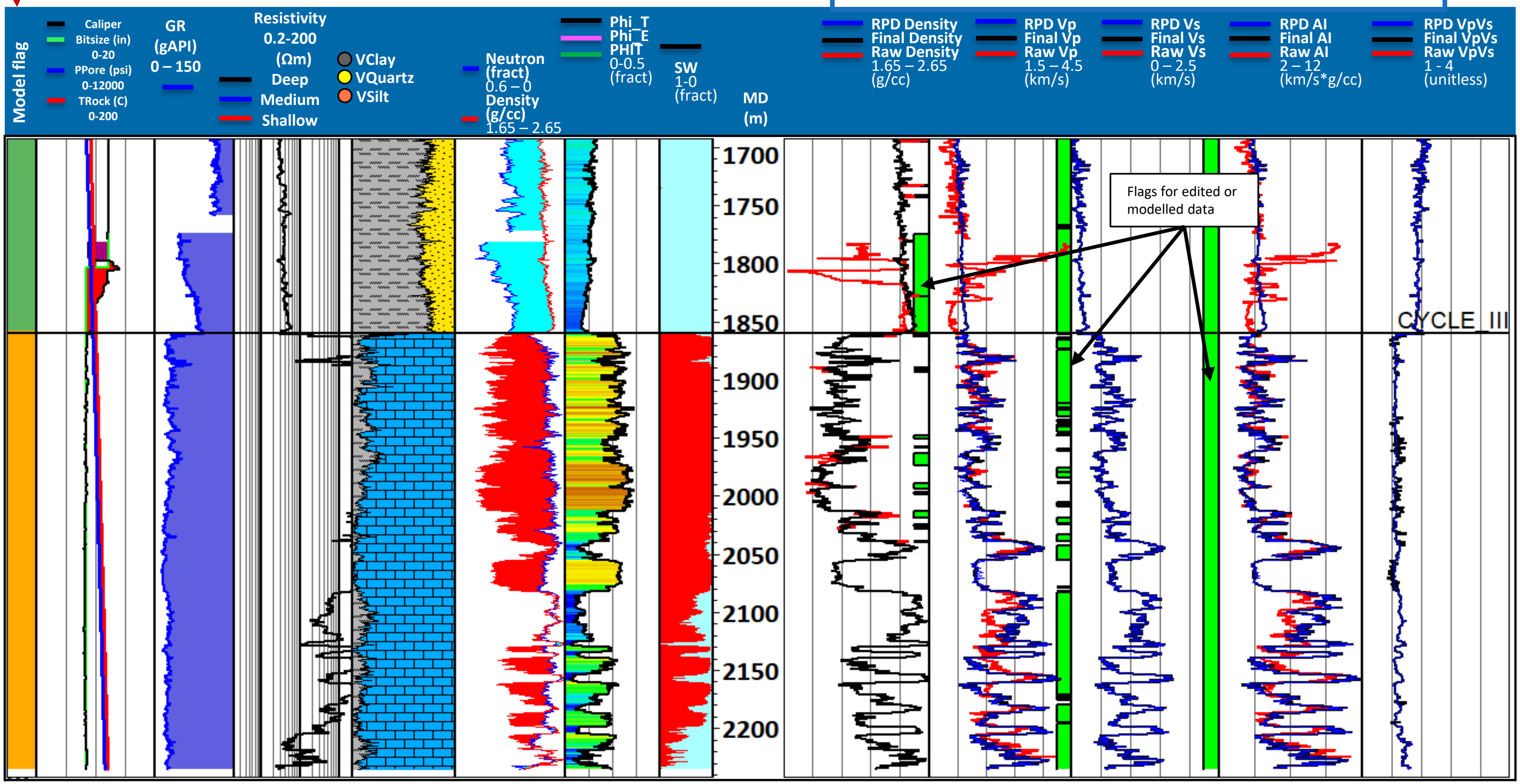
K5-2R1 Geophysical Well Log Analysis (GWLA) – (Carbonate Section)

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

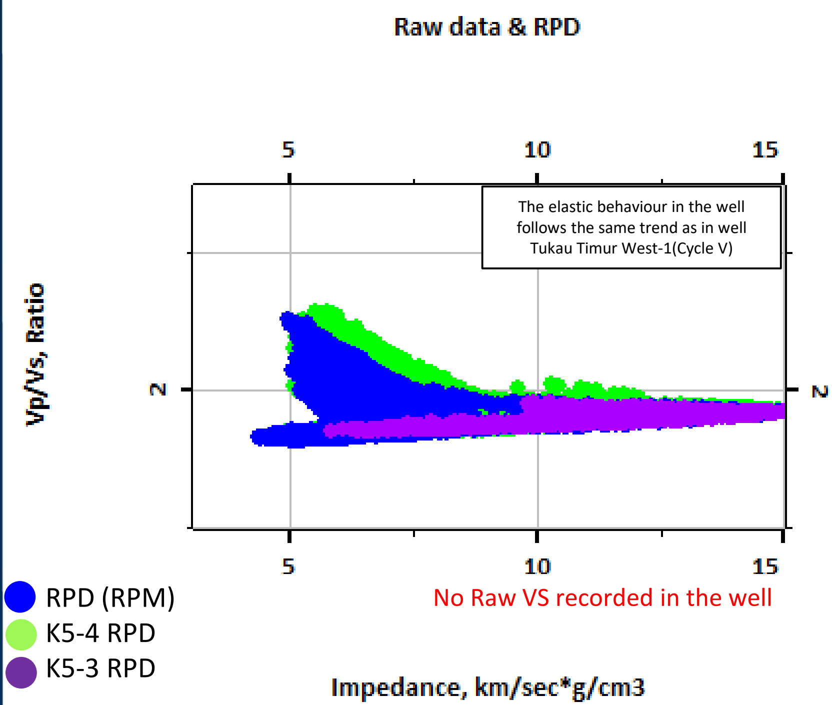


Stiff model is used for all carbonates, soft is used where clay is present was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data and well calibrated to the reference well K5-4.

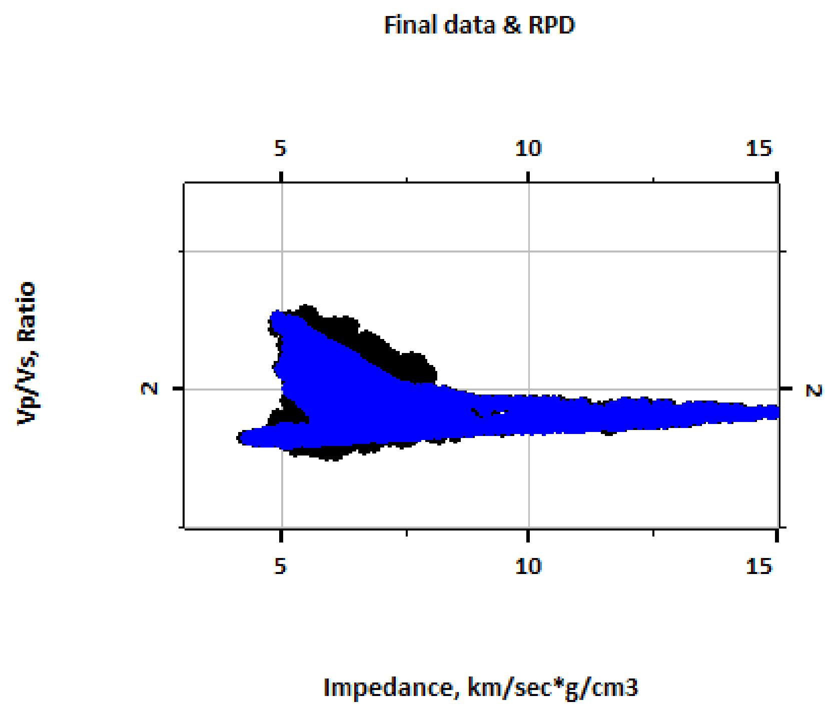
K5-2R1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the K5-2R1 well RPD with the nearby wells K5-4 and K5-3(carbonate section).

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).



RPD (RPM)
K5-4 RPD
K5-3 RPD

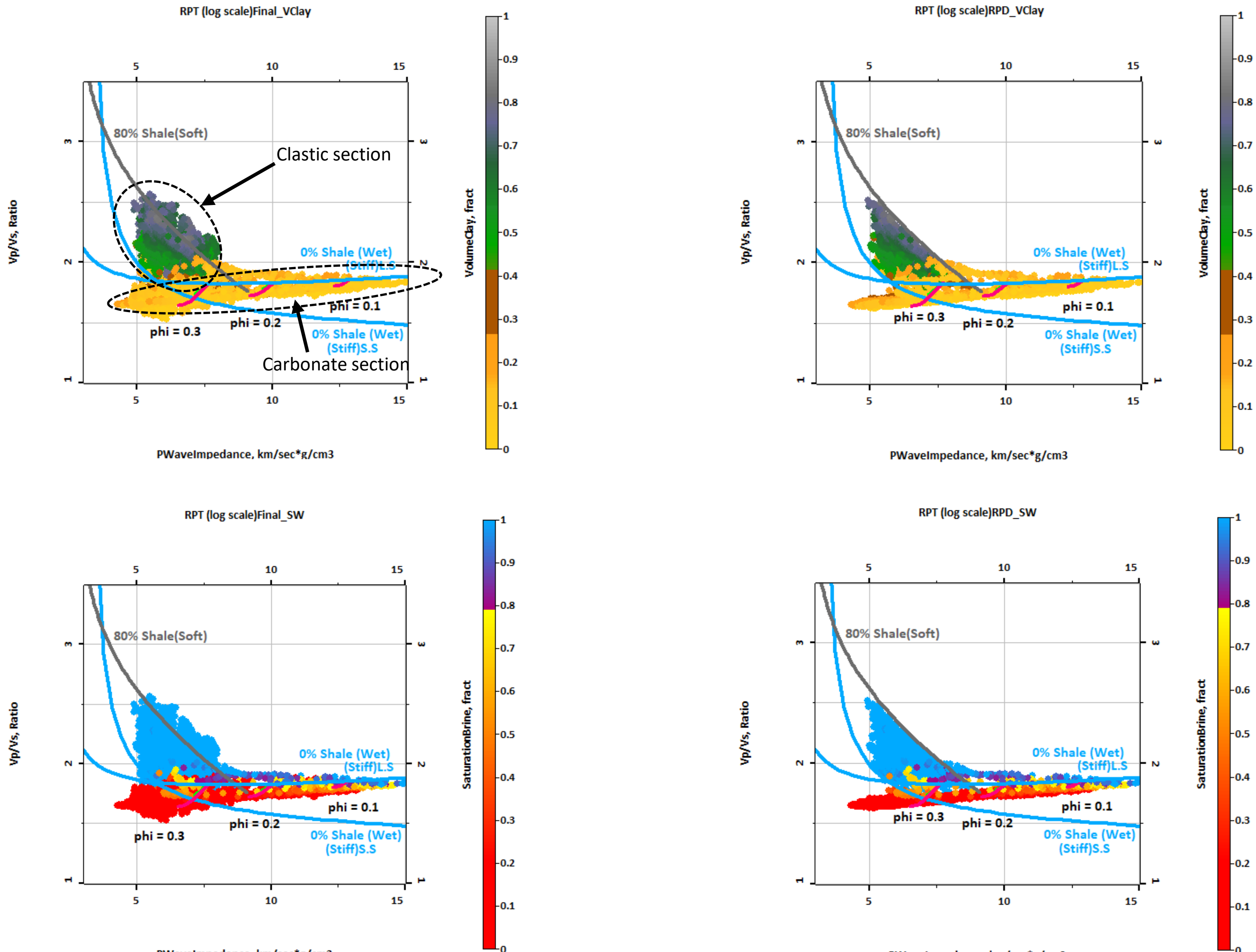


RPD (RPM)
Final (conditioned)

K5-2R1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

K5-3

K5-3 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is good. Density, compressional and shear velocities are available in the entire carbonate section while in the clastic section shear velocity is missing. Client's petrophysical evaluation for the well was not provided. There is a significant gap in logging, from 1805m-2090m where no logs are present.
- Shear wave velocity(VS)was fully modelled in the clastic interval of the well using the RPD after the model was carefully calibrated based on the offset well(K5-4) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby wells(K5-4 and K5-2R1).
- Due to the bad hole conditions in some intervals, VP and VS was corrected using the RPD especially in the high gas saturated carbonate interval.
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D except in the logging gap interval.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is a Middle to Late Miocene isolated carbonate platform build-up with porosity ranging from 15-25%, with an average of 18%, including karst pores. Additional clastic reservoirs are present in the upper section from 850m-1600m.

Volume of hydrocarbons:

- Gas saturation calculated in the carbonate reservoir was up to 95% near the top of the reservoir while in the all the penetrated sandstones in the clastic section were 100% brine saturated.

Water saturation (Sw):

- In the Carbonate section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 2217m-2226m Rw is 0.142 Ωm, at 249° F NaCl is 13000ppm. Water saturation was calculated using Simandoux's equation.
- In the Clastic section: Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone from 1150m-1165m Rw is 0.0785 Ωm, at 145° F NaCl is 44000ppm. Water saturation was calculated using Simandoux's equation.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the stiff sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clastic and carbonate reservoirs, whereas the soft sediment model proved best in the clay rich lithologies when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed using both K5-4 and K5-2R1 as reference wells.
- To model the shear velocity in the shallower clastic section the elastic behavior for the well was carefully calibrated with the nearby wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to K5-4 well, so S-wave velocity completely modelled in that interval based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells(K5-4 and K5-2R1).

Fluid properties:

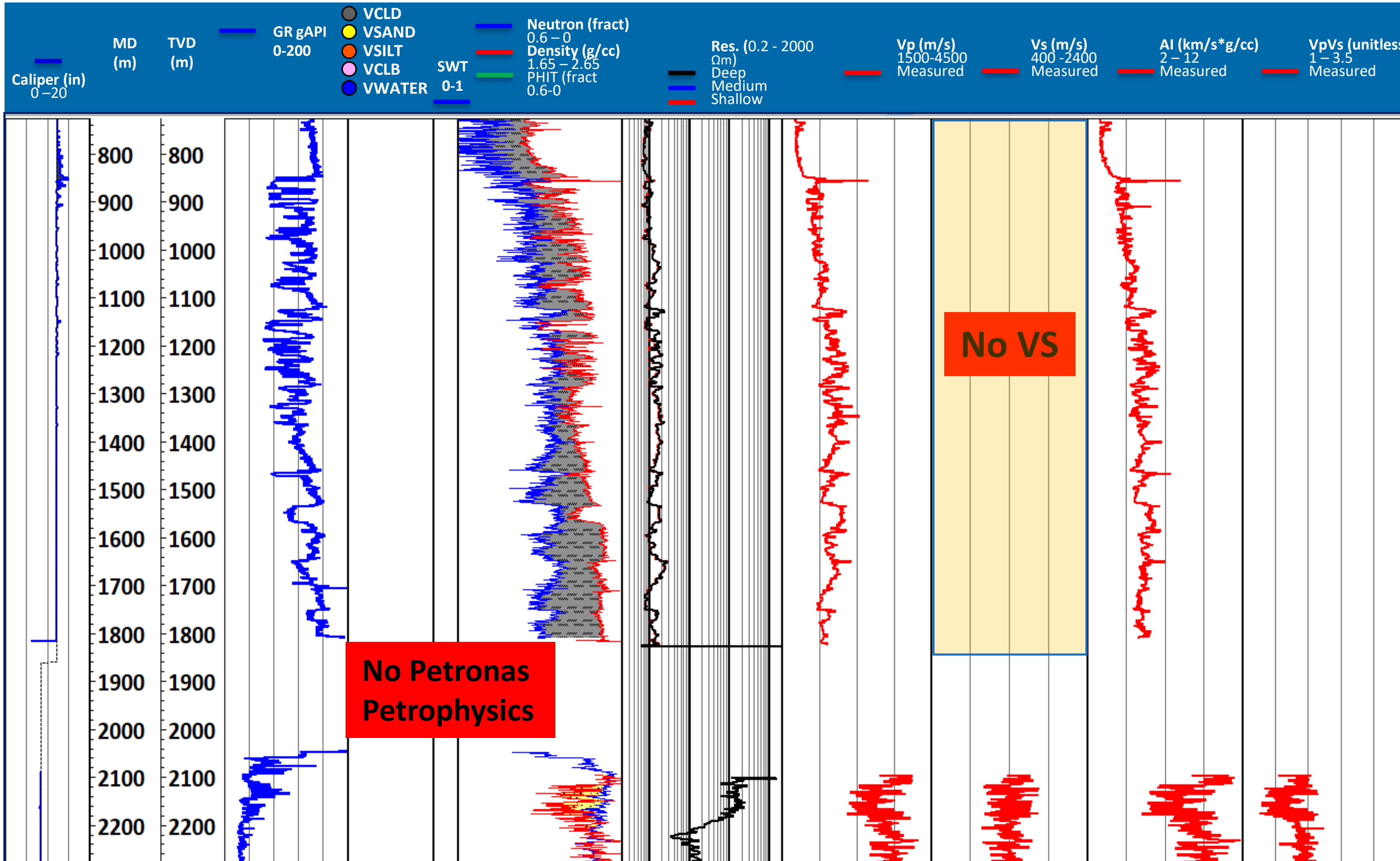
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 13000-44000 ppm
- Gas gravity: 0.886[assumed]
- Oil Gravity: 40 API[assumed]
- Gas / Oil ratio: 50 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene carbonates and the shallower clastic reservoirs using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- In the carbonate section AVA class IV was observed near the gas saturated carbonates top@ 2215m for all fluid cases at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay volume) No noticeable changes were observed to the AVA classes.
- In the clastic section also AVA class IV was observed near the wet sandstone@ 1145m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay volume) No noticeable changes were observed to the AVA classes.

K5-3 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions(Final geological report).

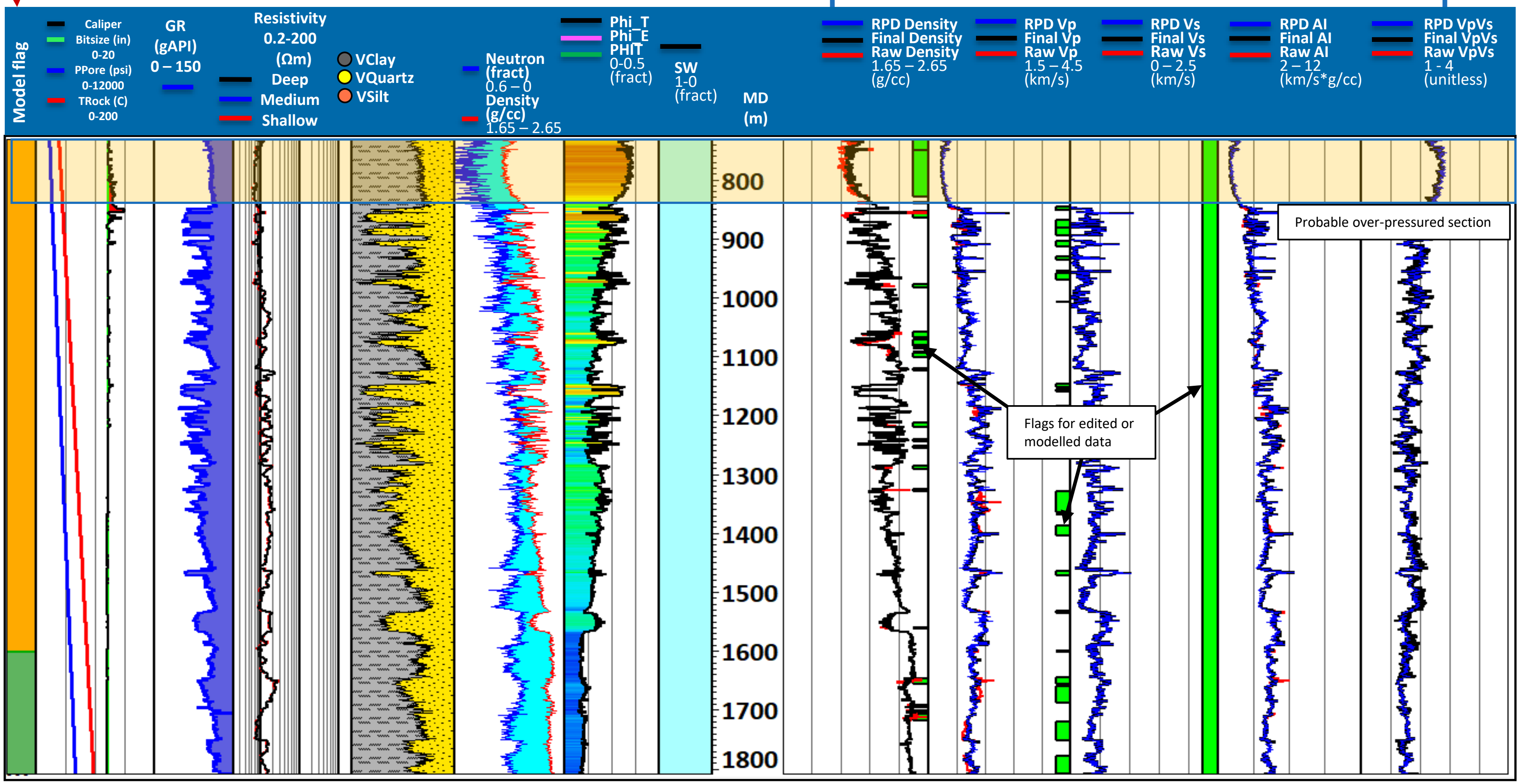
K5-3 Geophysical Well Log Analysis (GWLA) – (Clastic Section)

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model



Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data and with the nearby reference well K5-4.

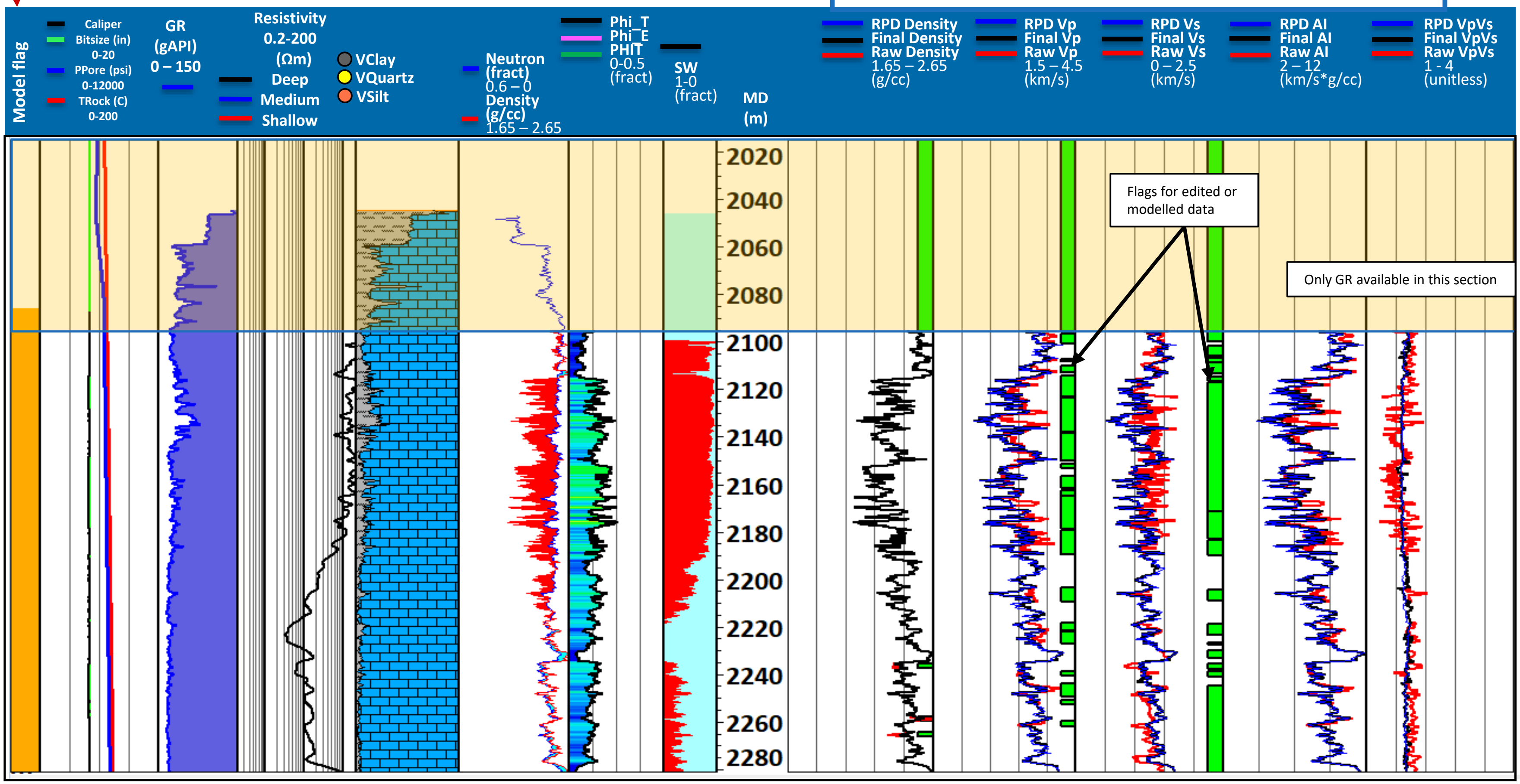
K5-3 Geophysical Well Log Analysis (GWLA) – (Carbonate Section)

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

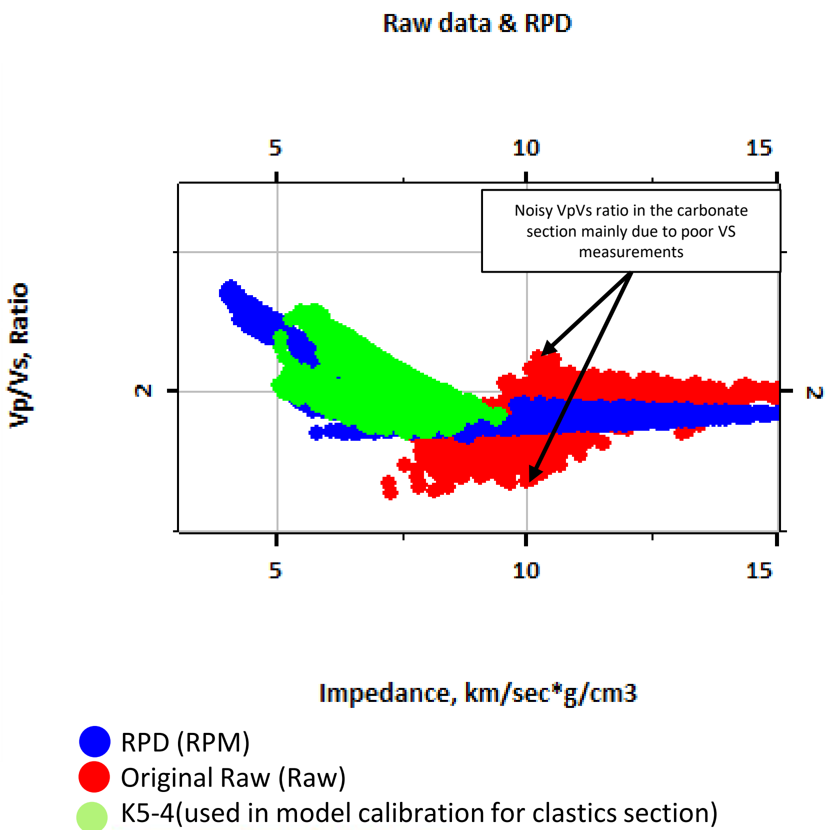


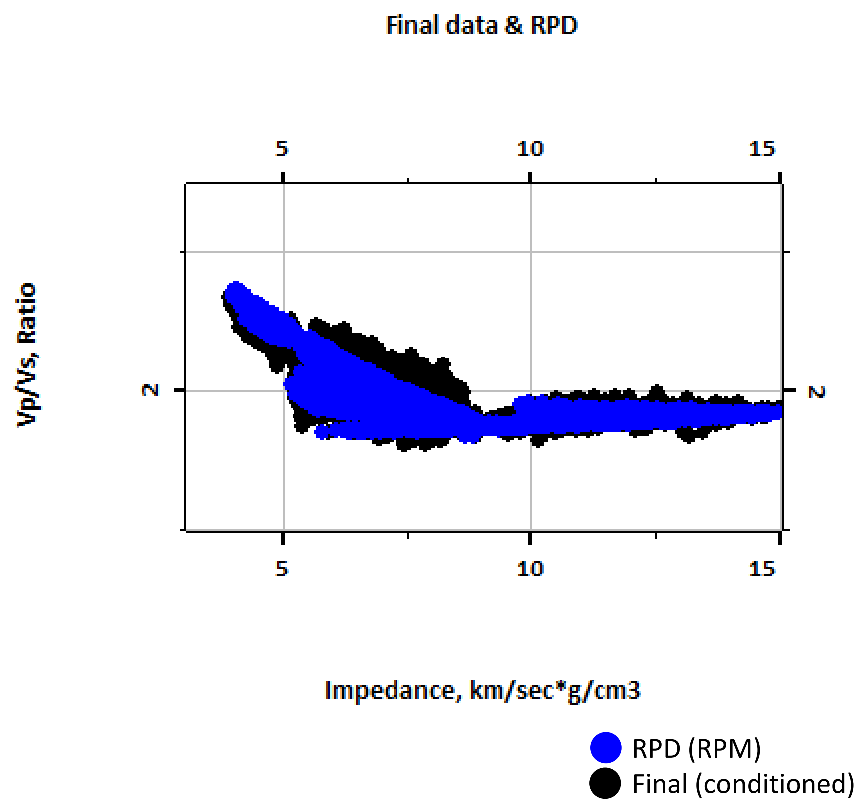
Stiff model is used for all carbonates, soft is used where clay is present was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data and well calibrated to the reference well K5-4.

K5-3,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

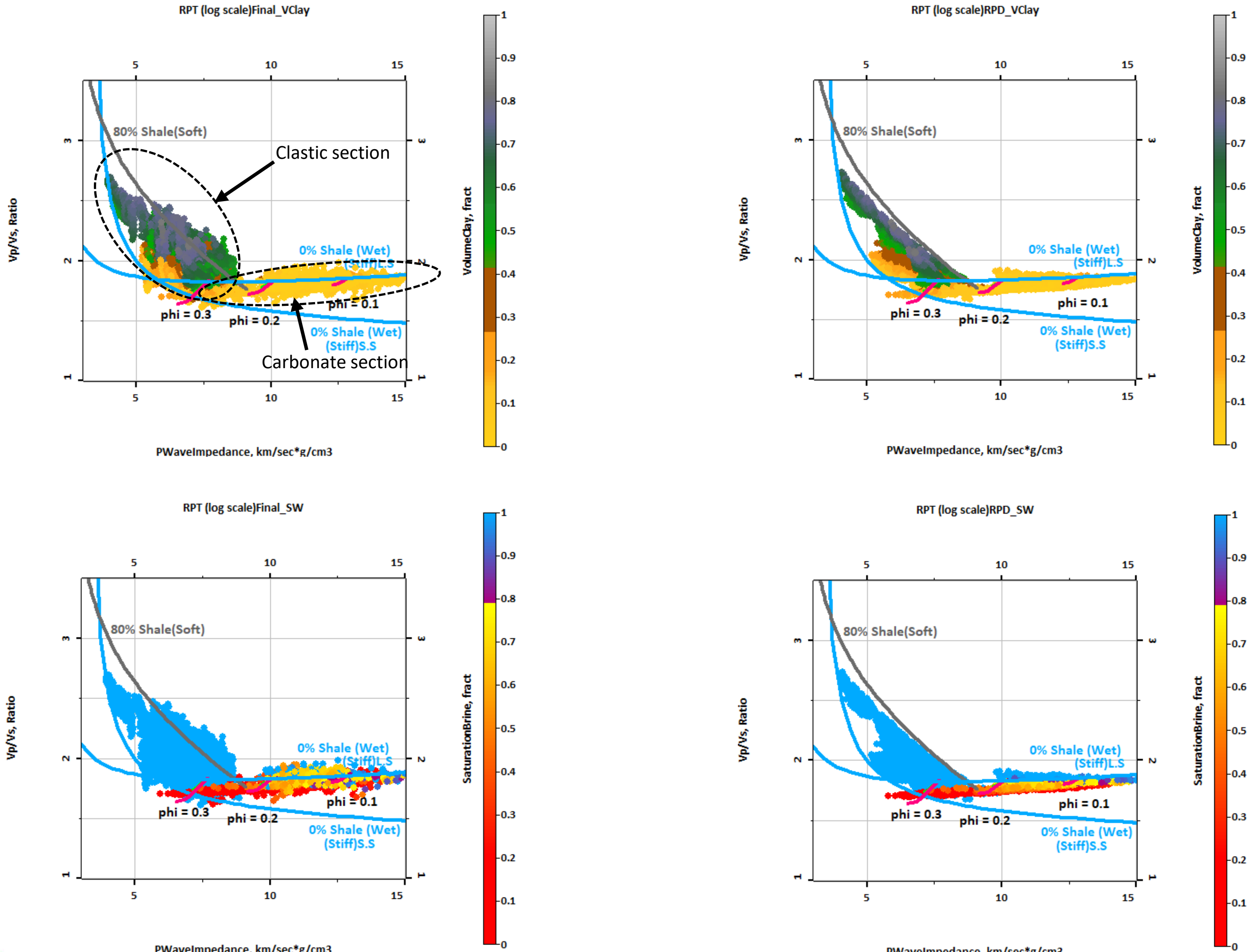




K5-3,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

K5-4

K5-4 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is strong. Density, compressional and shear velocities are available from 1000m-2358m, though there is a gap in the shear in the 12.25” section where compressional is also very slow compared to surrounding sediments and density. Client’s volume shale, total porosity, and total water saturation were provided as a reference. In the carbonate 8.5” hole section the Vp and Vs have been depth shifted from 2-3m to align with density, gamma ray, and resistivity. There are two significant gaps in logging, from 1428m-1554m and 1895m-1921m where no logs are present.
- Vp measurement is high quality, with the exception of the 12.25” section only some rare erroneous measurements have been edited using the RPD model. In the 12.25” section the Vp is fully replaced by the model given the very slow response when comparing the relationship against depth and against bulk density in surrounding sediments and in other wells. All edits are from the RPD curves.
- The Vs is generally very strong – edits have occurred in the 12.25” section and in the shallower clastic section for some anomalously low measurements showing a clearly high Vp/Vs response. Edits elsewhere are minor to increase consistency between density and Vp. The RPD curve was used for all edits.
- Density is high quality. Invasion correction has been performed in the carbonate despite lack shallow resistivity to confirm invasion. Primary justification is based on comparison to wells K5-2 and K5-3, this correction provides strong correlation across wells in the porosity vs. velocity space. Very few anomalous measurements have been corrected. All edits are made using the RPD.
- Other logs used in the analysis include Gamma, Neutron, and Deep Resistivity run over the full interval.

Clay volume (VClay):

- This volume was derived from a combination of the linear Gamma Ray and Neutron/Density crossplot methods.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is a Middle to Late Miocene isolated carbonate platform build-up with porosity ranging from 17-30%, with an average of 20%, including karst pores. Additional clastic reservoirs are present in the upper section from 1000m-14xxm(logs cut off mid-reservoir).

Volume of hydrocarbons:

- There is a 234m gas column in the carbonate with gas present where porosity is present. Gas saturations are 90%.

Water saturation (Sw):

- Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2.5 and Saturation exponent (n)=2.5, at the wet zone from 2245m-2265m Rw is 0.08 Ωm, at 252° F NaCl is 24000ppm. Water saturation was calculated using Simandoux’s equation.

K5-4 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the stiff sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clastic and carbonate reservoirs, whereas the soft sediment model proved best in the clay rich lithologies when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed without the use of an analog well.

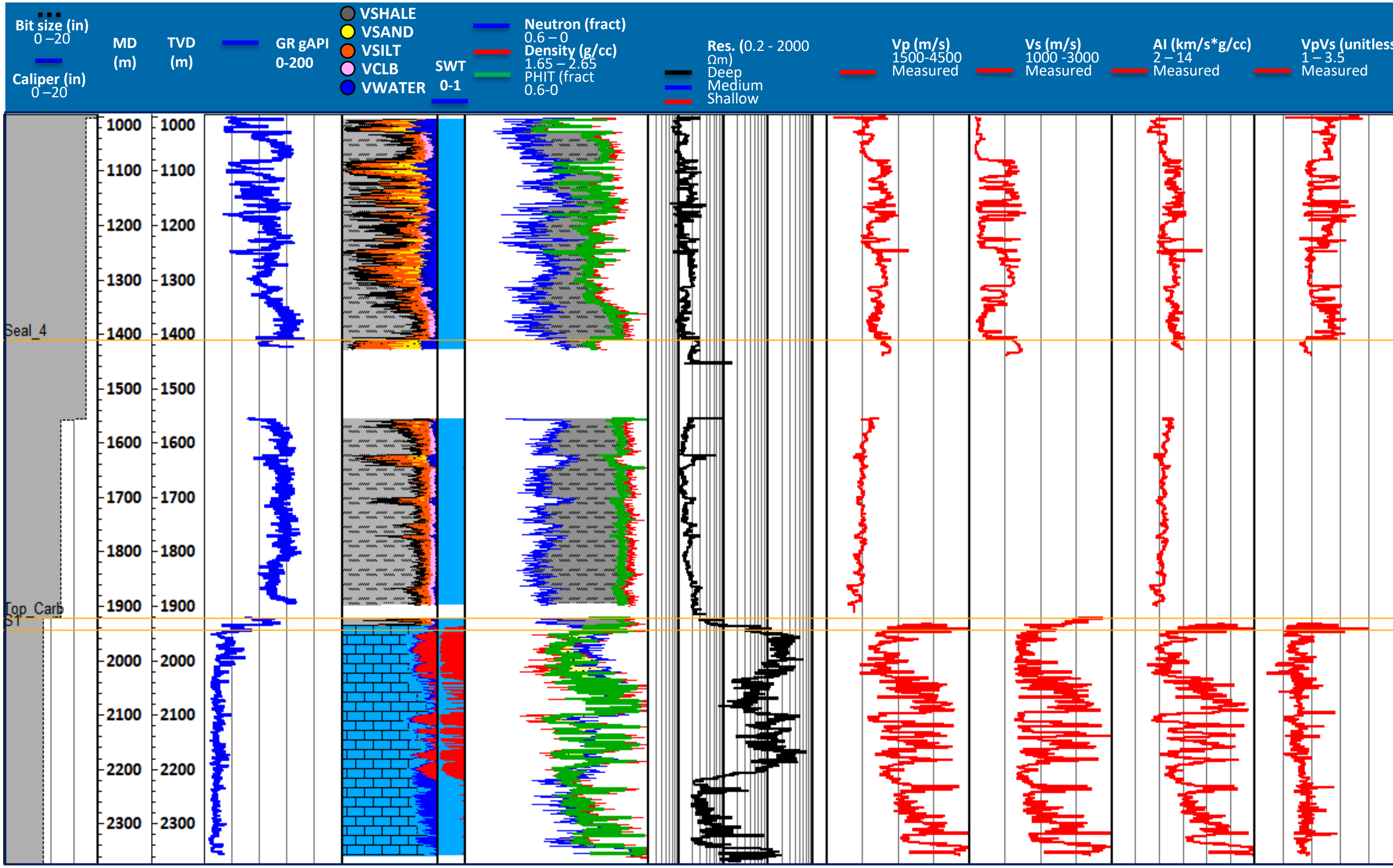
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 24000 ppm [Rw]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the shallow clastic reservoirs and the deeper carbonate reservoir. The rockAVO projects have been split into two projects accordingly. Perturbational modelling is using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination with the brine sands in the clastic reservoirs and decent discrimination in the carbonate reservoirs.
- At in situ conditions the carbonate shows a IIP AVA response at the top of the reservoir. Improving reservoir quality drives the response down to a Class III with good fluid discrimination.

K5-4 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

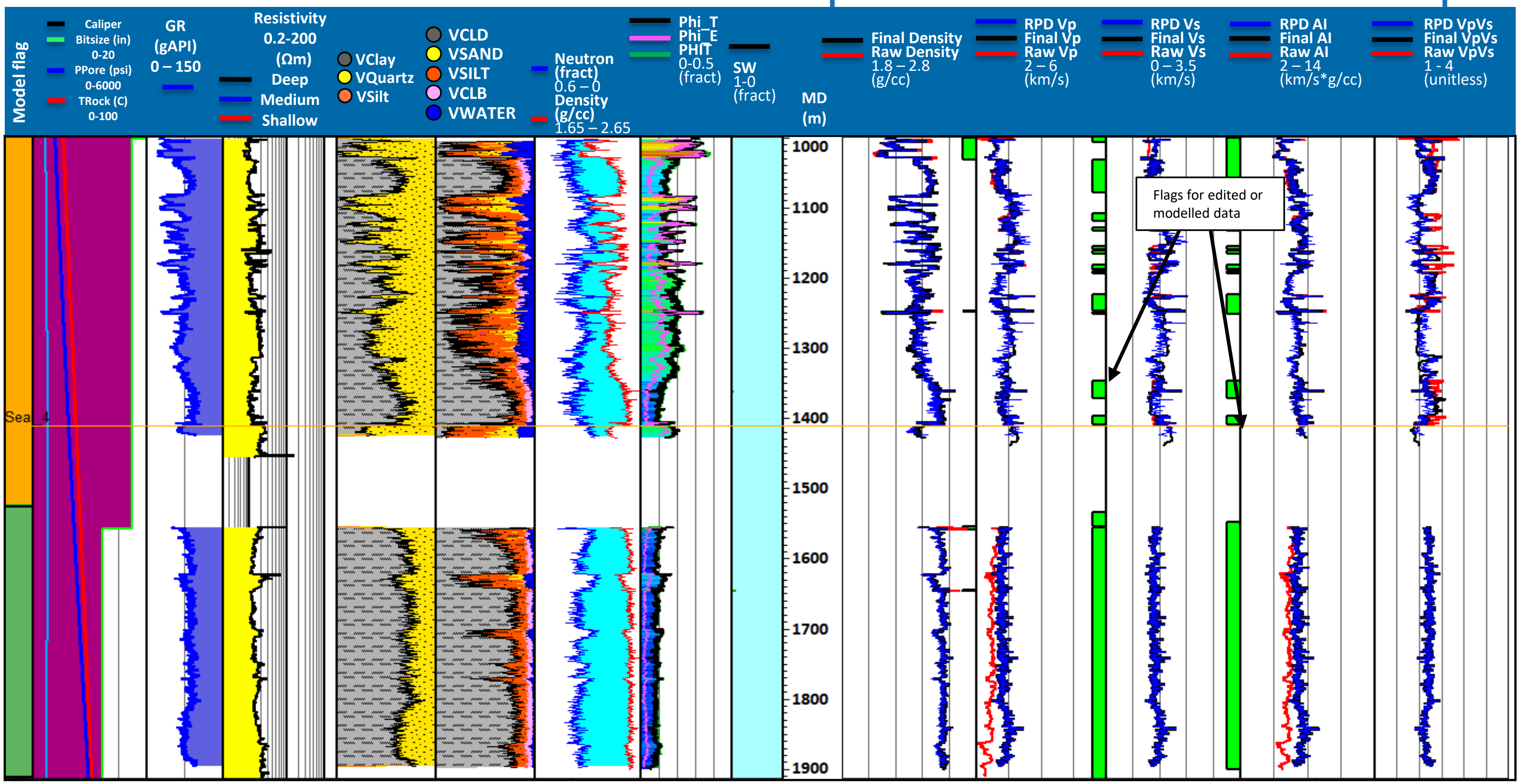
K5-4 Geophysical Well Log Analysis (GWLA) – Interval from Top of logs to 1900m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to Vp and Vs to increase consistency, and totally modelled Vp and Vs in 12.25" section. Granular media model, stiff sand for the sands in the upper section and soft in the lower section, and soft for all claystones was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data.

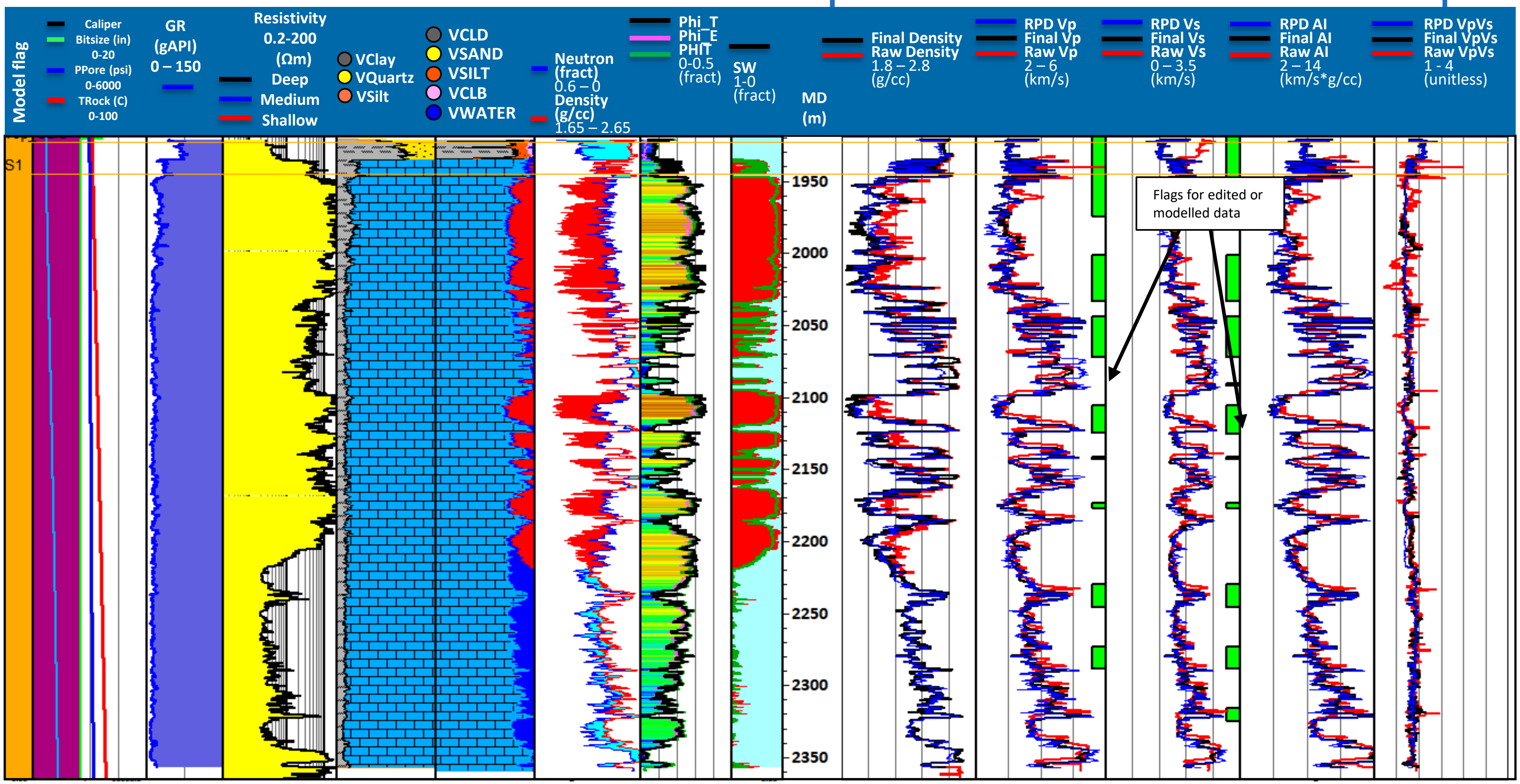
K5-4 Geophysical Well Log Analysis (GWLA) – Interval from 1900m to TD

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

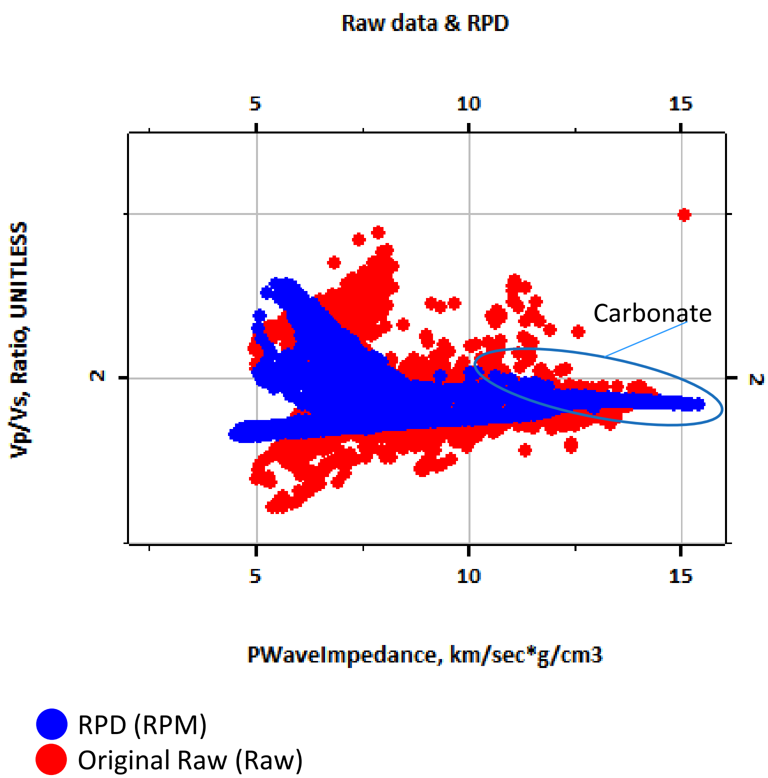


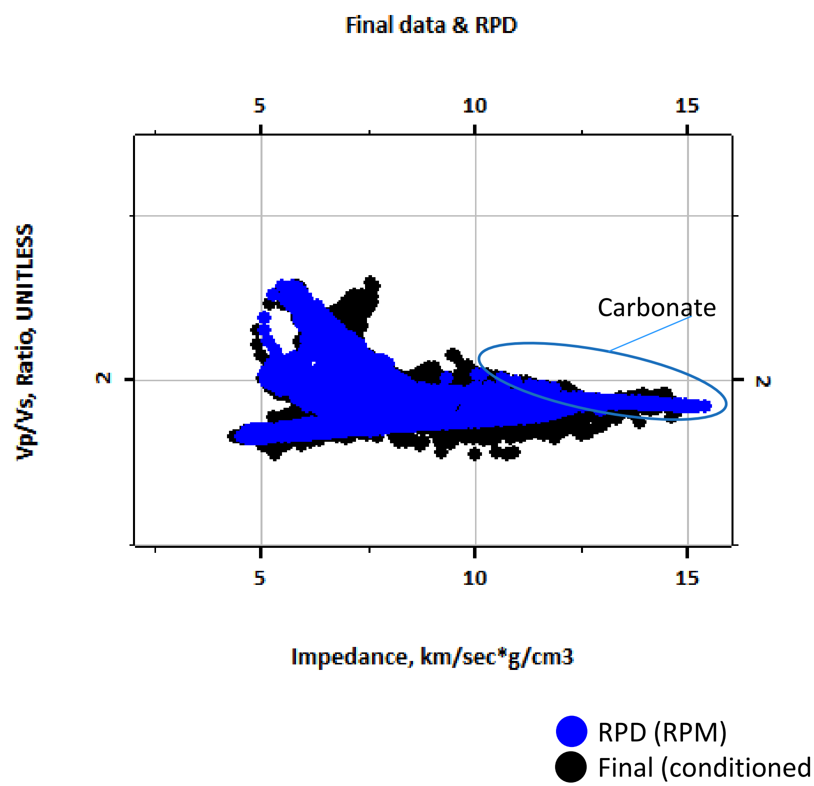
Invasion correction has been performed despite lack shallow resistivity to confirm invasion. Primary justification is based on comparison to wells K5-2 and K5-3. Depth shift to Vp and Vs provided better consistency and minor edits to Vp and Vs to improve overall consistency with porosity and lithology response. Stiff model is used for all carbonates, soft is used where clay is present was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data.

K5-4,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

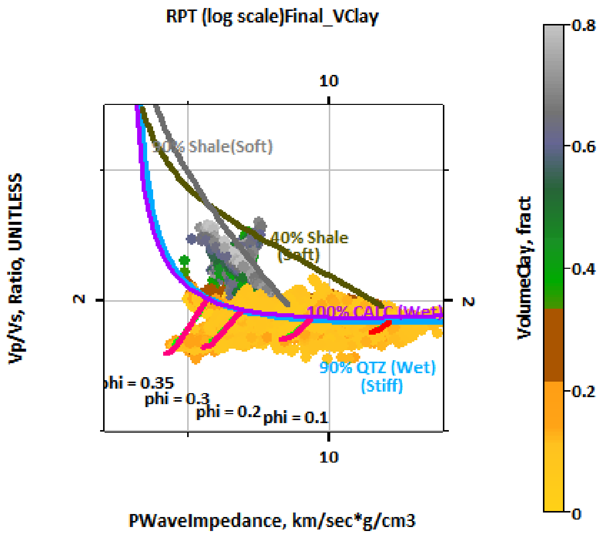


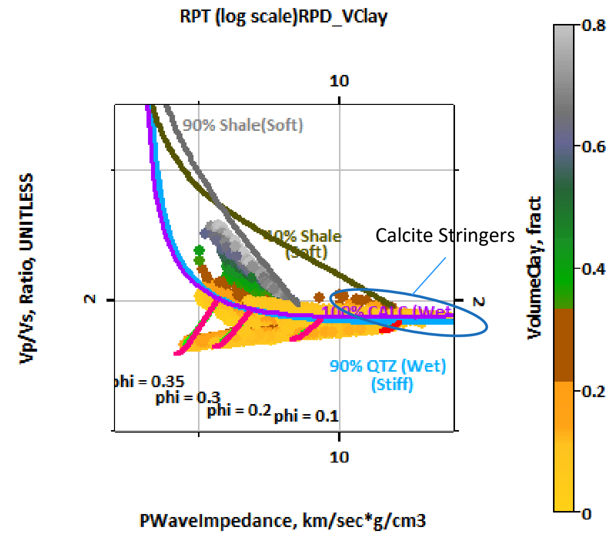


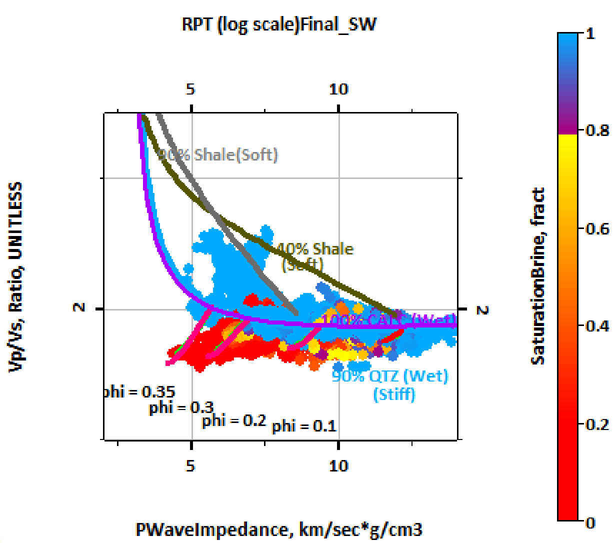
K5-4,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

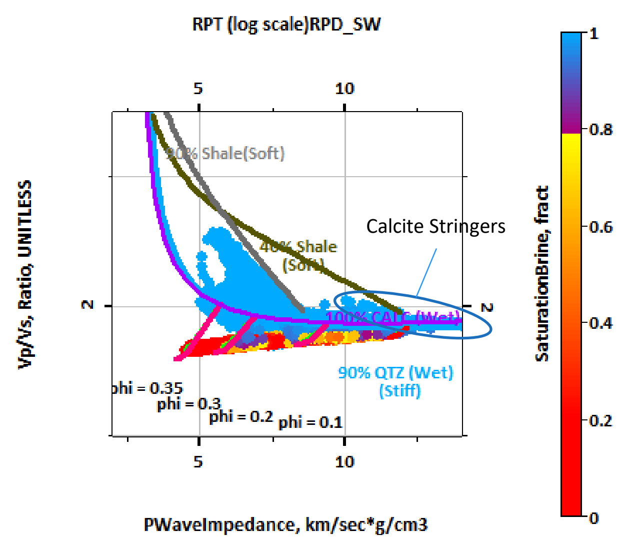
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Kudalaut-1

Kudalaut-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Missing/bad VP, density and VS measurements were estimated using RPD.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir target is the Intra cycle VII sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes.

Volume of hydrocarbons:

- Some gas shows was interpreted in sands in 3329m – 3569 with an average of 10 -30 % gas saturation.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Water saturation was calculated using Simandoux's equation with RW of 0.06ohm @$250\ F$, constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 yielding salinity value of~ 30000ppm (based on the well report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2767m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Faust model was used to estimate the VP data where RPD looks unreliable.

Fluid properties:

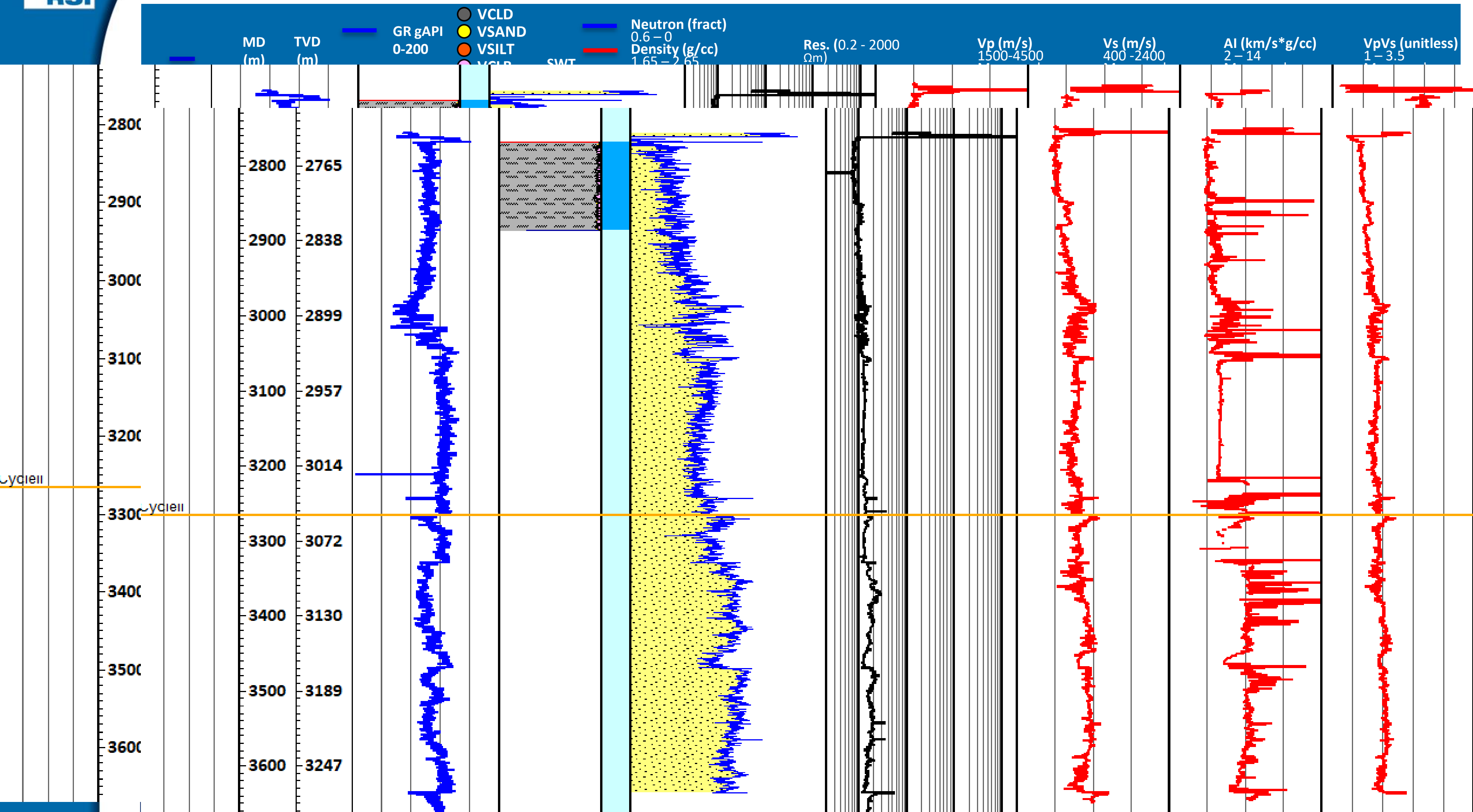
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 30000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

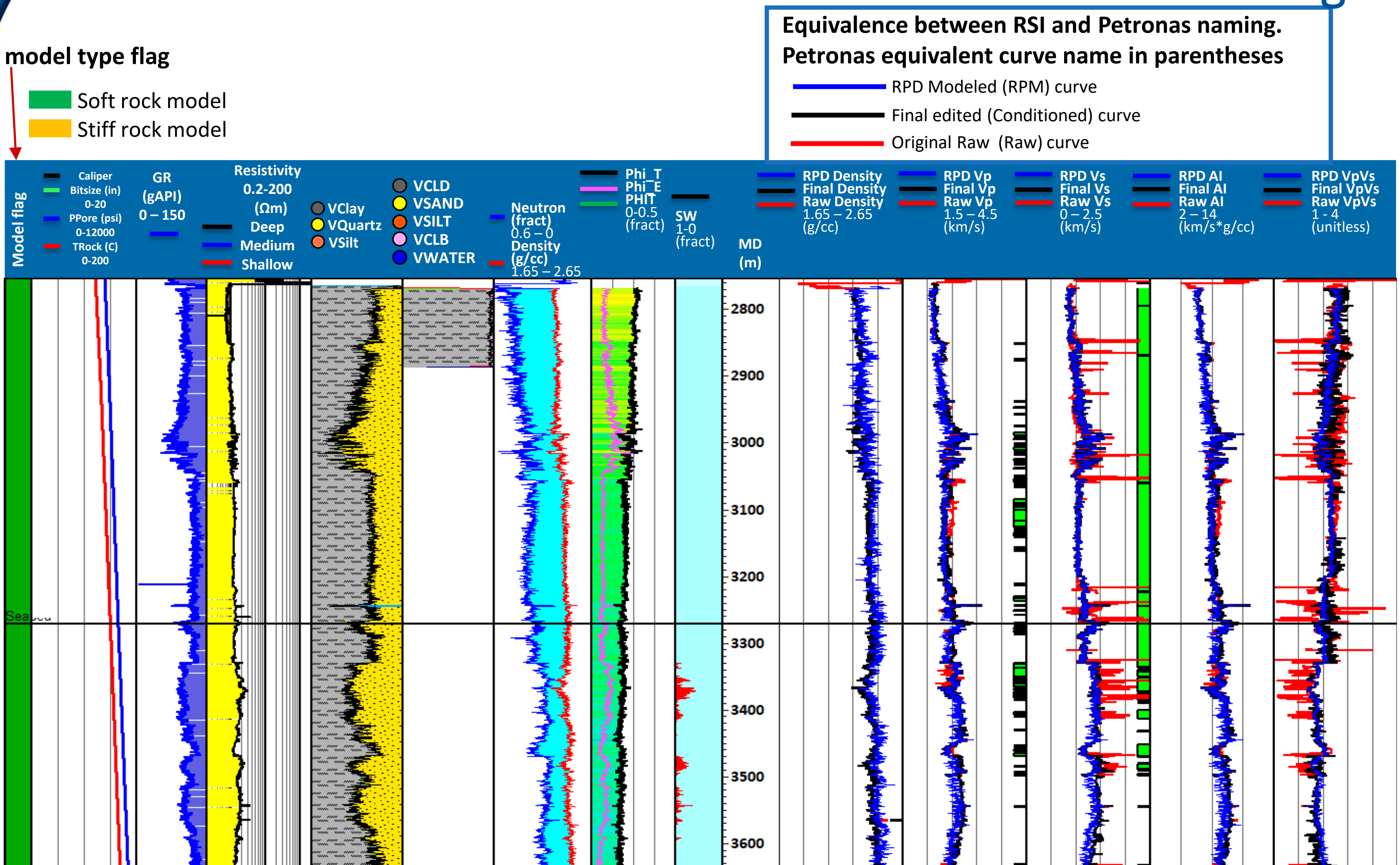
- Perturbational modelling was performed in the different sands of Intra cycle VII and other reservoir quality sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class IIP was observed near a good porosity sand @ 3334m for the hydrocarbon fluid cases at in situ reservoir conditions while AVA class I was observed for the wet scenario.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content), AVA class II is observed for the hydrocarbon scenarioS.

Kudalaut-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Kudalaut-1 Geophysical Well Log Analysis (GWLA) – Interval from 2180m to bottom of logs

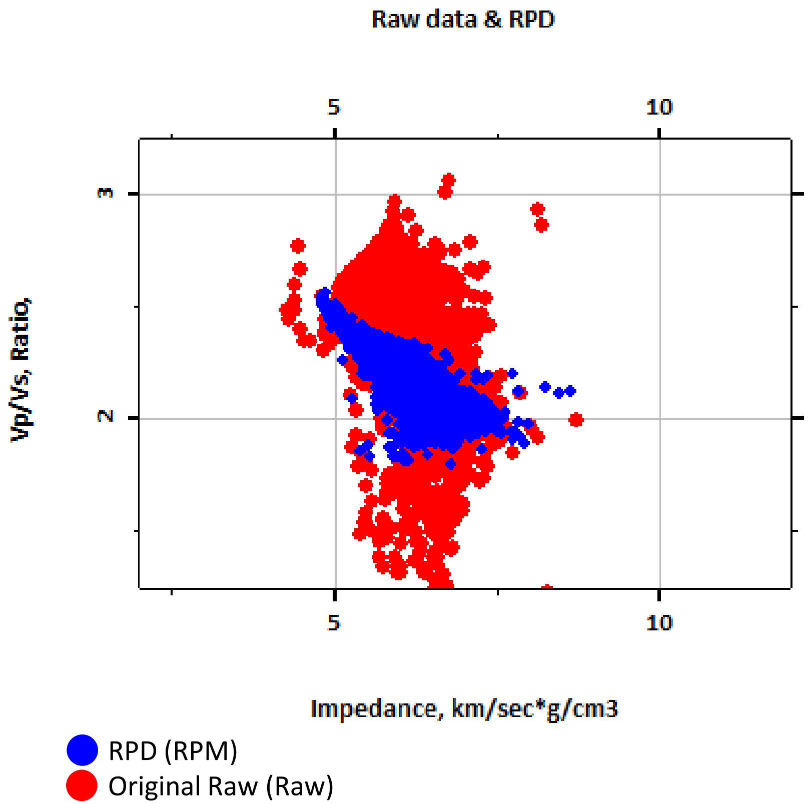


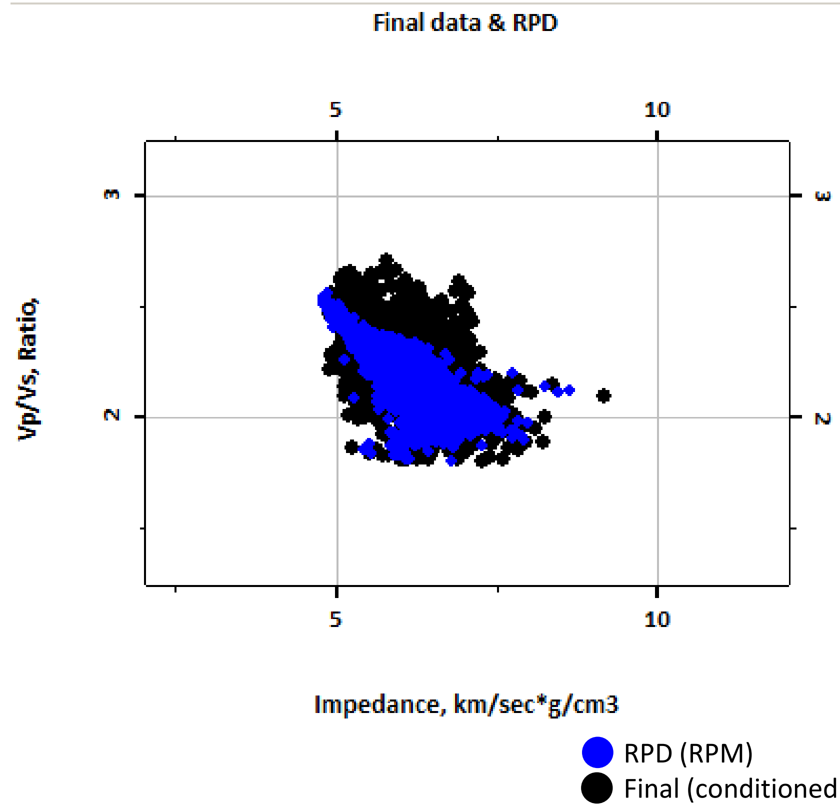
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Kudalaut-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

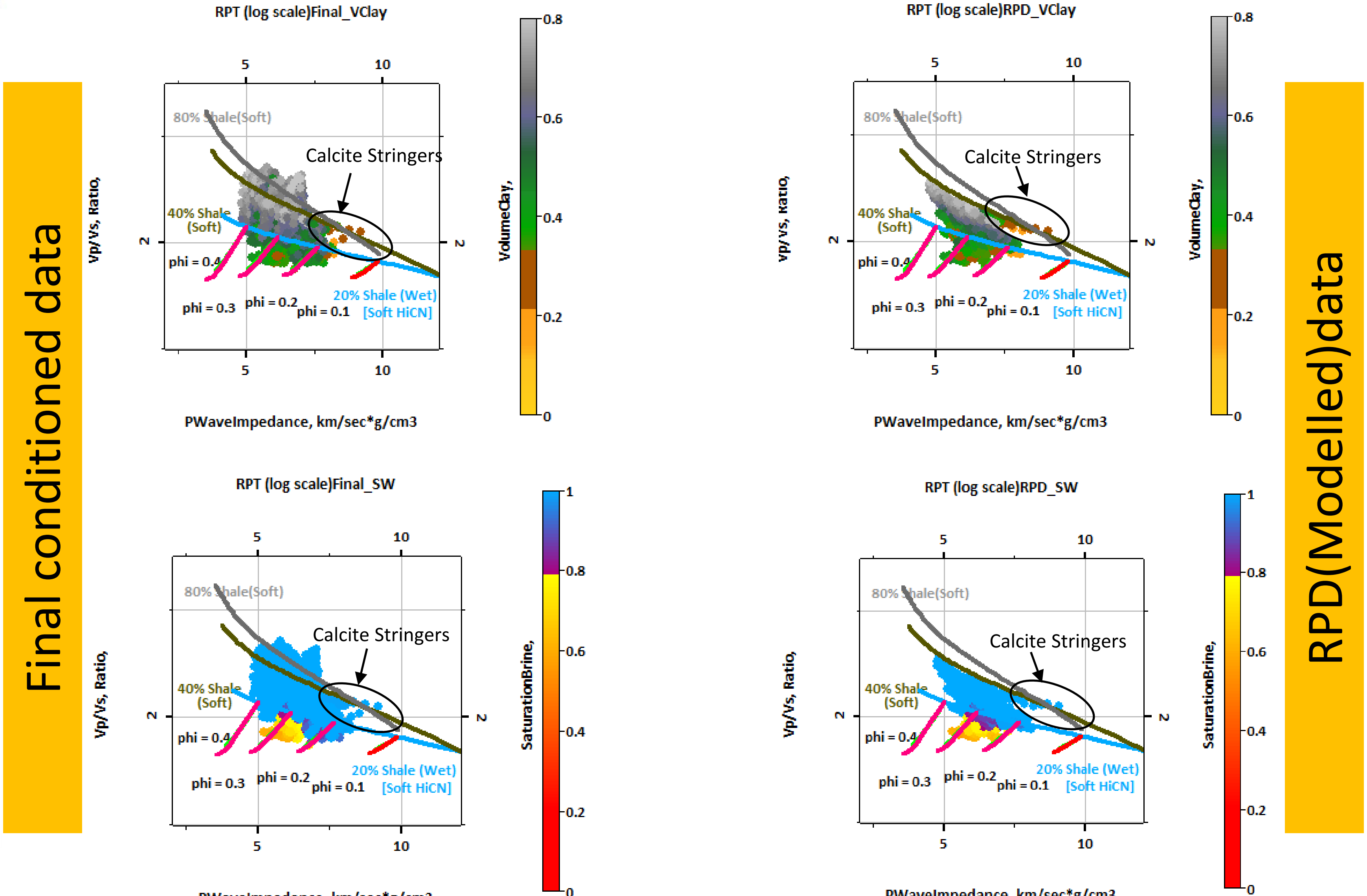




Well_Tops_Betty_Timur1.txt
Well_Tops_Bario_West_1.txt

Kudalaut-1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.



Labu-1

Labu-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is good. Vs data is only available in the 3020-3264 m interval. Most of the well logs suite run from 2510 to 3266 m.
- Density measurements are of good quality. Density was estimated in the 2755-2807 m, 2878-3022 m sections due to measurement gaps, some attributable to operational issues.
- Vp quality, when available, is good. Vp has been predicted using Faust in the 2782-2800 m, 2870-3020 m intervals. Vp was not available in most of the 8.5" hole (TB 3.2) due to operational problems.
- GR was linearly interpolated in the 2791-2800 m section. Measurements are noisy in the overlying 2746-2791 m interval. Because density was not present in this section either, this noisy character has been translated in its estimation.
- Deep Resistivity is an additional log available.

Clay volume (VClay):

- This volume was estimated using only the Linear Gamma Ray method due to the unavailability of a Neutron log.

Reservoir characteristics:

- The primary objective of this well was to explore the TB3.1 (formerly known as Kamunsu) reservoir for commercial hydrocarbon. The secondary objective is to explore the TB3.4, TB3.3 and TB3.2 (formerly known as Lingan sands) reservoirs for commercial hydrocarbon, and in the case of TB3.4 is to calibrate the DHI model. Sands are present throughout the well but often thin, and silty. The majority of pressure data taken where logging information is available, resulted in tight events implying poor reservoir properties of these sands.

Volume of hydrocarbons:

- Residual gas saturation was interpreted towards the base of TB 3.2, and in TB 3.1. At 3174 m, a 2m-thick sand yields the highest gas saturation interpreted in the well (36%)

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux’s equation. Archie’s parameters were taken from Pickett Plot and resulted in: Rw=0.17 Ohmm @ 122F (21,000 ppm), with a=1, m=2, and n=2.

** Depths referred in this report are MD.

Labu-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft Sediment Model proved to be the best predictor in both clay-rich and sand facies. Vs was also estimated using Granular Media Models and considering a Soft Sediment Model for both facies. Elastically, the well is analogue to Bidara-1 and Langsat-1 wells.

Fluid properties:

Gas properties used in substitution have been taken from PVT analysis on nearby Bidara-1 well. Hydrocarbon properties, on the other hand, were taken from Jelawat-1 well. Main parameters used in this modelling are summarized as follows:

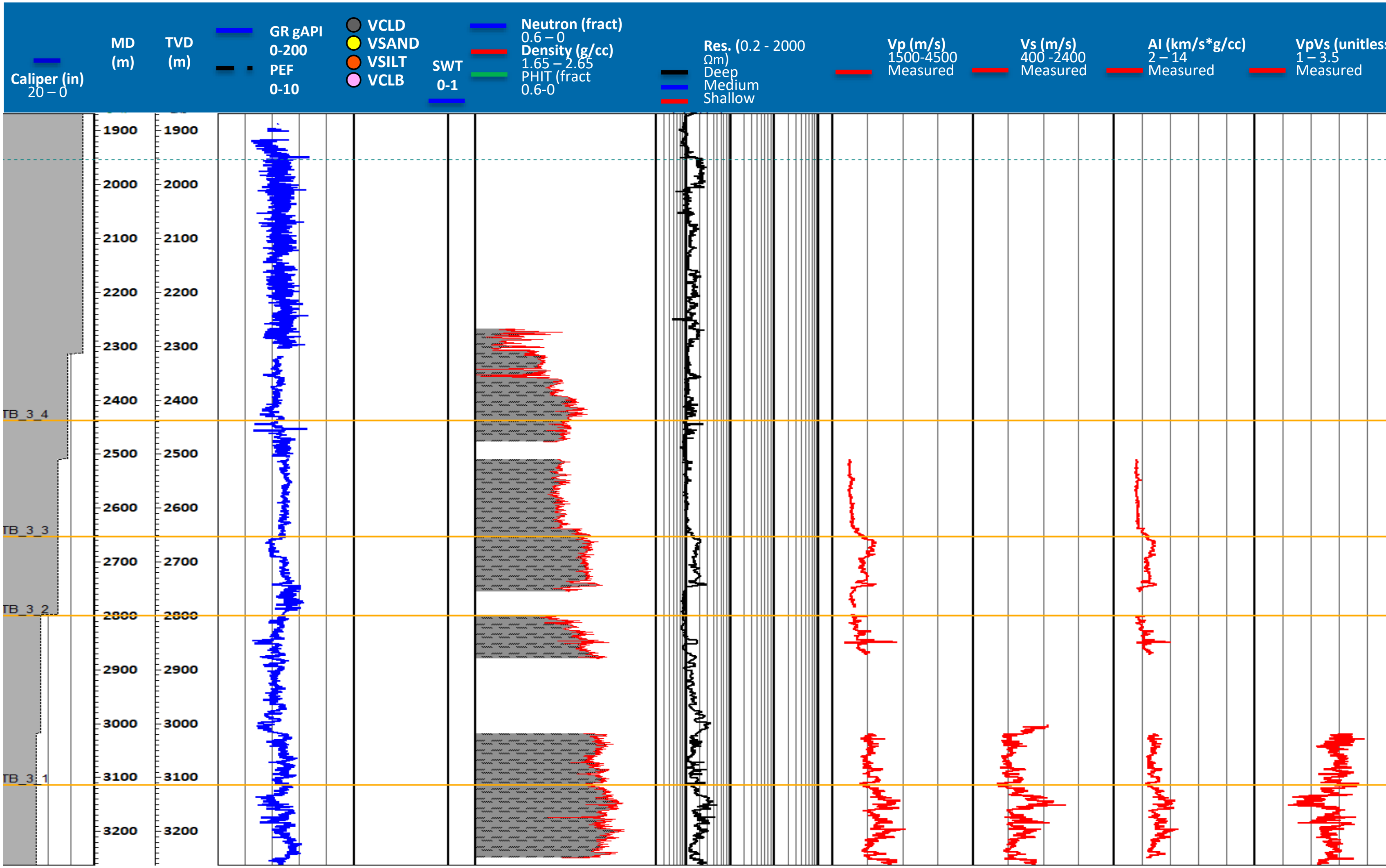
- Brine salinity: 21,000 ppm
- Gas gravity: 0.62
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in Upper Miocene sediments (TB 3.3, TB 3.2 and TB 3.1).
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Labu-1



Additional data includes mud weight data, pressure data, as well as regional, operational, and well reports. Caliper and Neutron logs were unavailable.

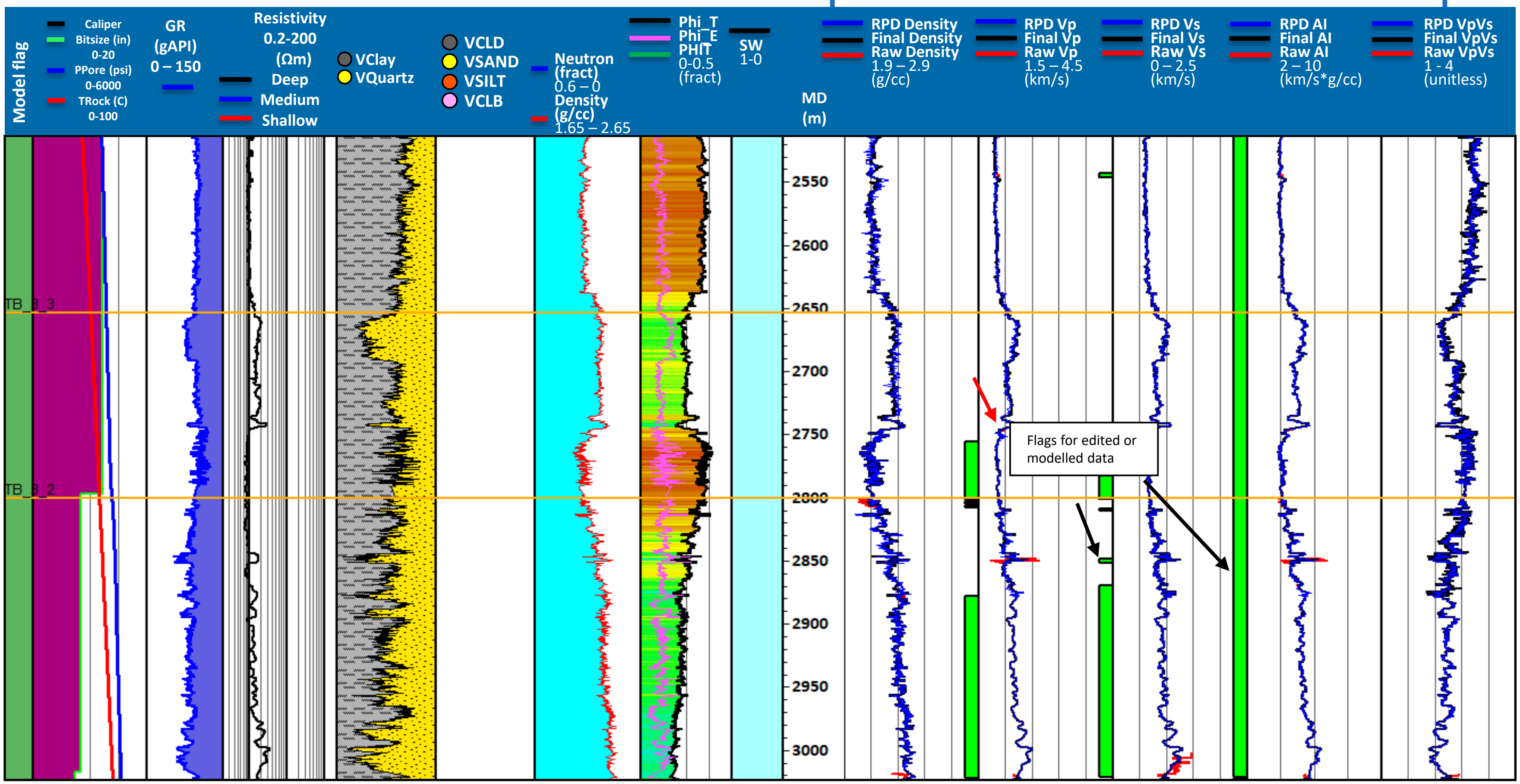
Labu-1 Geophysical Well Log Analysis (GWLA) – Interval from 2510 to 3010 m

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

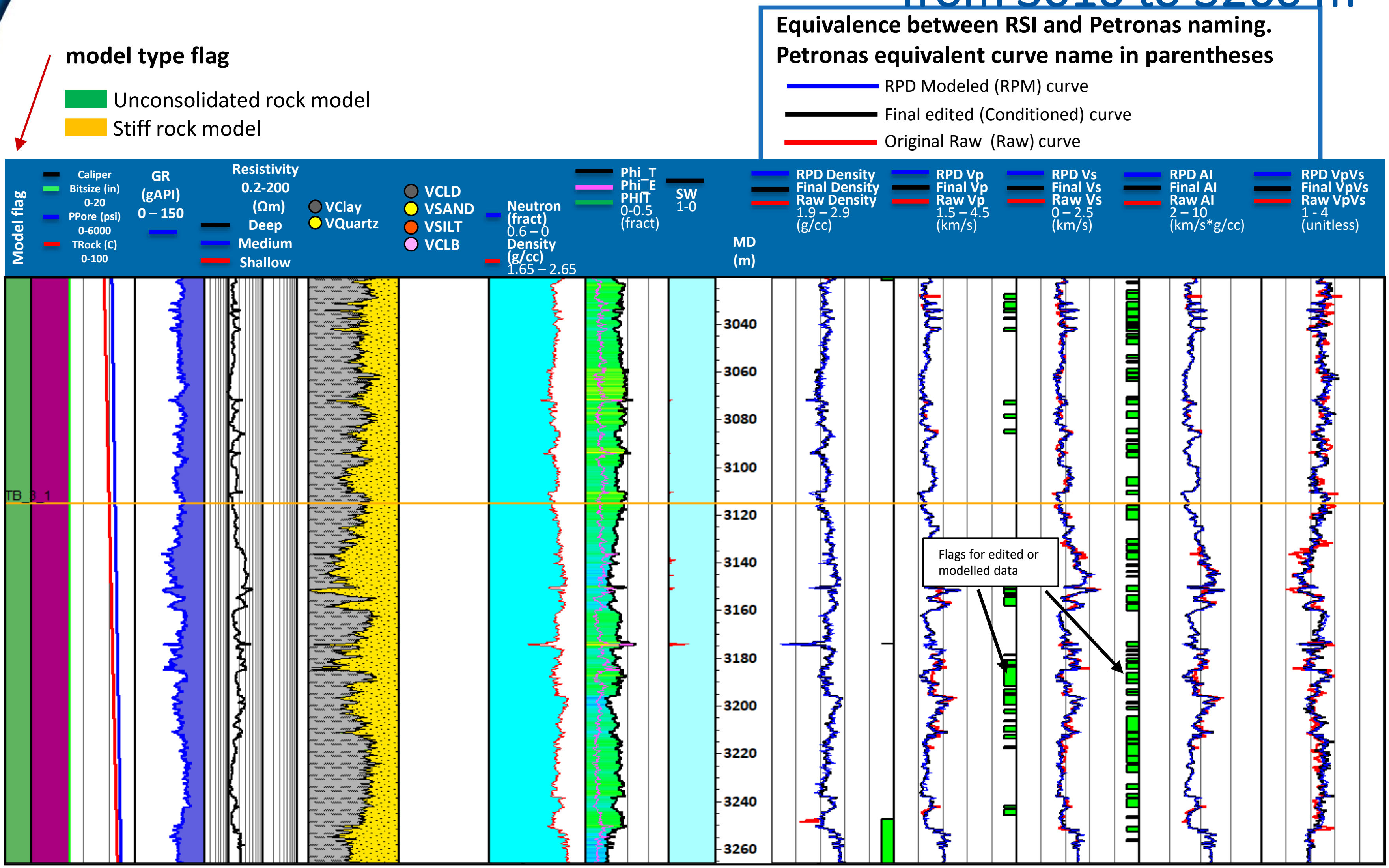
model type flag

- Unconsolidated rock model
- Stiff rock model



A Soft Sediment Model provided the best results when predicting elastic responses in both, clays and sands. Sands have been generally reported as loose and also attested by the unsuccessful results obtained from some of the pressure tests taken in the well. Elastic logs are of good quality. Possible onset of overpressure at around 2750 m, as indicated by the red arrow. Operational problems prevented from acquiring elastic data in most of the TB 3.2 section. In the 2750-2800 m section, the Gamma response appears to be somewhat noisy.

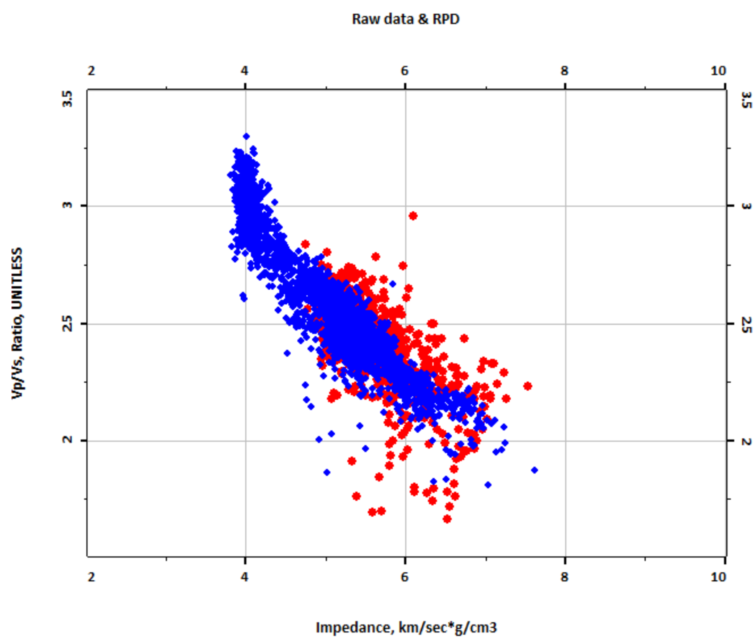
Labu-1 Geophysical Well Log Analysis (GWLA) – Interval from 3010 to 3260 m



Elastic data quality is good in this section. Density values have been extended towards the bottom of the well. Sands in this interval appear to be ratty, poorly developed and with poor reservoir property characteristics as suggested by the pressure tests taken in this section.

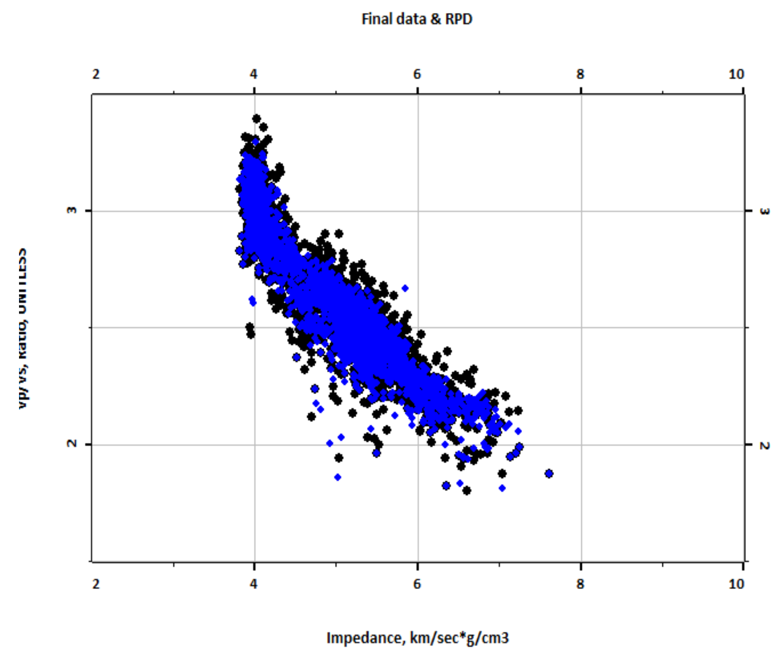
Labu-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing only the RPD model estimated elastic variables.



- RPD (RPM)
- Original Raw (Raw)

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

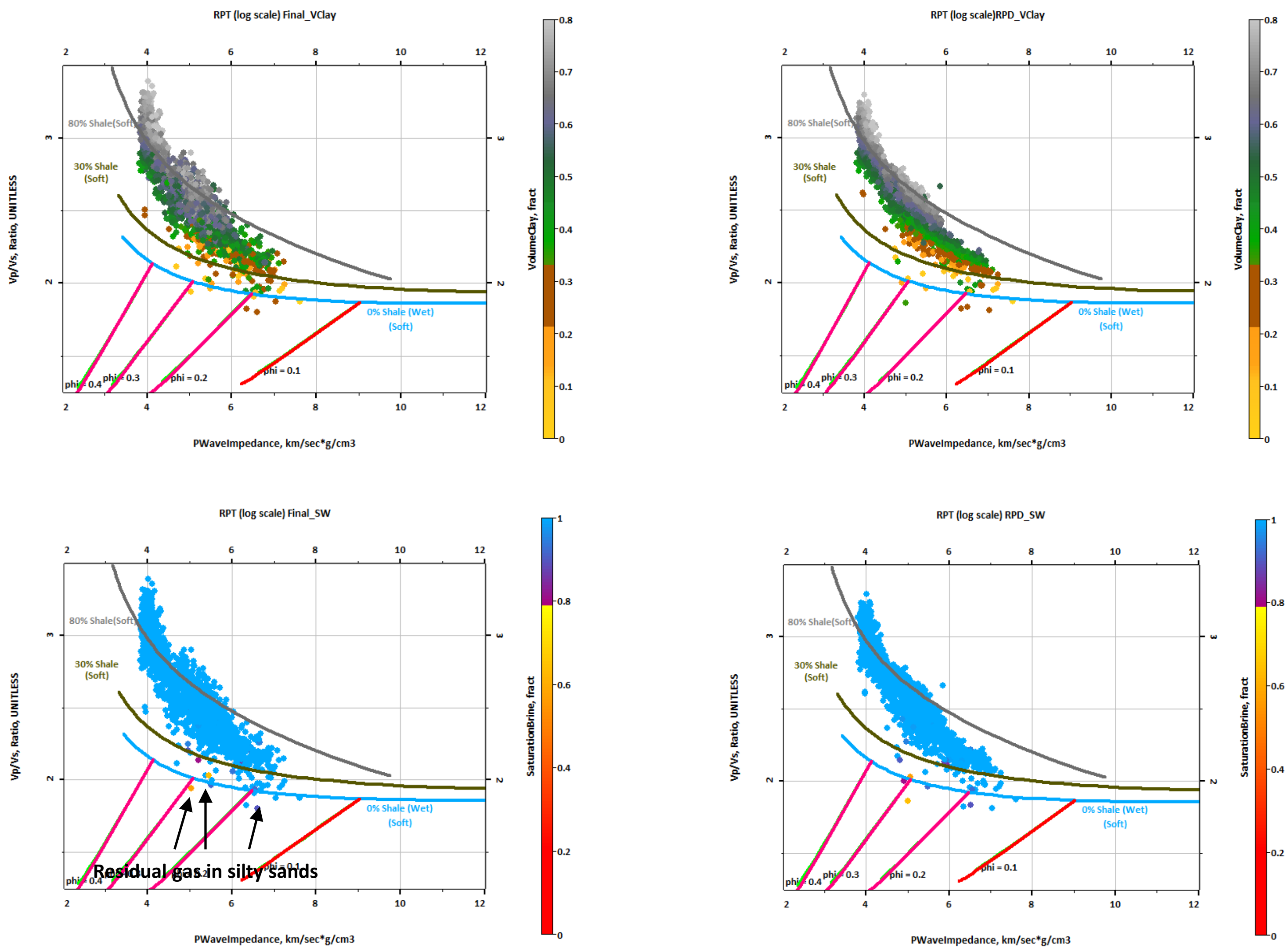


- RPD (RPM)
- Final (conditioned)

Labu-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Extraordinary Results. By Any Measure.

Lalawak-1

Lalawak-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited near the casing depth(42970-4350m) using the RPD due to bad measurement.
- Missing VP in sections such as ~3964-4018m was predicted using Faust relations while the density and VS data were estimated using RPD.
- Missing density in section between 2475m-3027m was predicted from Vp using RPD. Sections above 2475m was not analyzed due to missing elastic logs.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Intra cycle III and II sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with decreasing porosity towards the base of the section.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Water saturation was calculated using Simandoux's equation with RW of 0.06ohm @160 ℃, constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 yielding salinity value of~ 25000ppm (based on the well report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2900m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Faust model was used to estimate the VP data where RPD looks unreliable.

Fluid properties:

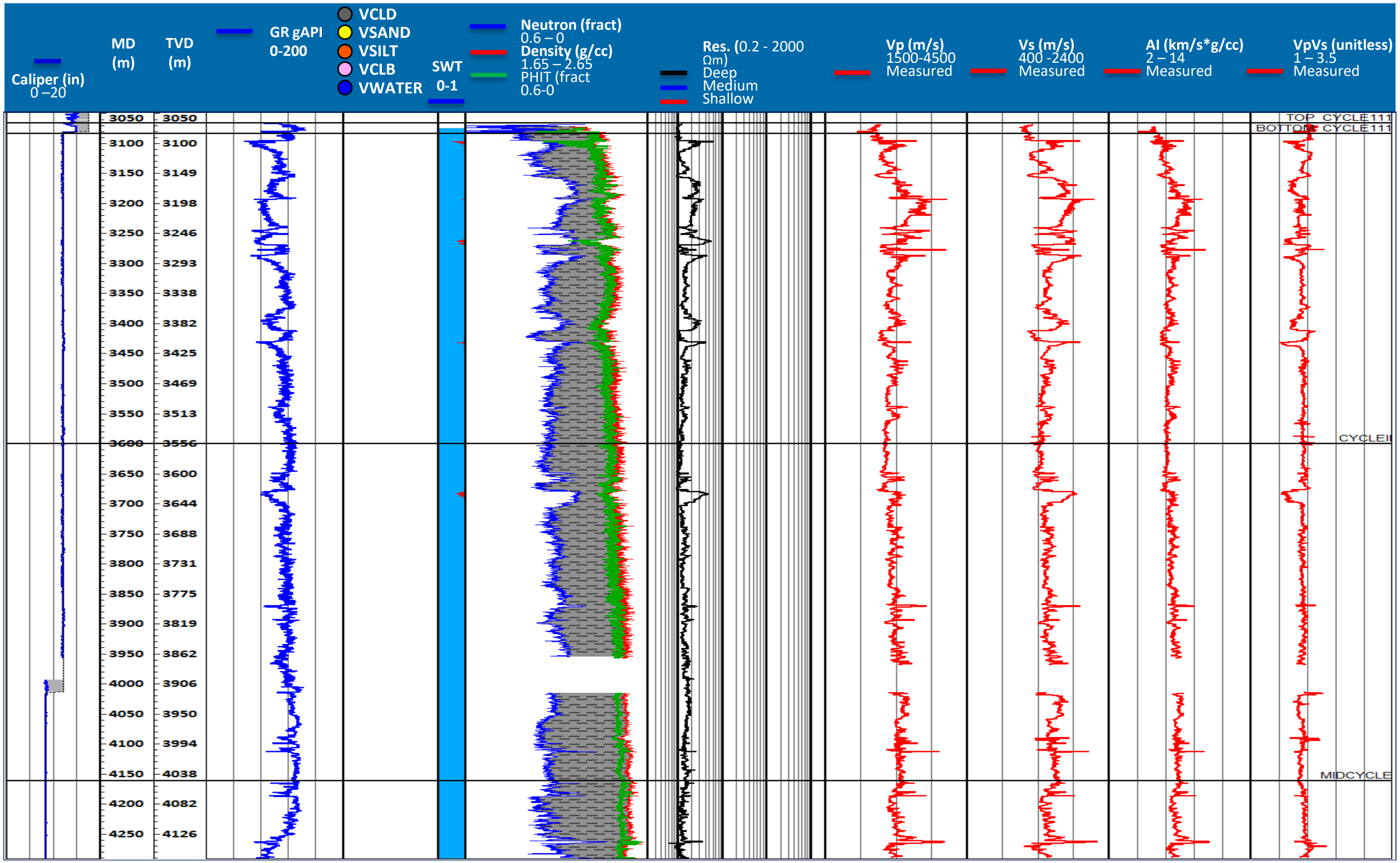
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 25000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of Intra cycle III and II using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class III was observed near a good porosity sand @ 3098m for the hydrocarbon fluid cases at in situ reservoir conditions while AVA class II is was observed for the wet scenario..
- By downgrading the reservoir quality(decreasing by 8%), AVA class II is observed for the hydrocarbon scenarios.

Lalawak-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Lalawak-1 Geophysical Well Log Analysis (GWLA) – Interval from 3100m to bottom of logs

model type flag

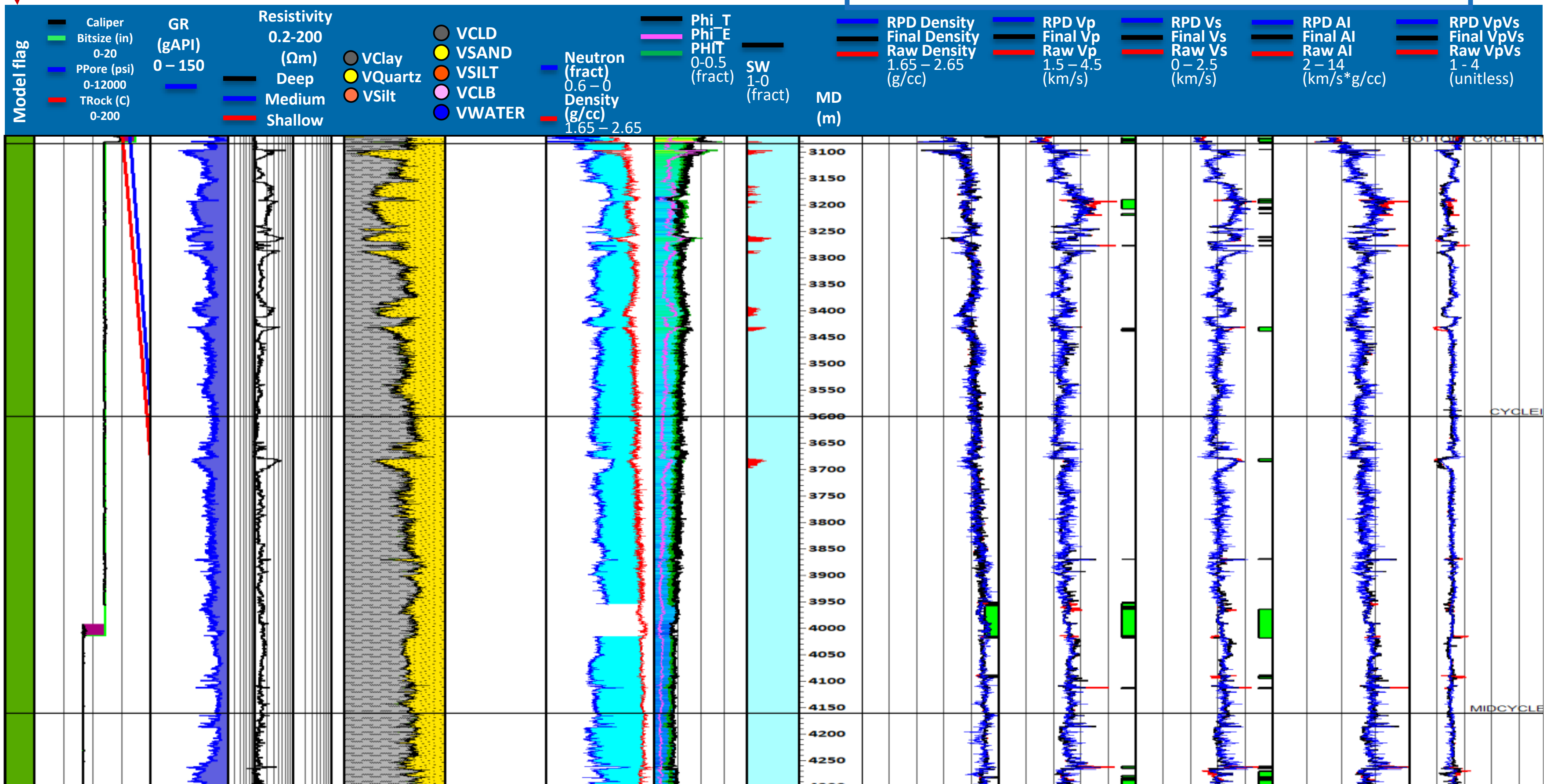
Soft rock model

Stiff rock model

Above depth of 2490m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

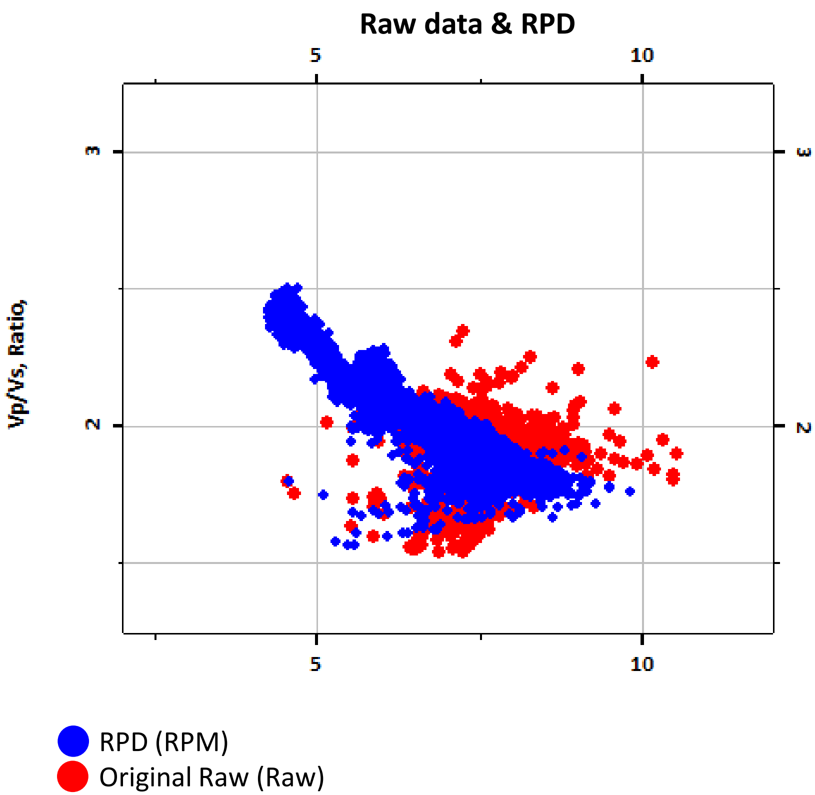


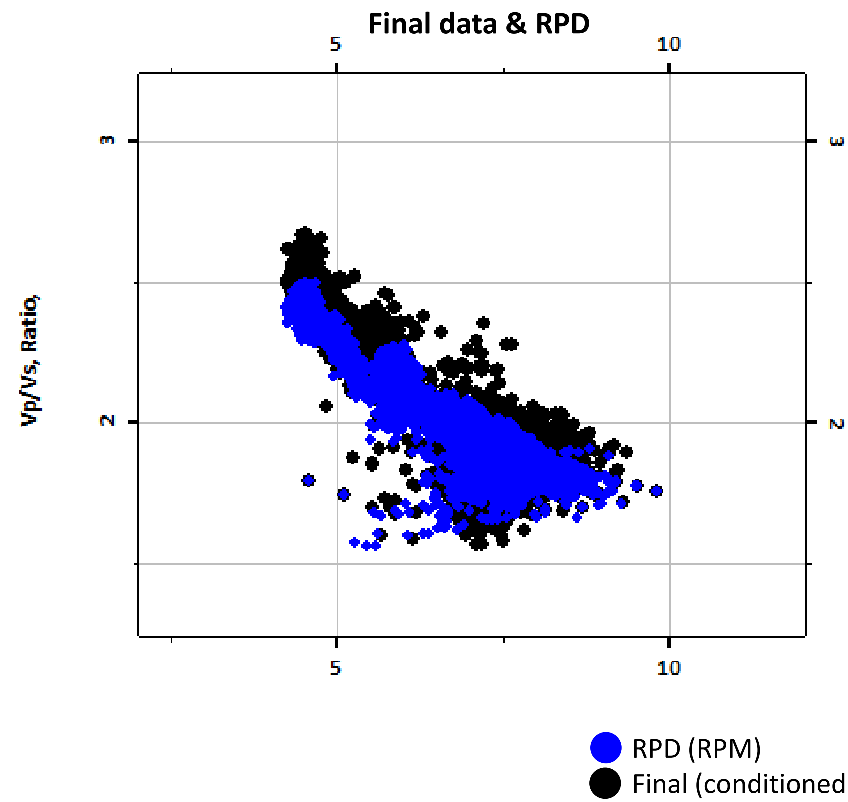
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Lalawak-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

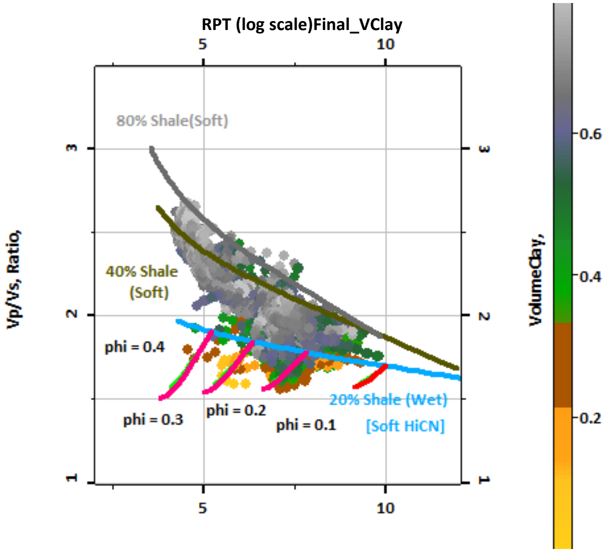


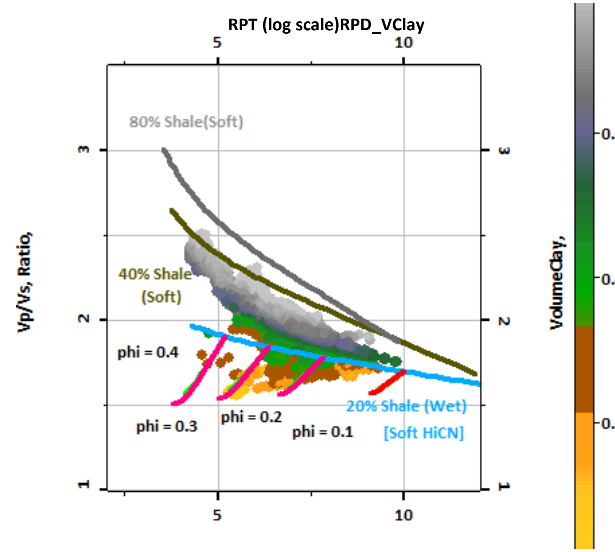


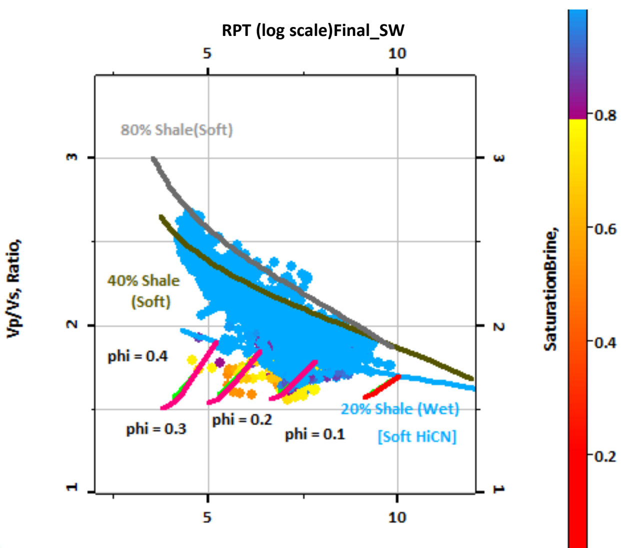
Lalawak-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

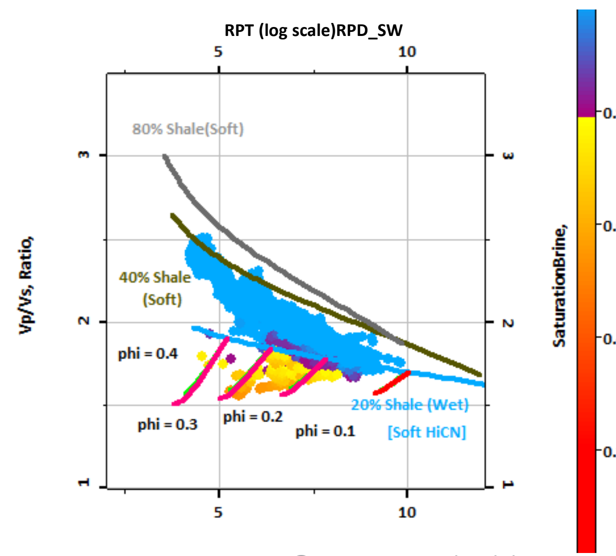
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

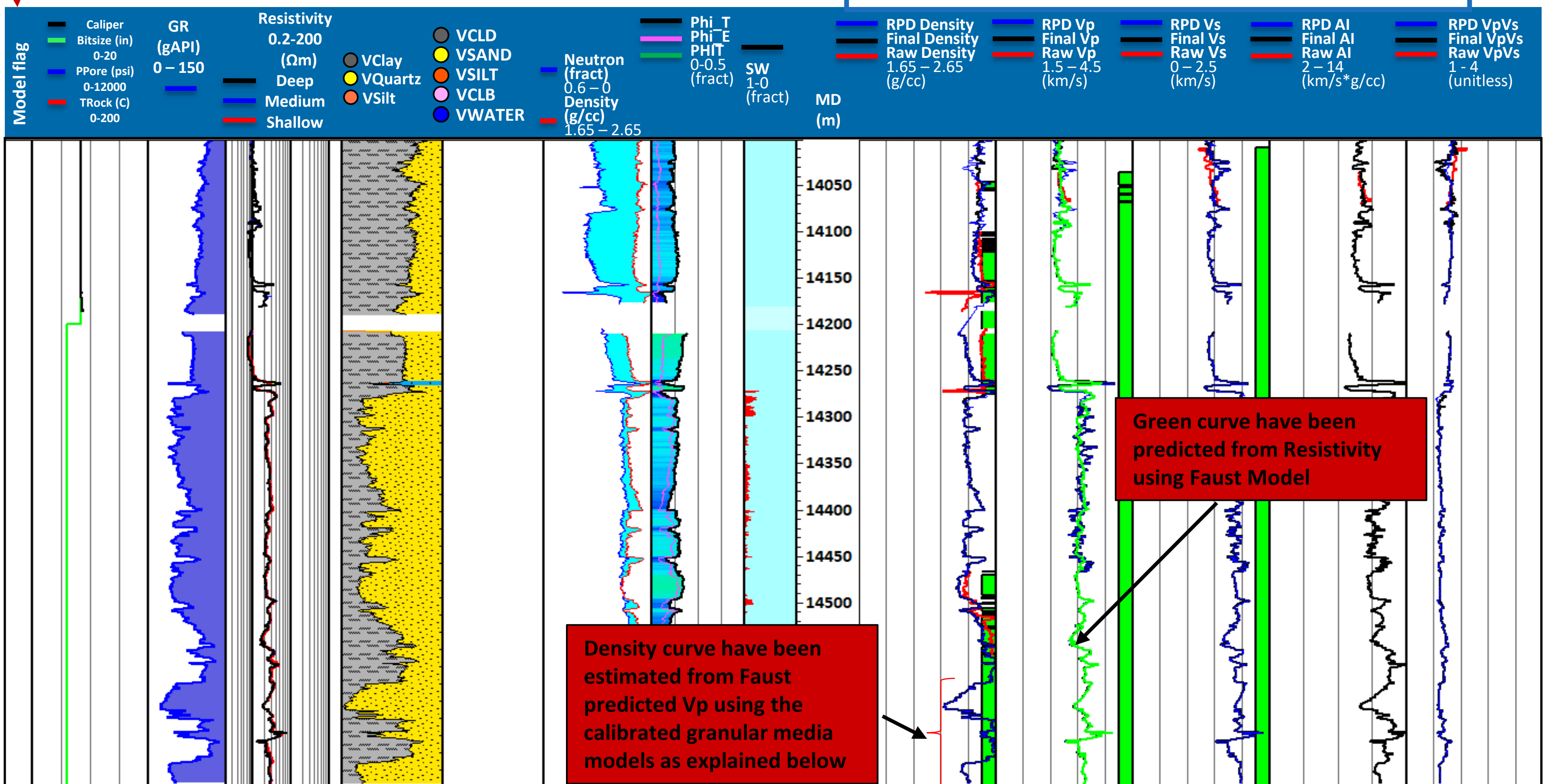
Lalawak-1ST1 Geophysical Well Log Analysis (GWLA) –

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Langsat-1

Langsat-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is fair to good. Vs data is only available in the 3678-4049 m, but with various gaps. Most of the well log suite runs in the 3157-4247 m interval.
- There is a remnant depth shift in the GR with respect to the density neutron curves in the 3954-3970 m section.
- Density measurements are of good quality. A major edit was applied in the 3900-3955 m section due to the casing shoe location. There are indications of borehole rugosity 3156-3494 m section but the density measurements appear to be consistent throughout.
- Vp log quality is fair. Semblance plots were available and helped during the acoustic logs QC process. Vp was edited in various intervals in order to preserve the major elastic trend in the well. Faust was applied in 3922-3933 m, and 3951-3955 m to estimate Vp from resistivity and due to the poor density log conditions in these sections.
- Other logs include, Neutron, Caliper, Deep and Medium resistivities.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation in the whole well.
- From 3936-3955 m there is no cuttings and the logs are conspicuously affected by borehole conditions. The mineralogy in this section has been interpreted based on an interpolation between the trends from above and below and using the Linear Gamma Ray approach with extreme values when interpreting clay content in the section.

Reservoir characteristics:

- Langsat-1 was an exploration well drilled offshore Sarawak to test hydrocarbon potential in a high relief broad four-way dip closure of the Oligocene age, Cycle 1 interval. The well was designed to evaluate the potential of a working petroleum system below the Mid- Miocene Unconformity (MMU) in deep-water Sarawak.
- In general, the column is claystone and siltstone dominated. Clean sands are not well developed and interpreted with high clay content. Sands seem to have reasonable porosity values but due to the high clay content, the reservoir properties are interpreted as poor. Some of the sands in the upper section of the Cycle 1B were reported and interpreted as showing traces of pyrite. Pressure tests were tight in attempts within the Cycle 1C, suggesting poor reservoir conditions.

Volume of hydrocarbons:

- Some sands within the Cycle 1B and Cycle 1C have been interpreted as residual gas saturated. There were some gas shows events during drilling, although no fluorescence was reported from cuttings.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=2n=2, and an Rw=0.095 Ohmm @ 194 F (~22,000 ppm).

** Depths referred in this report are MD.

Langsat-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and three different rock physics models were considered, based primarily in elastic properties:

1. Both clay-rich and sand facies were modelled as soft.

2. Velocities in both facies are considerably higher suggesting a rock physics model with higher coordination numbers for both facies.

3. Both, clay-rich and non-clay facies correlate better with a soft model. However, different elastic trends with depth were observed and strong contrasts and trend breaks were noticeable that may imply differences in both pressure regimes and rock properties and hence in the rock physics modelling parameterisation within this section.

Pressure regime differences along the well have been reported. Various pressure kick events were experienced while drilling. The elevated tectonic stress exerted on these rocks due to the folding controlling the structural component of this well might have had an additional impact, besides the overburden pressure, on the overall effective pressure, and hence the rock physics modelling parameterization applied on the well.

Fluid properties:

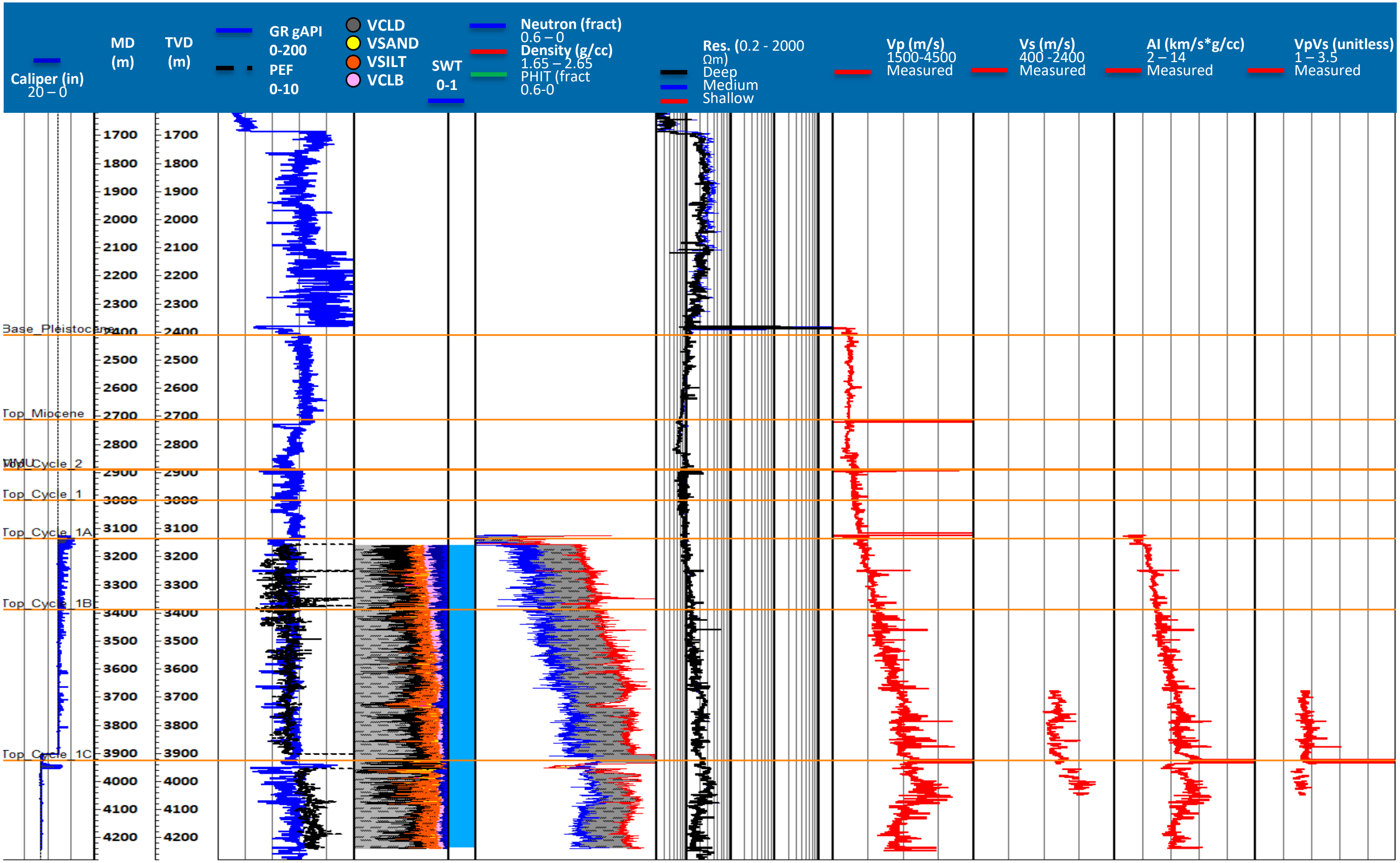
Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken from nearby wells. Gas gravity has been taken from Bidara and oil properties have been taken from Jelawat-1. Main parameters used in this modelling are:

- Brine salinity: 22,000 ppm (average value between Petronas and Conoco fluid saturation sensitivity exercises. This salinity value has also been interpreted from nearby wells).
- Gas gravity: 0.62 (PVT report of Bidara well)
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

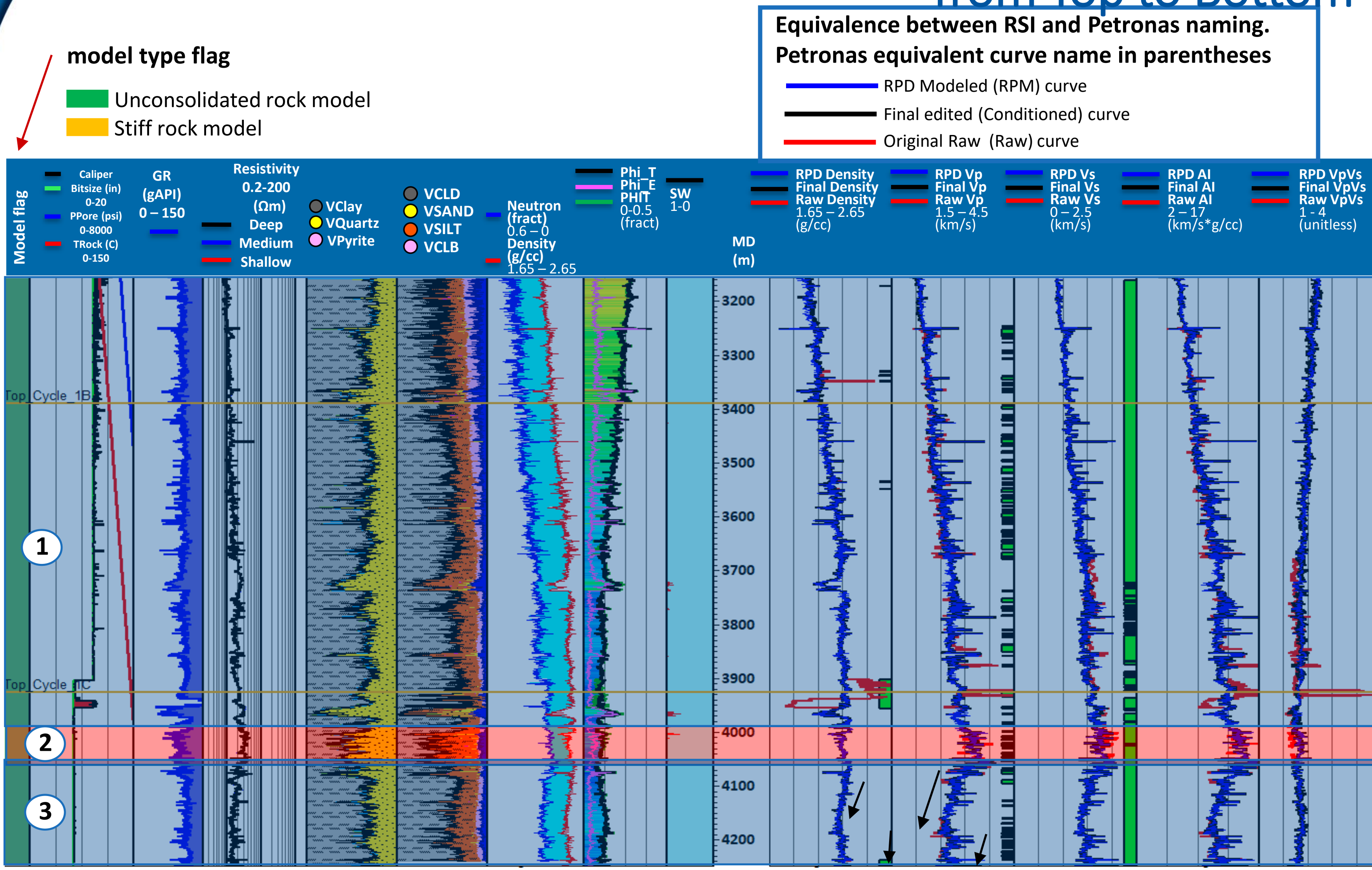
- Perturbational modelling was performed in the Oligocene sands (Cycle 1A, Cycle 1B and Cycle 1C).
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – Langsat-1



Additional data includes mud weight data, pressure data, petrophysics and well log reports. Sonic log semblance analysis is also available for QC purposes.

Langsat-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to Bottom



Three different rock physics models were considered and applied in this well, based primarily in pore pressure regimes and elastic properties:

1. Both clay-rich and sand facies were modelled as soft.
2. Velocities in both facies are considerably higher suggesting a rock physics model with higher coordination numbers for both facies.
3. Both, clay-rich and non-clay facies correlate better with a soft model. However, the black arrows indicate differences in the elastic trends and a strong contrast at around 4190 m that imply differences in the rock frame and hence in the rock physics modelling parameterisation within this section

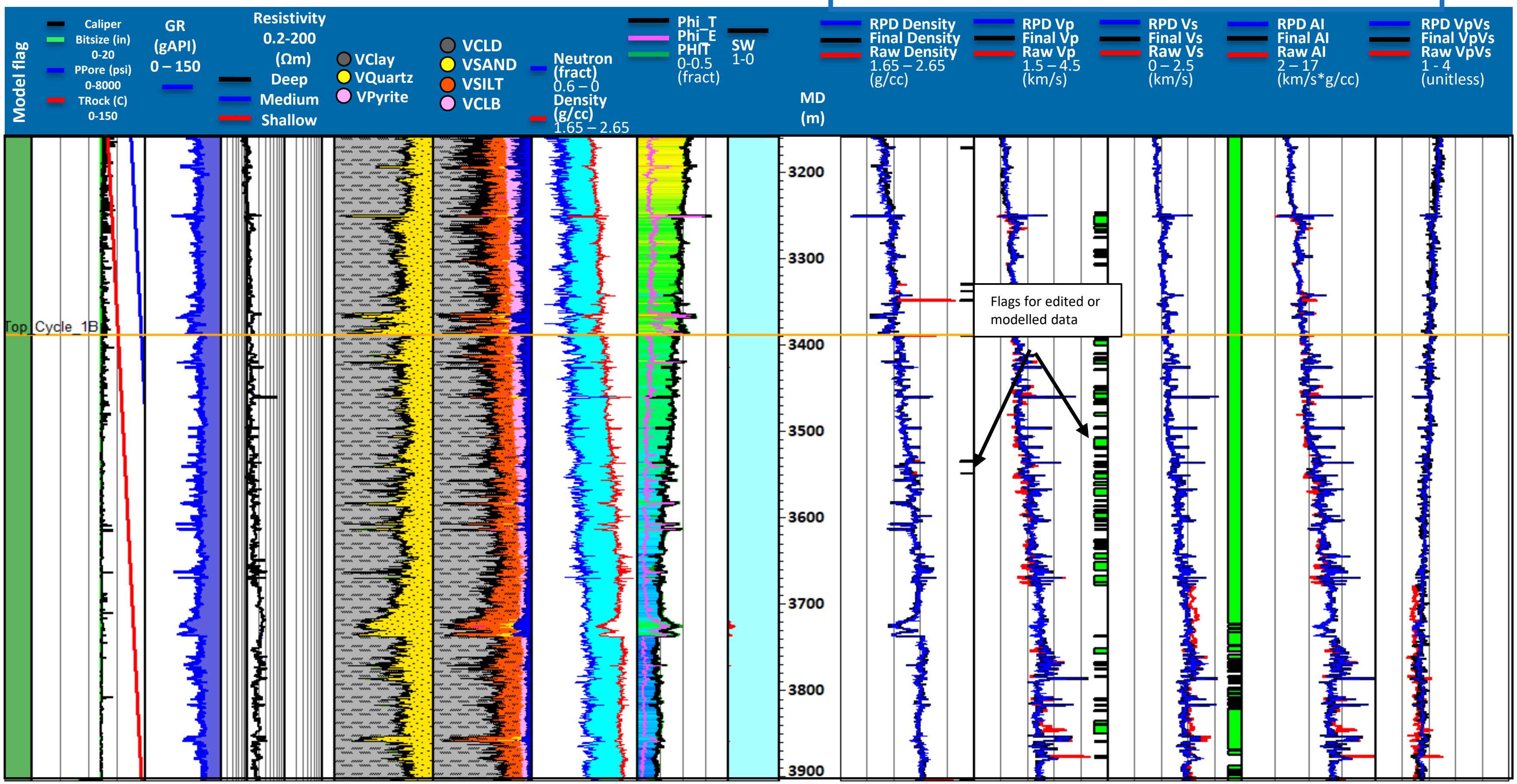
Langsat-1 Geophysical Well Log Analysis (GWLA) – Interval from 3150 to 3900 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Although poorly developed, above 3400 m (Cycle 1A) is where perhaps the best reservoir quality sands were encountered in this well. A Soft Sediment Model honoured the elastic trends of both facies, sands and clays in this section. Vp/Vs trend decreases almost monotonically with depth following the same trend exhibited by the porosity.

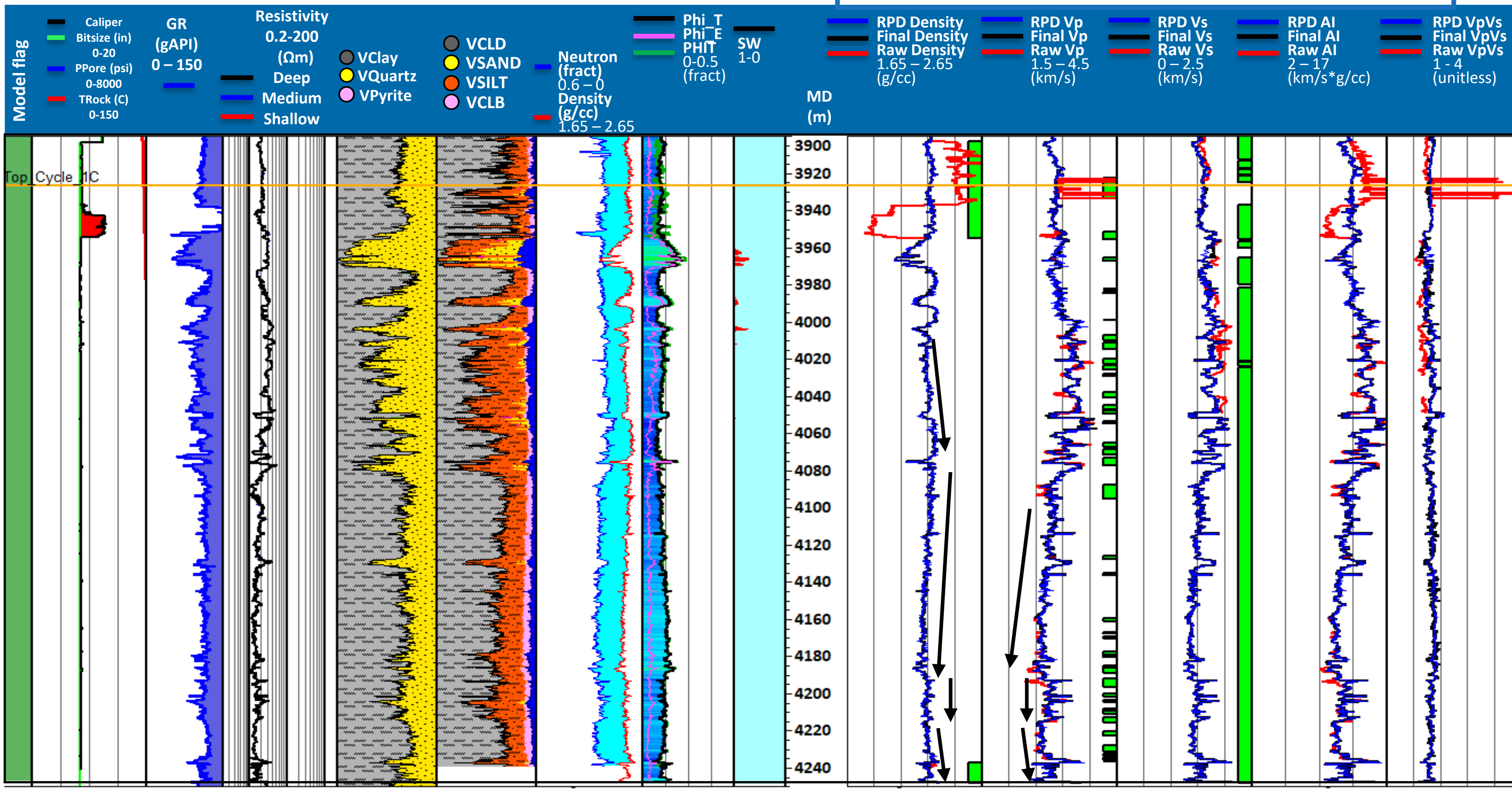
Langsat-1 Geophysical Well Log Analysis (GWLA) – Interval from 3900 m to Bottom

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

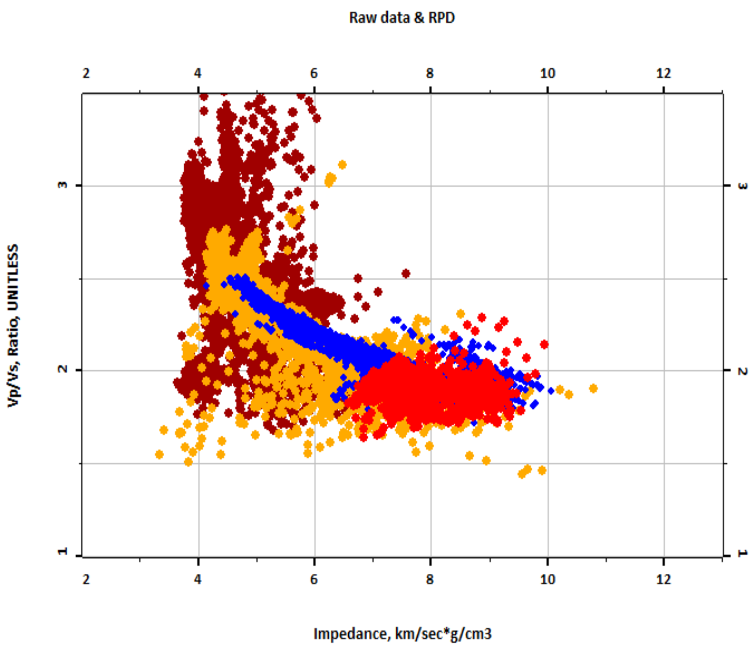
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



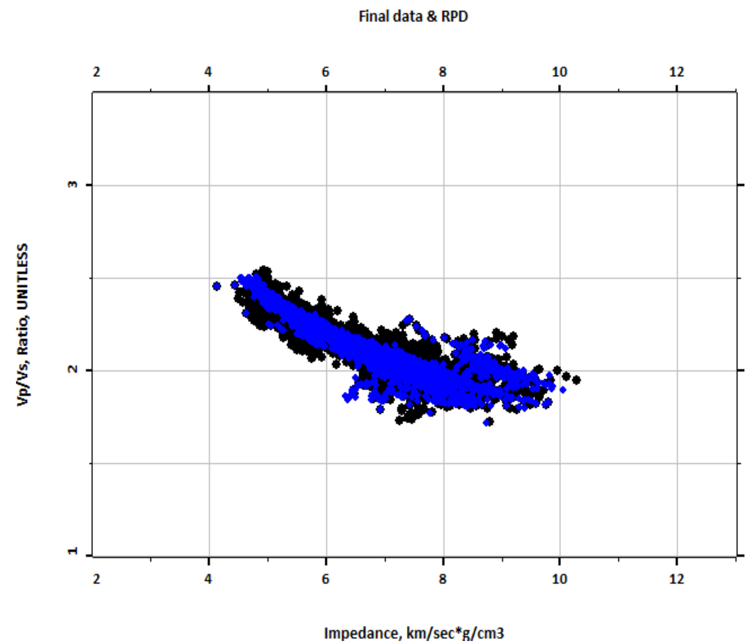
This section shows variability in the elastic trends as sketched by the black arrows. The coarsening upwards sequence in the 3980-4070 m shows a trend in which both, Vp and density, generally increases with depth. Velocities are high in both sands and claystones. Below 4080 m, elastic trends start to vary with noticeable trend breaks (e.g. 4210 m, 4230 m) that may suggest the presence of different pressure regimes. This will impact the rock physics modelling parameterisation within the section.

Langsat-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data, along with elastic data from analog wells with similar trends in the elastic space.



P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



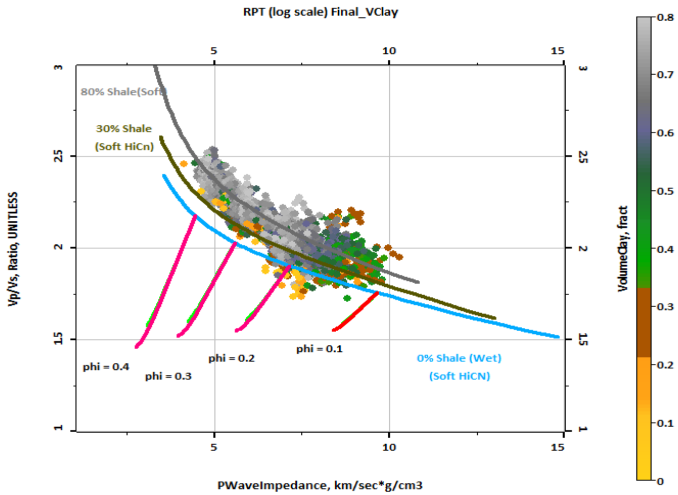
Langsat-1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

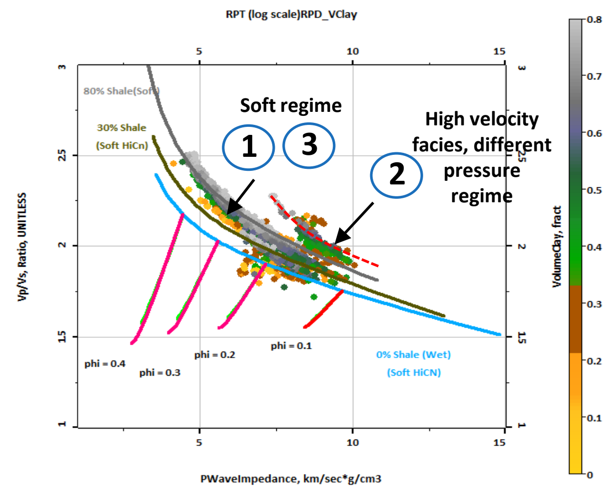
Rock Physics Models

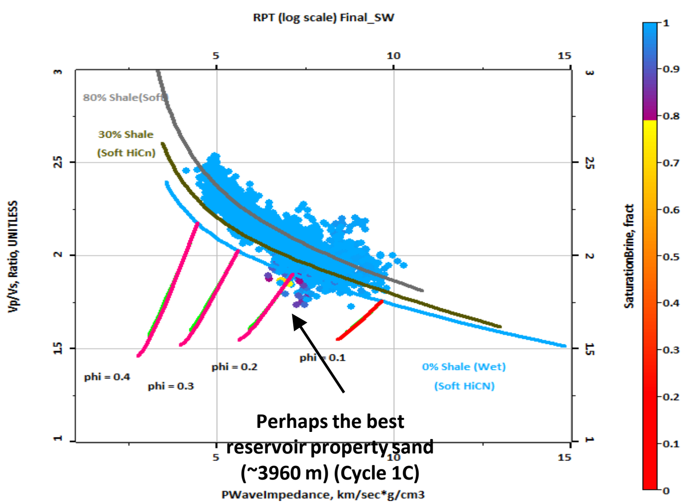
1. Soft facies
2. High velocity facies
3. Soft facies with different elastic-pressure regimes

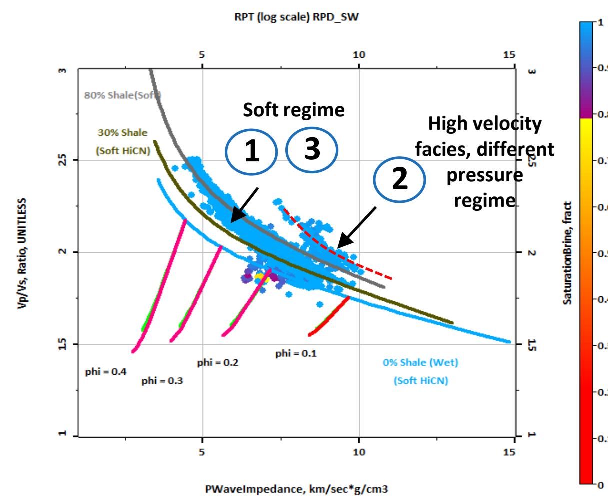
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Lanjak-1

Lanjak-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is fair. Most of the well log suite runs in the 3157-4247 m interval.
- Density measurements are of very good quality. Edits were applied only in the marl at the top of the 8 ½" section.
- Vp log quality is fair. Few edits were performed. The log was extended towards the total depth.
- Vs has been entirely modelled in this well using Granular Media. Vs trends observed in acoustically analogue wells such as Talang, assisted in the Vs modelling parameterization.
- Other logs include Neutron and Deep Resistivities.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method. Petronas VClay interpretation has also been a useful resource when revisiting the clay interpretation in the whole well.

Reservoir characteristics:

- The primary objective of this well was to prove the hydrocarbon potential of the sub-unconformity lower Miocene sandstones.
- The best reservoir property sands are located in the 2530-2535 m section, with porosities of 26%, but brine saturated. On the AI-VpVs space, these sands overlaps the gas bearing marls located in the 2408-2416 m section. Silty sands with greater thicknesses were encountered in the well, but with no hydrocarbon prospectivity.

Volume of hydrocarbons:

- Gas readings were measured during drilling in the 2407-2416 m, in a marly section at the top of the 8 1/2" hole. The rest of the reservoir quality sands were interpreted as wet.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=2n=2, and an Rw=0.1 Ohmm @ 194 F (~23,000 ppm).

** Depths referred in this report are MD.

Lanjak-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in clay-rich facies, whereas an Intermediate Stiff Sediment Model (with a higher Coordination Number) honored best the elastic responses of the sand facies. A specific parameterization using a Stiff Sediment Model was required when modelling Vp-Vs-Rhob in the marly section (2407-2416 m) These models have been used to edit the Vp, Rhob, and Vs data where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock physics modelling (RPM) stage of the project. Vs was fully estimated; Vp and Vs trends from nearby wells that proved to be analogues from an acoustic perspective (Talang, Mulu) were used as a guide during the estimation.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from nearby wells (Jelawat-1). Main parameters used in this modelling are:

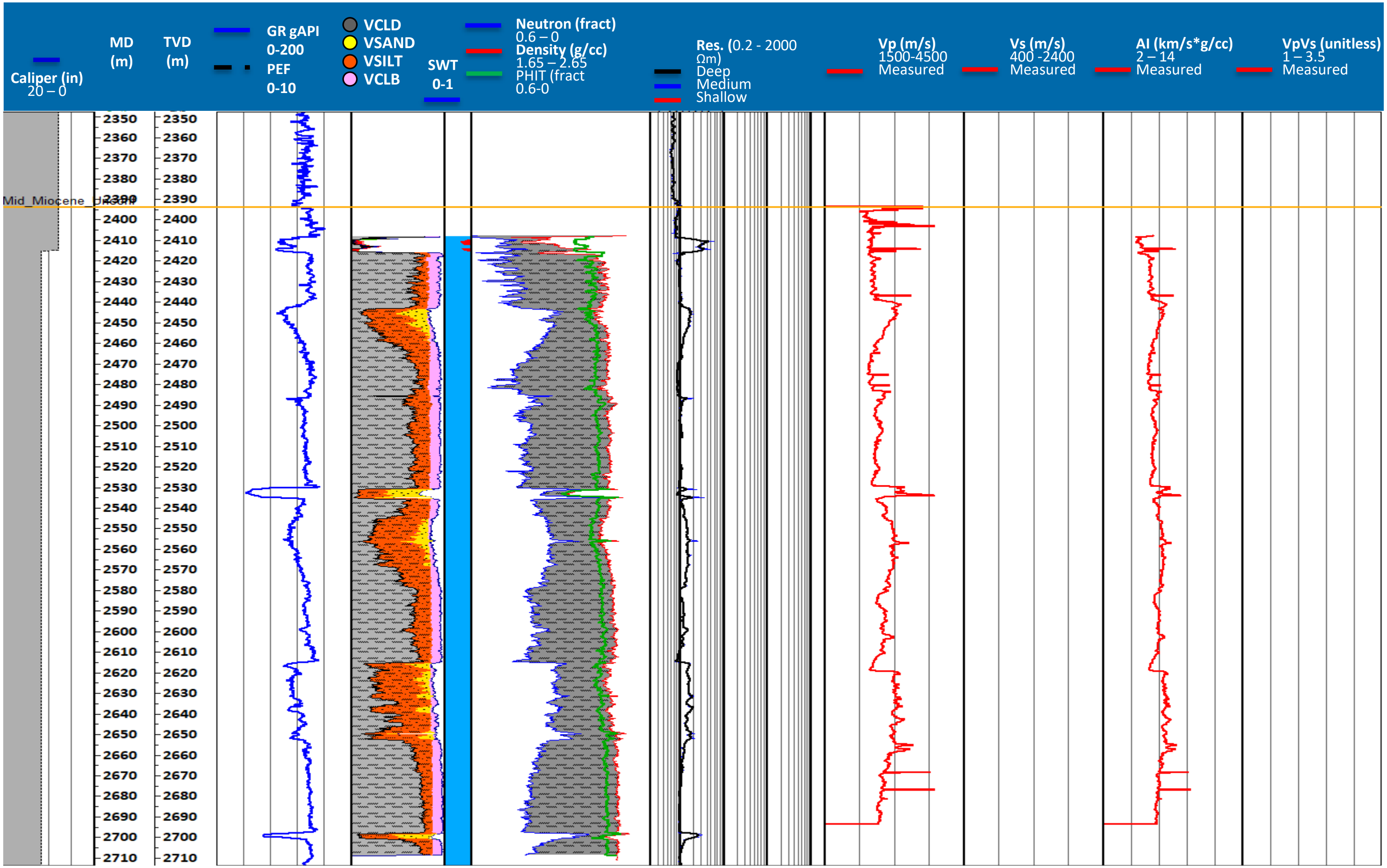
- Brine salinity: 23,000 ppm (based on nearby Talang well).
- Gas gravity: 0.80
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Mid Miocene sediments.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Lanjak-1



Additional data includes mud weight data, pressure data, petrophysics and well log reports.

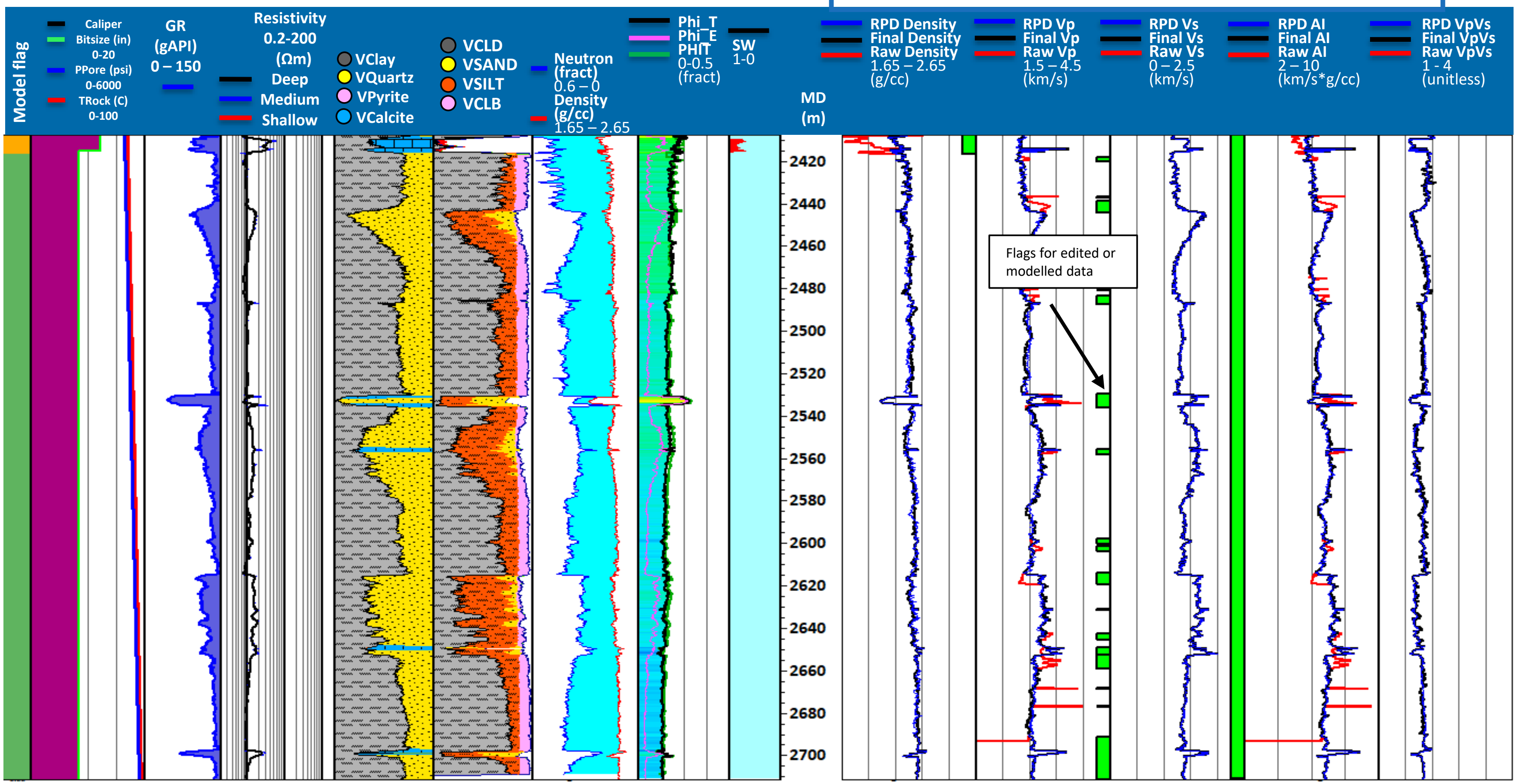
Lanjak-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to Bottom

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

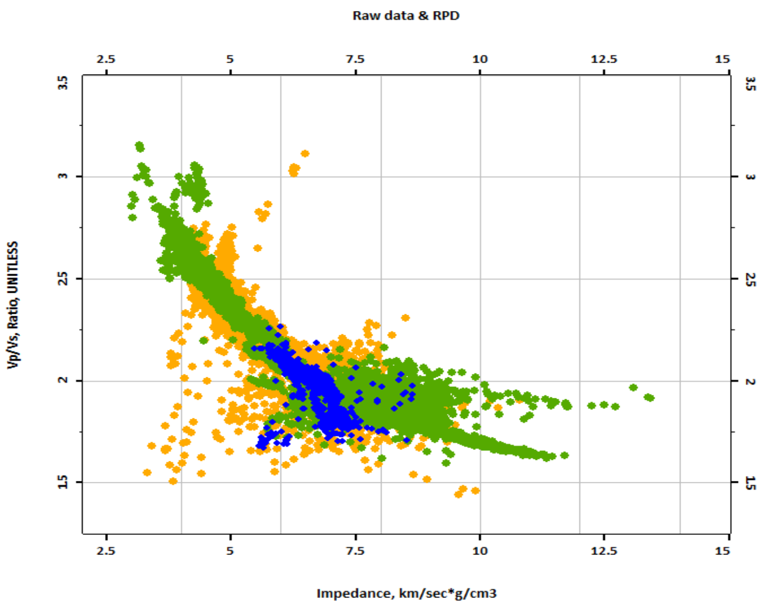
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Granular media model (soft sand with variable Coordination Number) was used for the Rhob and Vp curves prediction with good correlation with the measured data. The shallow section characterised by the presence of a gas bearing marl required a different rock physics parameterisation (Stiff Sediment Model for the calcareous component). Vs was not acquired in the well and thus, it was fully estimated using granular media and Vs trends from analogue wells. The quality of the elastic logs is fair. Some Vp edits appear to be a consequence of remnant depth shifts present in the data. Vp has been extended towards the total depth. Densities in the marly section appear to be highly affected by the presence of the casing shoe and it was therefore edited.

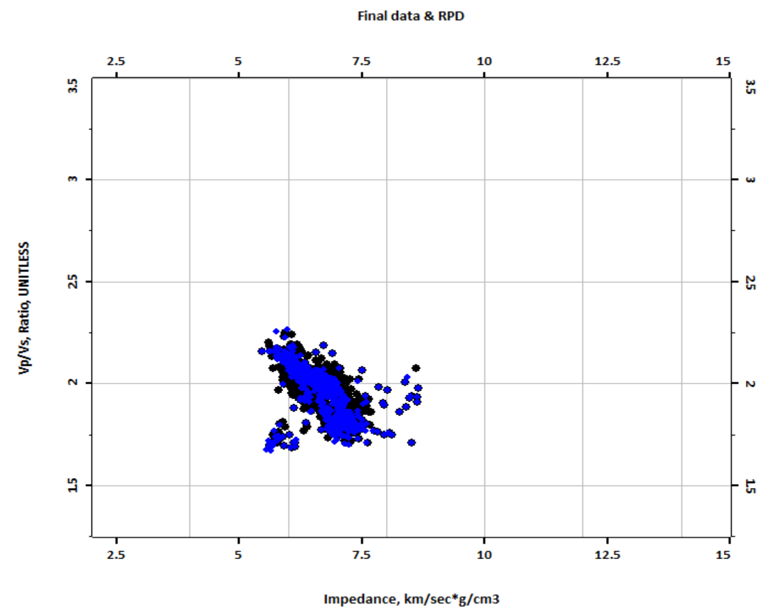
Lanjak-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data. Full Well

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the analogue wells with similar trends in the elastic data, given the measured shear in Lanjak-1 is not available



RPD (RPM)
Mulu-1
Talang-1 (raw)

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

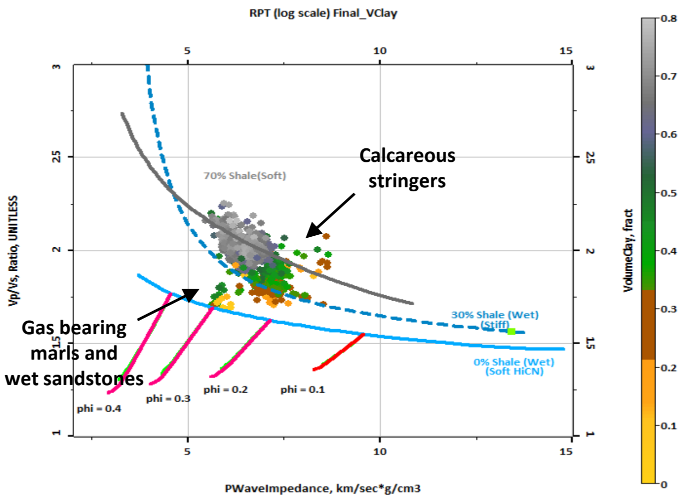


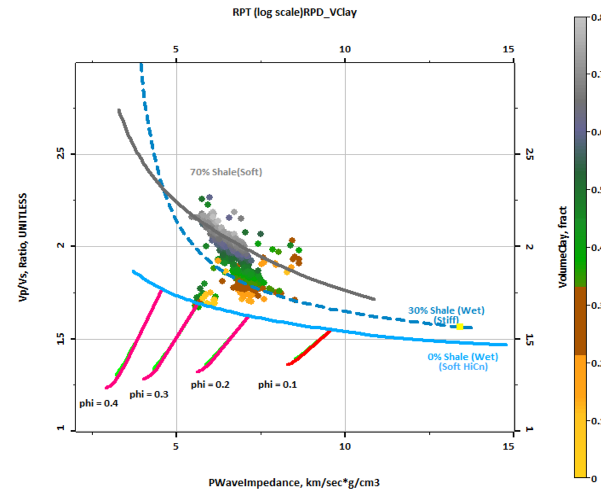
RPD (RPM)
Final (conditioned)

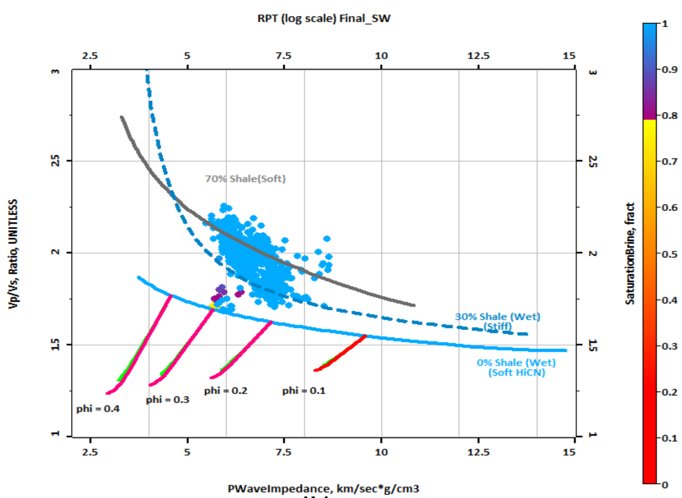
Lanjak-1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

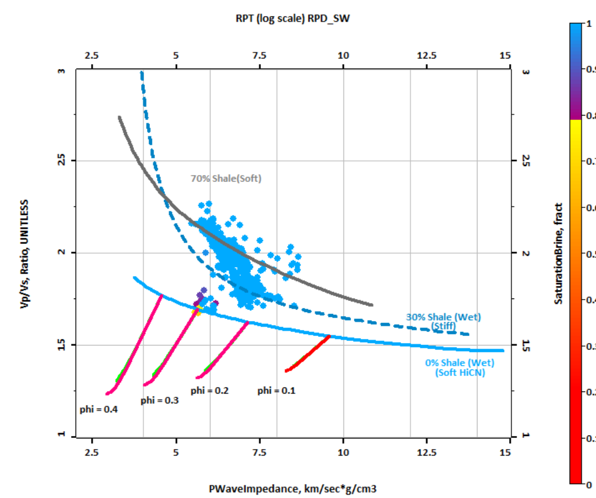
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Laya-1

Laya-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density log was very stable in most of the well intervals except few poor measurements due to the hole conditions where it was corrected using the RPD.
- Vs and Vp were heavily edited in many intervals in the well due to flat or lazy readings especially in the section(2415-2560m)using the RPD in order to have consistent VpVs ratio results and normal relationship between quartz rich and clay rich sediments.
- The hole encountered some local over-pressure layers causing sudden drop in the velocity, density and resistivity readings.
- Other logs include Gamma, Neutron, Caliper and Deep Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the cycle VIII, VII and VI sands. Only sands in cycle VI were penetrated in the well with a poor-quality reservoir characteristics(silty sandstones). These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with blocky shape intercalated with claystone layers.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated.

Water saturation (Sw):

- Water salinity obtained from the final geological report of the well based on the area knowledge and was about 34000ppm. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=2 (based on regional area knowledge).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(1900m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- The hole encountered some local over-pressure sections causing sudden drop in the P and S-wave velocity, density and resistivity readings.

Fluid properties:

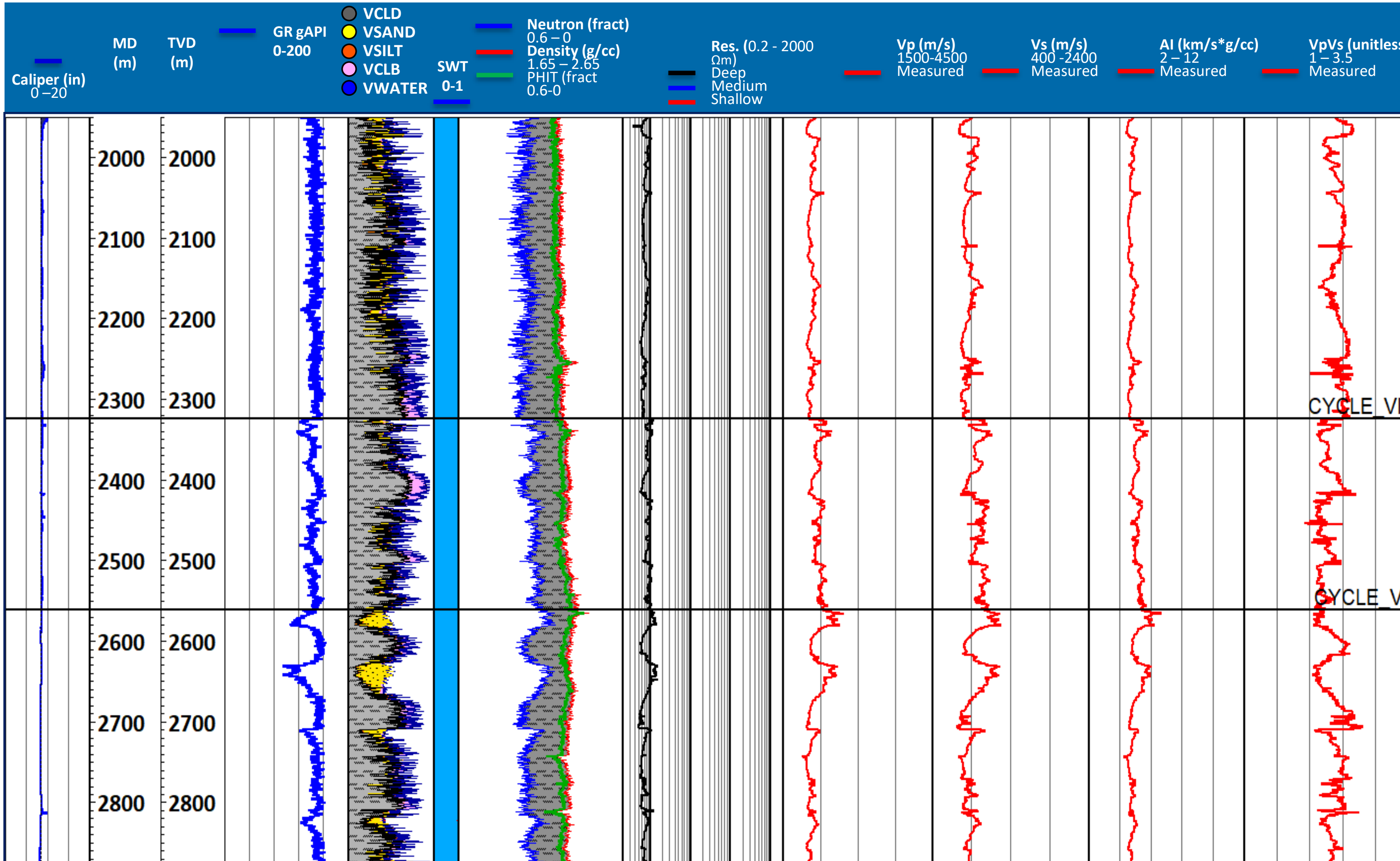
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 34000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

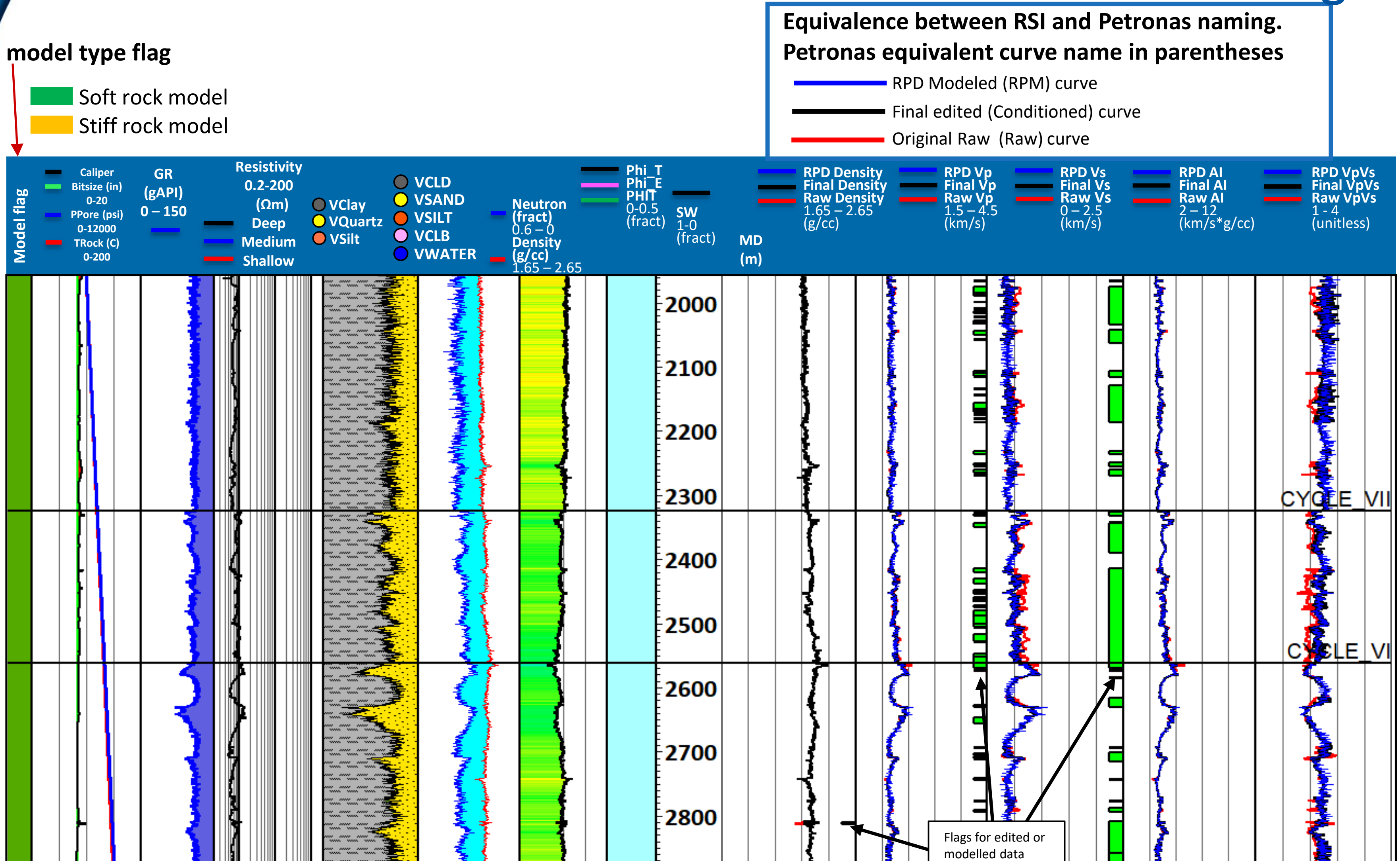
- Perturbational modelling was performed in the different sands of cycle VI using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the top sand of cycle VI @ 2565m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no significant change for the AVA class could be noticed.

Laya-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Laya-1 Geophysical Well Log Analysis (GWLA) – Interval with elastic logs

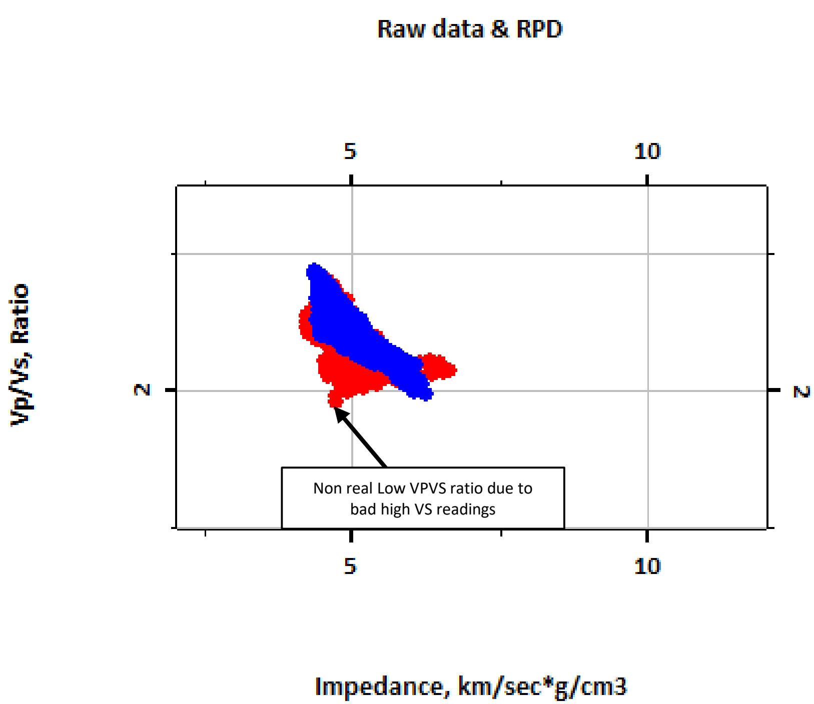


Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

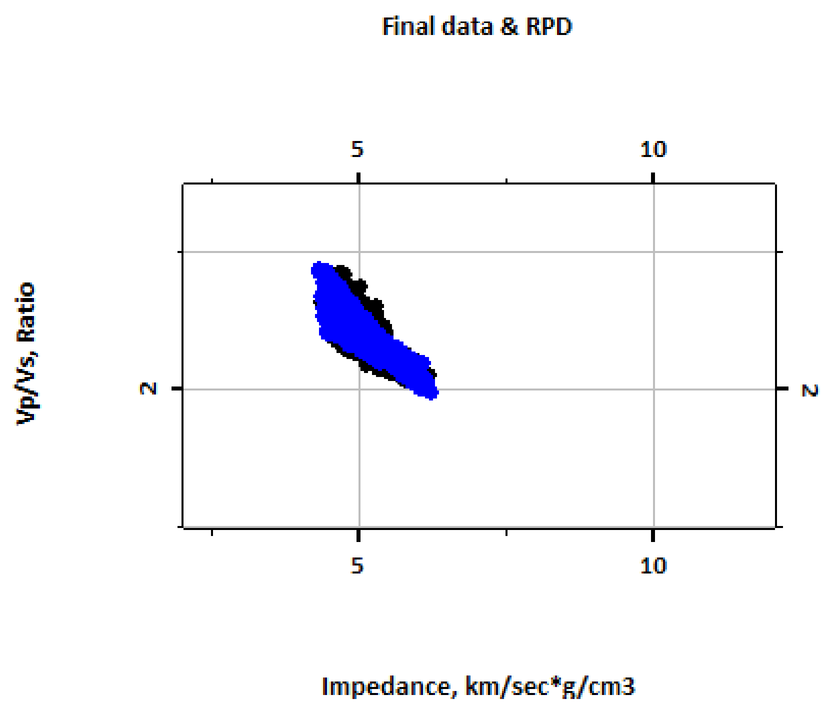
Laya-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)

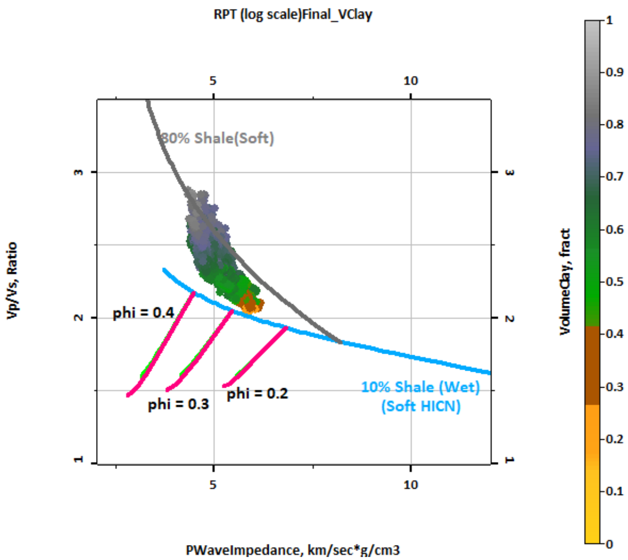


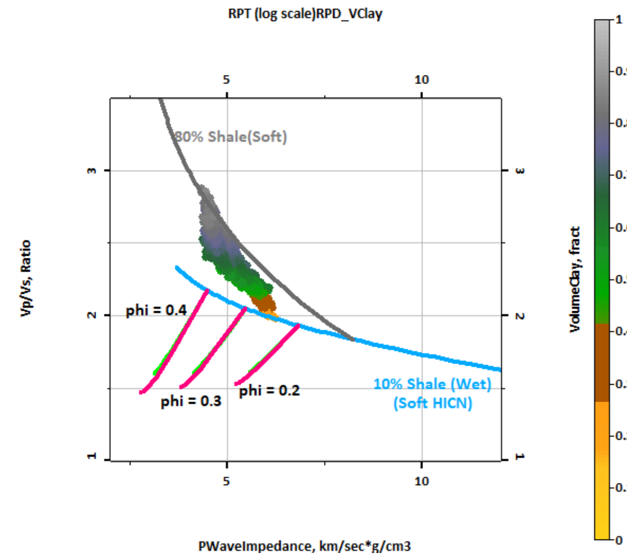
RPD (RPM)
Final (conditioned)

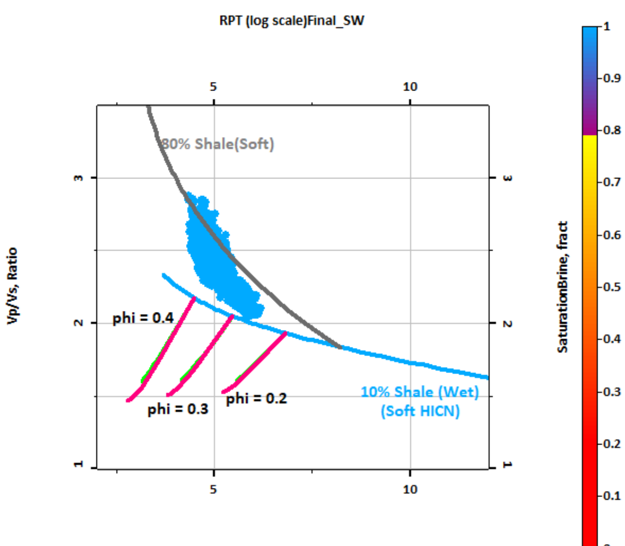
Laya-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

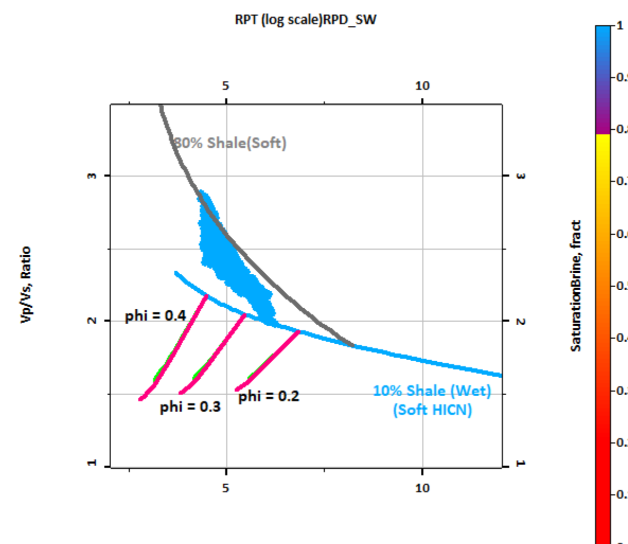
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Mawar-1R1S1

Open

Mawar-1R1S1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is very poor especially the elastic measurements(density and the sonic) in many intervals where the hole encountered very bad washout. Client's petrophysical interpretation was provided for this well just as a reference. Full elastic logs except VS were available throughout the wellbore covering the interval (1450m-T.D.)
- Shear wave velocity(VS)was fully modelled in the well using the RPD after the model was carefully calibrated based on the offset wells(not very nearby) behaving elastically the same and also using the VP-Rhob relation to predict best model to use. The resulted Vs honors the trend in the nearby wells(Hibiskus-1, Jelawat-1 ST1 and Jemuduk-1 ST1)
- Due to the sever bad hole conditions in the section(1450-2050m), density and sonic in many intervals were completely replaced using resistivity via Faust equation to predict the velocity then density was predicted using the RPD based on the calibrated model(where measured data was reliable).
- Vp was also totally replaced with the modelled one in some intervals where it looks lazy and not responding to any lithology variations after carefully calibrated the model with the good measured data present in the well and also in the offset wells to honor the regional trend in the area.
- Other logs include Gamma, SP, Caliper, Deep resistivity and Neutron which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands(Cycles VI and V). These are a series of turbiditic sands with some calcareous cement and less porosity especially the cycle V sands.

Volume of hydrocarbons:

- Some sands encountered in the well were gas saturated up to 60% especially in the V cycle .

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly the clean sand section of cycle V(2280-22850m) yielded a formation water salinity of 19000 PPM(which matched with the reported one in the final well report and the one used in Hibiskus-1 well). Water saturation was calculated using Simandoux's equation with constants used were (a)=0.62, Cementation exponent (m)=1.15 and Saturation exponent (n)=2 (based on final well report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the full elastic log suite started(1450m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Elastic behavior for the well was carefully calibrated with the nearby wells and other wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to Hibiskus-1 well, so S-wave velocity completely modelled in the well based on the same model which resulted in a matched trend with the calibrated nearby wells and very well behaved model when compared to the modelled results in the other wells.

Fluid properties:

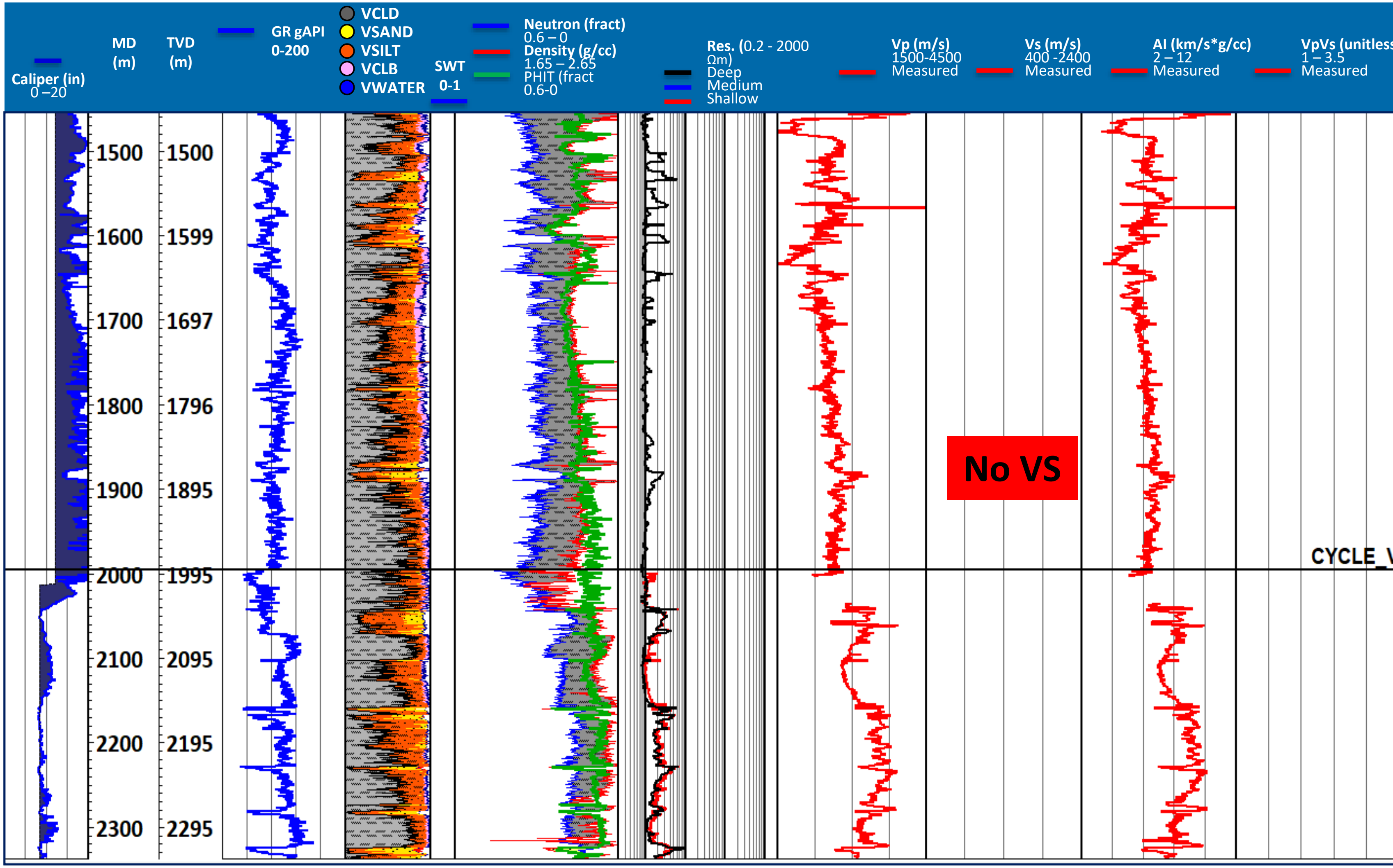
Fluid properties used in substitution have been assumed based on the well MDT and nearby area information. Main parameters used in this modeling are:

- Brine salinity: 19000 ppm[Pickett plot]
- Gas gravity: 0.827[MDT]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(cycle VI and V) using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the top of a thin gas sand in cycle V @2228m for all fluid cases at in situ reservoir conditions with very poor discrimination between the wet and the hydrocarbon cases.
- By downgrading or upgrading the reservoir quality no noticeable change in the AVO response could be observed.

Mawar-1R1S1 Input Logs



Additional data includes pressure, temperature data, core and XRD reports and cuttings descriptions(Final geological report).

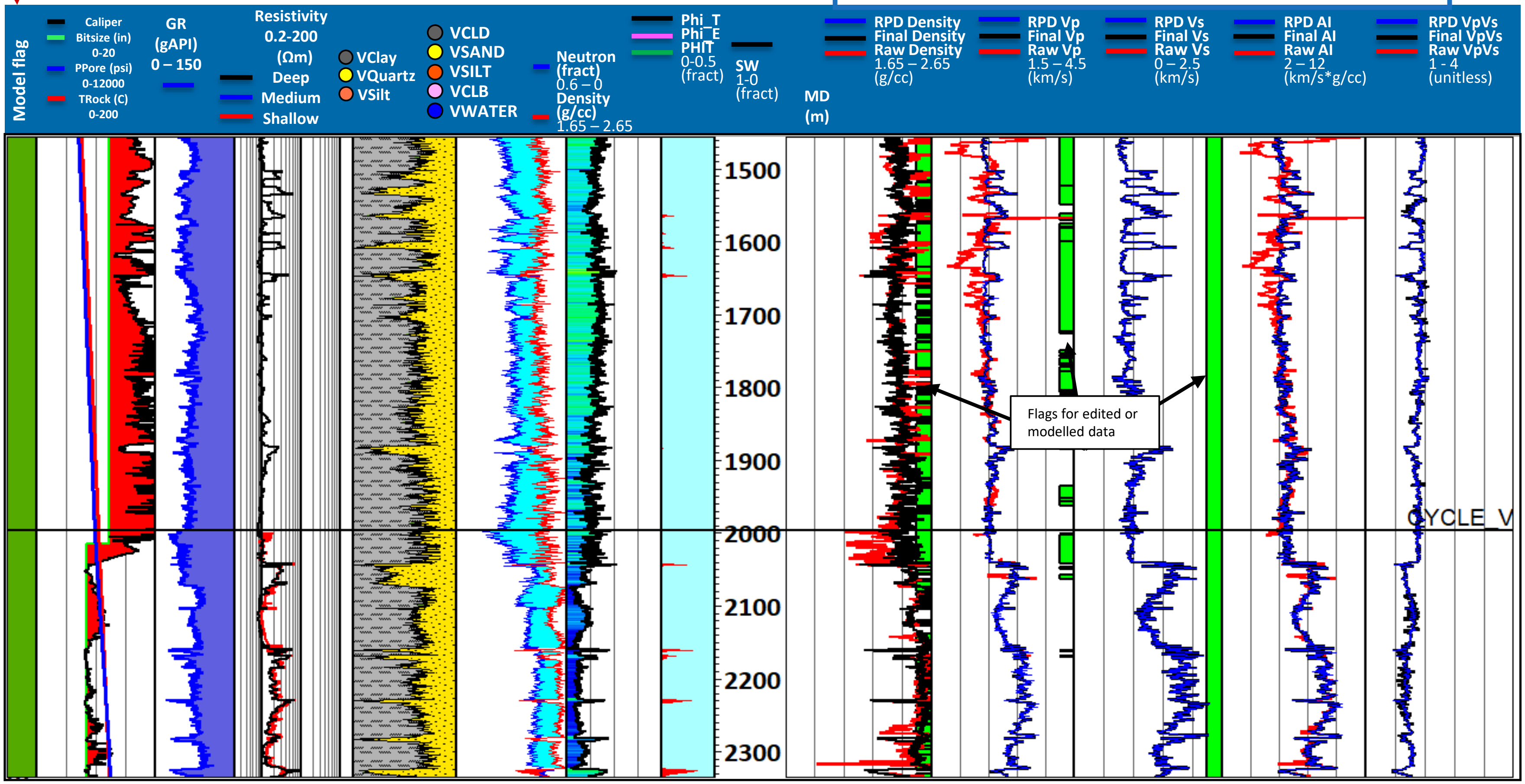
Mawar-1R1S1 Geophysical Well Log Analysis (GWLA) – All Well Interval

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

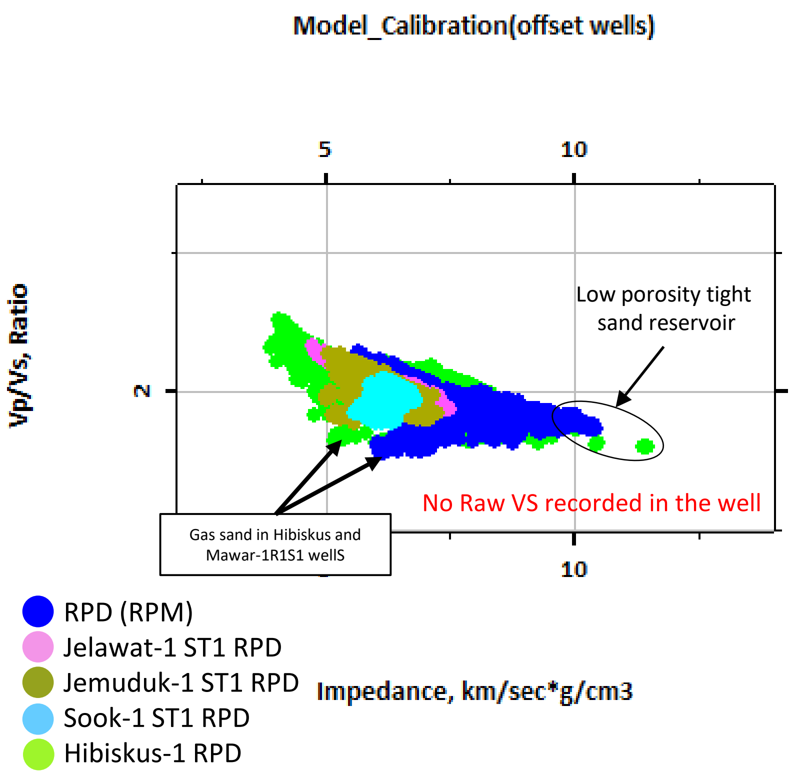
- Soft rock model
- Stiff rock model



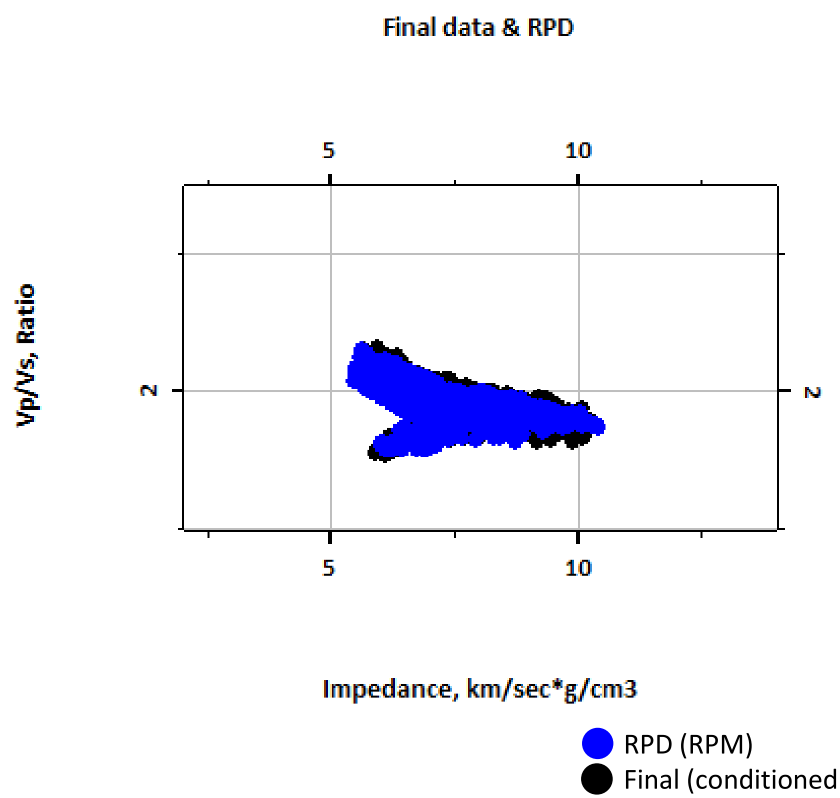
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Mawar-1R1S1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the Mawar-1R1S1 well RPD with the nearby wells Hibiskus-1, Jemuduk-1 ST1, Jelawat-1 ST1 and Sook-1 ST1.



P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

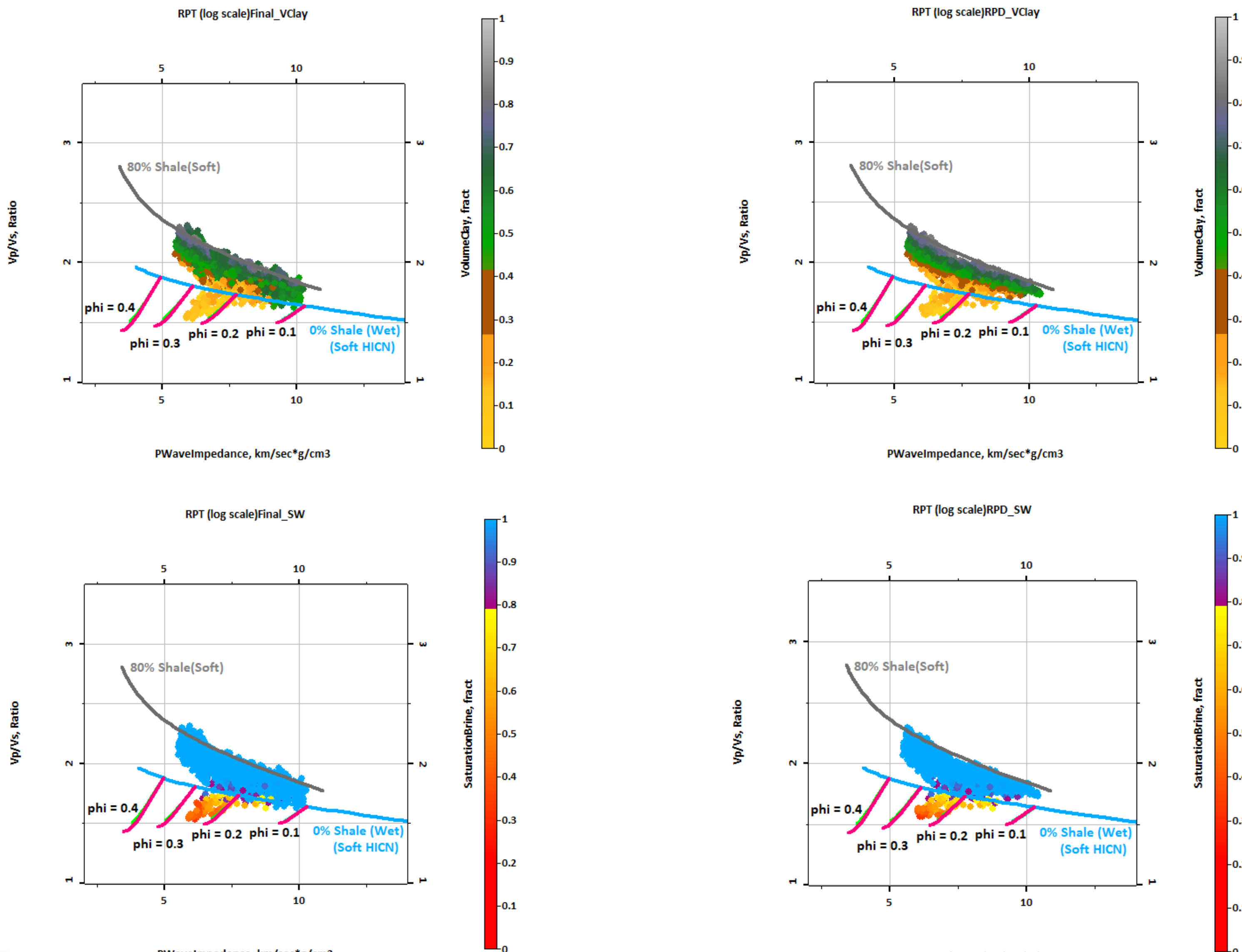


Mawar-1R1S1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data

RPD(Modelled)data



Mayong-1

Mayong-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Petrophysical interpretation is provided by Petronas. The final RSI curves are from the following provided curves (RSI curves in bold): VClay = VCLD_QI; SW = SWT_QI; DTC_ORG = DTCOMP; DTS_ORG = DTSH; RHOB_ORG = DENB. In general, data quality appears strong. Density, compressional and shear velocities are available from 572m-2886m. Additionally the Petronas QI Rock Physics Model curves are also provided, though RSI performed individual model calibration and curve generation for rockAVO purposes.

Clay volume (VClay):

- VCLD_QI is provided by Petronas, though RSI models require VClay as a fraction of the rock matrix rather than the bulk rock therefore final VClay = VCLD_QI/(1-PHIT_QI).

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Cycle I, III, IV, V and VI sandstones interbedded with claystones and a Cycle IV carbonate.

Volume of hydrocarbons:

- Gas is present in Cycle I, III, V, and VI sandstones with saturations up to 75% gas.

Water saturation (Sw):

- SWT_QI has been provided by Petronas and final RSI Sw is equal to SWT_QI.

Mayong-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both sand rich and clay rich intervals when compared to the measured data and also when compared to good measured data in the nearby reference wells. The Petronas QI group RPM curves have been provided as well in order to help guide calibration. There is a distinct shift in the rock response at the Cycle IV carbonate and below which translates to the elastic domain. This deeper domain uses a higher coordination number in the reservoir rocks and represents the intermediate stiff sediment model (ISS).

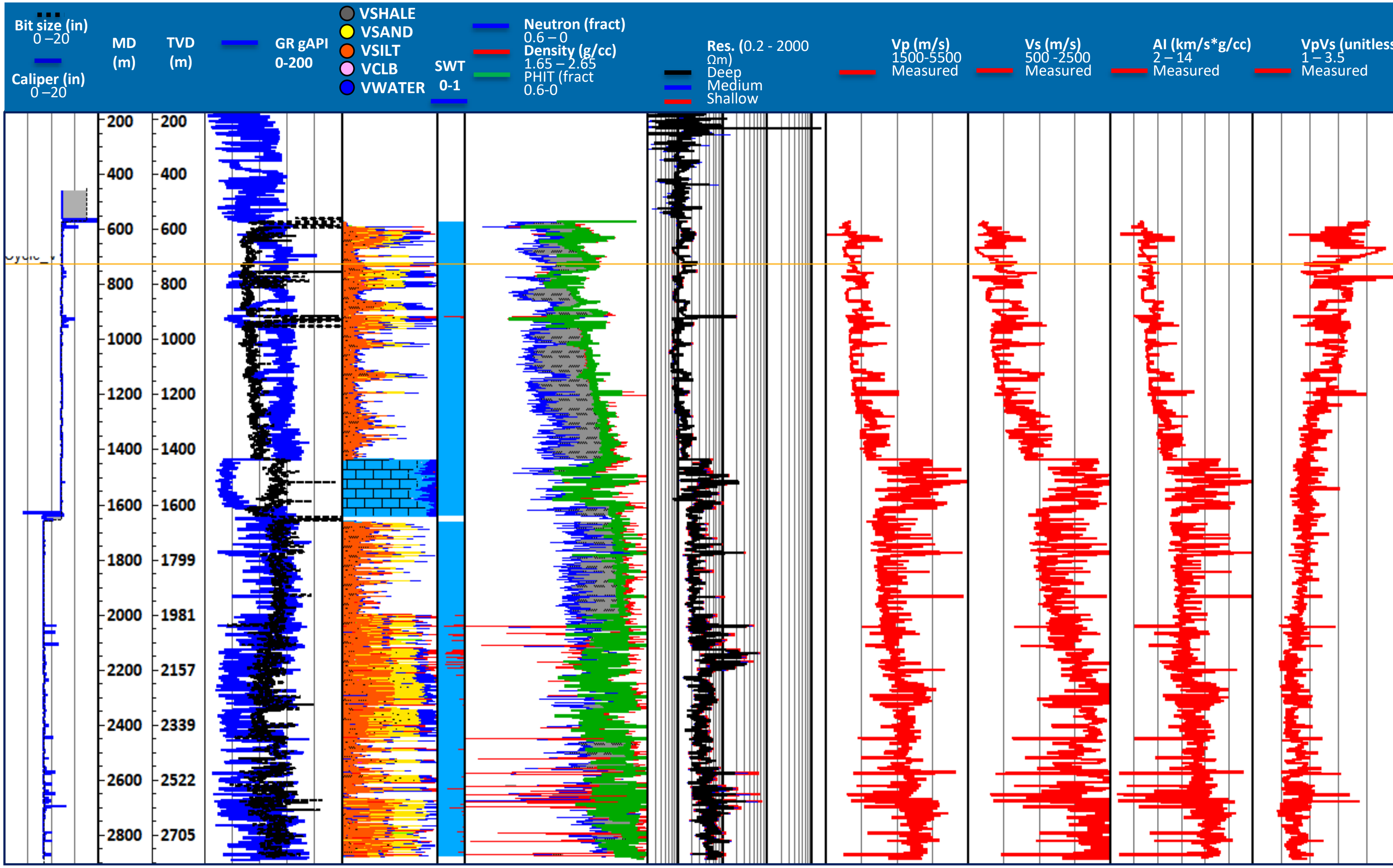
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 19000 ppm [Reporting]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Cycle I, III, IV, and V sandstones and Cycle IV carbonate using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination with the brine sands.
- At in situ conditions the Cycle V sandstones show a strong Class I response with good fluid discrimination, decreasing porosity decreases the amplitude and fluid discrimination. The Cycle IV carbonate shows a Class I response with poor fluid discrimination, when increasing porosity the response becomes a weak Class III with good fluid discrimination. The Cycle III gas sands show no AVO anomaly at in situ conditions – with increasing porosity the response becomes a Class III with some fluid discrimination. The coals in Cycles II and I complicate the AVO response.

Mayong-1 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

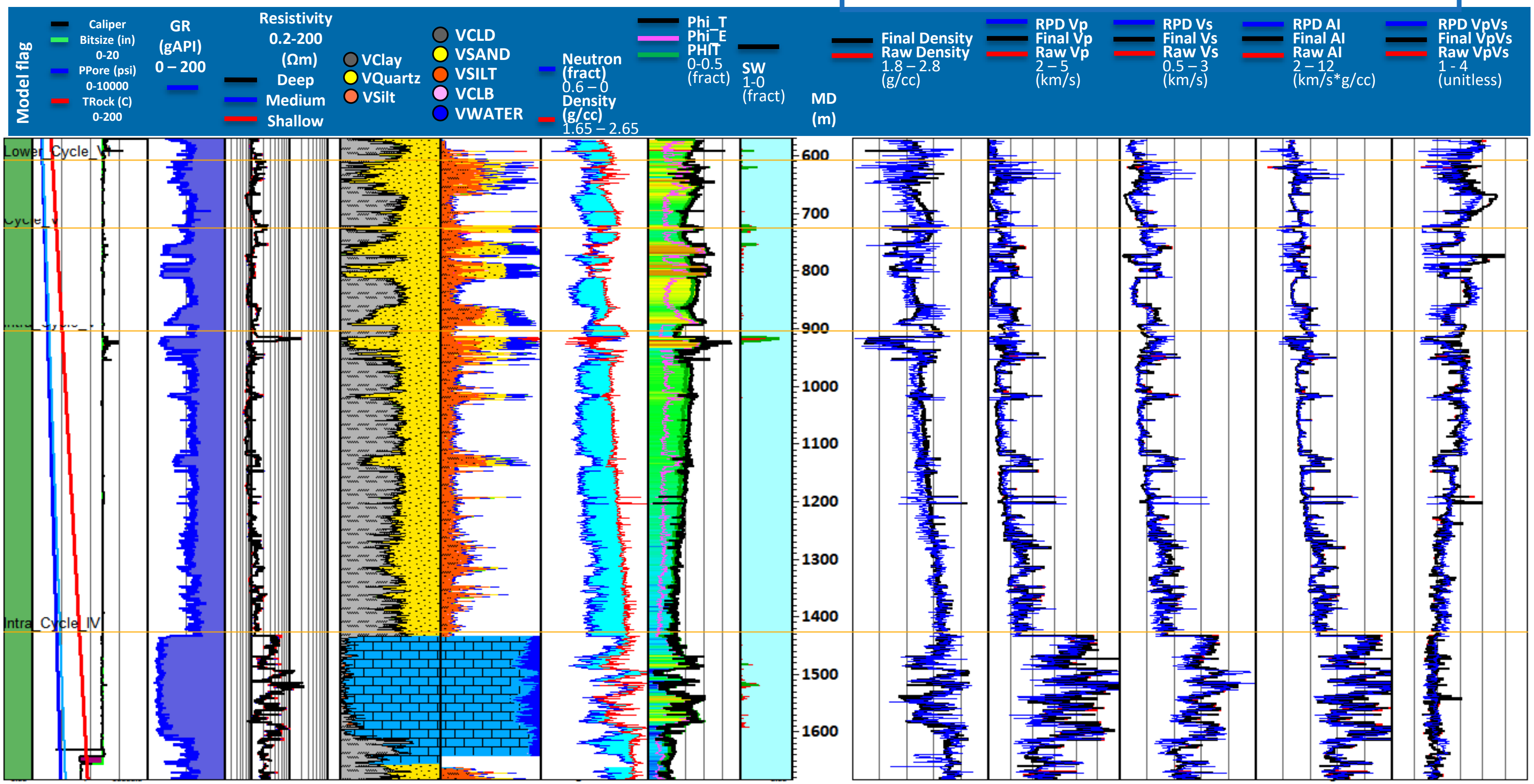
Mayong-1 Geophysical Well Log Analysis (GWLA) – Top to 1700m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



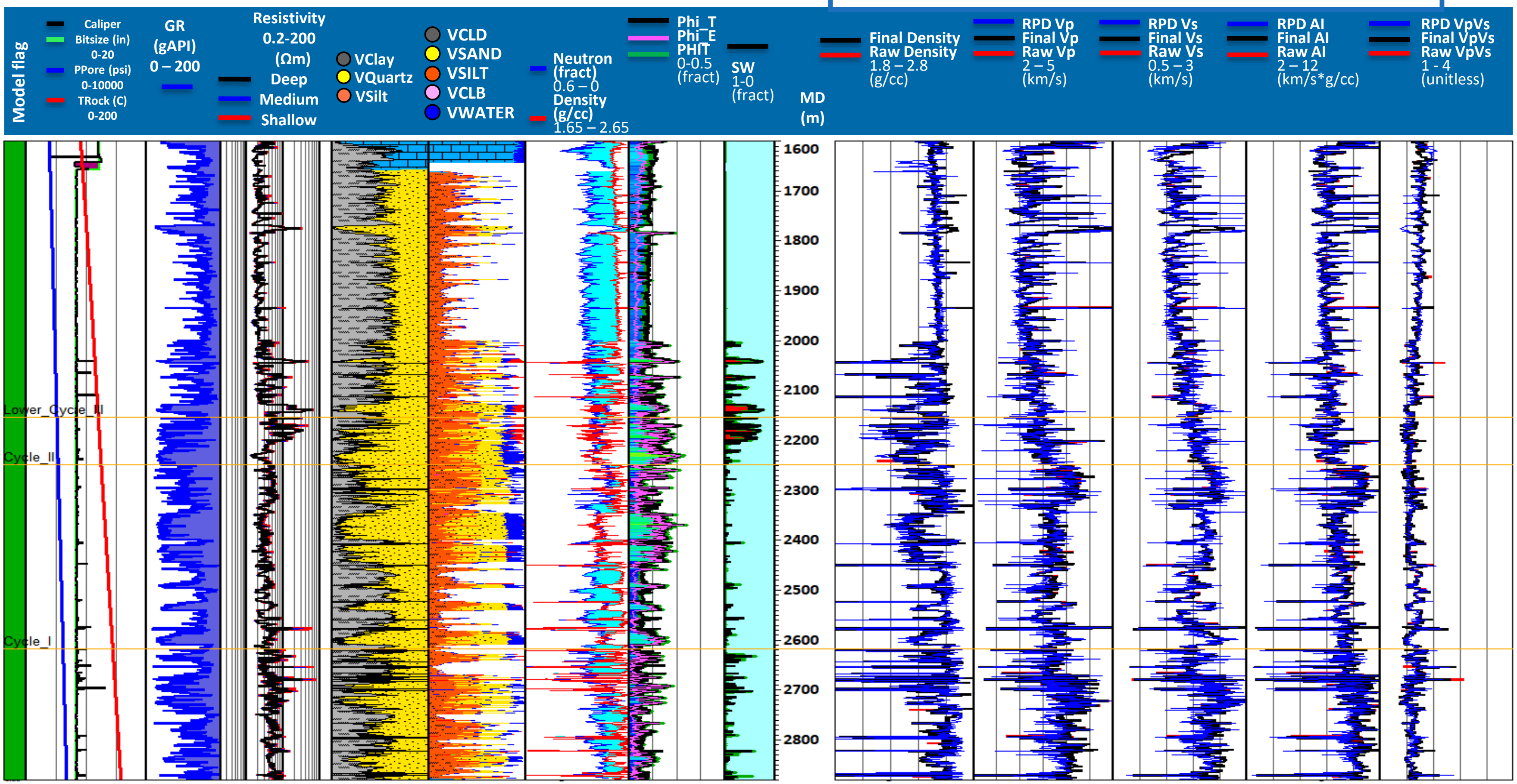
Mayong-1 Geophysical Well Log Analysis (GWLA) – 1600m to TD

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

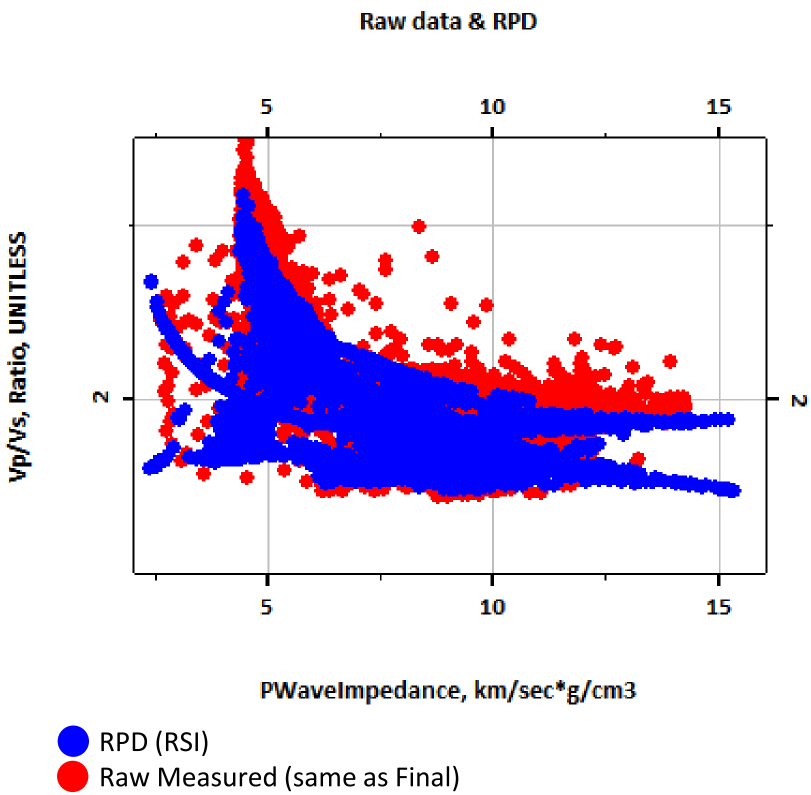
- Unconsolidated rock model
- Stiff rock model

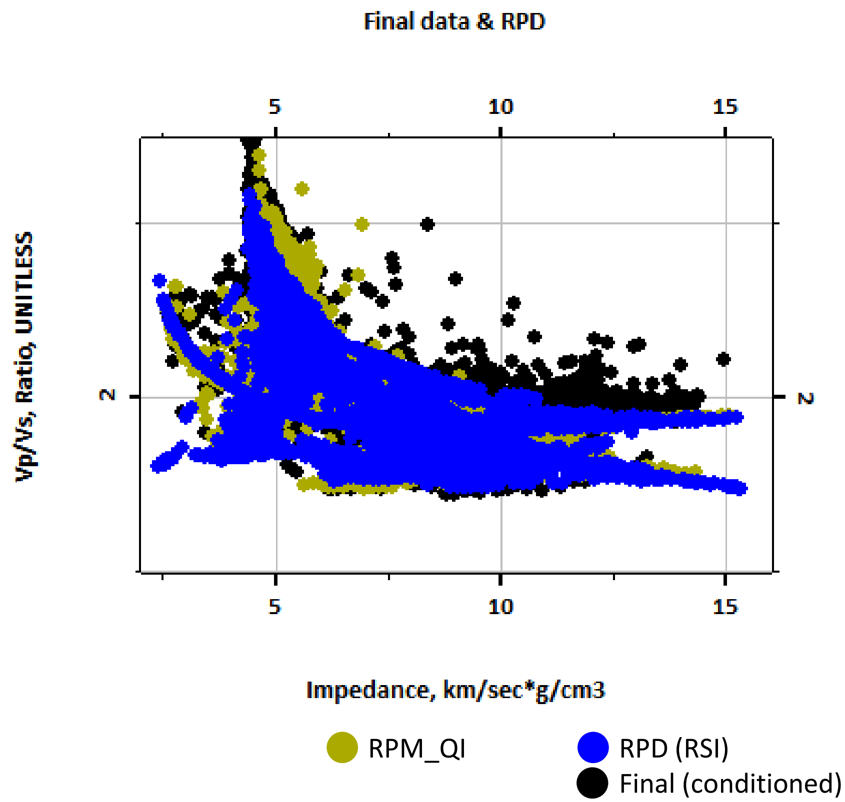


Mayong-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the "measured" data (same as final data – could have edits).

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

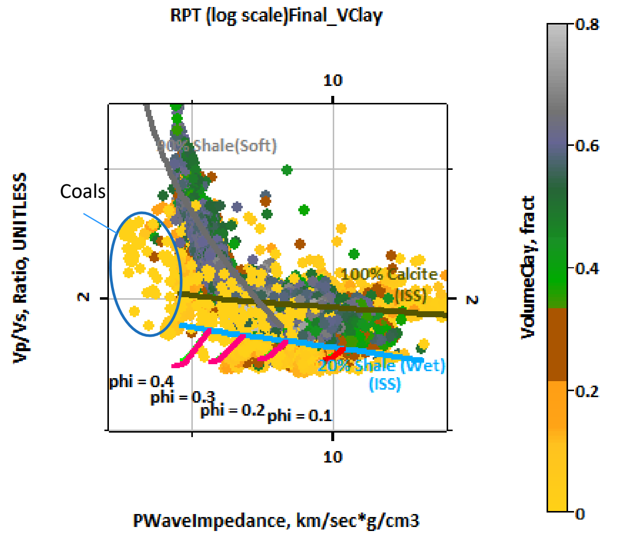


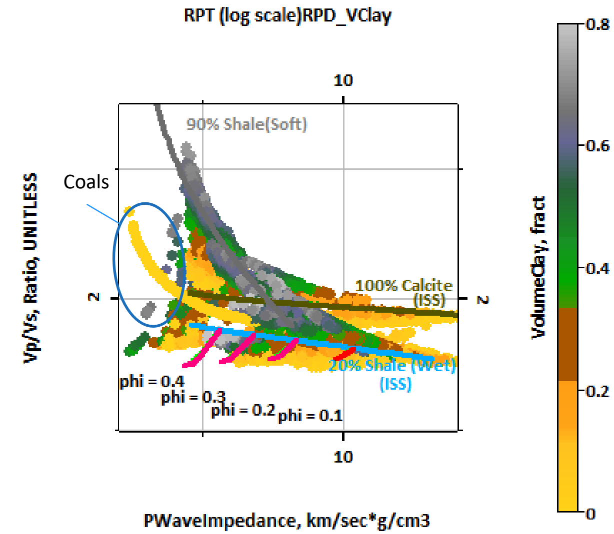


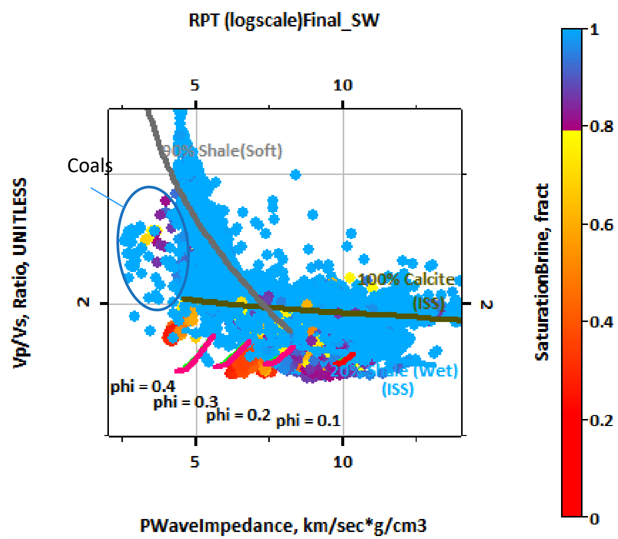
Mayong-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

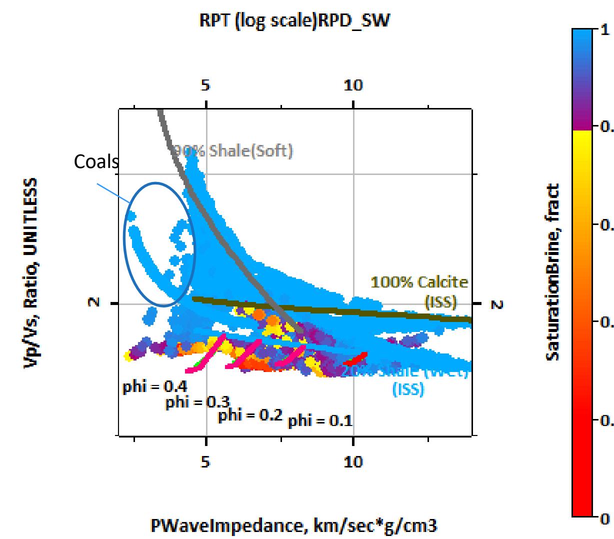
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Midin-1

Midin-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is fair. Vp and density logs are of good quality, but the shear wave data appears to be highly unreliable. Most of the well log suite runs in the 1150-2495 m interval.
- Density measurements are of very good quality. Above 1200 m, the density was edited due to the effects of the presence of a casing shoe.
- Vp has been edited in certain intervals, but no major correction was needed. Vp exhibits a consistent trend with depth. At some sections (e.g. 1850-913 m), a possible remnant depth shift might exist between the density and the Vp logs, and therefore the latter has been edited to tackle this issue.
- Raw Vs log seems to be low quality. It shows a highly anomalous trend with depth: the log displays faster velocities in the shallow section and slower velocities towards the bottom of the well. This anomalous trend is not consistent with the Vp trend encountered in this well, and with the Vs and Vp/Vs trends observed in different wells in the area. Based on the raw Vp/Vs, some claystones exhibit values of 1.1 which is very low in these type of facies and based on the experience in the area. Above 1800 m, the Vs data is rugged and noisy, and measurement gaps are present rather often. Vs has been estimated using Granular Media models and trends from nearby wells and the raw data has been edited accordingly.
- Other logs include, Neutron, Caliper, Deep and Medium resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach.

Reservoir characteristics:

- The primary objective of the well is to test the hydrocarbon potential of the TB3.6 and TB3.7 Pliocene sandstones (Upper Cycle VI – Lower Cycle VII) which are mainly in a shallow marine/deltaic environment. Particularly the TB3.7 exhibits thicker sands with high porosities, whereas the TB3.6 sands are less developed, but still with high porosities. Below 1750 m, the occurrence of sand bodies diminish slightly and when present, their reservoir quality seems to decrease.

Volume of hydrocarbons:

- No prospective reservoirs and no indications of hydrocarbon were encountered in the well.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were taken from a Pickett Plot (1900-1950 m): Rw=0.1 Ohmm @ 181 F (26,000 ppm), with a=1, m=2, and n=2.

** Depths referred in this report are MD.

Midin-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor, with a Cn=15 for clay-rich facies and Cn=18 in average for sands. These models have been used to edit the Vp and Rhob data where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock physics modelling (RPM) stage of the project. Vs data was modelled using Granular Media and efforts were directed to produce a better correlation with the raw Vs log in the 2275-TD section where the original Vs log appeared to be of better quality and more engaged with the facies interpreted. The trends in the AI-Vp/Vs space of nearby wells with raw Vs data (Talang-1 and Sikau North-1) assisted in the Vs modelling parameterization of this well.

Fluid properties:

Hydrocarbon properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modelling are:

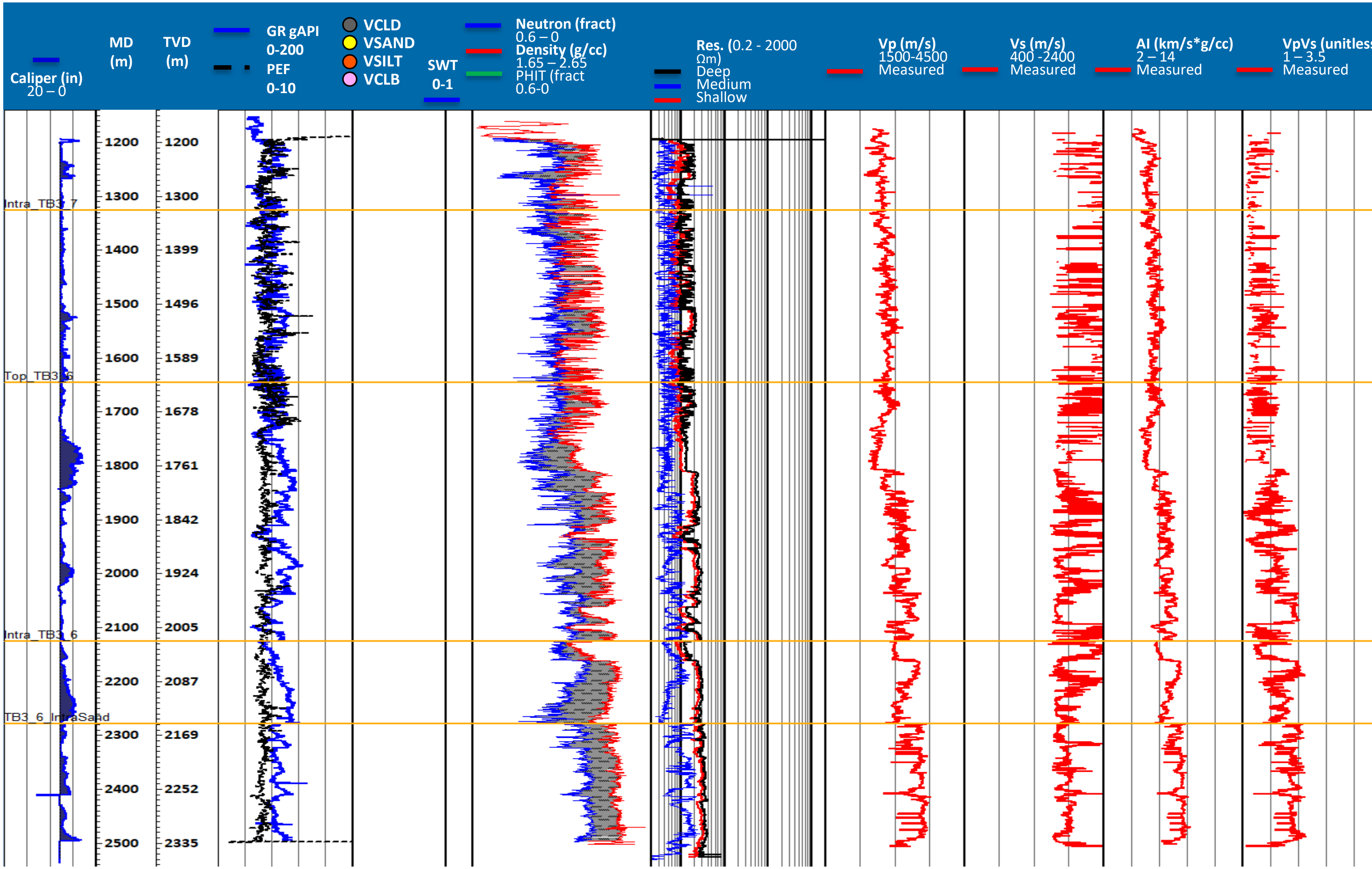
- Brine salinity: 26,000 ppm
- Gas gravity: 0.82
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Pliocene sandstones of the Upper Cycle VI – Lower Cycle VII interval.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Midin-1



Additional data includes mud weight data, pressure data, and well reports. There was no curves of previous petrophysical interpretation performed by the client in this well.

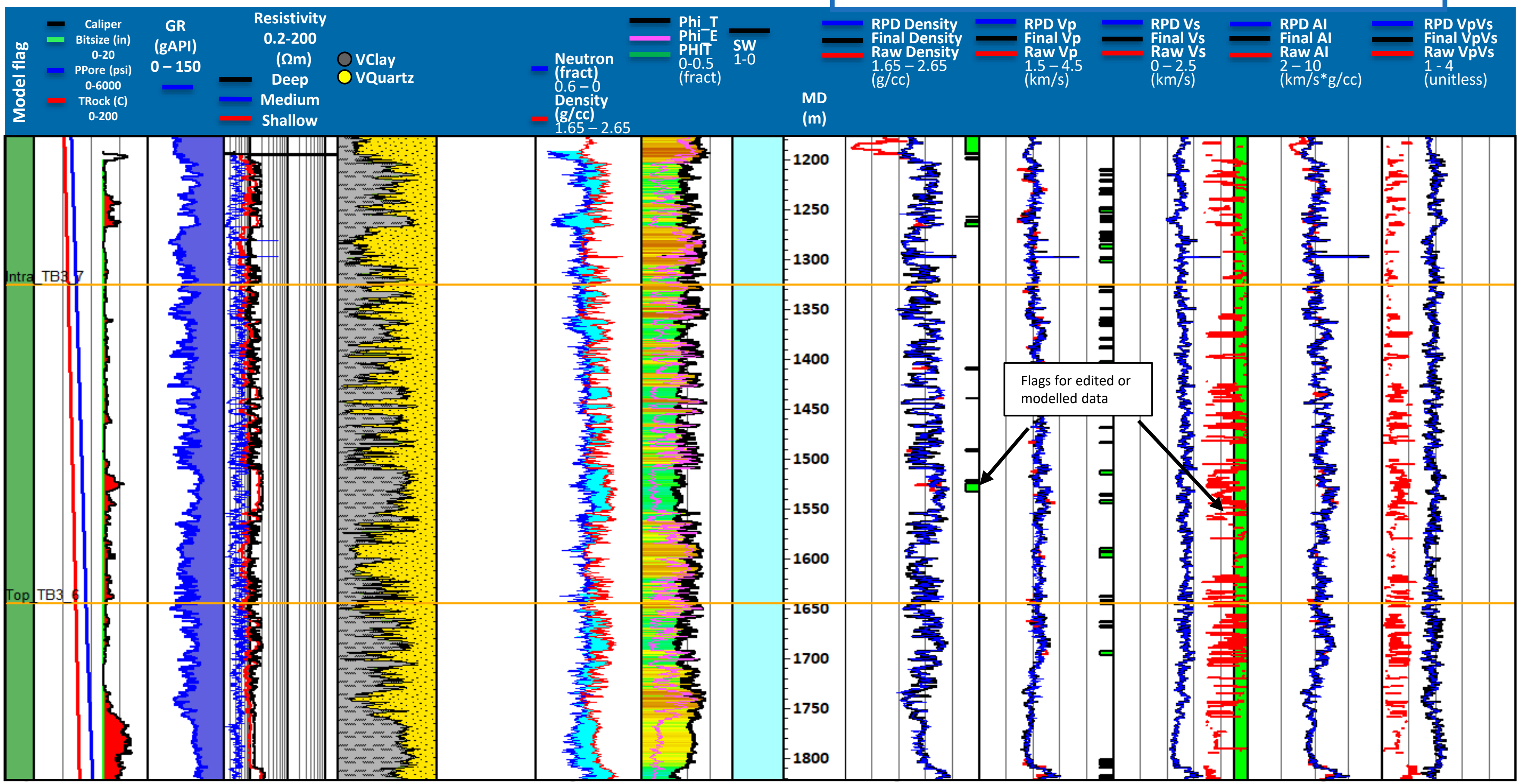
Midin-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to 1800 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Density and Vp logs exhibit good quality in this section and very minor editing were needed. On the other hand, raw Vs looks noisy and plenty of measurement gaps. Vs trend looks off with depth: faster velocities in the shallow section and lower velocities deeper in the column. Granular Media was used to estimate a Vs curve that would exhibit a consistent trend with other wells in the area. Important to note the low raw Vp/Vs observed in this section, even in facies characterised by high Vp/Vs (e.g. porous claystones)

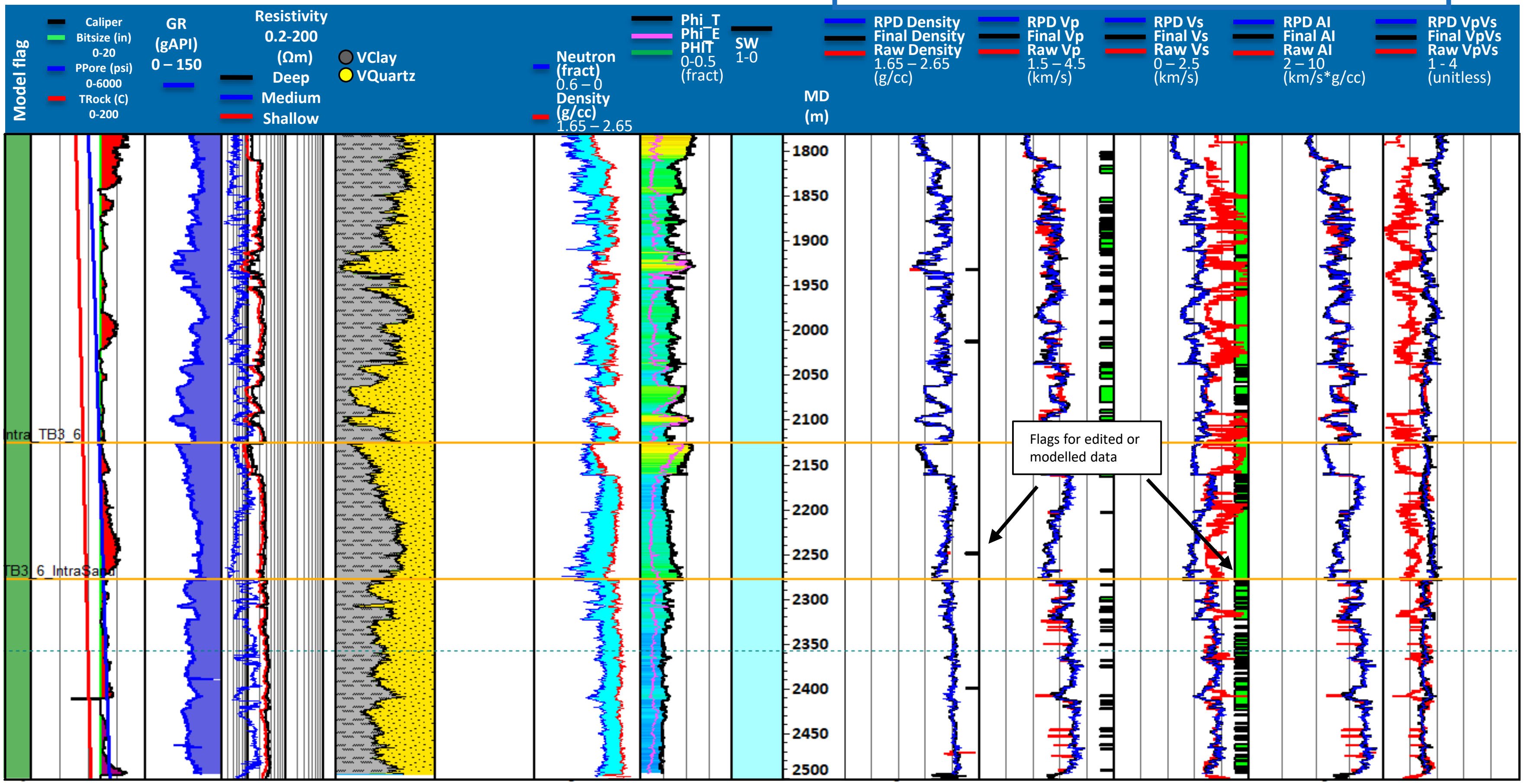
Midin-1 Geophysical Well Log Analysis (GWLA) – Interval from 1800 m to Bottom

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

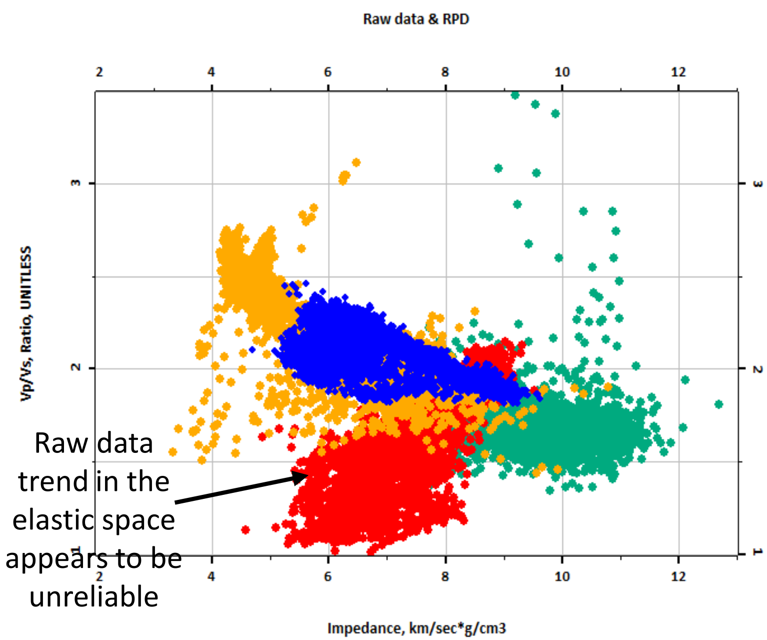


Vs is still showing off trend values in this section. Vs modelling parameterization was focused on the 2275-TD interval where a general, background trend of the raw Vs appeared to be more consistent with the facies interpreted. Borehole integrity looks compromised in some claystone sections but this seems not to be an effect of overpressure, but to the presence of a softer, less competent rock. No overpressure were reported.

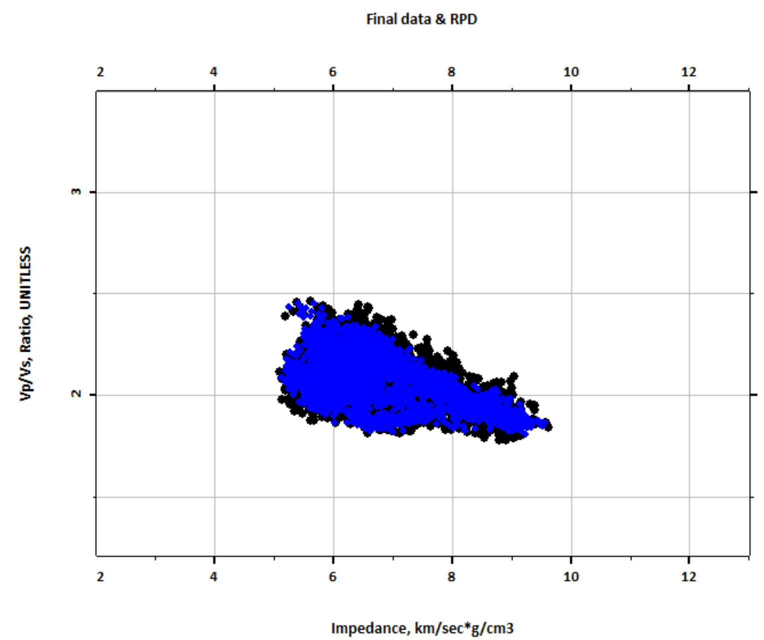
Midin-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data, along with elastic data from analog wells with similar trends in the elastic space.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)
Sikau North-1 (Raw)
Talang-1 (Raw)

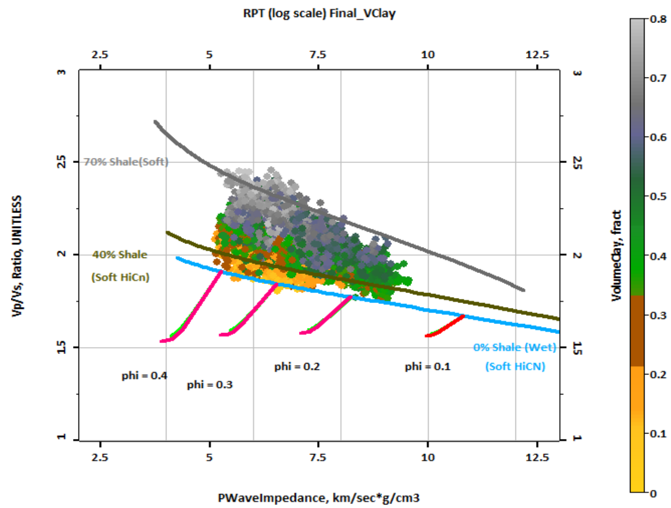


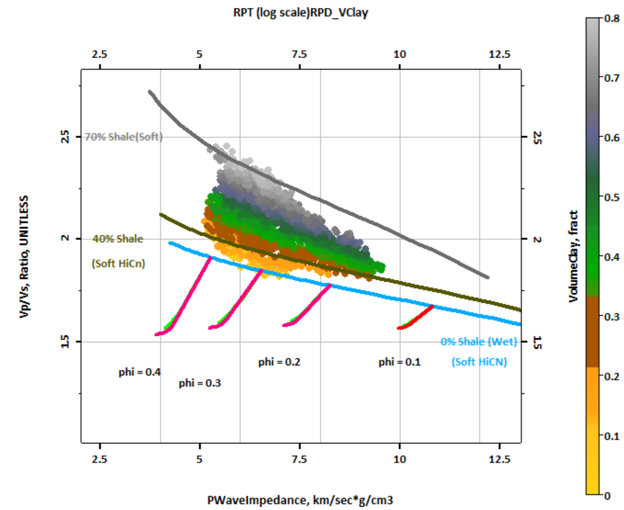
RPD (RPM)
Final (conditioned)

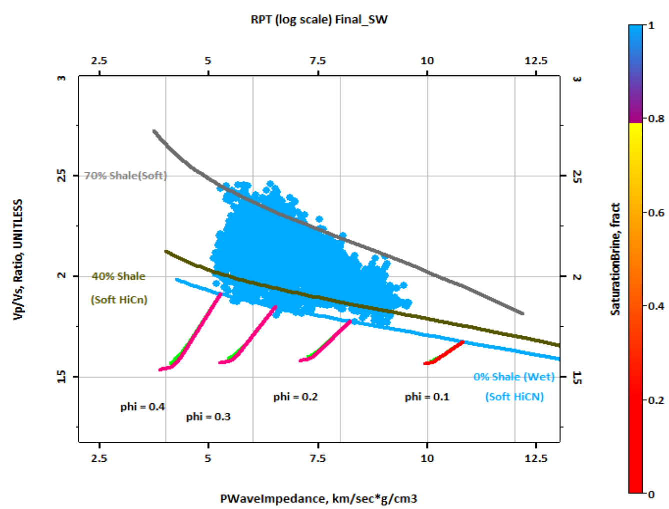
Midin-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

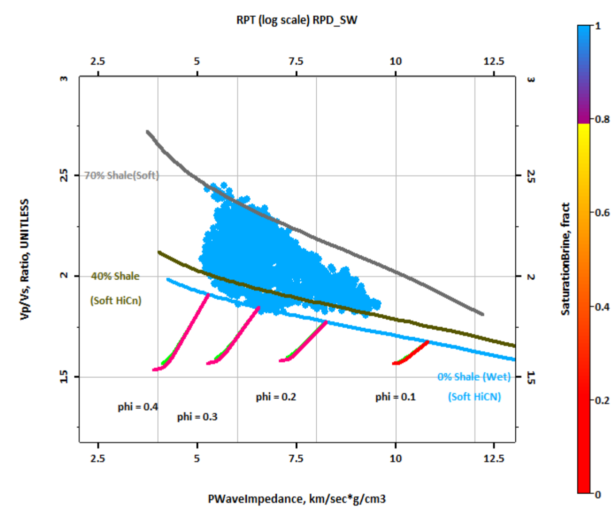
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Mulu-1

Mulu-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Density and compressional velocity is available from 1922m – 5060m, no shear is available.
- Edits to Vp are minor and are primarily done to provide better consistency with modelled shear.
- The major edit to density occurs in the overburden from data top to the base of the 17.5” section at 3100m where caliper shows substanstial washout – all density in this zone is replaced by RPD. Other edits to density are also minor and are primarily made at casing zones and to provide better consistency between measured Vp and modelled shear.
- Other logs include Neutron, Gamma Ray, and Deep resistivity run over the same zone as Vp and density, 1922m-5060m.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method with Neutron/Density in places.

Reservoir characteristics:

- In terms of lithology the reservoir targets are in interval II and consist of sandstones interbedded with claystones.
- Porosities in the clean zones range up to 28% and down to 10%, with an average around 17%.

Volume of hydrocarbons:

- The well is interpreted as fully brine saturated.

Water saturation (Sw):

- Rw has been calculated from Pickett plot as 0.1 Ωm at the clean sand at 3240m, temperature is 209° F for a salinity of 23000ppm.

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the elastic logs started down to the T.D. the Soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both sand rich and clay rich zones. Primary analog well for calibrating models is the Talang-1.

Fluid properties:

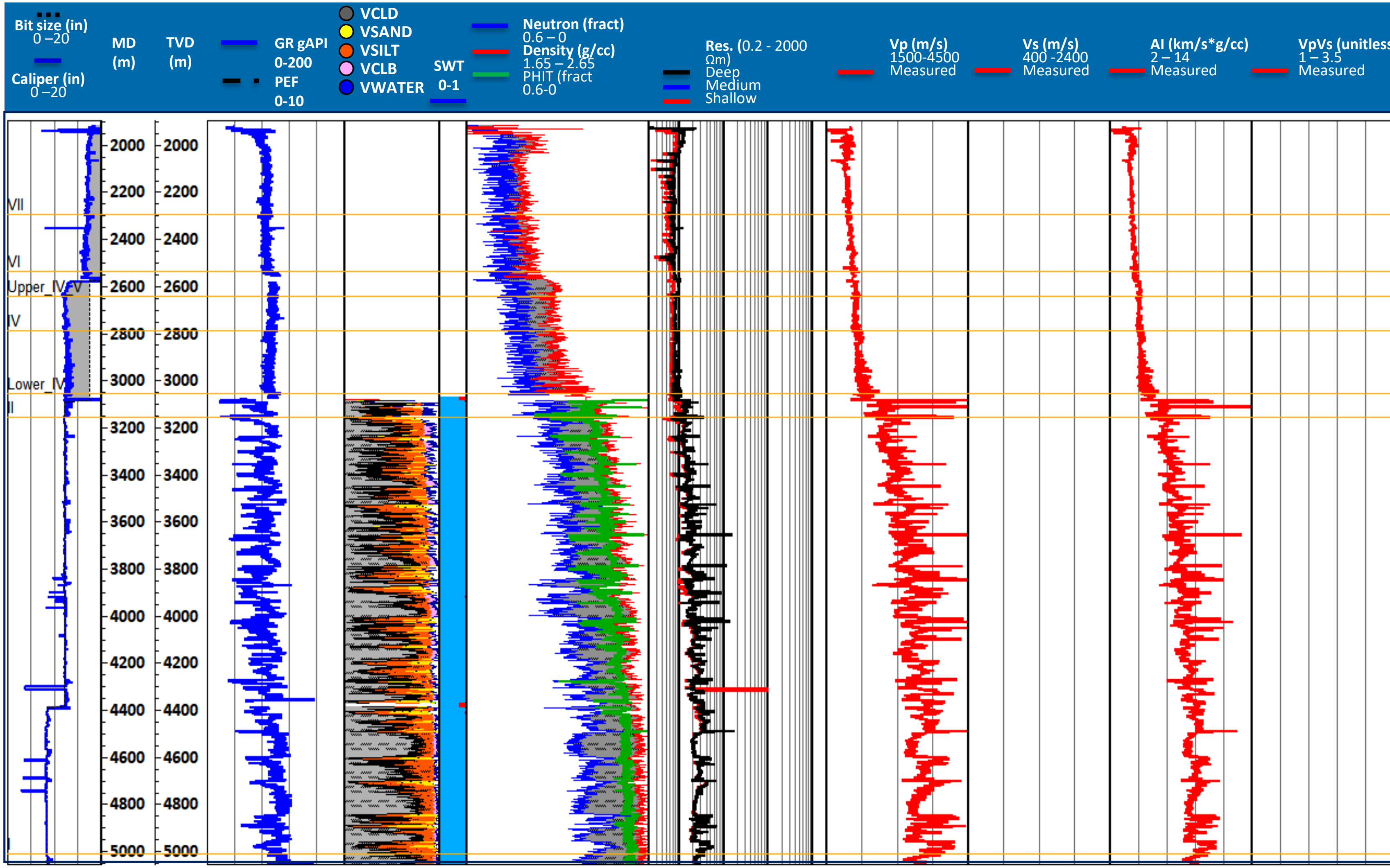
Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:

Brine salinity:	24000 ppm [Rw]
Gas gravity:	0.82
Oil Gravity:	38.9° API
Gas / Oil ratio:	500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Lower IV and II interval reservoirs using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with poor to fair discrimination with the brine sands.
- The uppermost reservoir of the Lower IV interval shows a class II AVA response with poor fluid discrimination that decreases to a Class III with good fluid discrimination when porosity is added.

Mulu-1 Input Logs



Additional data includes mud weight, temperature data, deviation survey, cuttings descriptions and final geological report.

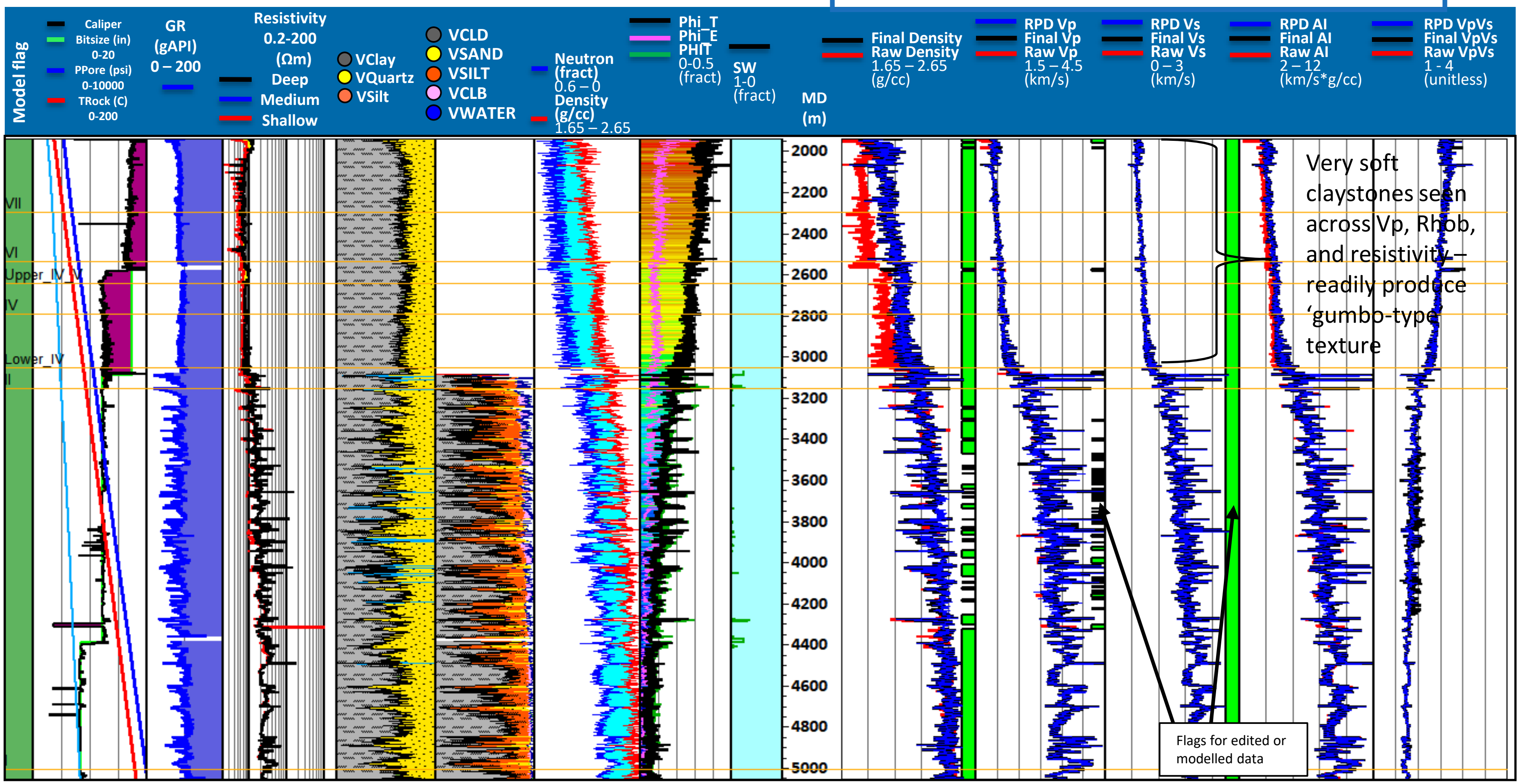
Mulu-1 Geophysical Well Log Analysis (GWLA) – Full Well

model type flag

- Unconsolidated rock model (green)
- Stiff rock model (yellow)

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve (blue)
- Final edited (Conditioned) curve (black)
- Original Raw (Raw) curve (red)

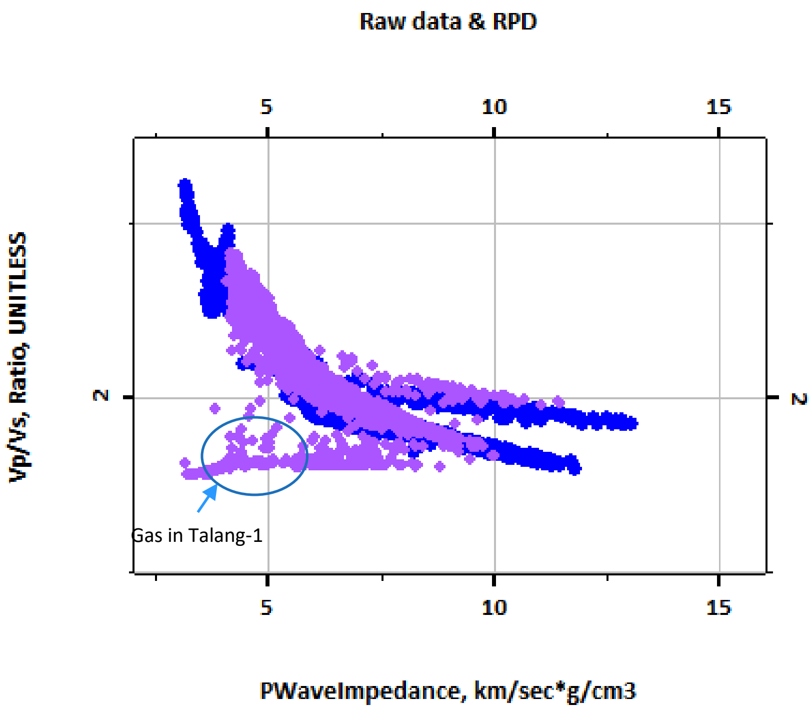


All of the shear data is predicted. Outside the overburden where density has been fully replaced density and Vp are edited for minor errors, typically around casing and to improve consistency with modelled shear. Granular media model (soft sand with variable Coordination Number) was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data and to measured shear in Talang-1.

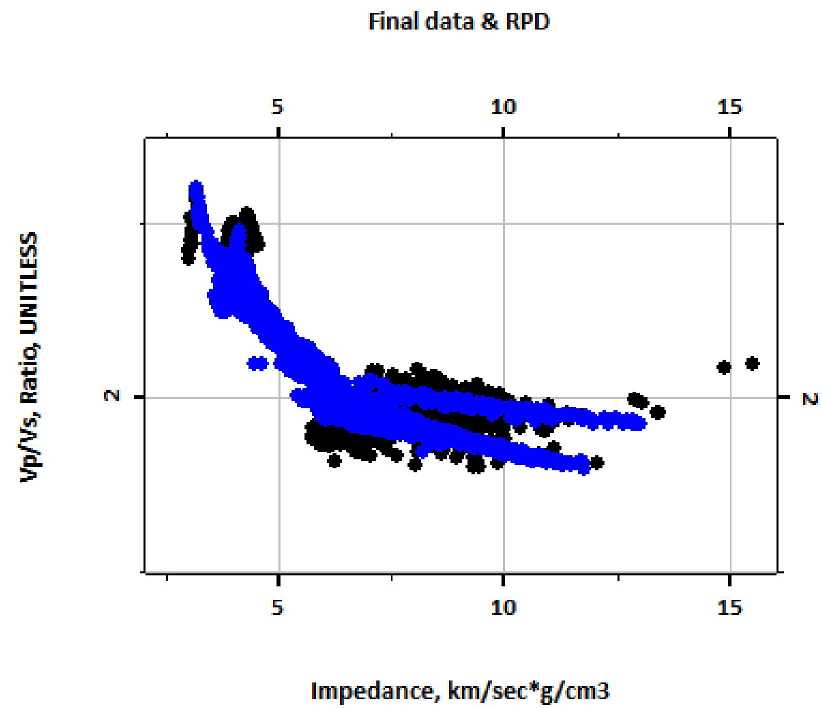
Mulu-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the analog well Talang-1 with similar trends in the elastic data, given measured shear in Mulu-1 is present.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)
Talang-1 RPD

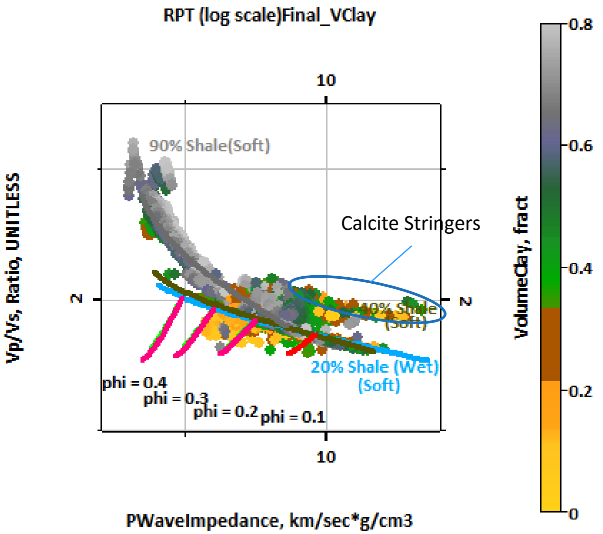


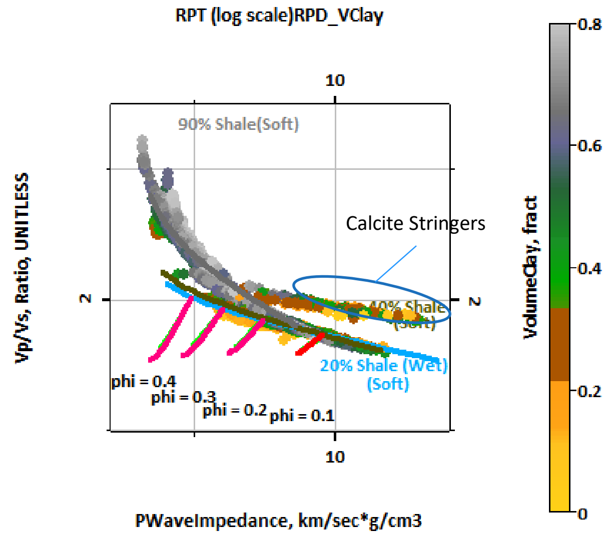
RPD (RPM)
Final (conditioned)

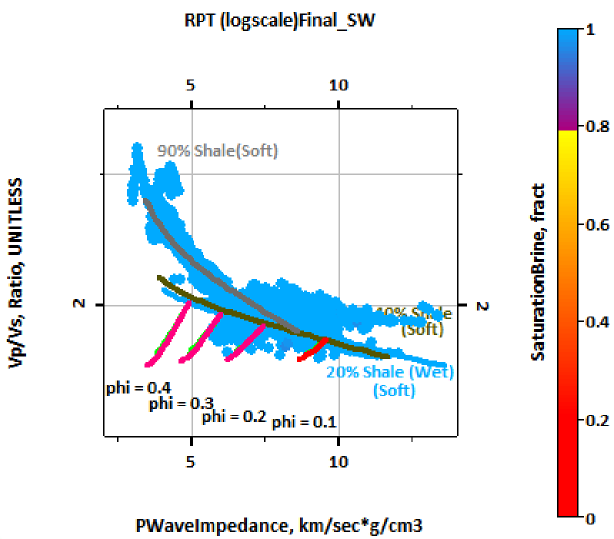
Mulu-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

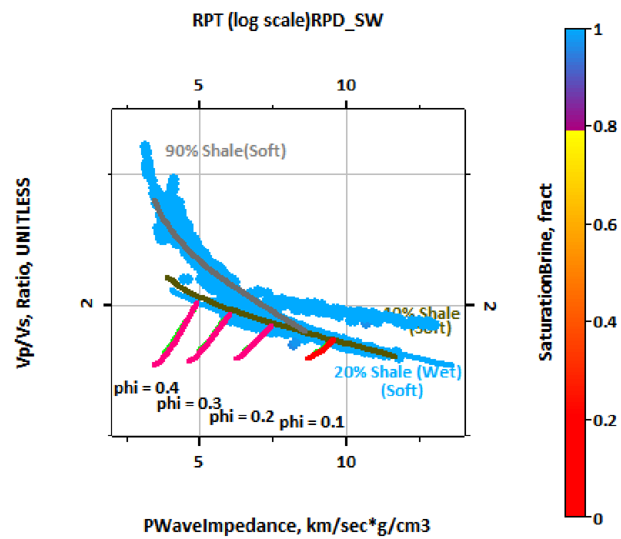
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

North Acis-1

North Acis-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair to good and it has lower frequency content in compressional and shear velocities than those present in the density log. Data is available from around 700m to 2000 m **.
- Density measurements are of good quality in general and was edited where it was determined it is affected by borehole conditions.
- Vp log quality is considered good, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies.
- Vs was not measured in this well and it was completely estimated using rock physics model.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The primary objective of North Acis-1 well was to target reservoir sands of cycle I and II. In general the sands present low thicknesses with the exception of the sand body located at 2100 m. Porosities overall are higher above cycle I ranging from 15% to more than 25%. Sand present in cycle I show porosities with values around 15% and higher.

Volume of hydrocarbons:

- Several sands in the well has been interpreted as oil and hydrocarbon bearing at 670 m and in the deep section of the well, in cycle I at 2150 m and 2240 m. However realtively low hydrocarbon saturation values were calculated for all this intervals.
- Well North Acis-1 was plugged and abandoned as an oil and gas discovery..

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=2. Water resistivity used to interpret Sw: Rw=0.2 ohmm @ 213 F (10,000 ppm).

** Depths referred in this report are MD.

North Acis-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from reports. Main parameters used in this modelling are:

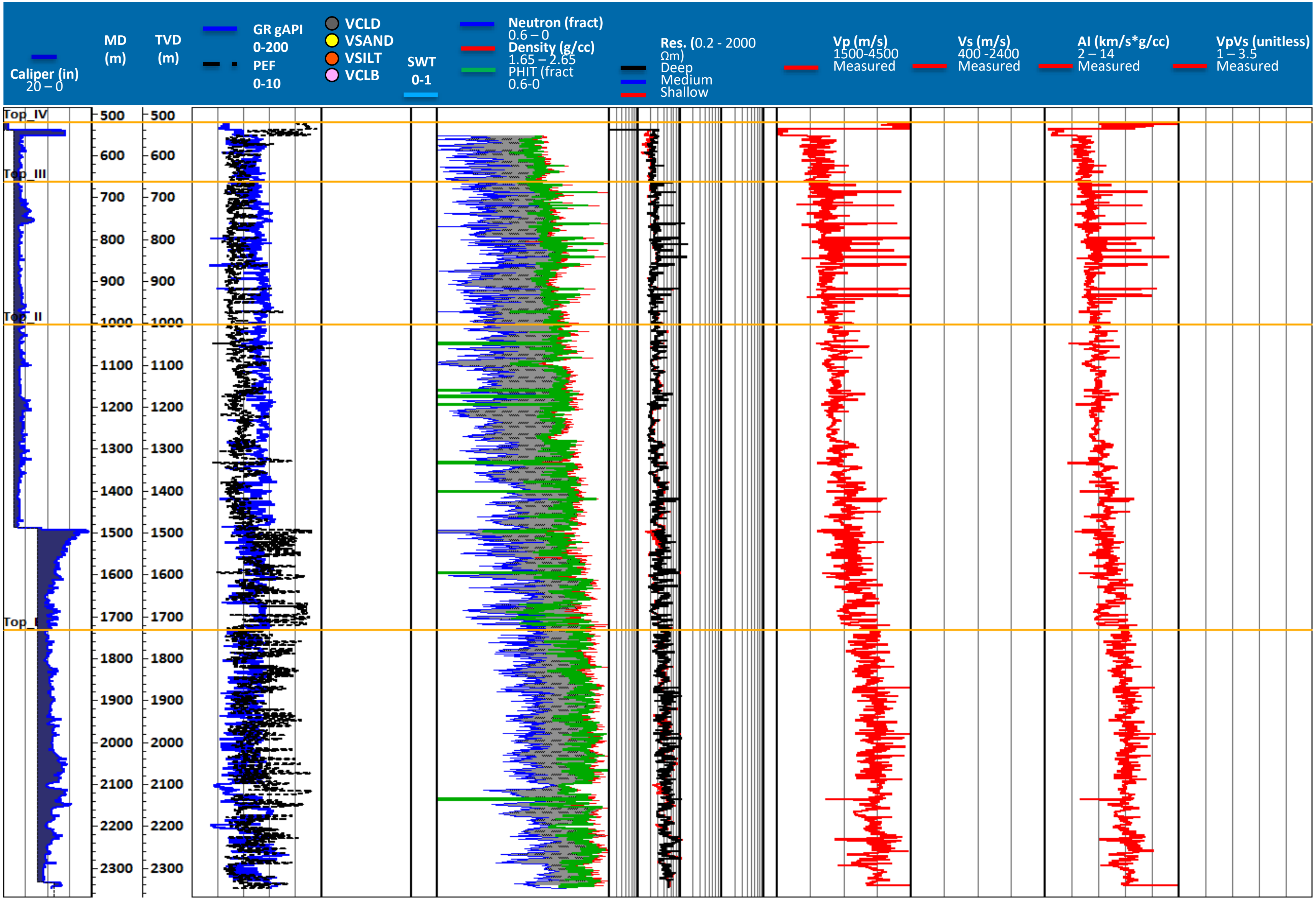
- Brine salinity: 10,000 ppm (Pickett Plot analysis)
- Gas gravity: 0.6 (North Acis-1 well report)
- Oil Gravity: 22.3 API (North Acis-1 well report)
- Gas / Oil ratio: 17.7 (L/L) (North Acis-1 well report)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in the well developed sand appearing in cycle I at 2110 m. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Gassmann and Brie models.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As in the selected example, the sand package at 2060m (Water bearing sand in Cycle I) was gas substituted allowing the Water saturation to be reduced to 20%. Porosity was preserved for this exercise. This exercise showed lower values for VpVs ratio and lower values for Acoustic Impedance compared to the wet case.

** Depths referred in this report are MD.

Input Logs – North Acis-1



Additional data includes mud weight data, pressure data, petrography and well reports.

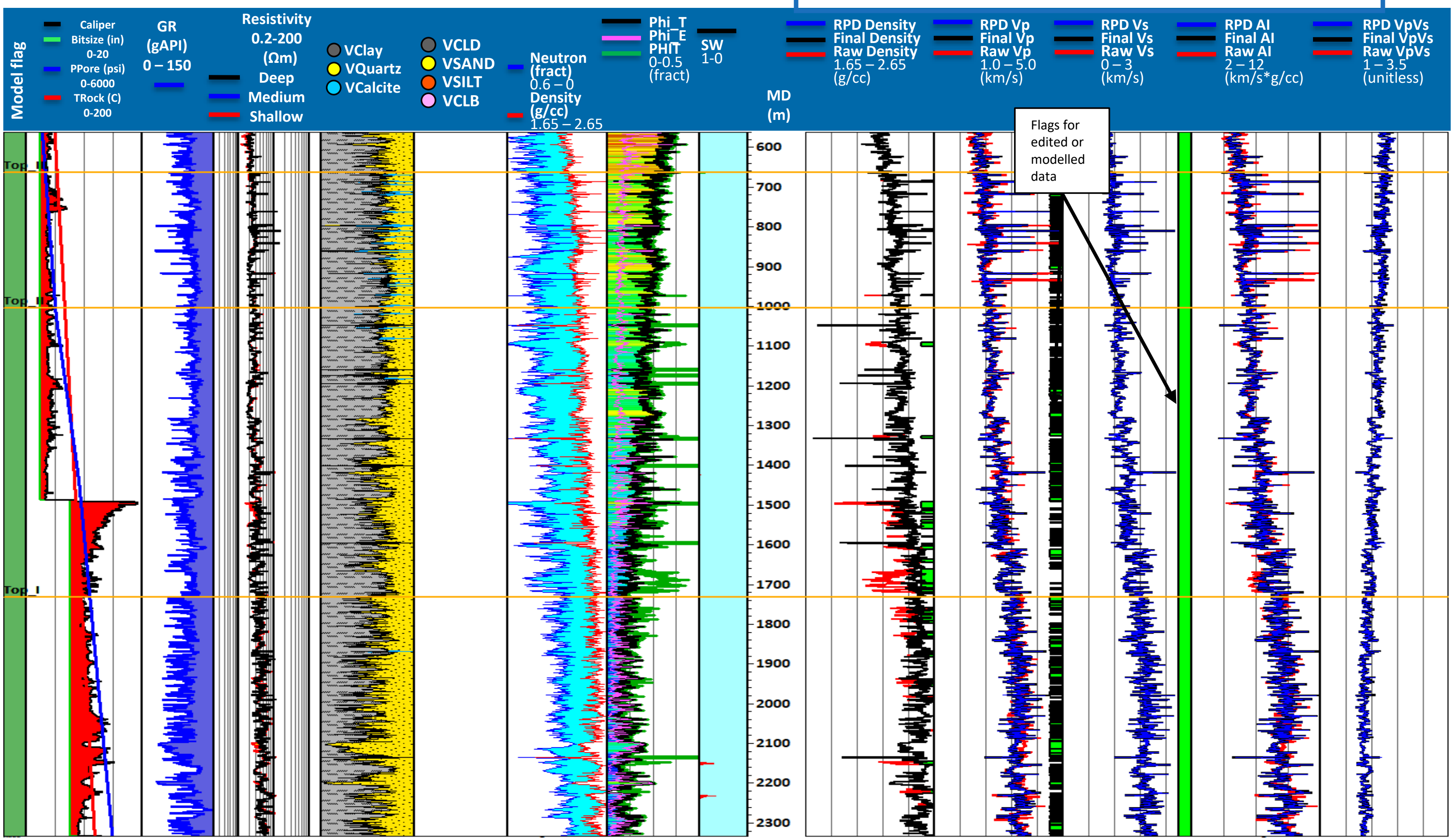
North Acis-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m

model type flag

- Unconsolidated rock model (green)
- Stiff rock model (orange)

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve (blue)
- Final edited (Conditioned) curve (black)
- Original Raw (Raw) curve (red)

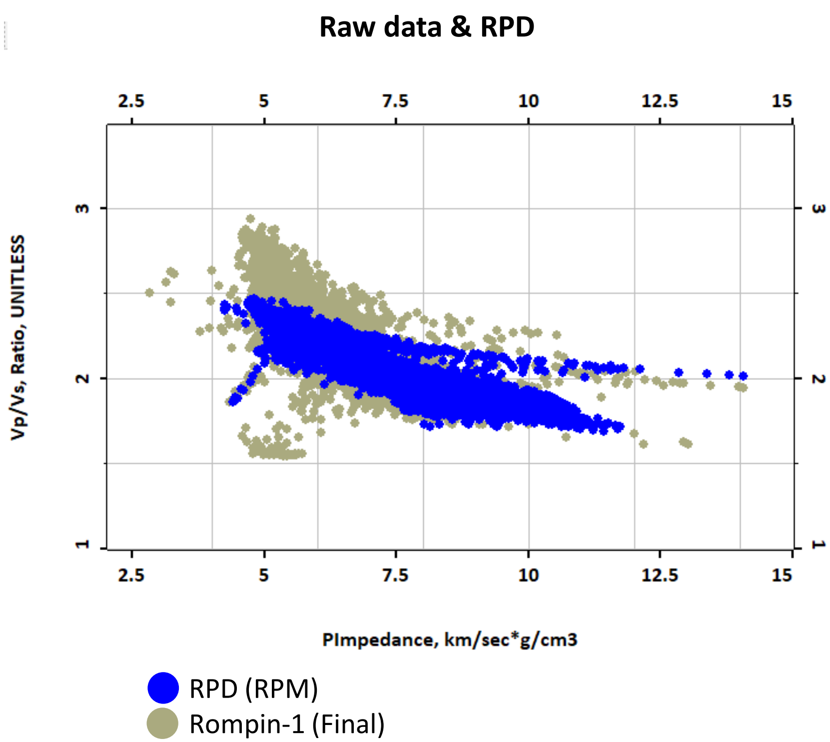


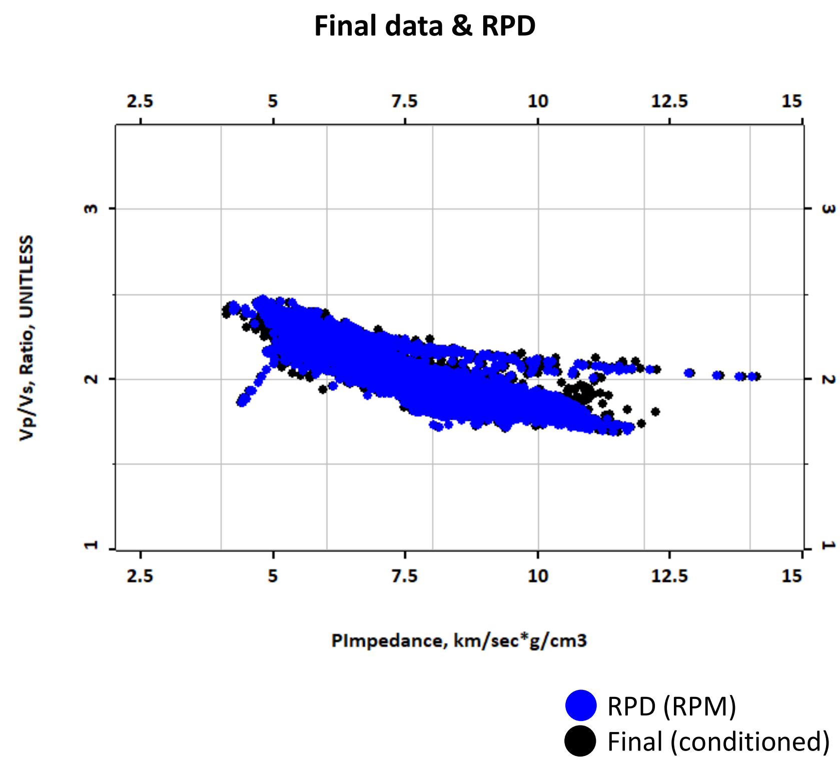
Density has been estimated in the vicinity of 1500 m and 1800 m, due to casing shoe locations. Vs has been entirely modelled in the well.

North Acis-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables elastic data from wells with reliable shear measured data, in this case well Rompin-1 Final edited data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



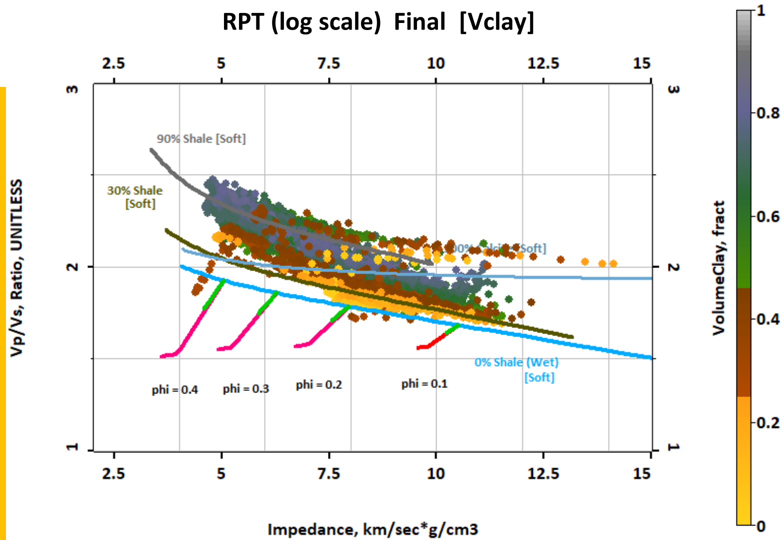


North Acis-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

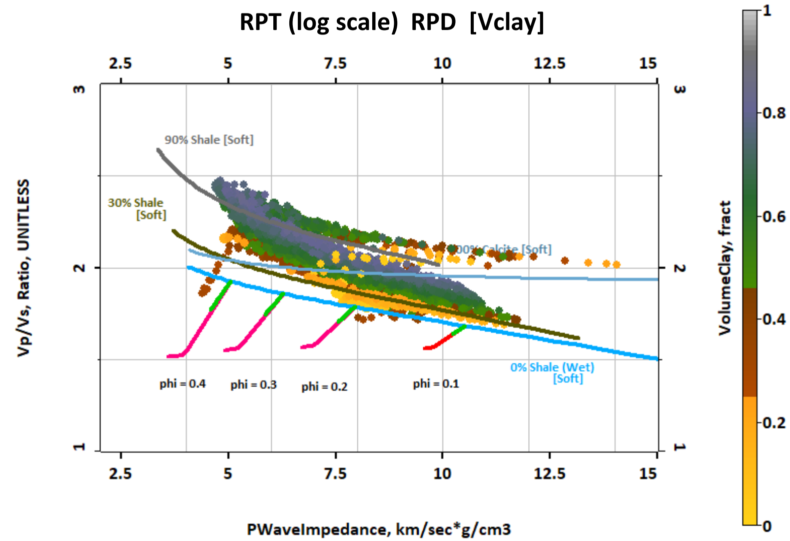
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data

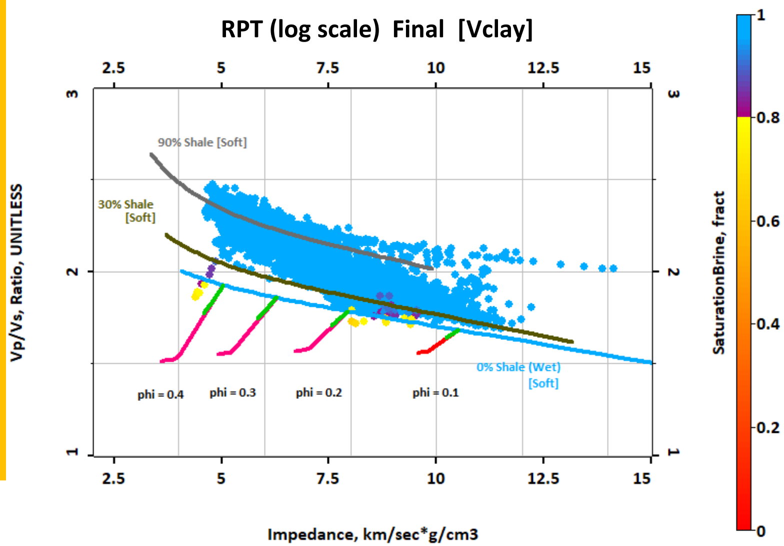
RPT (log scale) Final [Vclay]



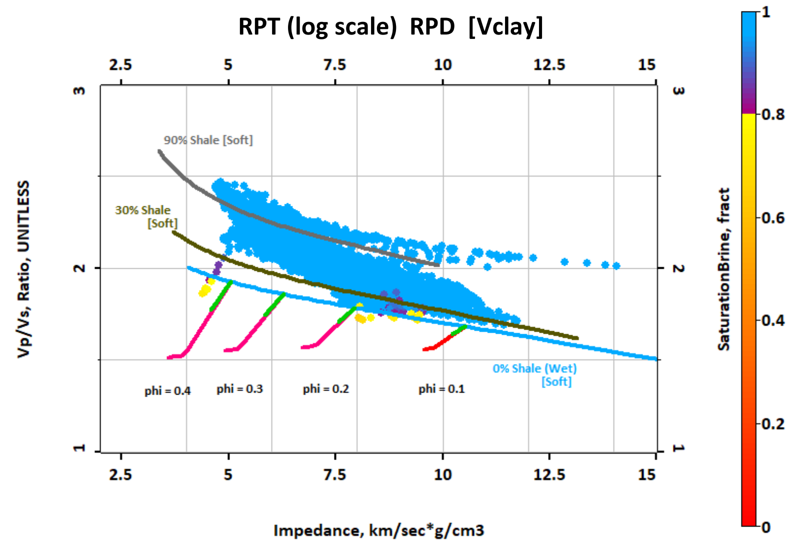
RPT (log scale) RPD [Vclay]



RPT (log scale) Final [Vclay]



RPT (log scale) RPD [Vclay]



RPD(Modelled)data

Nuang-1

Nuang-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is fair but the density and the sonic in some intervals looks very poor and lazy, but the data availability is good. Client's petrophysical interpretation was provided for this well except water saturation. Full elastic logs except VS were available throughout the wellbore covering the interval (400-895m).
- Other deeper run covering the basement section was not available at the time the study was performed.
- Shear wave velocity(VS)was fully modelled in the well using the RPD after the model was carefully calibrated based on the offset well(Dayung-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby well(Dayung-1)
- Due to the sever bad hole conditions in some intervals, density and sonic was completely replaced using resistivity via Faust equation to predict the velocity then density was predicted using the RPD based on the calibrated model.
- Vp was also totally replaced with the modelled one in some intervals where it looks lazy and not responding to any lithology variations after carefully calibrated the model with the good measured data present in the well and also in the offset wells to honor the regional trend in the area.
- Due to the sever bad hole conditions in the interval(717-825m) density was also totally replaced with the modelled after carefully calibrated the model with the good measured data present in the well and also in the offset wells to honor the regional trend in the area.
- Other logs include Gamma, SP, Caliper, Deep resistivity and Neutron which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands(Cycle V). These are a series of turbiditic sands with some calcareous cement and very tight in some intervals.

Volume of hydrocarbons:

- Best gas sand penetrated in the well was the sand 1 in cycle V around 415m(MD)with gas saturation reached to an average of 50% while other sands in the deeper level of cycle V encountered some oil saturation that have and average of 40%.

Water saturation (Sw):

- Water salinity obtained from water sample test in well Nuang-1 was used and reflected RW of about 0.175phmm @ 123 degF. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (based on regional area knowledge).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the full elastic log suite started(400m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Elastic behavior for the well was carefully calibrated with the nearby wells and other wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves closely(VP-RHOB wise) to Dayung-1 well, so S-wave velocity completely modelled in the well based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells.

Fluid properties:

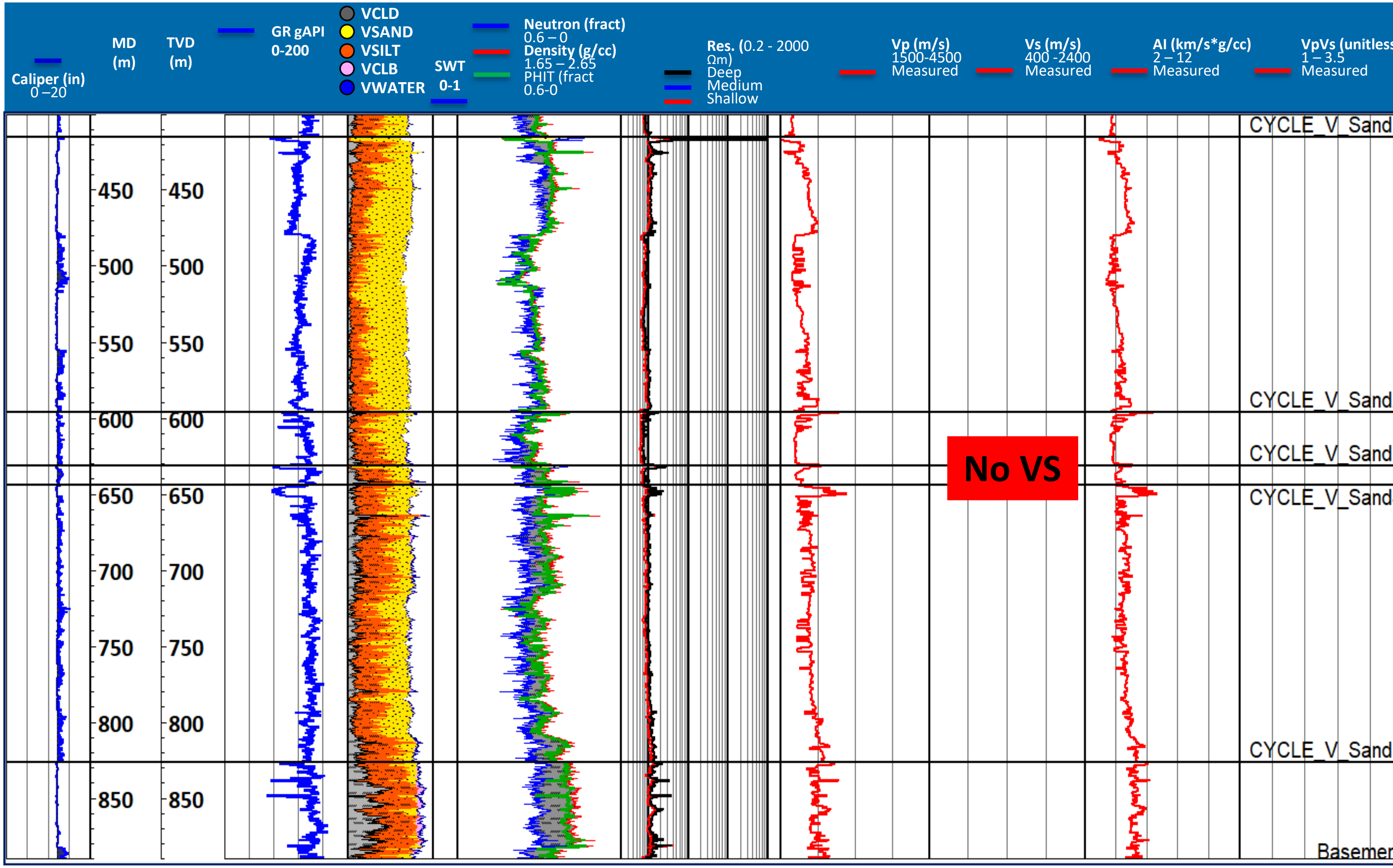
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 21550 ppm[Pickett plot]
- Gas gravity: 0.86[assumed]
- Oil Gravity: 38.1 API[assumed]
- Gas / Oil ratio: 263 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(cycle V) using the final modelled elastic curves as an input.
- Gassmann’s fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- No significant AVO class was observed when run the model near the top of a gas sand @623m since all the fluid cases interfered with the background shales at the insitu conditions.
- By downgrading or upgrading the reservoir quality no noticeable changes occurred to the AVO class for all the fluid scenarios.

Nuang-1 Input Logs



Additional data includes pressure, temperature data, core and XRD reports and cuttings descriptions(Final geological report).

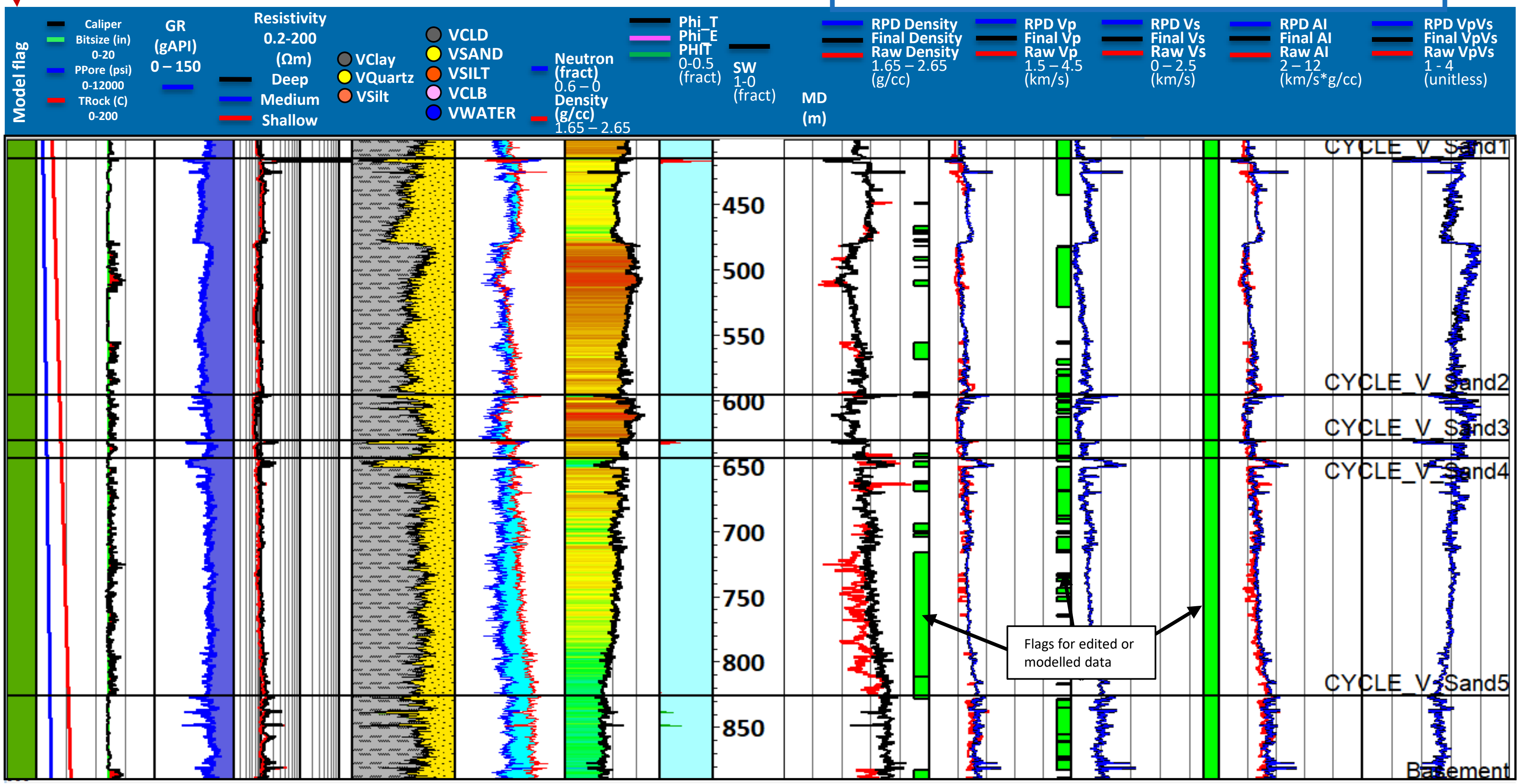
Nuang-1 Geophysical Well Log Analysis (GWLA) – All Well Interval

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

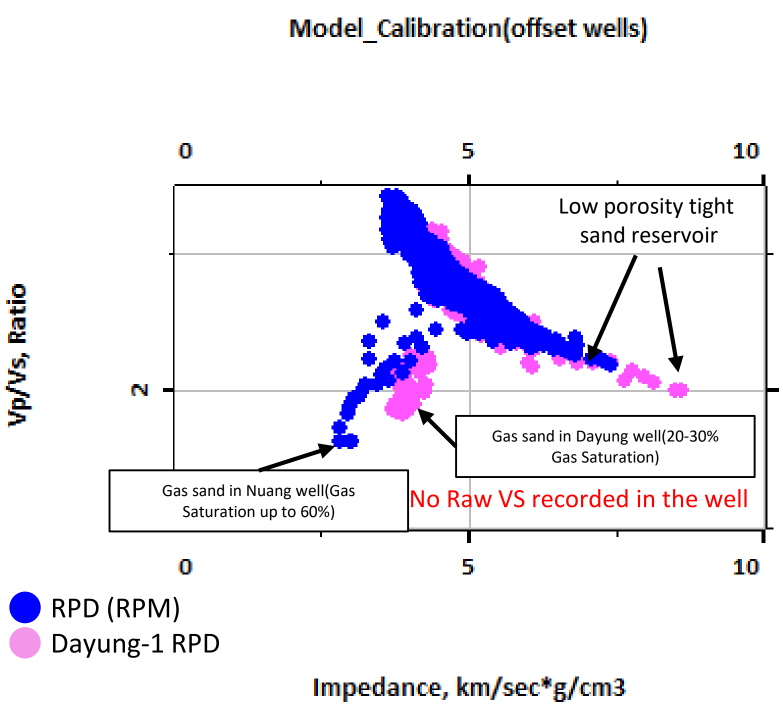


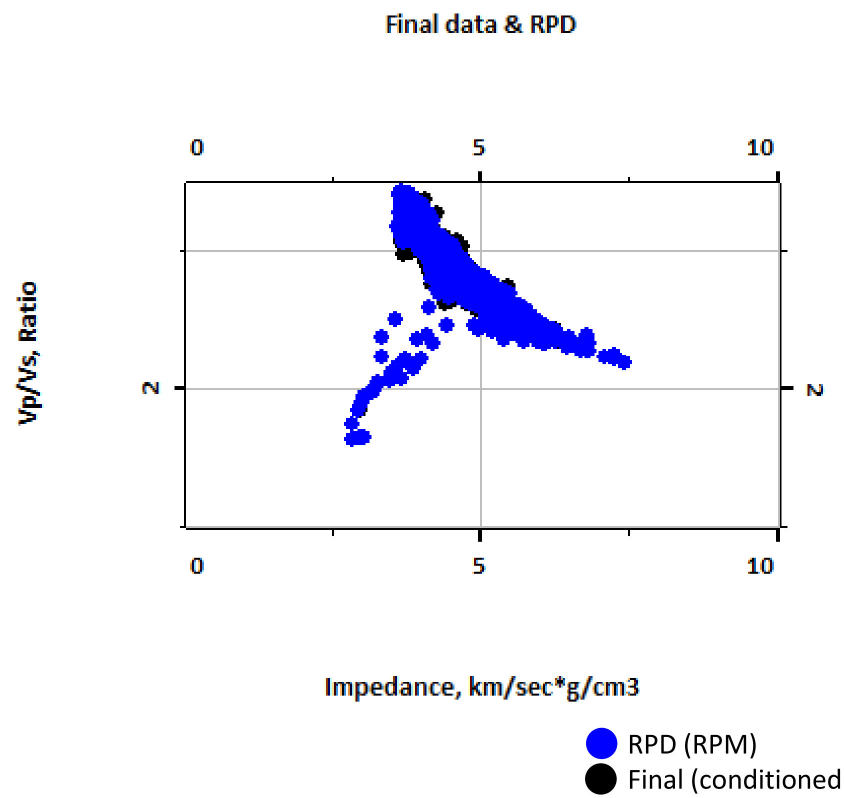
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Nuang-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the Nuang-1 well RPD with the nearby well Dayung-1.

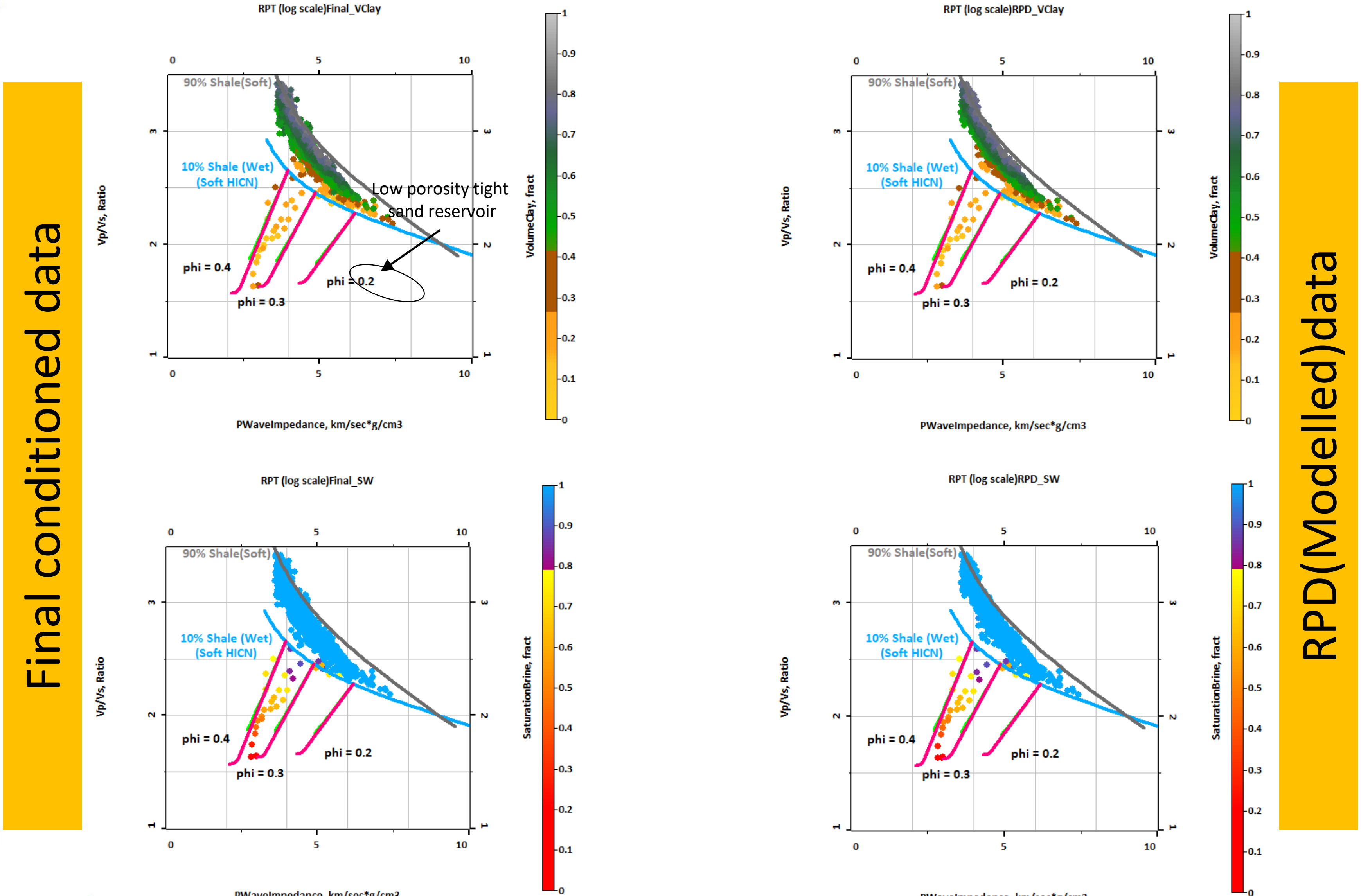
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).





Nuang-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.



NW Bayan-1

NW Bayan-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is poor. Density and compressional velocity are available in the provided data set(800-1900m), no shear velocity runs in the well. Client's petrophysical evaluation for the well was not provided.
- The density log was heavily edited using the RPD in most of the well intervals due to the bad hole conditions, the original raw density was replaced in those affected zones by the modelled one after the model was carefully calibrated with nearby wells and other wells in different fields honoring same elastic trend in the well(where measured data are reliable)
- Shear wave velocity(VS)was fully modelled in the entire well interval using the RPD after the model was carefully calibrated with many offset wells(D8-1 and Sikau North-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use from the available measured data in the well. The resulted modelled VPVS ratio and P-wave impedance follow the same trend of the measured data in the nearby wells.
- Some invasion correction was applied to the measured density in the zones with high gas saturation.
- In the intervals where both Vp and density were affected by the bad hole conditions Faust equation was used to predict Vp using deep resistivity curve as an input then the RPD used to calculate the density.
- Other logs include Gamma, Caliper, Deep resistivity which all run for the full logging run to the T.D except in the logging gap interval.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the cycles III, II and I sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences) with decreasing porosity towards the base of the section.
- A lot of coal layers were penetrated in the well especially in cycle I and III.

Volume of hydrocarbons:

- Many hydrocarbon saturated sands were penetrated in the well with oil and gas component as reported.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section the clean wet sand section(1509-1515m) yielded a formation water salinity of 12700 ppm(which also matched with the calculated salinity from water samples reported in the final geological report as 13000-17000ppm). Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2900m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Krief model was used to predict the VS data in the coal intervals .

Fluid properties:

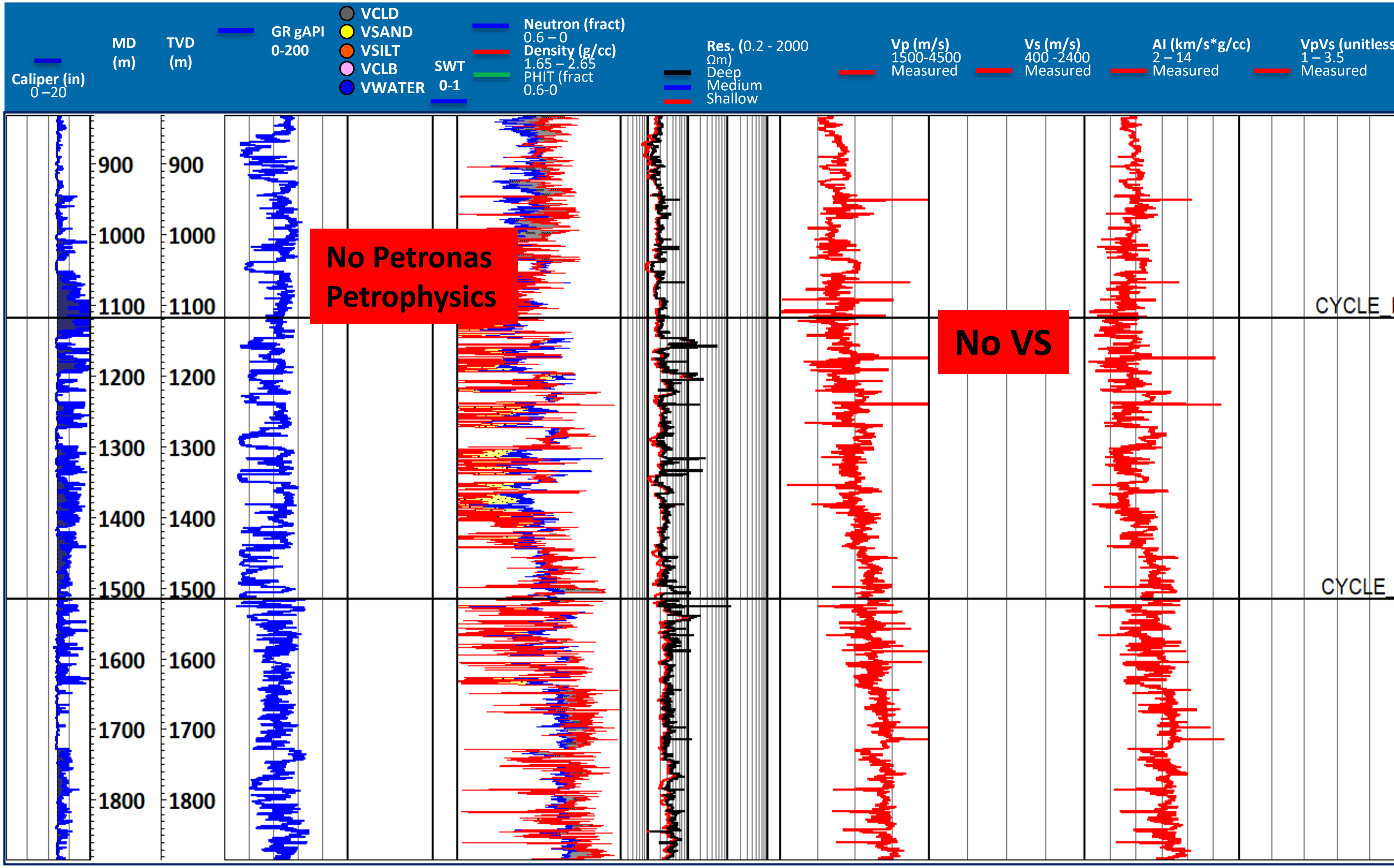
Fluid properties used in substitution have been assumed based the well information reported in the final drilling report. Main parameters used in this modeling are:

- Brine salinity: 12700 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 41 API
- Gas / Oil ratio: 450 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of cycles I, II and III using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class Iii was observed near a good porosity sand @ 1280m for all hydrocarbon cases while class II for the wet case at in situ reservoir conditions.
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) no significant change for the AVA class could be noticed.

NW Bayan-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

NW Bayan-1 Geophysical Well Log Analysis (GWLA) – (All Available Data Set)

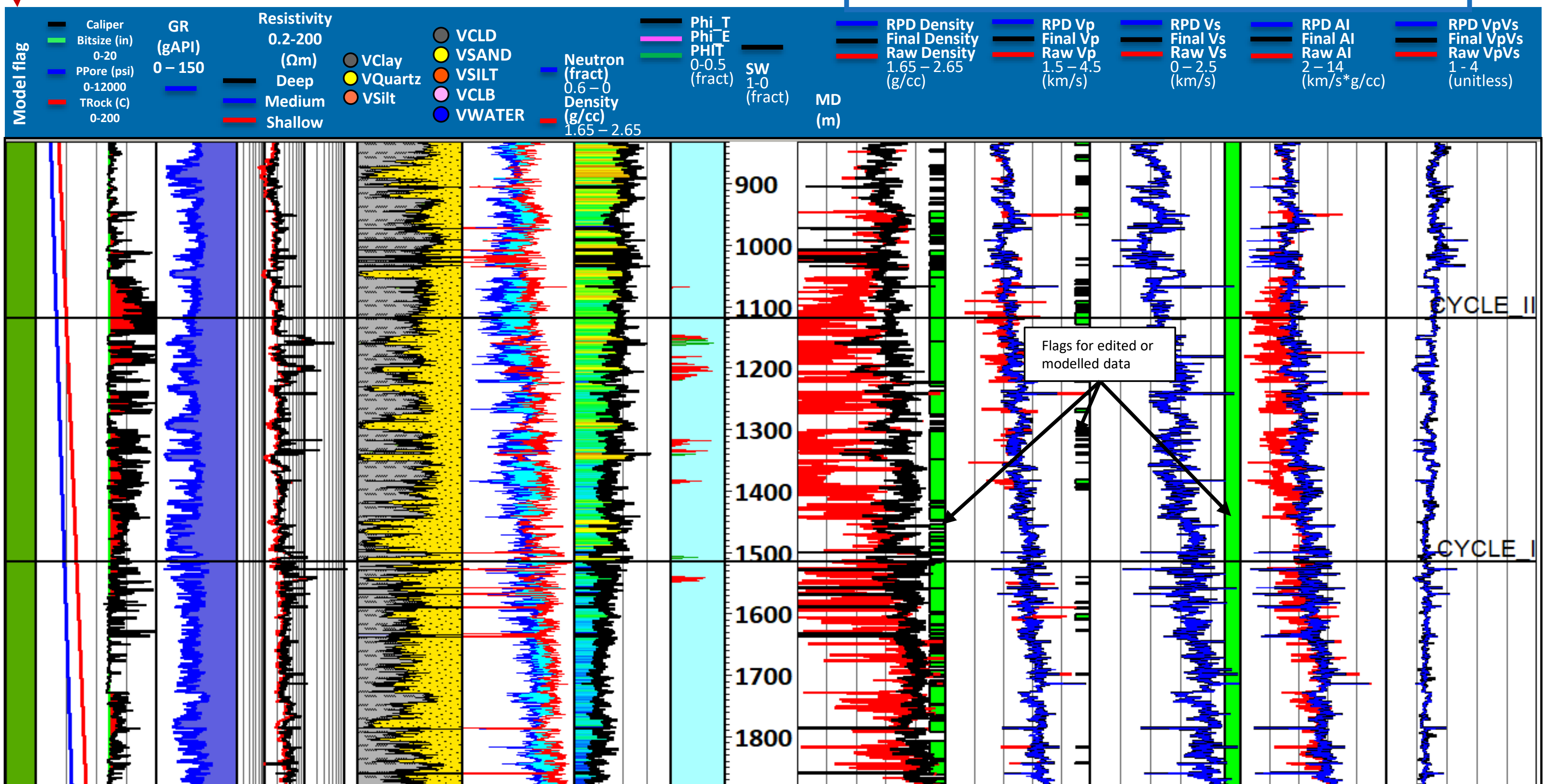
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2900m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

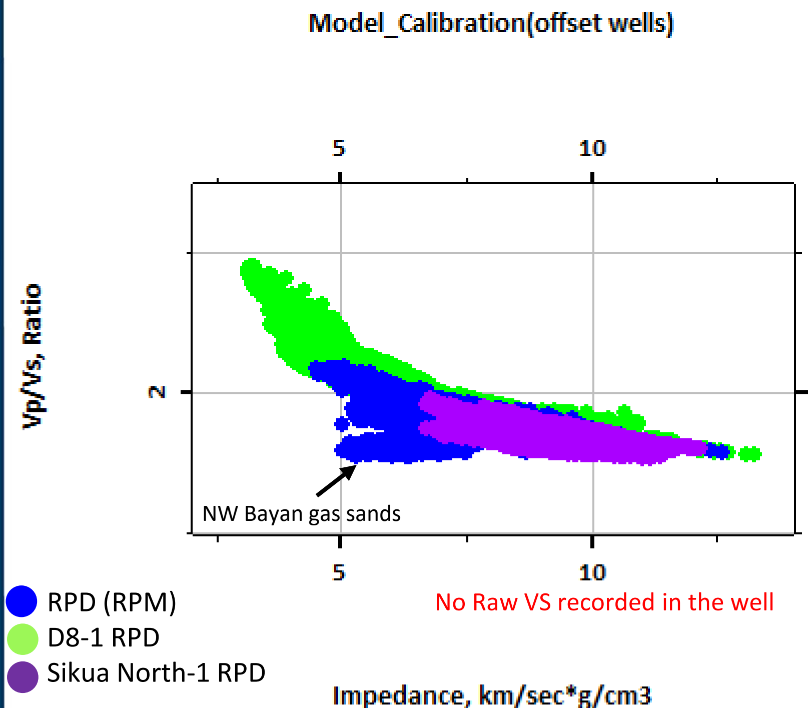


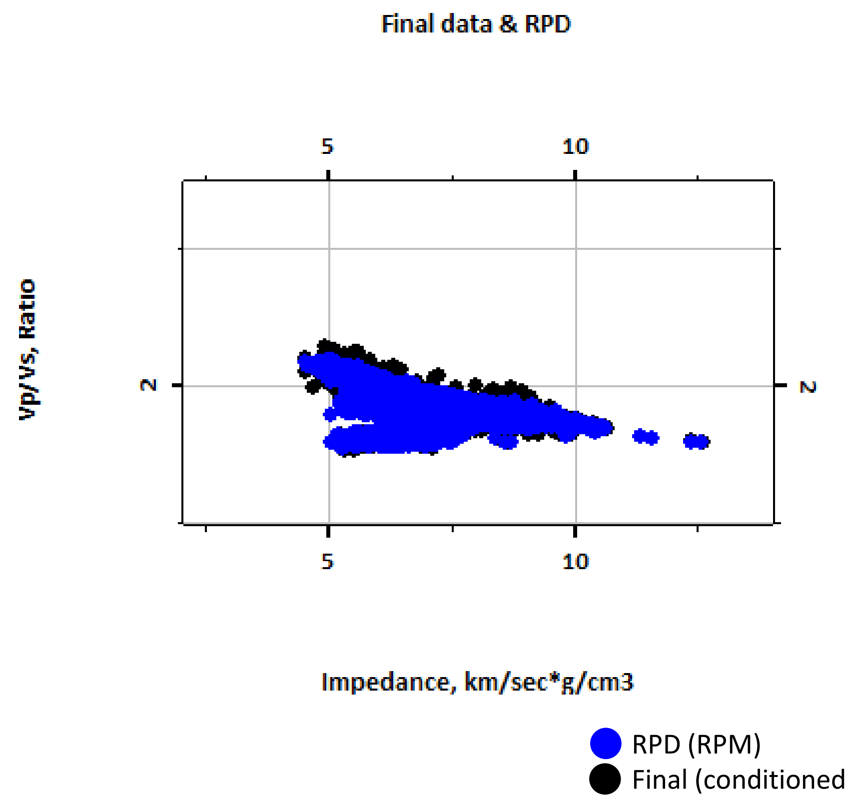
Heavy edits to the measured data(especially the density) and model calibration is strong where measured data are reliable. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

NW Bayan-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the NW Bayan-1 well RPD with the nearby wells Sikau North-1 and D8-1.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

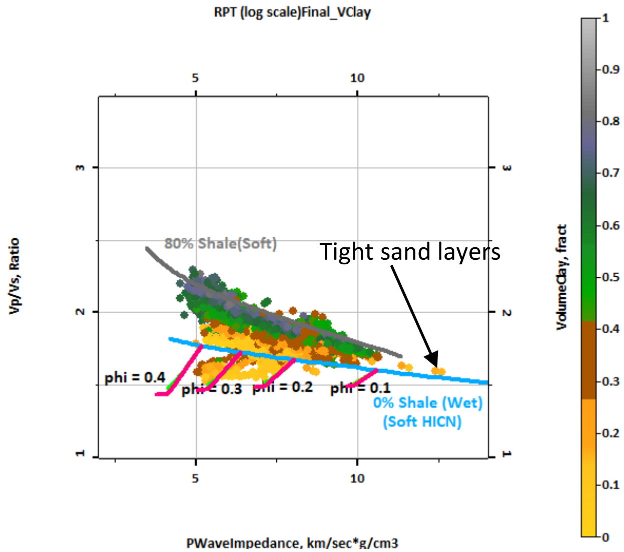


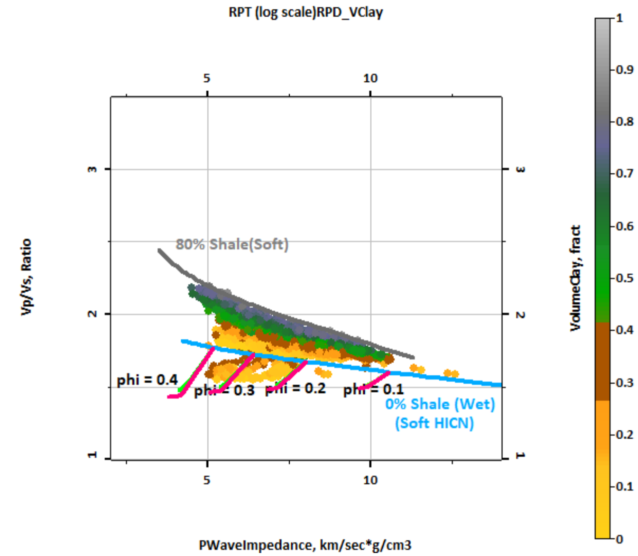


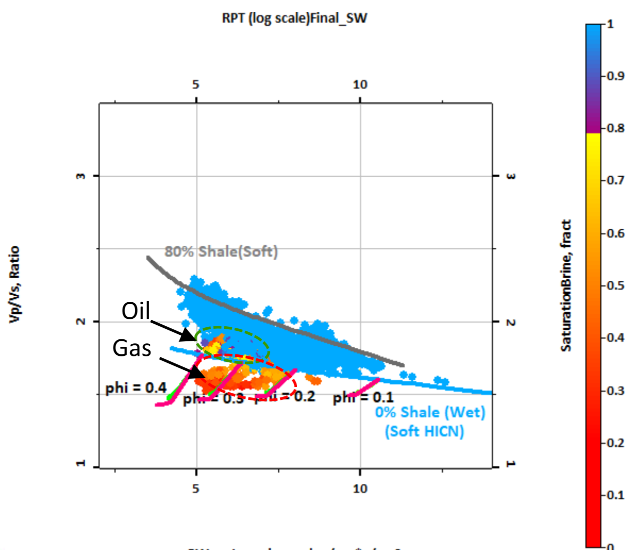
NW Bayan-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

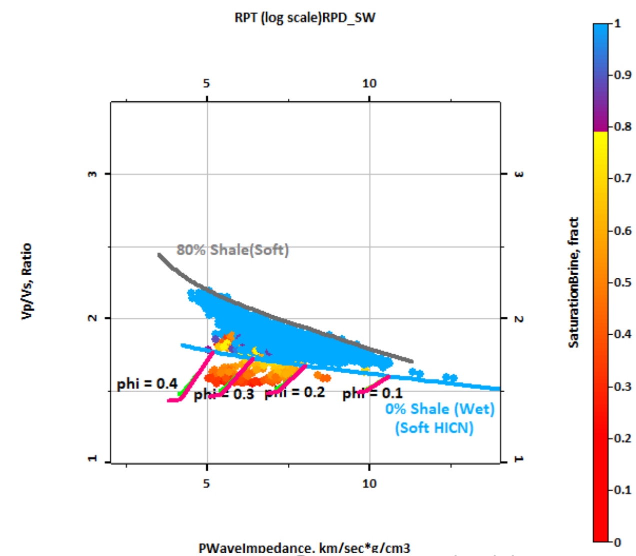
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Paus-1

Paus-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is strong. Density, compressional and shear velocities are available from 2725m-3675m, with some minor gaps. Client's volume shale, total porosity, and total water saturation were provided as a reference.
- Vp measurement is high quality, the only edits are to improve consistency with RHOB and Vs. All edits are from the RPD curves.
- The Vs is generally very strong. Some edits in the deeper section are for anomalously high values compared to surround shear values and Vp and RHOB response. Edits elsewhere are minor to increase consistency between density and Vp. The RPD curve was used for all edits.
- Density is high quality. Very few anomalous measurements have been corrected. All edits are made using the RPD.
- Other logs used in the analysis include Gamma, Neutron, and Deep Resistivity run over the full interval.

Clay volume (VClay):

- This volume was derived from a combination of the linear Gamma Ray and Neutron/Density crossplot methods.

Reservoir characteristics:

- In terms of lithology the primary reservoir is Early Oligocene Cycle 1 fluvio-deltaic sandstones, the top 13m of the reservoir is porous limestone, the remainder is sandstone interbedded with claystones. Porosity ranges from 12%-35% with an average of 23%. Complicating the reservoirs are abundant coal and tight calcite stringers distributed throughout the full section.

Volume of hydrocarbons:

- There is a gross gas column of 111m with 10m of oil below. Gas saturations are 75% and the oil is 30%.

Water saturation (Sw):

- Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet zone at 3650m Rw is 0.092 Ωm, at 256° F NaCl is 20000ppm. Water saturation was calculated using Simandoux's equation.

Paus-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both sand rich and clay rich intervals when compared to the measured data. Based on the rhob vs. vp and rhob vs. vs tool response the bulk modulus of the calcite has been reduced from 76.7 GPa to 65 GPa. This well was processed without the use of an analog well, though measured VP, VS, and RHOB are high quality and an analog well is unnecessary.

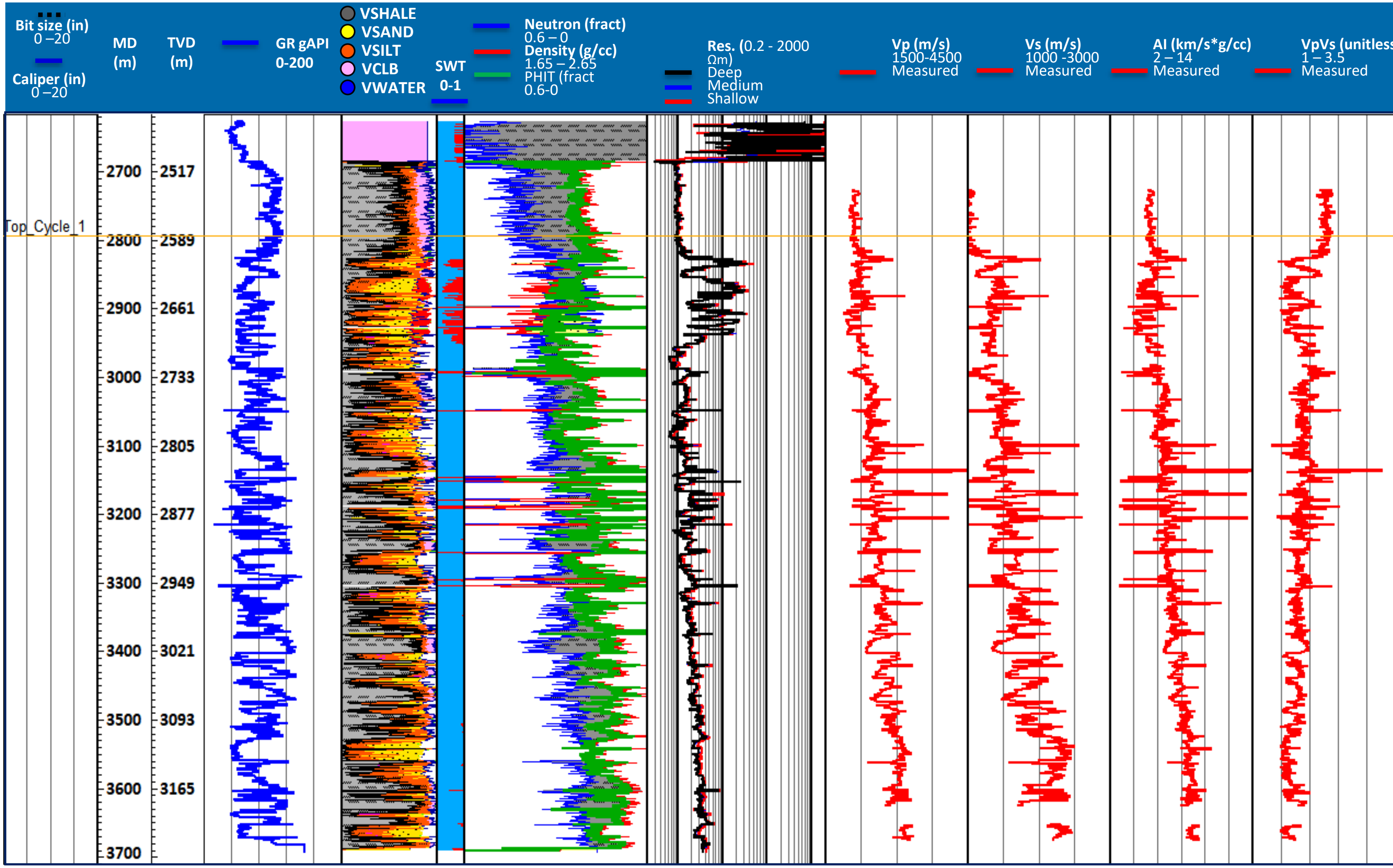
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 20000 ppm [Rw]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Cycle 1 reservoirs using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination.
- At in situ conditions the top of the gas reservoir shows a near zero AVA response with flat gradient, though there is good discrimination from the wet case. With improving reservoir conditions the intercept becomes more negative, though gradient remains flat for a Class III/IV AVA response.

Paus-1 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

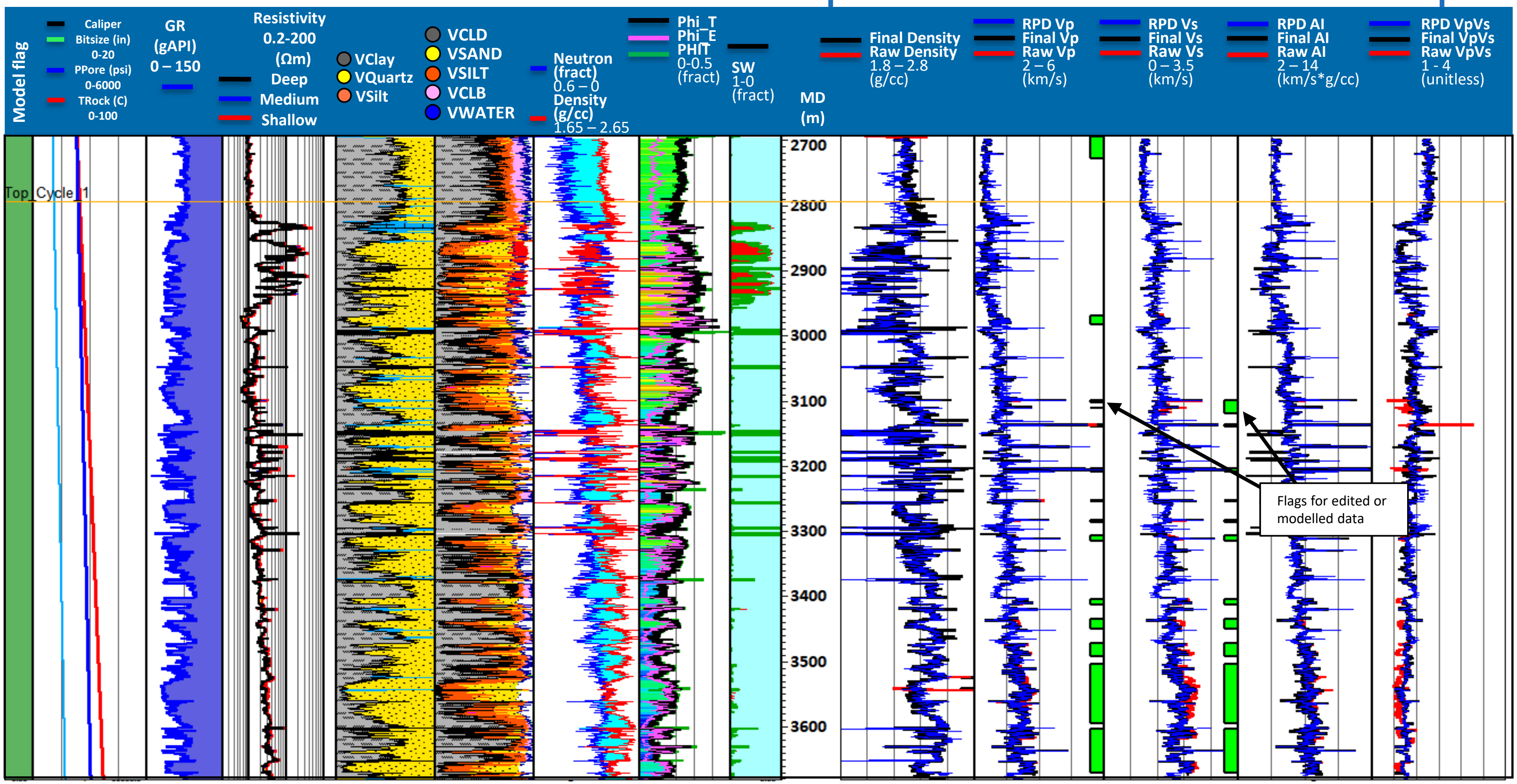
Paus-1 Geophysical Well Log Analysis (GWLA) – Full Well

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Unconsolidated rock model
- Stiff rock model

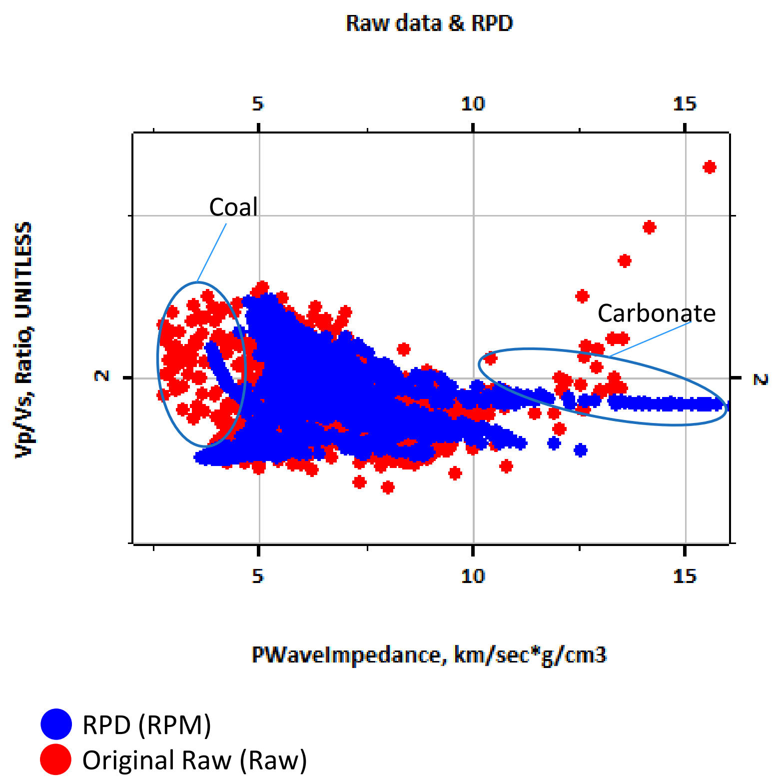


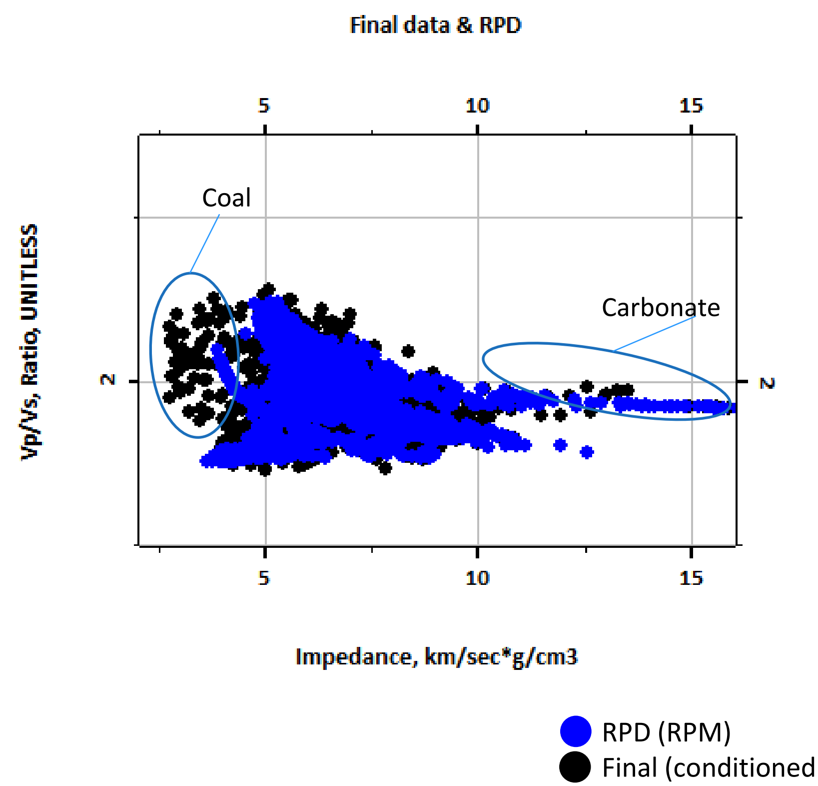
Some edits to Vp and Vs to increase consistency, also edits to Vs in deeper section for anomalously high measurements compared to surrounding sediments. Granular media model, soft sand for the sands and claystones was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data.

Paus-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

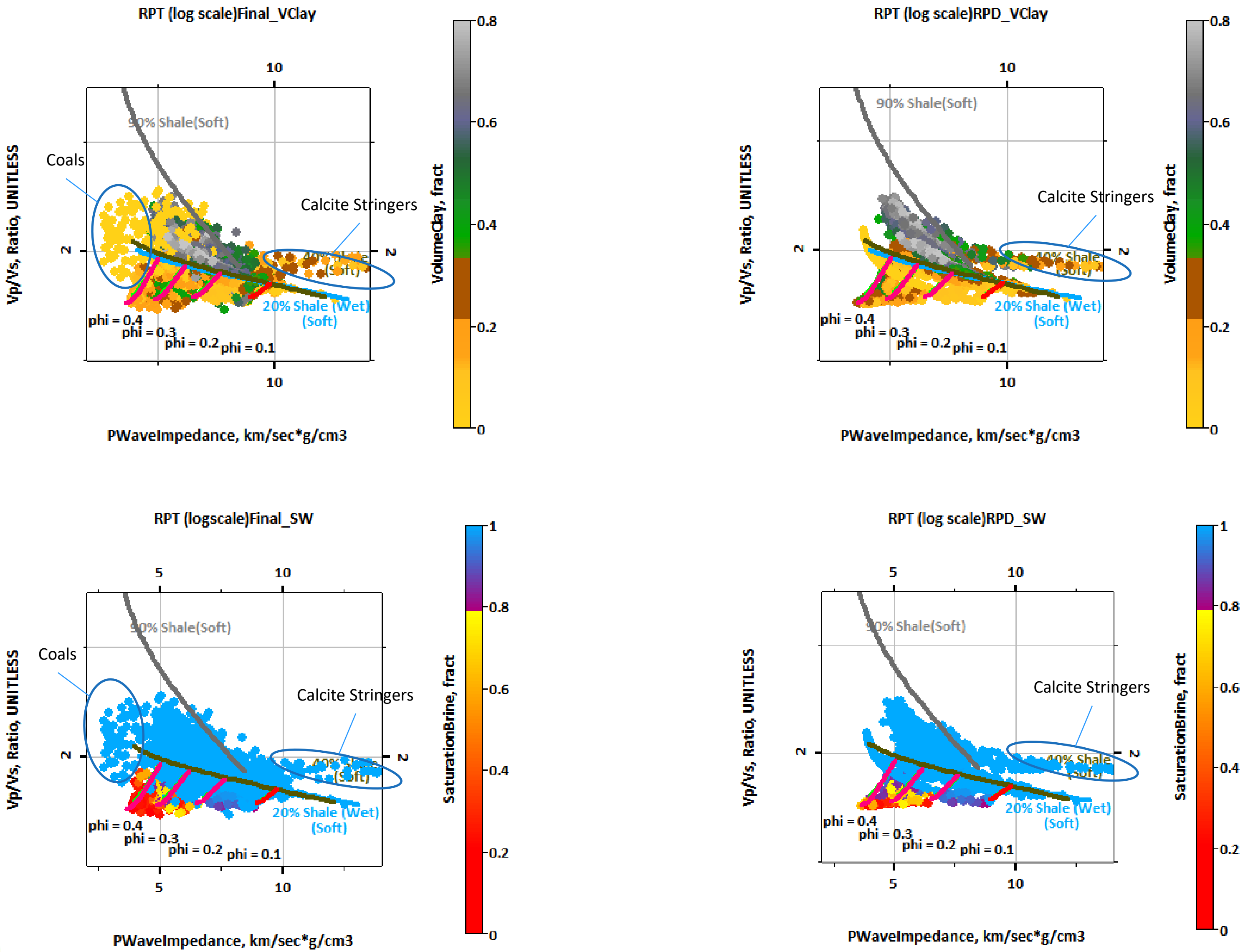




Paus-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Paus North-1

Paus North-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality and availability is good in the section studied (2477-2842 m). Vs is available.
- Density measurements are of very good quality. Density was estimated in the 2832- 2842 m to extend it towards the bottom of the logging run.
- Raw Vp was depth shifted with respect to the density log in the 2721-2749 m, 2817-2833 m intervals. The section between the MMU and the Top_Cycle_I markers show velocity values that are off trend with respect to the rest of the well. The section appears to be softer with respect to its surroundings based on the Vp behaviour (and in a lesser extent on Vs), but this was not observed in other logs (e.g. density, neutron). No indications of overpressure were observed in other logs, nor reported during the drilling operations.
- Other logs include, Neutron, Caliper, Deep and Medium resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method. In localized zones, the density/neutron approach assisted the interpretation.

Reservoir characteristics:

- The primary reservoir target at Paus North-1 is the pre-MMU Oligocene-Early Miocene Cycle I. It consists of sandstones interbedded with claystones and more infrequently with siltstones. Some limestone and coal stringers were observed in the lower part of this formation. Average porosities in these sands are about 31% and higher. Overlying this section, a claystone dominated interval (MMU) is present. Some silty sands, coal stringers (shallower) and limestone stringers (deeper) were also encountered in this section.

Volume of hydrocarbons:

- No prospective reservoirs and no indications of hydrocarbon were encountered in the well.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were taken from a Pickett Plot (2705-2730 m): Rw=0.08 Ohmm @ 205F (28,000 ppm), with a=1, m=2, and n=2.

** Depths referred in this report are MD.

Paus North-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in clay-rich and an Intermediate Stiff Sediment Model was more suitable in the non-clay rich facies. However, in the 2542-2705 m section, the elastic responses suggest the presence of softer facies. Even though there are no indications of overpressure reported, mud weight was increased considerably in this interval. Both, Vp and Vs trends look consistent and reliable in the whole section. A rock physics model parameterization in which both clay-rich and non-clay rich facies are described by a Soft Sediment Model was used in the Vp-Rhob and Vs-Rhob spaces within this section.

Fluid properties:

Hydrocarbon properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modelling are:

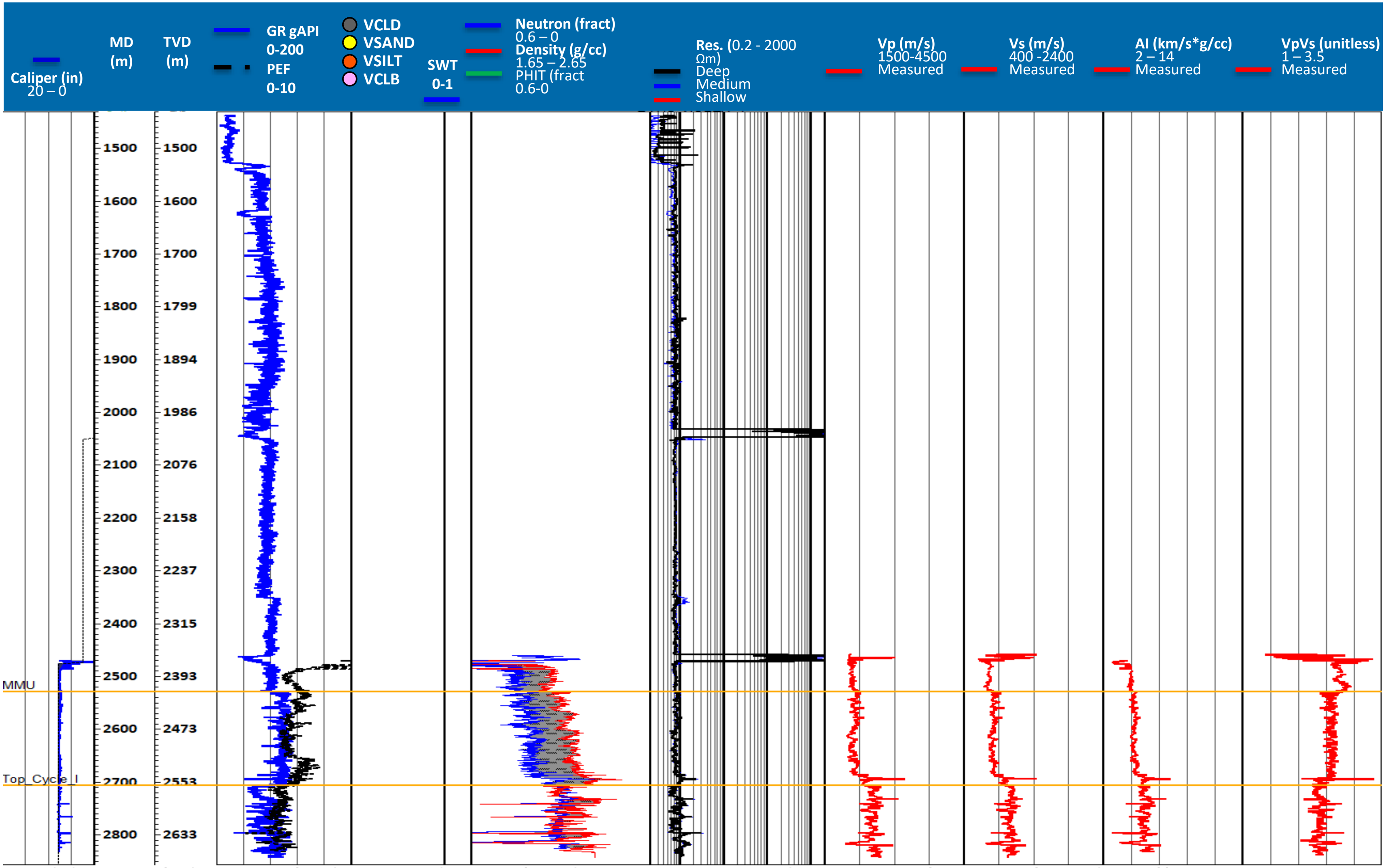
- Brine salinity: 28,000 ppm
- Gas gravity: 0.82
- Oil Gravity: 38.9 API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the sediments below the Mid Miocene unconformity (MMU).
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Paus North-1



Additional data includes mud weight data, pressure data, geochemical and well reports.

Paus North-1 Geophysical Well Log Analysis (GWLA) – Interval from Top to Bottom

model type flag

Unconsolidated rock model

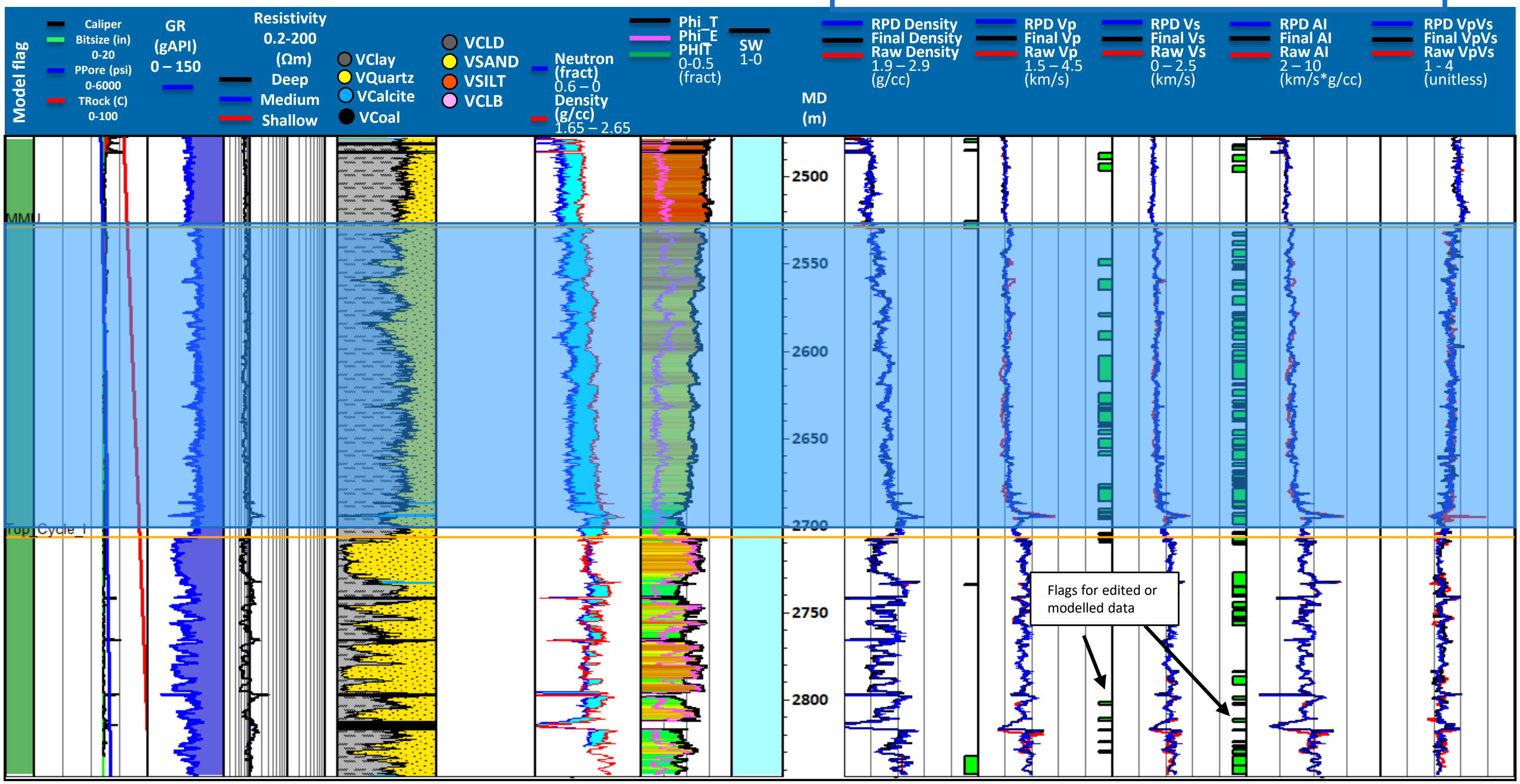
Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve

Final edited (Conditioned) curve

Original Raw (Raw) curve



The highlighted section shows a softer elastic trend when compared to the rest of the data. Although there are no indications of overpressure reported during drilling, the Mud Weight pressure gradient is higher here than in the rest of the well. Both, Vp and Vs are slower in this section and the trend of both logs seem to be consistent and reliable throughout. A different Rock Physics Model parameterization for Vp-Rhob and Vs-Rhob was therefore applied in the highlighted interval.

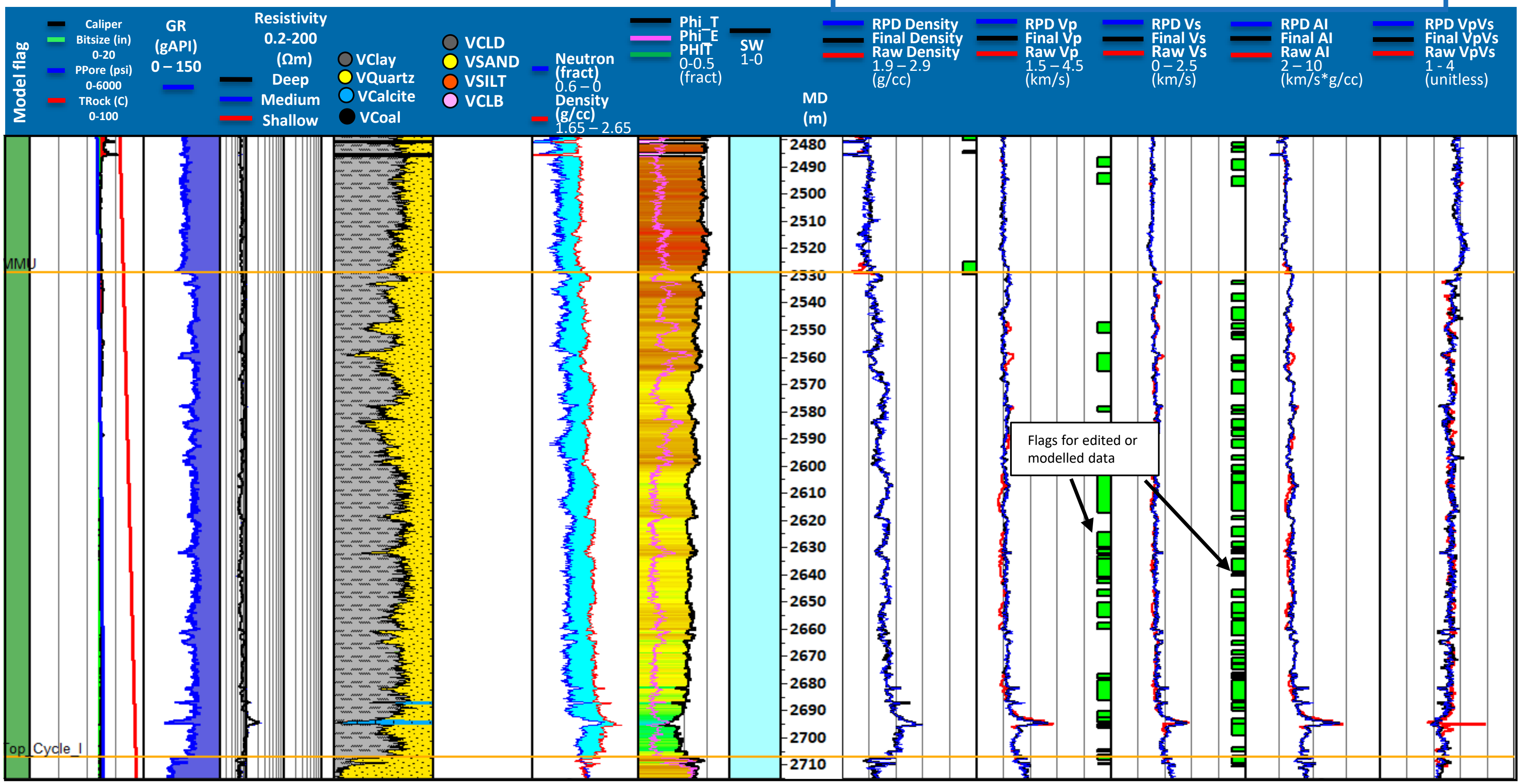
Paus North-1 Geophysical Well Log Analysis (GWLA) – Interval from 2480 to 2715 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Density and Vp logs exhibit fair to good quality data in this section and minor editing was needed. Raw Vs looks ok with some measurement gaps, especially in shallow depths.

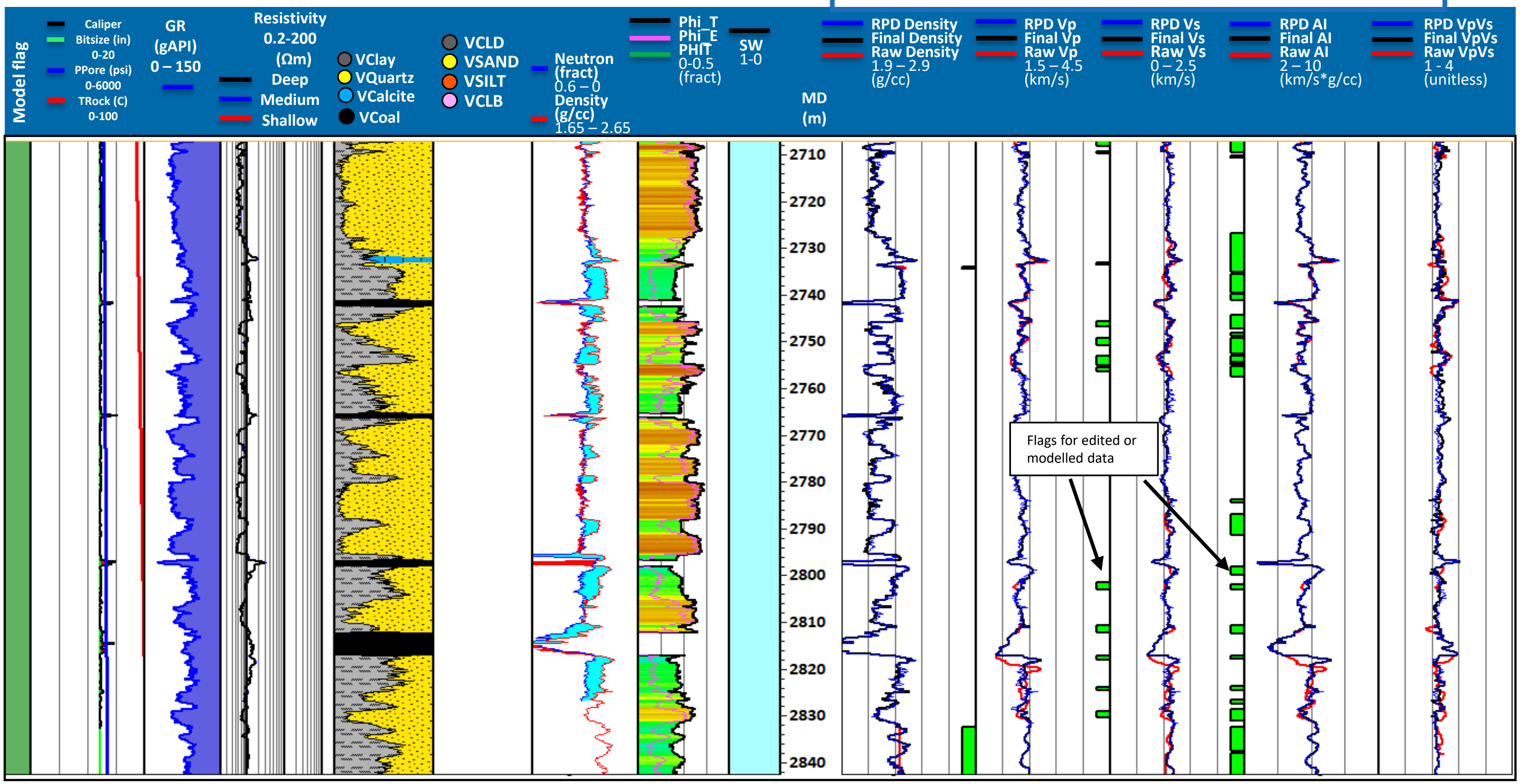
Paus North-1 Geophysical Well Log Analysis (GWLA) – Interval from 2710 to 2845 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

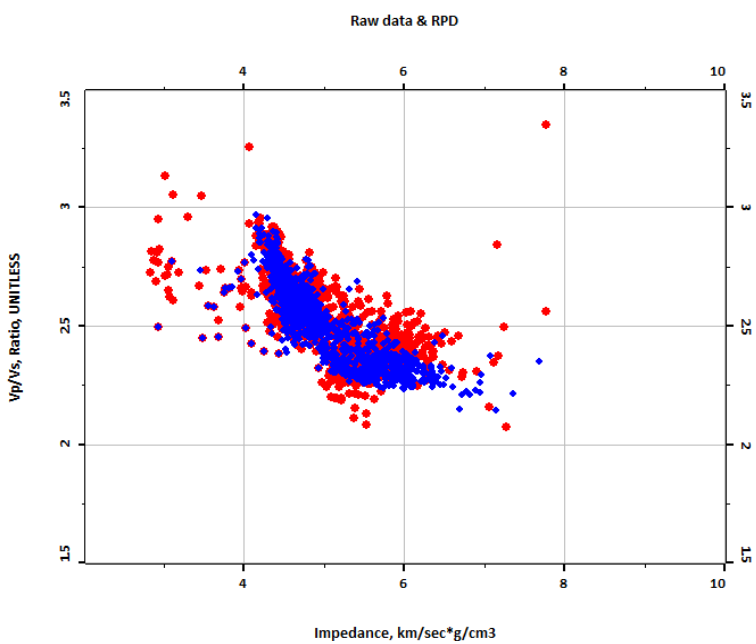


Depth shifts were required in the 2721-2749 m and 2817-2833 m intervals, in both Vp and Vs. Density was extended in the 2832-TD section. Good elastic log data quality in this interval.

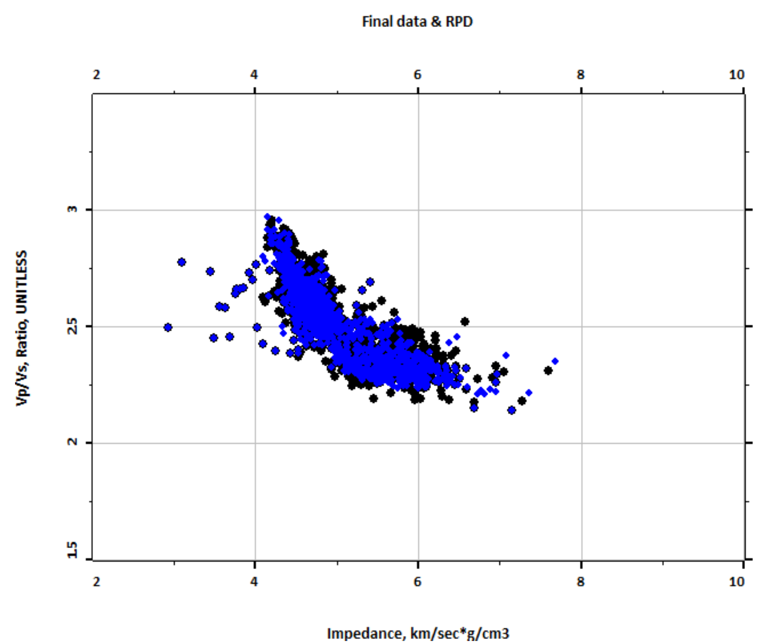
Paus North-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing only the RPD model estimated elastic variables.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)

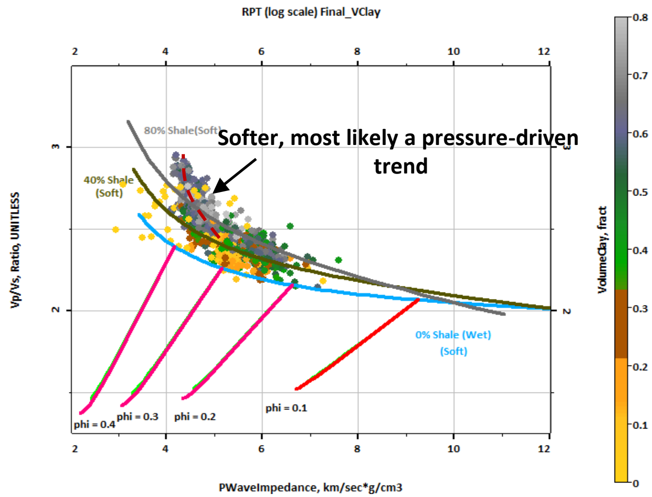


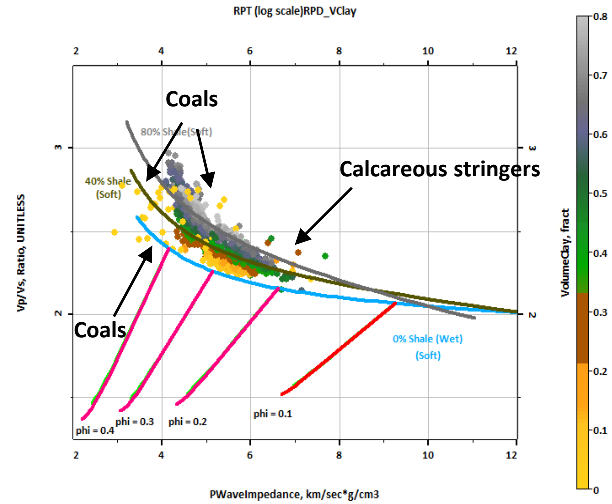
RPD (RPM)
Final (conditioned)

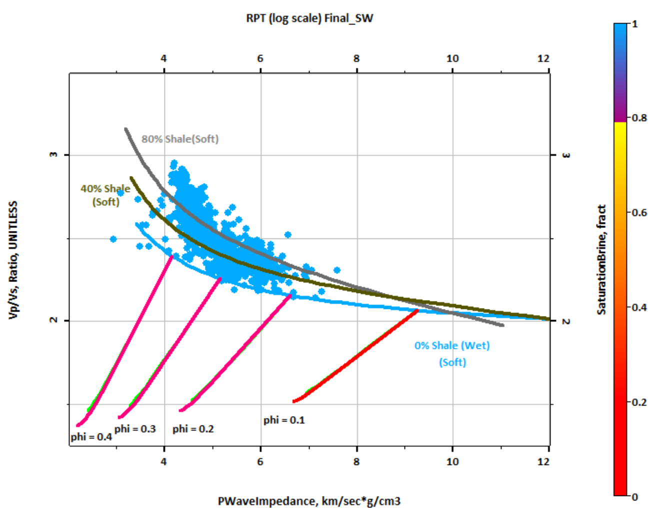
Paus North-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

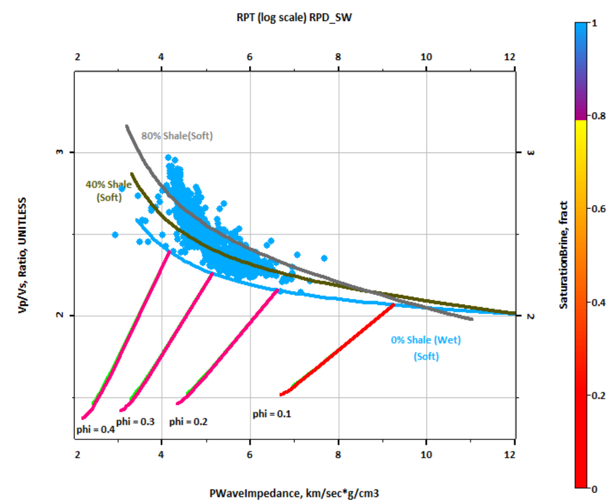
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Pelangi-1

Pelangi-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is fair. Most of the well logs are available in the 1431-2991.5 m section. Quality of the sonic logs appeared to be below average at certain sections based on the Vp/Vs trend and their correlation with other curves.
- Density measurements are good quality in most of the wellbore. In the 1800-1900; 2548-2562 m sections due to casing effects, the density was estimated using Vp.
- Compressional velocity logs are of fair quality. A local depth shift in the acoustic logs was applied in the 2478-2515 m section. Faust relationship was used to estimate Vp in hole sizes junctures.
- Other logs include, Neutron, Caliper (in some sections), Deep Resistivity, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method, but the density/neutron approach assisted the interpretation at certain sections.

Reservoir characteristics:

- In terms of well objectives, the primary goal was to perform full formation evaluation and sample (in case of positive results) the Pre-MMU Carbonate Play within the H825 and H835 potential reservoirs, respectively upper Cycle II carbonates (Lower Miocene) and Cycle I/II carbonates (Late Oligocene to Early Miocene). The H835 isolated carbonate platform is the main objective of the well with regards to prospective resources. The secondary objective was to assess reservoir and fluid content of H300, H350, and H400 turbiditic clastic reservoirs, respectively of Early Pliocene to Late Miocene age.
- The carbonate platform was not encountered in the well. The well is mostly claystone dominated, with sand intervals no thicker than 8 mts, especially in the H310-H315 section. These sands offer the best reservoir properties with porosities that can be higher than 30%.
- Deeper in the well, sand development becomes poorer: sections become siltier and tighter.

Volume of hydrocarbons:

- The most prospective section in the well corresponds to the H310 and H315 sands. Gas saturation is around 66%, particularly in the H315 reservoir.
- Deeper sands in the H350, H410 and H480 sections exhibited gas shows during drilling and therefore residual saturation was interpreted in these intervals.
- Residual gas saturation was also interpreted at a very shallow sand at the top of H280, which was also validated by a gas reading increase while drilling.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were obtained from other wells in the area: Rw=0.1 Ohmm @ 77F (65,000 ppm), with a=1, m=2, and n=2.

Pelangi-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that in terms of P & S-wave velocity versus porosity space, the Soft sediment model proved to be the best predictor in clay-rich and sand facies. However, based on the elastic behavior of certain sands, an Intermediate Stiff Sediment Model with a variable Coordination Number with depth was more suitable in this type of facies. These models have been used to edit the Vp and Rhob data where necessary and to perturb the rock for changes to VClay and Phi_T during the Rock physics modelling (RPM) stage of the project. Vs data was modelled using Granular Media, and the acquired Vs log was edited when required.

Fluid properties:

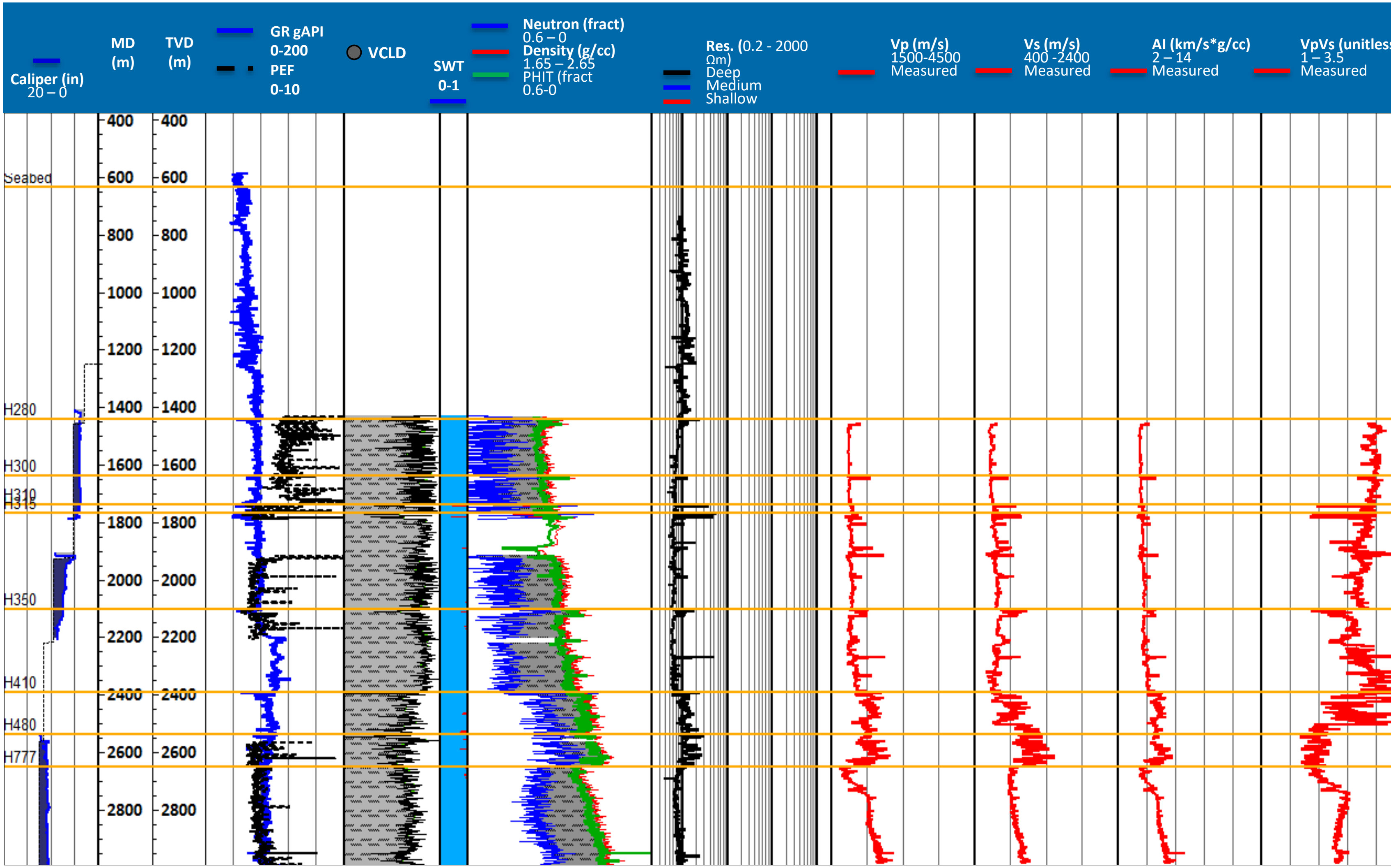
Hydrocarbon properties used in substitution have been obtained from PVT analysis performed on samples of the Spaoh-1 well:

- Brine salinity: 65,000 ppm
- Gas gravity: 0.68
- Oil Gravity: 52 API
- Gas / Oil ratio: 192 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the sands encountered in H300 down to the H480 section.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

Input Logs – Pelangi-1



Additional data includes mud weight data and well reports.

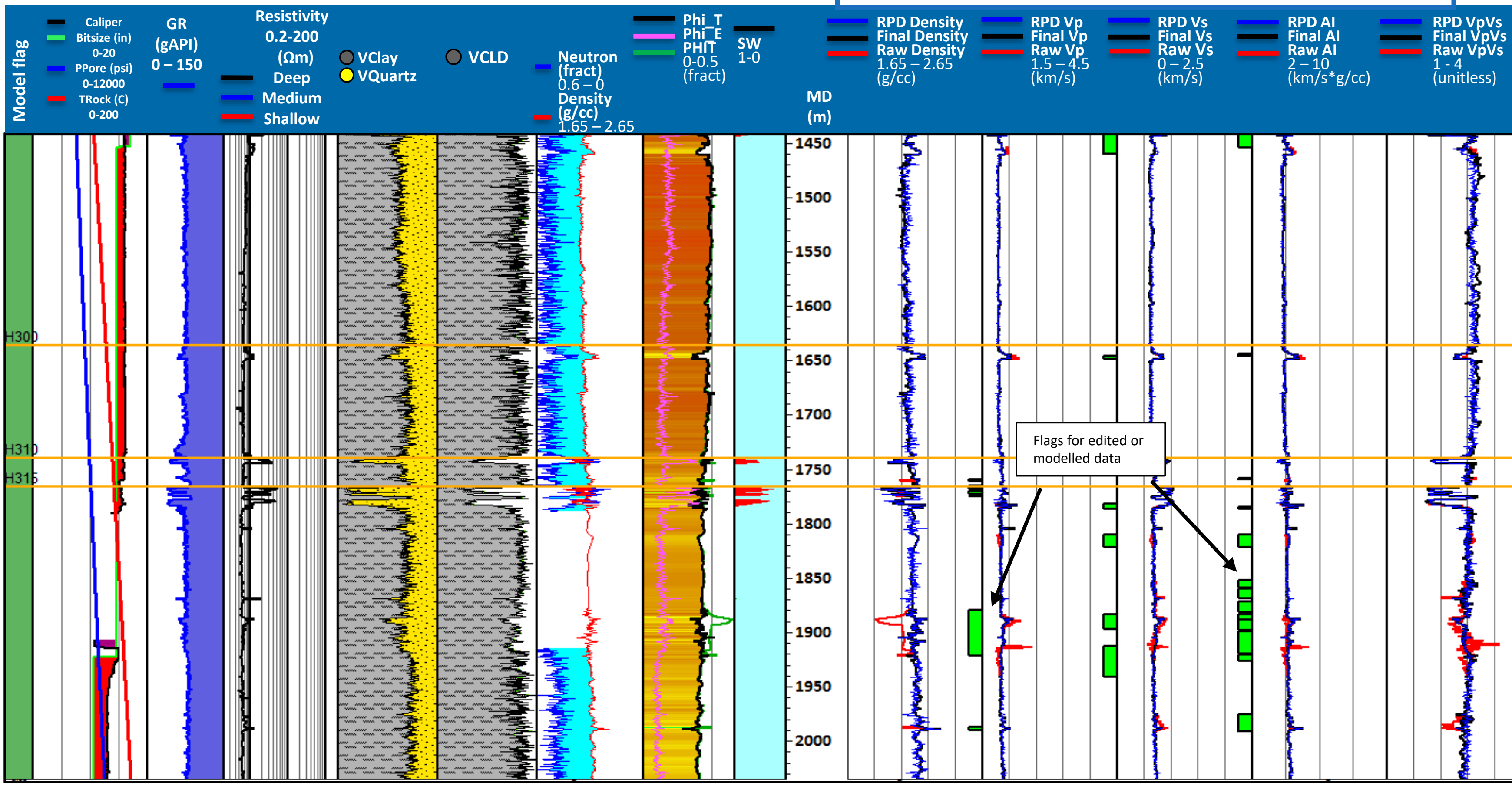
Pelangi-1 Geophysical Well Log Analysis (GWLA) – Interval from Top of logs to 2030 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Density and at some extent the velocity logs readings appeared to be affected in the 1800-1923 m section due to the casing shoe and edits were performed using rock physics modelling. Granular media model (soft sand with variable Coordination Number) was used for all elastic curves prediction (Rhob, Vp and Vs) with good correlation with the measured data.

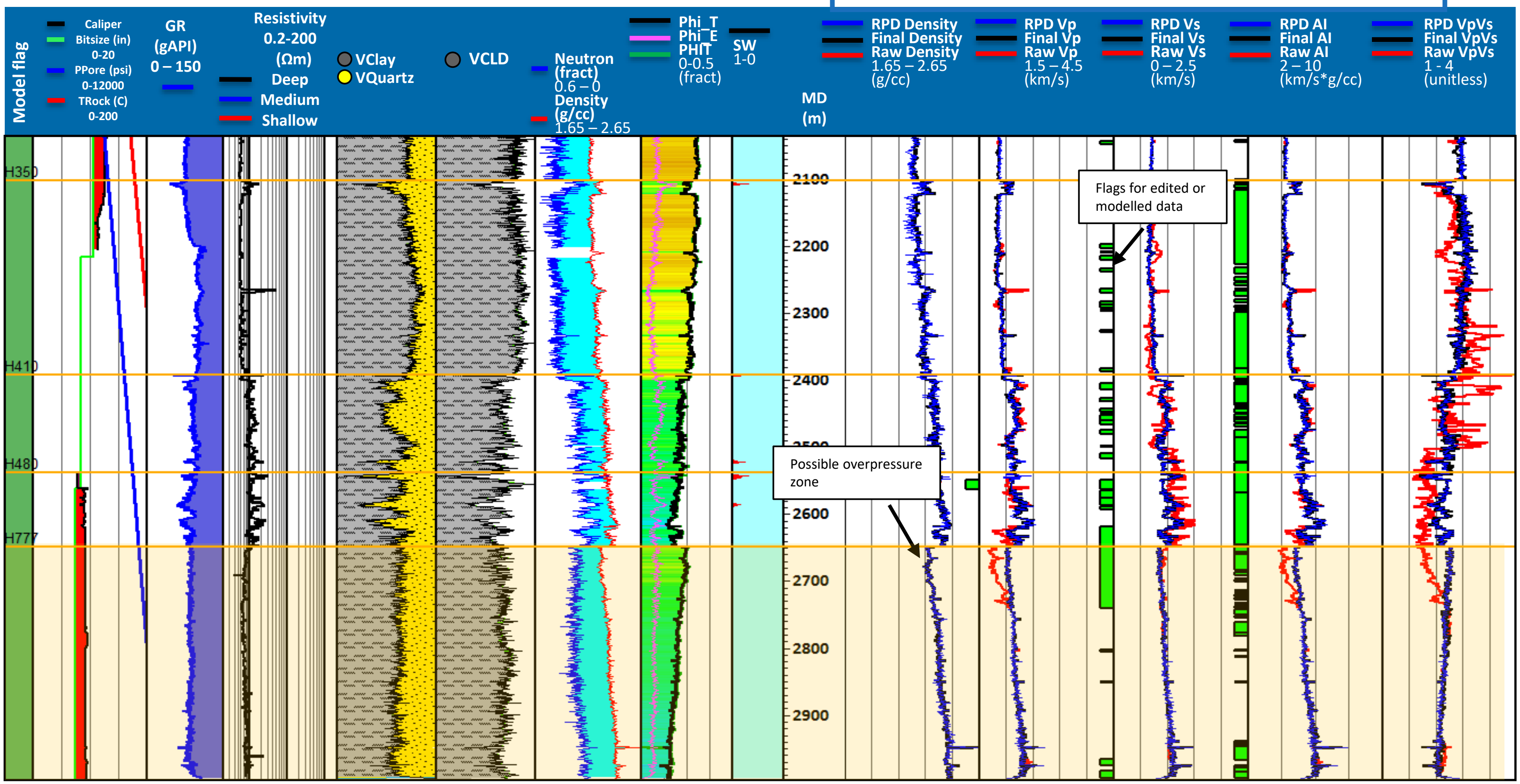
Pelangi-1 Geophysical Well Log Analysis (GWLA) – Interval from 2030 m to end of logs

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

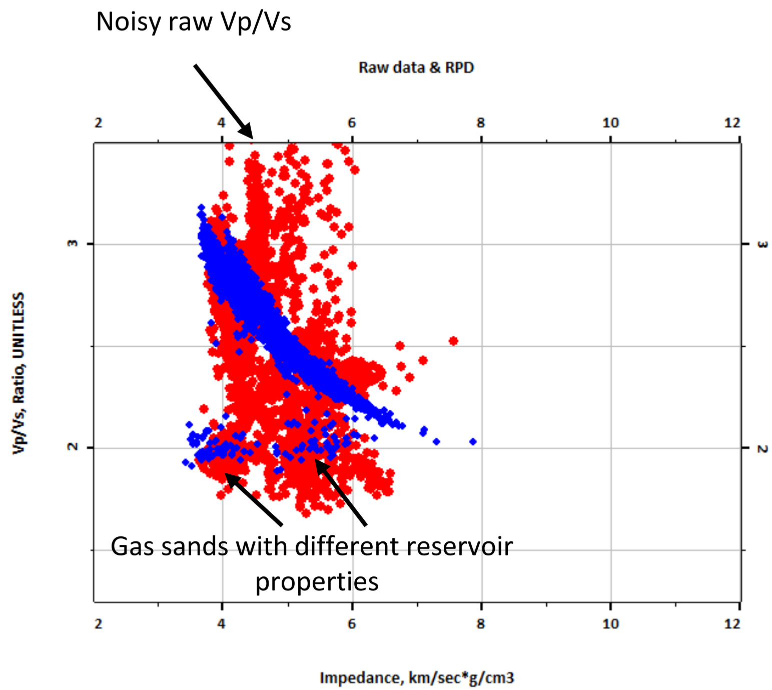
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Vp in the 2617.5-2740m section shows anomalously low values, not correlatable to the trend observed by other well logs in the same section. Vp/Vs in the 2200-2700 m is highly erratic, difficult to explain from a geological and/or rock properties perspective. Therefore, edits were performed in the Vp and Vs logs. The section close to the H777 well top displays the characteristic signature of an overpressure zone with a drop in all the elastic logs and resistivity and deviating from the normal compaction trend.

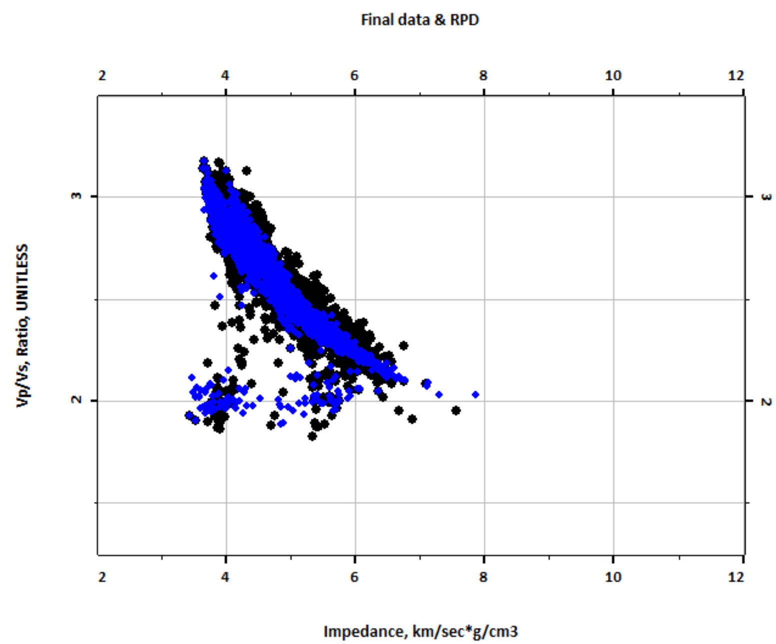
Pelangi-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing only the RPD model estimated elastic variables.



RPD (RPM)
Original Raw (Raw)

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

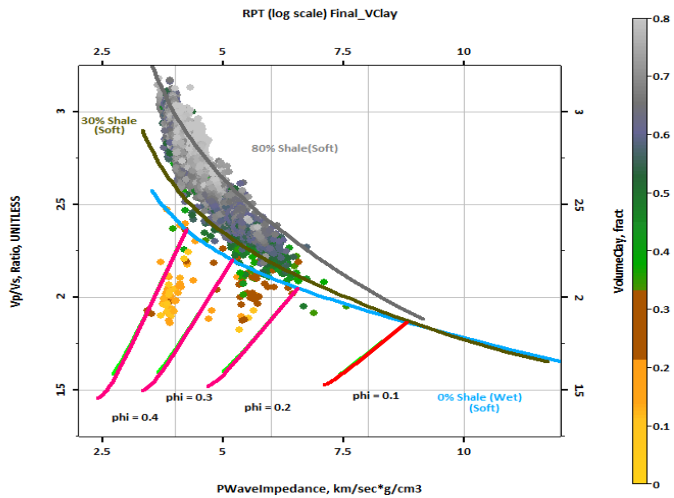


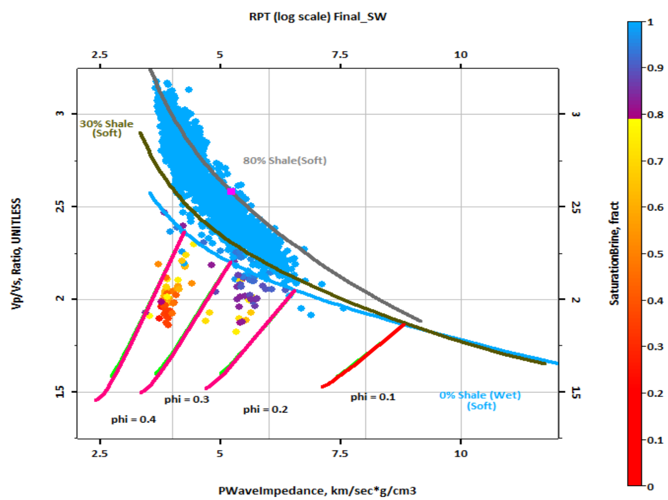
RPD (RPM)
Final (conditioned)

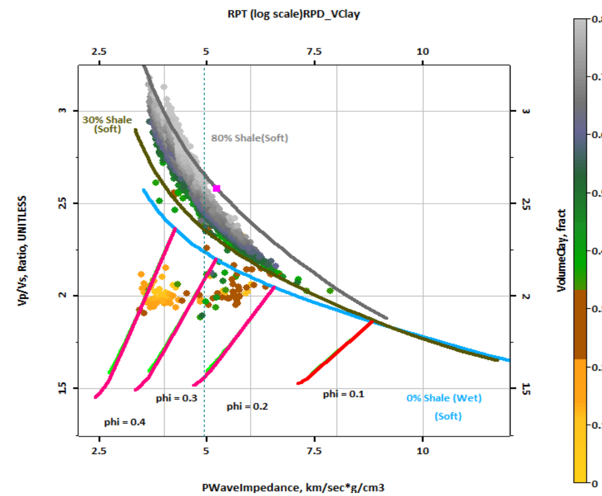
Pelangi-1,Rock Physics Diagnostics (RPD) Rock Physics Models, Full Well

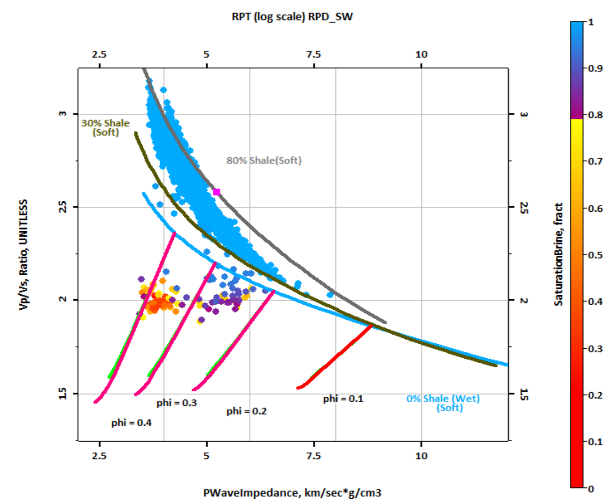
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Permas-1

Permas-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair and it has lower frequency content in compressional and shear velocities than those present in the density log. Most of the Vs data is unreliable. It was preserved as much as possible. Data os available from 650m, but most of the data is not useful until the well reaches about 960m. Most of the well log suites run from 960 m to 1800 m **.
- Density measurements are of good quality in general. Minor edits were applied in shallower intervals.
- Vp log quality is considered good, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies. This editions were maid in the internal from 1200 m to 1370 m.
- Vs required the most editions and was totally replaced from 970 m to 1450 m. Heavy editions were performed but it was preserved were data quality allowed.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The primary objective of Permas-1 well was to target reservoirs consisting of the Early-Middle Miocene (SK1870 to SK2I30) sands; corresponding to the same stratigraphic interval equivalent to the oil-bearing reservoirs at Endau. The prospective reservoirs at Permas-1 are interpreted as a succession of stacked coastal plain to shallow marine sandstones.
- There are fairly thick developments of sands especially from 1190 m to 1400 m, with porosity averaging 21%. Below 1600 m the well reveals another set of fairly developed sand, with lower porosity values averaging 16%. In this interval a sand package, of 21% porosity is present at 1705 m. This represents a local improvement in reservoir conditions.

Volume of hydrocarbons:

- Several sands in the well has been interpreted as oil and gas bearing, particularly in the upper sections of the well from 1190 m to 1250 m. In this interval gas saturated intervals showed a saturation of 60% or more, and oil intervals showed a saturation of 65% or more. The well was plugged and abandoned as an oil and gas discovery.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux’s equation. Archie’s parameters were assumed to be a=1, m=n=2. Water resistivity used to interpret Sw: Rw=0.17 ohmm @ 115 C (11,000 ppm).

** Depths referred in this report are MD.

Permas-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clay rich and sand facies.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken in a near by well (SPAOH-1), particularly the gas properties. Average values were taken from nearby wells for oil properties. Main parameters used in this modelling are:

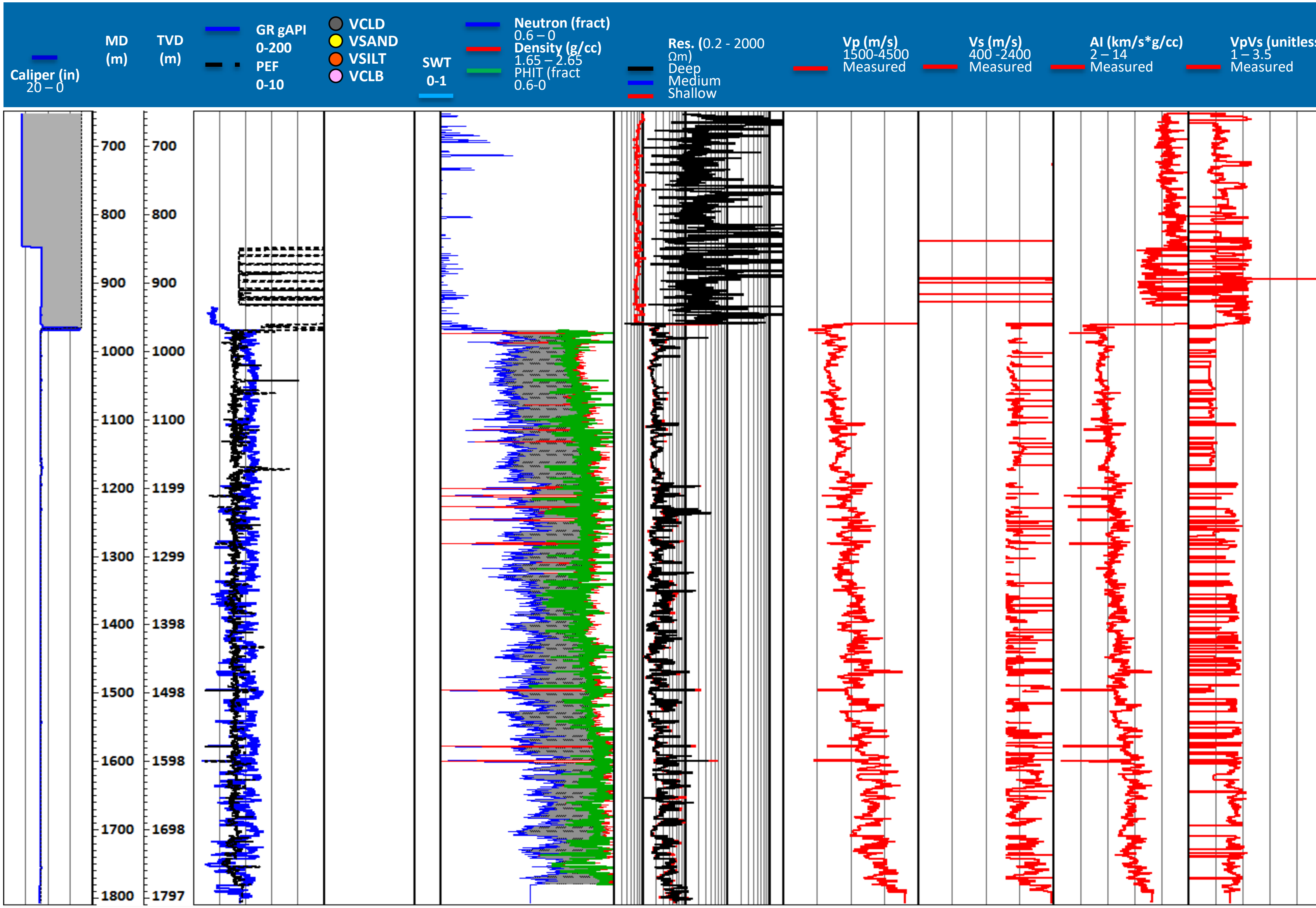
- Brine salinity: 11,000 ppm
- Gas gravity: 0.7 (PVT report SPAOH-1)
- Oil Gravity: 44.4 API (Average value based on nearby data)
- Gas / Oil ratio: 178 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene Cycle V sands.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Permas-1



Additional data includes mud weight data, pressure data, petrography and well reports.

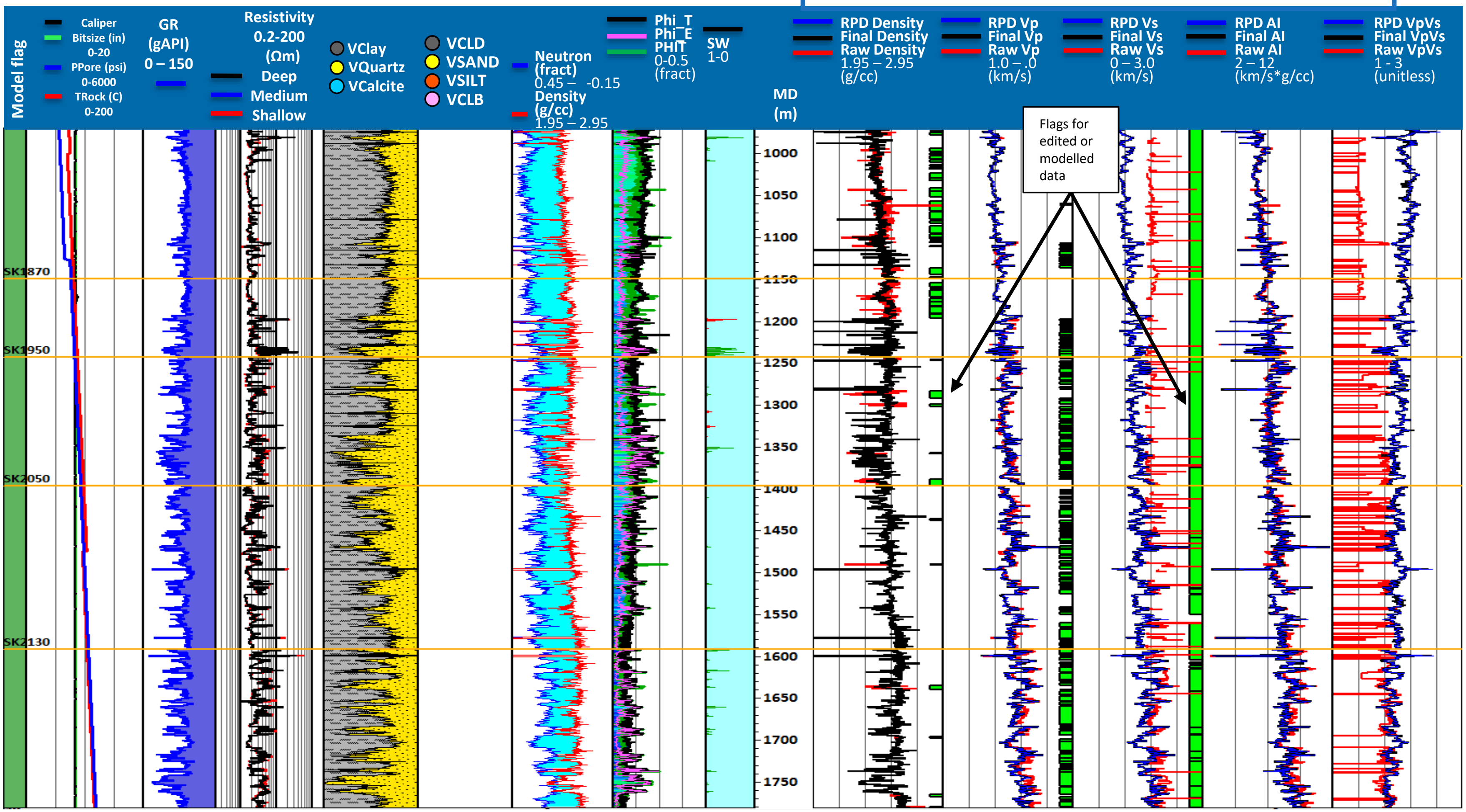
Permas-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m

model type flag

Unconsolidated rock model
Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve
Final edited (Conditioned) curve
Original Raw (Raw) curve



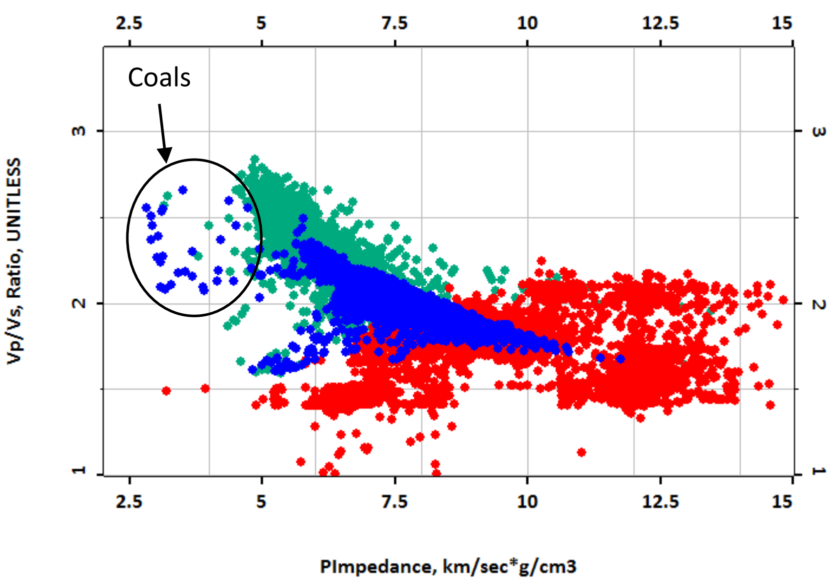
Results for well Permas-1. Density and Vp are not considered in general reliable. Density is considered more reliable in most of the section, being used as the base for edition of other logs.

Permas-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data. Rompin-1 well Final-Edited data is shown as a reference since the shear data of well Permas-1 is almost all not useful. Well Rompin-1 and Permas-1 are close to each other.

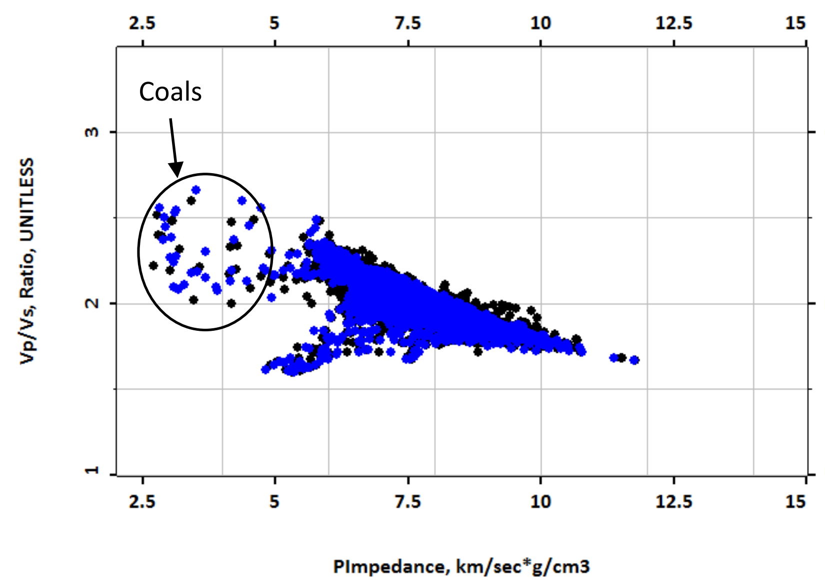
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

Raw data & RPD



RPD (RPM)
Original Raw (Raw)
ROMPIN-1 Final (Edited)

Final data & RPD

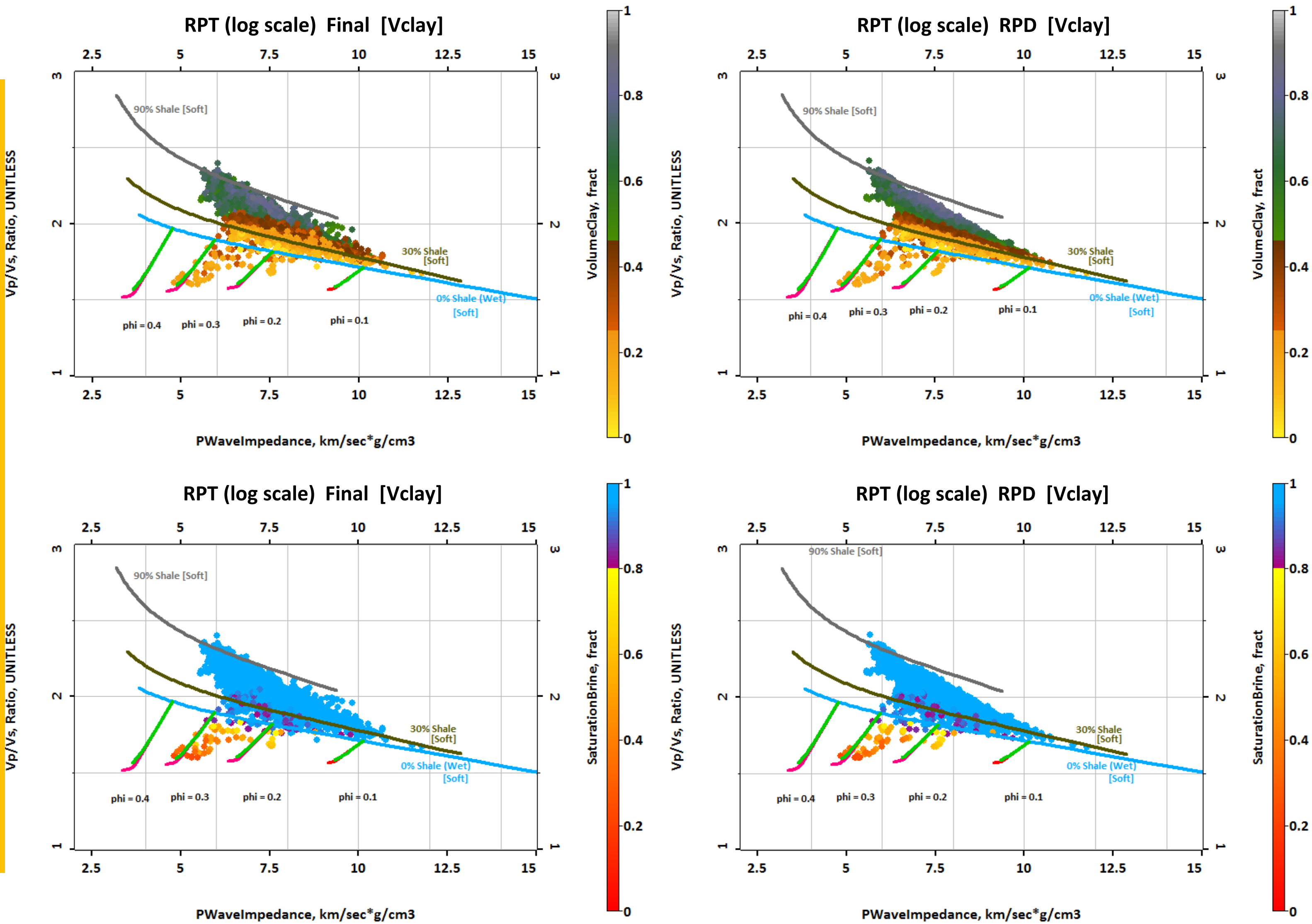


RPD (RPM)
Final (conditioned)

Permas-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Rebab-1

Rebab-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Rebab-1 well data has a mixed quality, poor in both the density and velocity. Fortunately both logs are not of bad quality in the same intervals. The well can be divided in two sections, the clastic and the carbonate, lithology and log quality wise. In the clastic section the density log is apparently heavily affected by borehole conditions. There is no caliper data available to validate this affirmation, it is assumed given the general response pattern observed in the density log, typical of a borehole affected density.

- On the other hand, the density log has a good quality in the carbonate interval, below 3610m, and compressional velocity measurements show to have a more erratic behavior. Most of the well log suites run from 2000 m to Bottom of the well, 5000 m **. Resistivity and compressional slowness have measurements from about 150m. Gamma ray measurements go all the way to Seabed.

- The density log was heavily edited in the clastic interval going from 2000m to 3610 m. Density log is of good quality in the carbonate interval, below 3610m. All logs were depth shifted, to align the responses and avoid noise in the results obtained from rock physics modeling. Density log was not edited in the carbonate interval, the edition flag is indicating where the density log was depth shifted.

- Compressional velocity log quality is considered good in the clastic interval, from 2000m to 3610m, and suffers from low frequency content and erratic behaviour in the carbonate section, below 3610m. Editions were mainly performed from the density log to recover the lost frequencies in this section. This editions were maid in the internal from 1200 m to 1370 m.

- Shear slowness data was not measured in this well.

- Other logs include, Neutron, Deep resistivity, pressure and temperature data and reports.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The Rebab-1 well was primarily targeted as an exploration well. It present a carbonate section which is the primary target of this well. The well presents low porosity values in general. Porosity values of up to 15% have been interpreted, in very few locations. In general the values are below 8%.

Volume of hydrocarbons:

- Several intervals in the carbonate section were interpreted as gas bearing. We believe that the high porosity intervals have an actual gas content. Other intervals may present high gas content but this intervals may not be commercially viable. The elastic responses agree more with the presence of gas, this may be due to the low porosity nature of the interval.

** Depths referred in this report are MD.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters and water resistivity were calculated by means of Pickett Plot analysis performed in the carbonate section. The analysis gave the following results, a=1, m=2.5, n=2.2. Water resistivity used to interpret Sw: Rw=0.09 ohmm @ 370 F (for a salinity ~ 16,000 ppm).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies. The soft sediment model also was calibrated for the carbonate section of the well. Data from the clastic and carbonate sections that proved to be of good quality were used to calibrate the rock physics model better suited for this well. Faust model was used to perform some minor editions in the clastic interval, where the compressional velocity log seemed to have anomalous measurements.

Fluid properties:

Water and hydrocarbon properties used in fluid substitution have been assumed to be the average of the area where the well was drilled. Water salinity was calculated using Pickett plot analysis. Main parameters used in fluid substitution are :

- Brine salinity: 16,000 ppm
- Gas gravity: 0.85 (PVT report SPAOH-1)
- Oil Gravity: 40 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

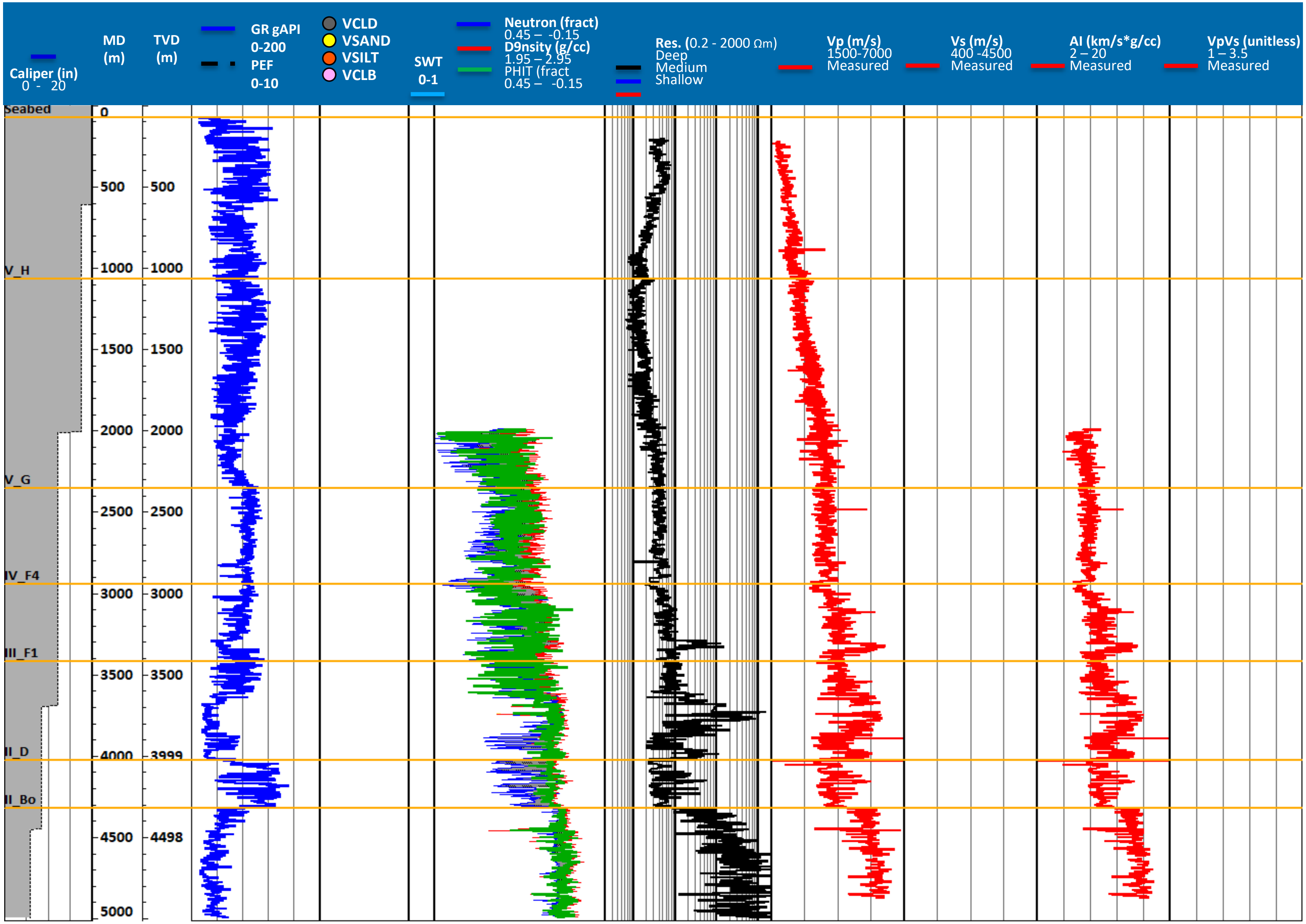
Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in any of the intervals corresponding to either the clastic or the carbonate interval. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated intervals show lower Vp/Vs ratios and lower compressional P-wave impedance (AI) values than wet intervals at log scale.

- Fluid substitution is performed via Gassmann and Brie models.

** Depths referred in this report are MD.

Input Logs – Rebab-1



Additional data includes mud weight data, pressure and temperature data and well reports. Shear slowness was not measured in this well

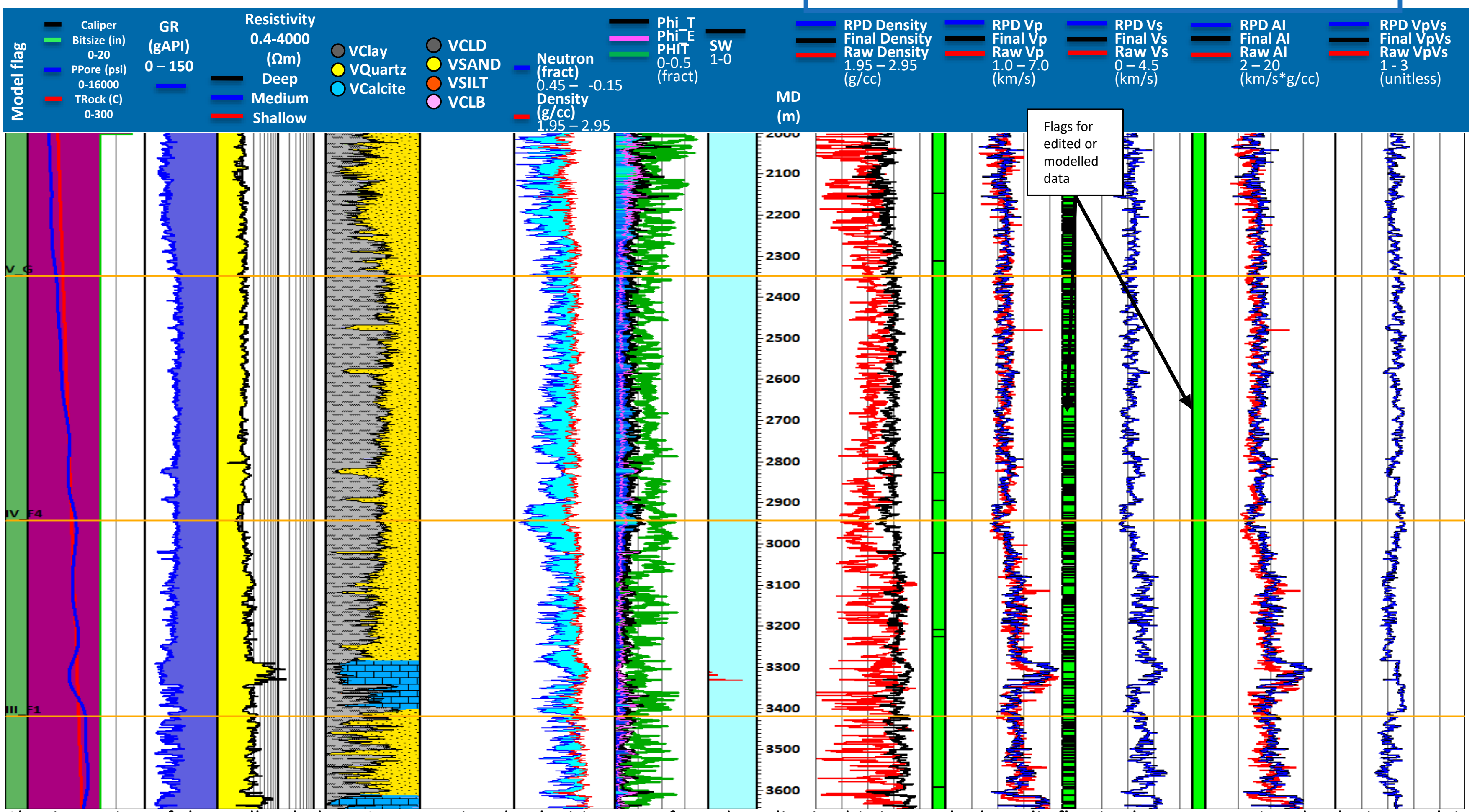
Rebab-1 Geophysical Well Log Analysis (GWLA)
Clastic section, Interval from 2000m to 3610 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Clastic section of the well Rebab-1. Compressional velocities are of good quality in this interval. The edit flag in the compressional velocity track is indicating where the compressional velocities were depth shifted to align with other logs. The shear velocity was completely estimated.

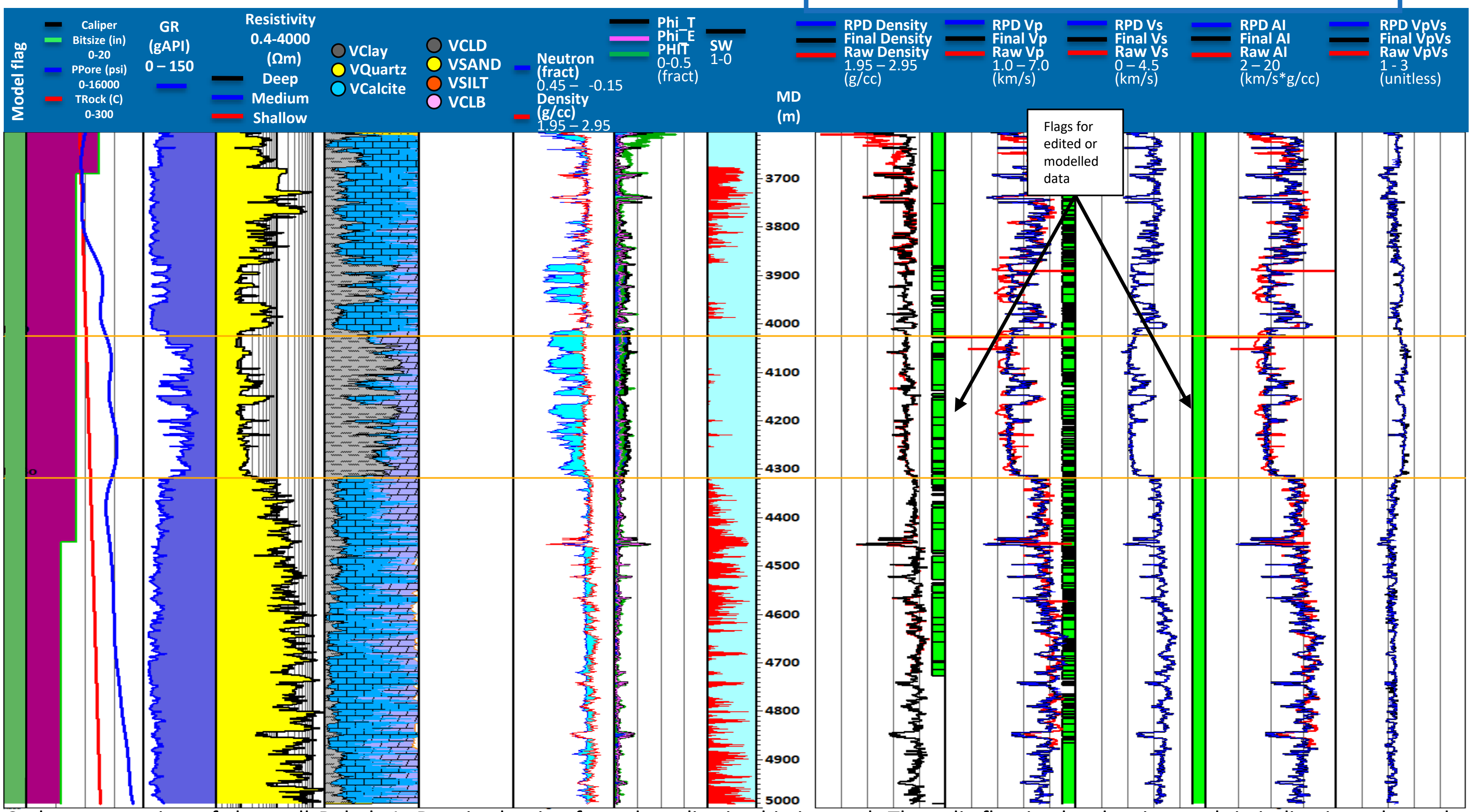
Rebab-1 Geophysical Well Log Analysis (GWLA)
Carbonate section, Interval from 3610m to 5000 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



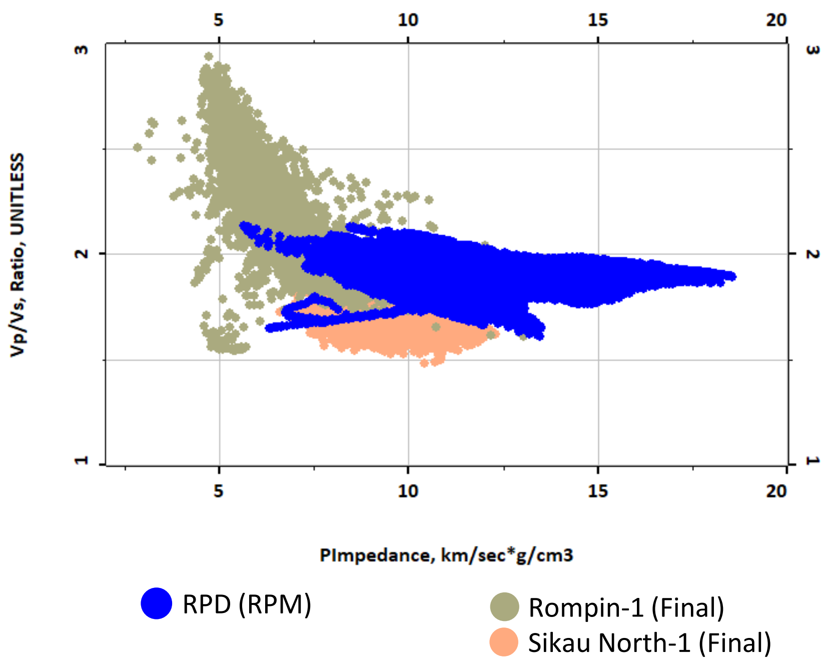
Carbonate section of the well Rebab-1. Density log is of good quality in this interval. The edit flag in the density track is indicating where the density log was depth shifted to align with other logs. The shear velocity was completely estimated.

Rebab-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

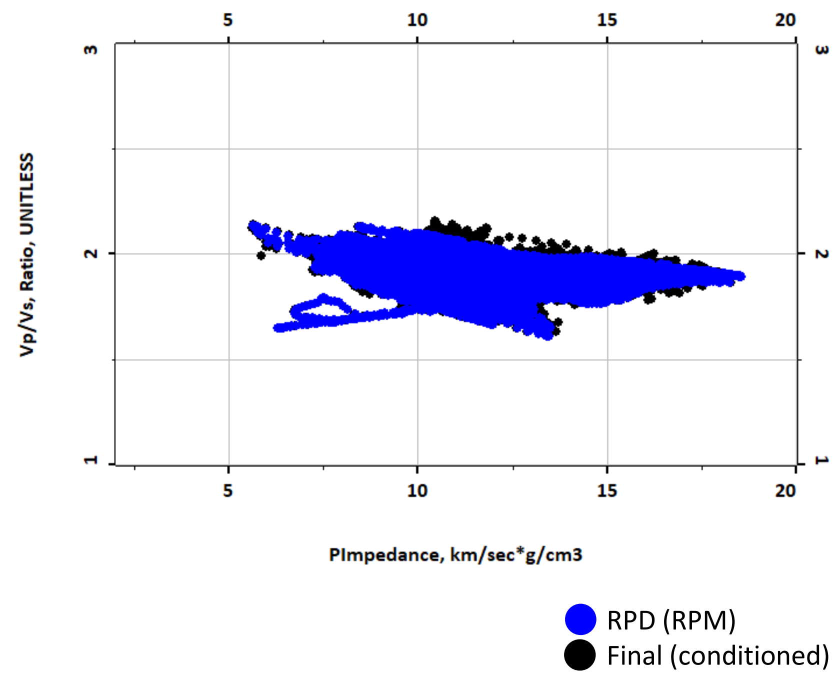
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data. Additional data is presented from nearby well Sikau North and Rompin-1, which is relatively far.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

Raw data & RPD



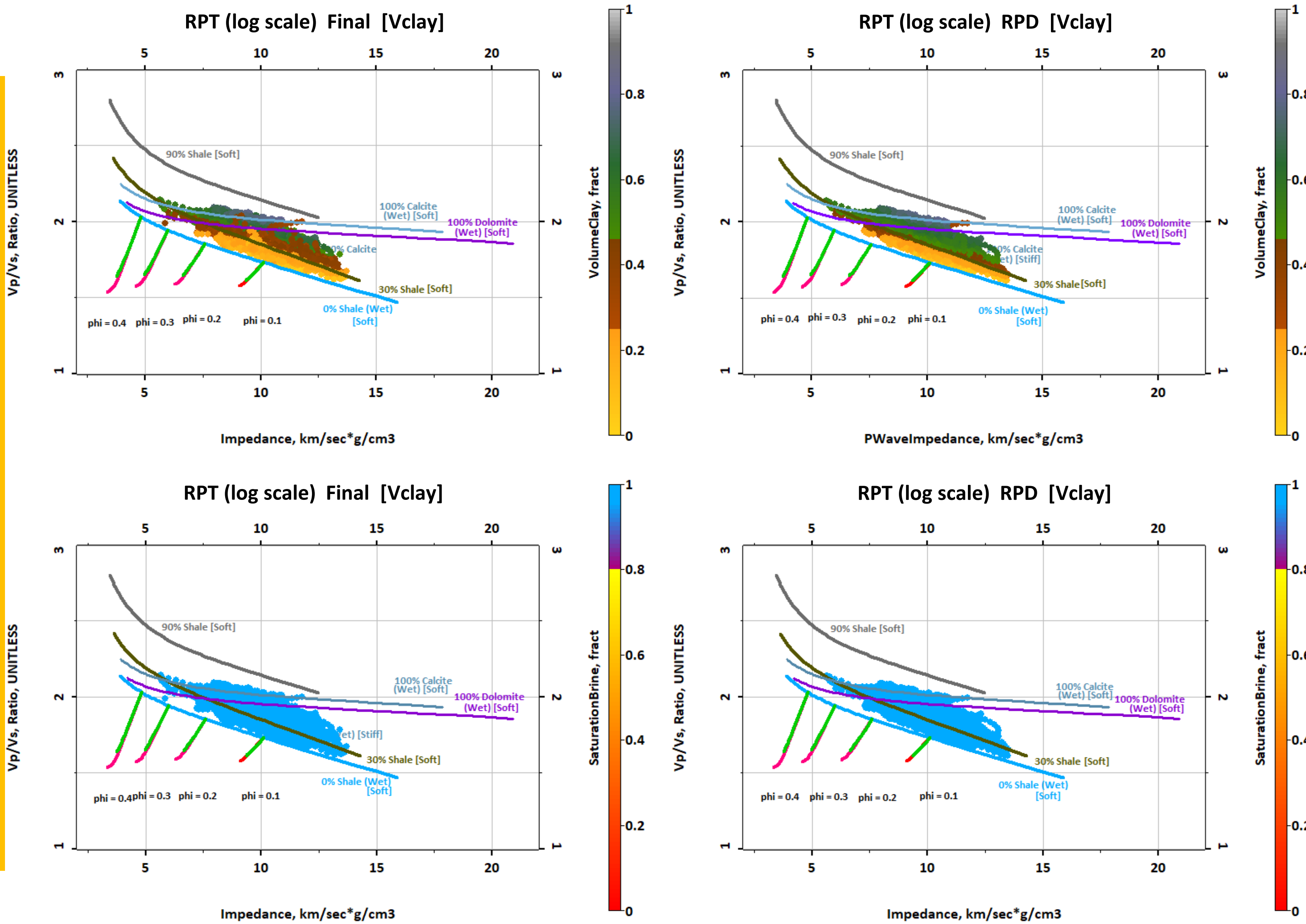
Final data & RPD



Rebab-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Clastic Section (2000m-3610m)

RPT cross plot shows the correlation between the rock physics model lines (soft sediment model) compared to both the final elastic data to the left and the modelled data to the right, color coded by clay volume and water saturation.

Final conditioned data

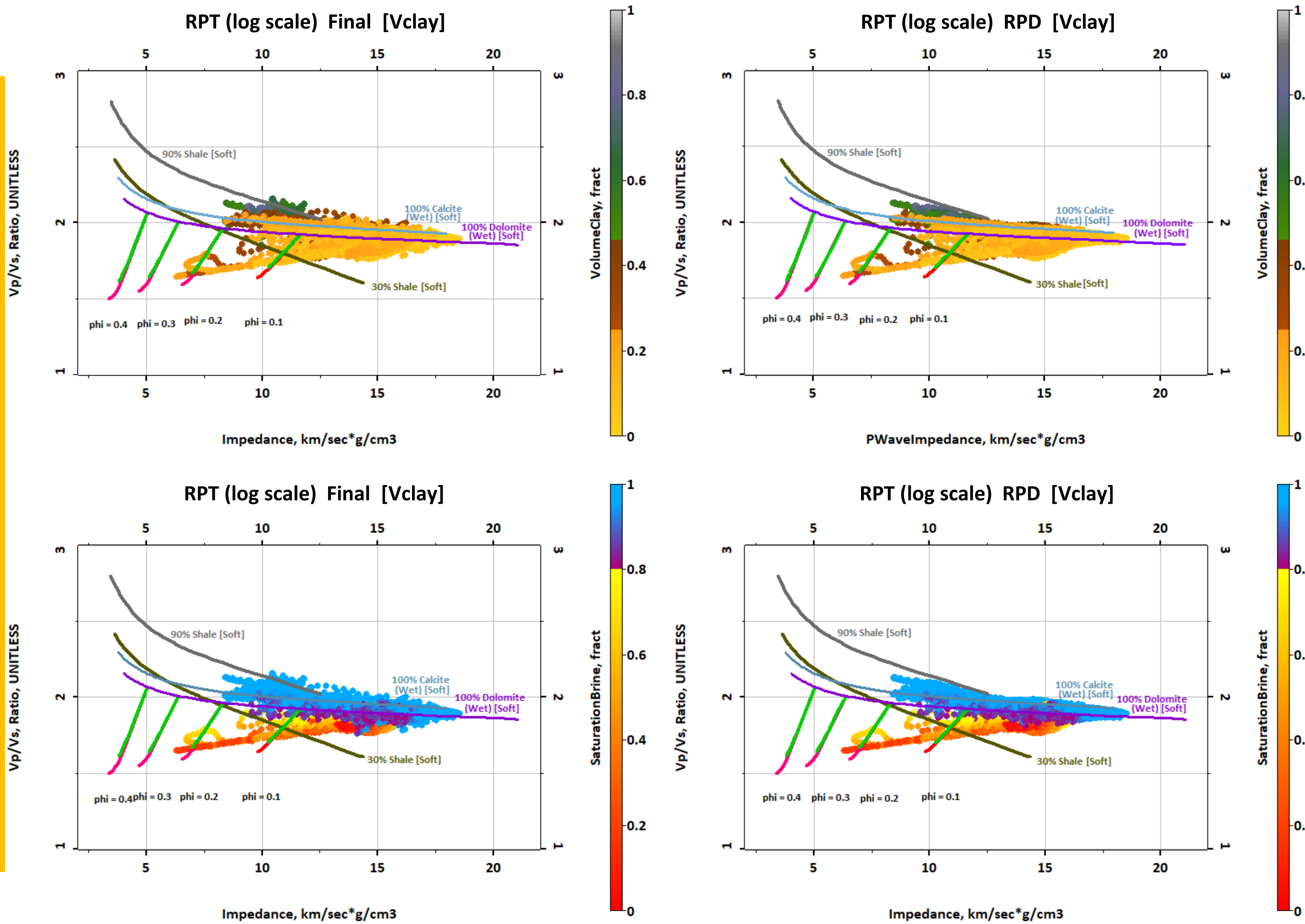


RPD(Modelled)data

Rebab-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Carbonate Section (3610m-5000m)

RPT cross plot shows the correlation between the rock physics model line s(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right, color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Rebana-1

Rebana-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Petrophysical interpretation and edited elastic curves are provided by Petronas. The final RSI curves are from the following provided curves (RSI curves in bold): VClay = VCL_QIRPM/(1-PHIT_QIRPM); SW = SWT_QIRPM; DTC(S)_ORG = DTCOMP(SH)_ED_QIRPM; RHOB_ORG = DENB_ED_QIRPM. In general, data quality appears strong. Density, compressional and shear velocities are available from 512m-2951m. Additionally the Petronas QI Rock Physics Model curves are also provided, though RSI performed individual model calibration and curve generation for rockAVO purposes.

Clay volume (VClay):

- VCL_QIRPM is provided by Petronas, though RSI models require VClay as a fraction of the rock matrix rather than the bulk rock therefore final VClay = VCL_QIRPM/(1-PHIT_QIRPM).

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Cycle II, III, and VI sandstones interbedded with claystones and a Cycle V carbonate.

Volume of hydrocarbons:

- Some low gas saturations are present throughout the well, in accumulations less than 0.5m and less than 50% saturation.

Water saturation (Sw):

- SWT_QIRPM has been provided by Petronas and final RSI Sw is mostly equal to SWT_QIRPM. However, there are some very low gas saturations, <5%, in the shallow Cycle VI shales where Sw has been set to 0. The primary reason for this is for the impact the gas has on the rock physics models, leading to very low Vp and Vp/Vs compared to measured data.

Rebana-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both quartz rich and clay rich intervals when compared to the measured data and also when compared to good measured data in the nearby reference wells, and the calcite rich Cycle V carbonate is best represented by the Stiff sediment model. The Petronas QI group RPM curves have been provided as well in order to help guide calibration. There is a distinct shift in the rock response at the Cycle V carbonate and below which translates to the elastic domain. This deeper domain uses a higher coordination number in the reservoir rocks and represents the intermediate stiff sediment model (ISS).

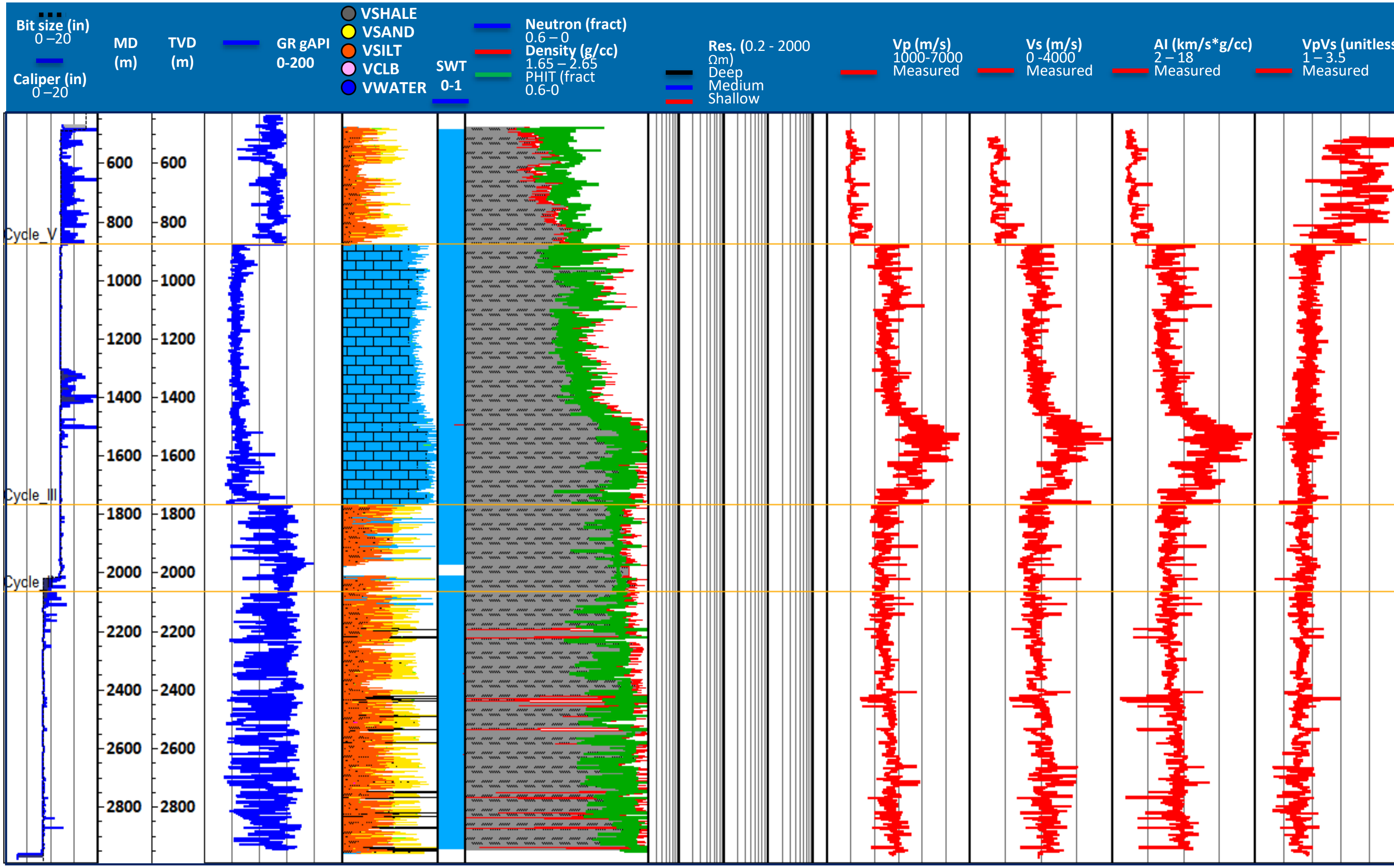
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 19000 ppm [Regional]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Cycle II, III, and VI sandstones and Cycle V carbonate using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination with the brine sands.
- At in situ conditions the Cycle VI sandstones show a strong Class I response for the wet case and Class II/IIP with crossover around 35°. Increasing the porosity generates a zero intercept Class II AVA response in the hydrocarbons. The Cycle V carbonate shows a strong Class I AVA at in situ conditions with poor fluid discrimination – increasing porosity leads to a Class IIP response in the hydrocarbons with crossover at 25-30°, with improved fluid discrimination.

Rebana-1 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

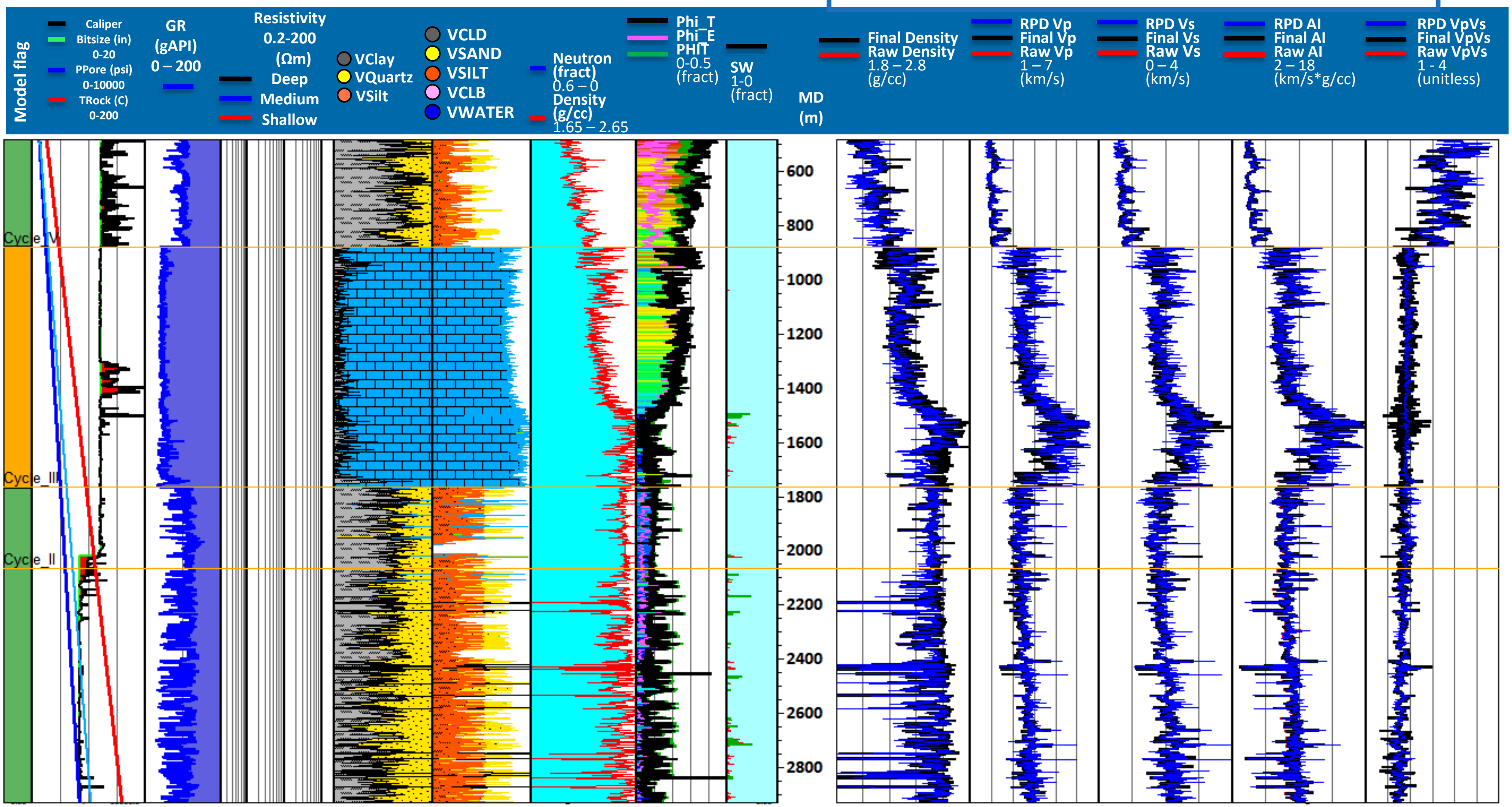
Rebana-1 Geophysical Well Log Analysis (GWLA) – Full Well

model type flag

- Unconsolidated rock model
- Stiff rock model

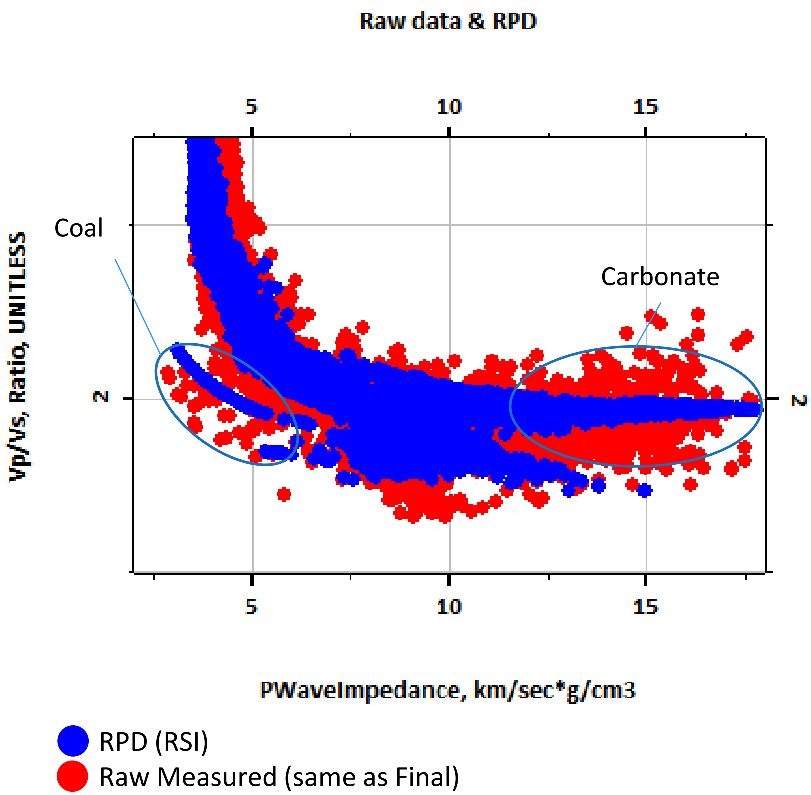
Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

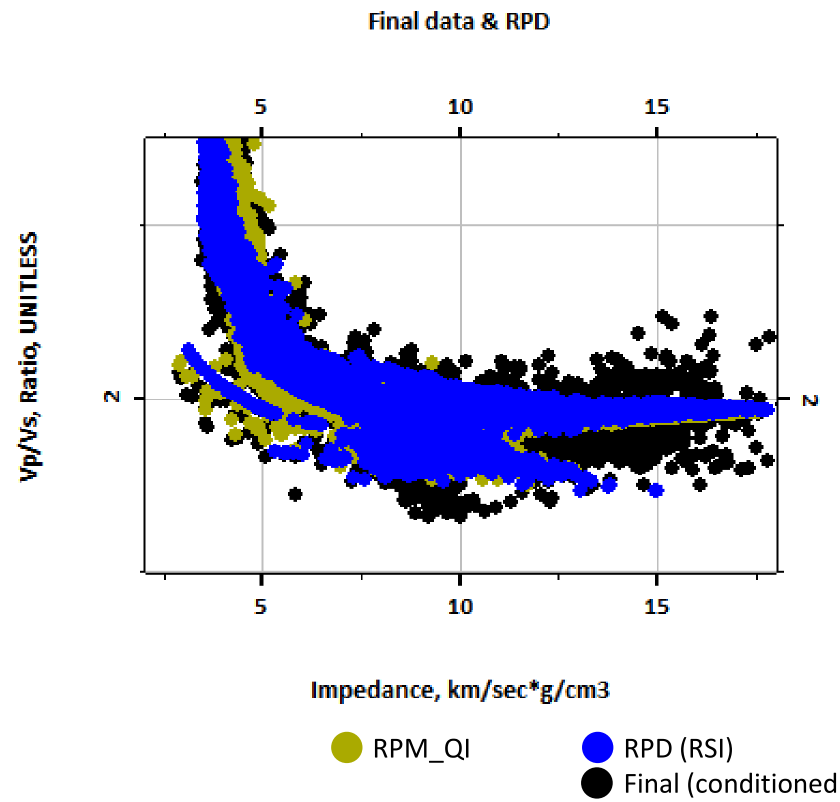


Rebana-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the “measured” data (same as final data – could have edits).



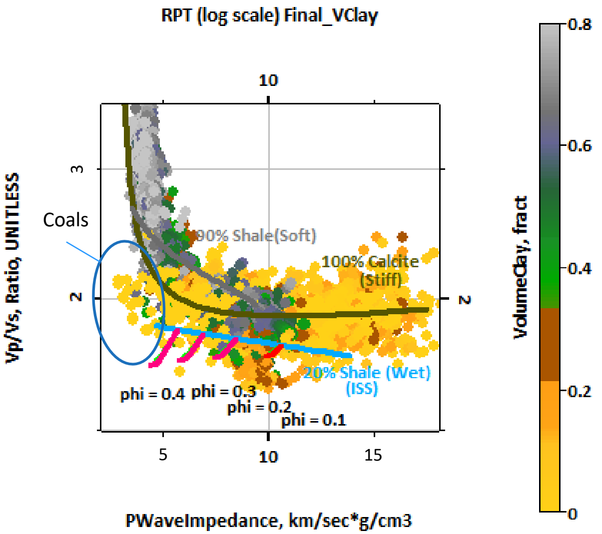
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

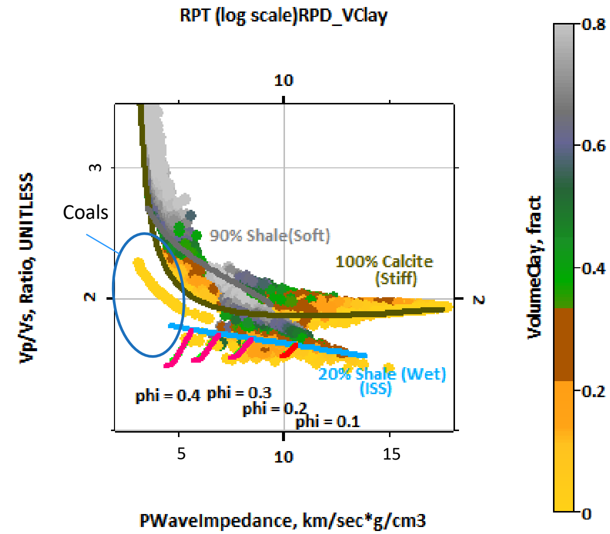


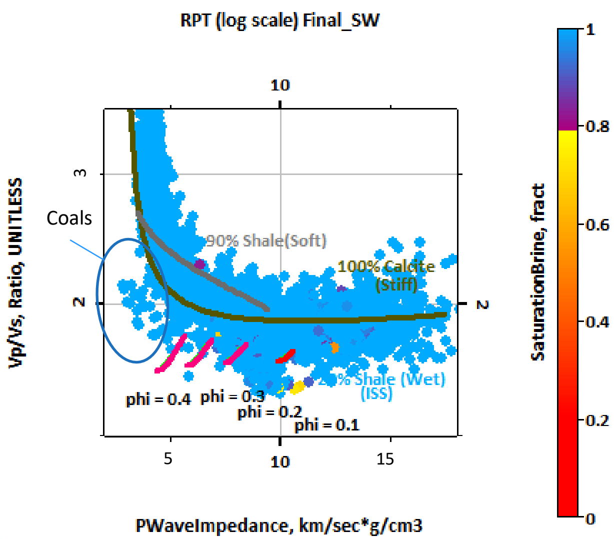
Rebana-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

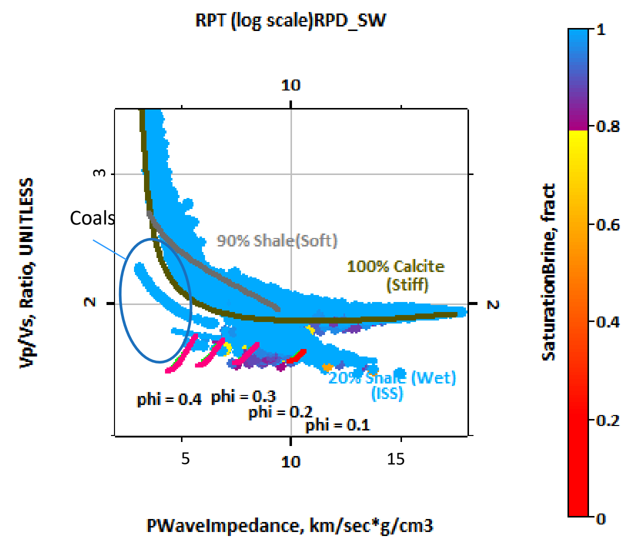
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Rompin-1

Rompin-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- Data quality is very good in this well and is a reliable source for the elastic responses present in this location, including the shear data. Most of the well log suite runs in the 460-1830 m interval.
- Density measurements are of very good quality. No edits were applied in this log. The density was completed by simple linear interpolation in the gap section present at 1050 m. No other method could be applied since there is no data of any kind present in that interval. Edition was made with the goal in mind not to introduce any seismic event in the section.
- Vp log quality is very good. Minor editions were applied in the shallower depth interval going from 460 m to 1000 m. The Vp was completed by simple linear interpolation in the gap section present at 1050 m. No other method could be applied since there is no data of any kind present in that interval. Edition was made with the goal in mind not to introduce any seismic event in the section.
- Vs log quality is very good. Minor editions were applied in the shallower depth interval going from 460 m to 1000 m. The Vs was completed by simple linear interpolation in the gap section present at 1050 m. No other method could be applied since there is no data of any kind present in that interval. Edition was made with the goal in mind not to introduce any seismic event in the section.
- Other logs include, Neutron, Caliper, Deep, Medium and Shallow resistivities.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The proposed well location was optimized to test the proven productive Early Miocene oil sands seen at North Acis-2 in the largest 4 way dip closure in the North Acis structural complex. In addition, the well was planned to look updip the proven productive Middle Miocene oil sands seen at North Acis-1.
- The Rompin-1 well penetrated reservoir quality rock showing multiple stacked hydrocarbon bearing reservoirs between the NA 663 and SK 1950 (541 m to 1272 m) and also in the deeper Rom 1705 m at 1741 m MD. Well Rompin-1 showed interpreted porosities generally ranged between 27 and 30% (average 29%) in the shallower sections and a slightly decreased range of porosities ranging from 15 to 30% (average 24%) in deeper sections.

Volume of hydrocarbons:

- Several sands in the well has been interpreted as oil and gas bearing, particularly in the upper sections of the well from 1230 m to 1260 m. In this interval gas saturated intervals showed a saturation of 85% or more. Oil interpreted intervals in the interval 1090 m to 1110 m showed saturations of 60% or more.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=2. Water resistivity used to interpret Sw: Rw=0.24 ohmm @ 75 C (11,000 ppm).

** Depths referred in this report are MD.

Rompin-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both clay rich and sand facies.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken in a near by well (SPAOH-1), particularly the gas properties. Average values were taken from nearby wells for oil properties. Main parameters used in this modelling are:

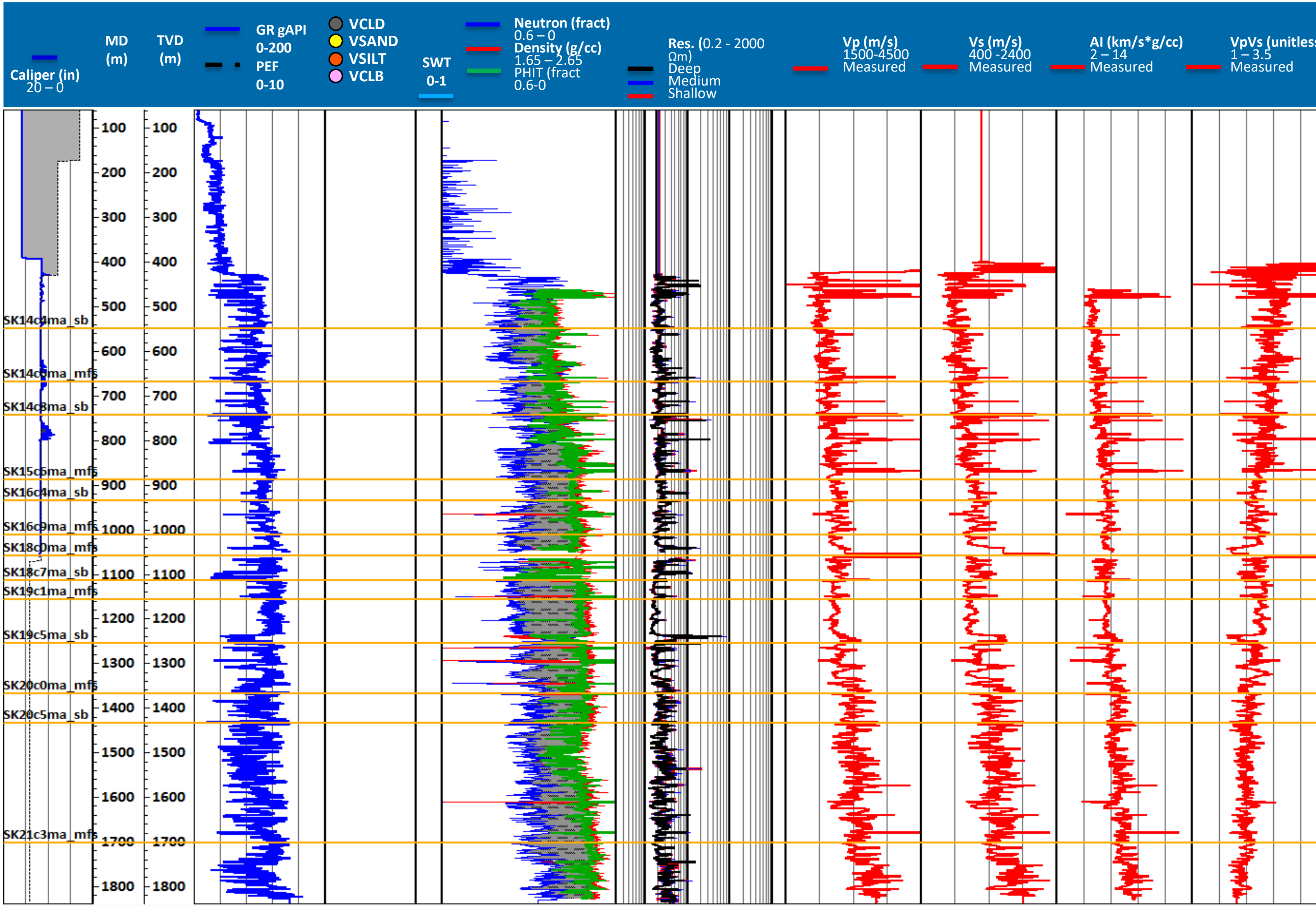
- Brine salinity: 11,000 ppm
- Gas gravity: 0.7 (PVT report SPAOH-1)
- Oil Gravity: 44.4 API (Average value based on nearby data)
- Gas / Oil ratio: 178 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the Miocene Cycle V sands.
- The standard Gassmann's fluid substitution method was used to perturb the different modelling scenarios.
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Hydrocarbon sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale.

** Depths referred in this report are MD.

Input Logs – Rompin-1



Additional data includes, pressure data, temperature data and well reports.

Rompin-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m

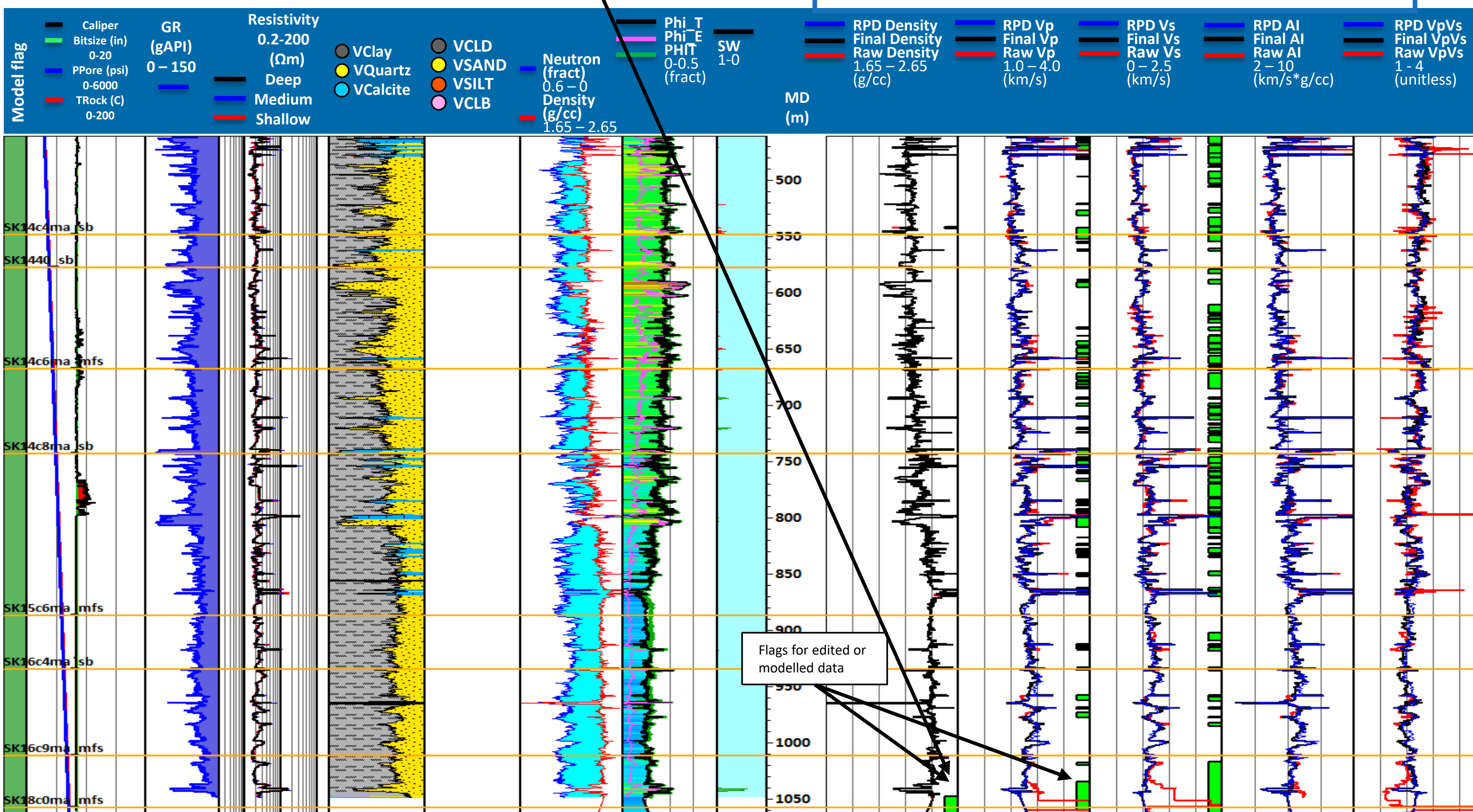
model type flag

- Unconsolidated rock model
- Stiff rock model

Gap editing was performed by simple interpolation taking care not to create any seismic event

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Very few editions have been performed in the section running from top of well to 1050 m. Data is considered of good quality. Elastic logs in the gap section at 1050 m have been linearly interpolated given there is no data available.

Rompin-1 Geophysical Well Log Analysis (GWLA) – Interval from 1050 to Well Bottom

model type flag

Unconsolidated rock model

Stiff rock model

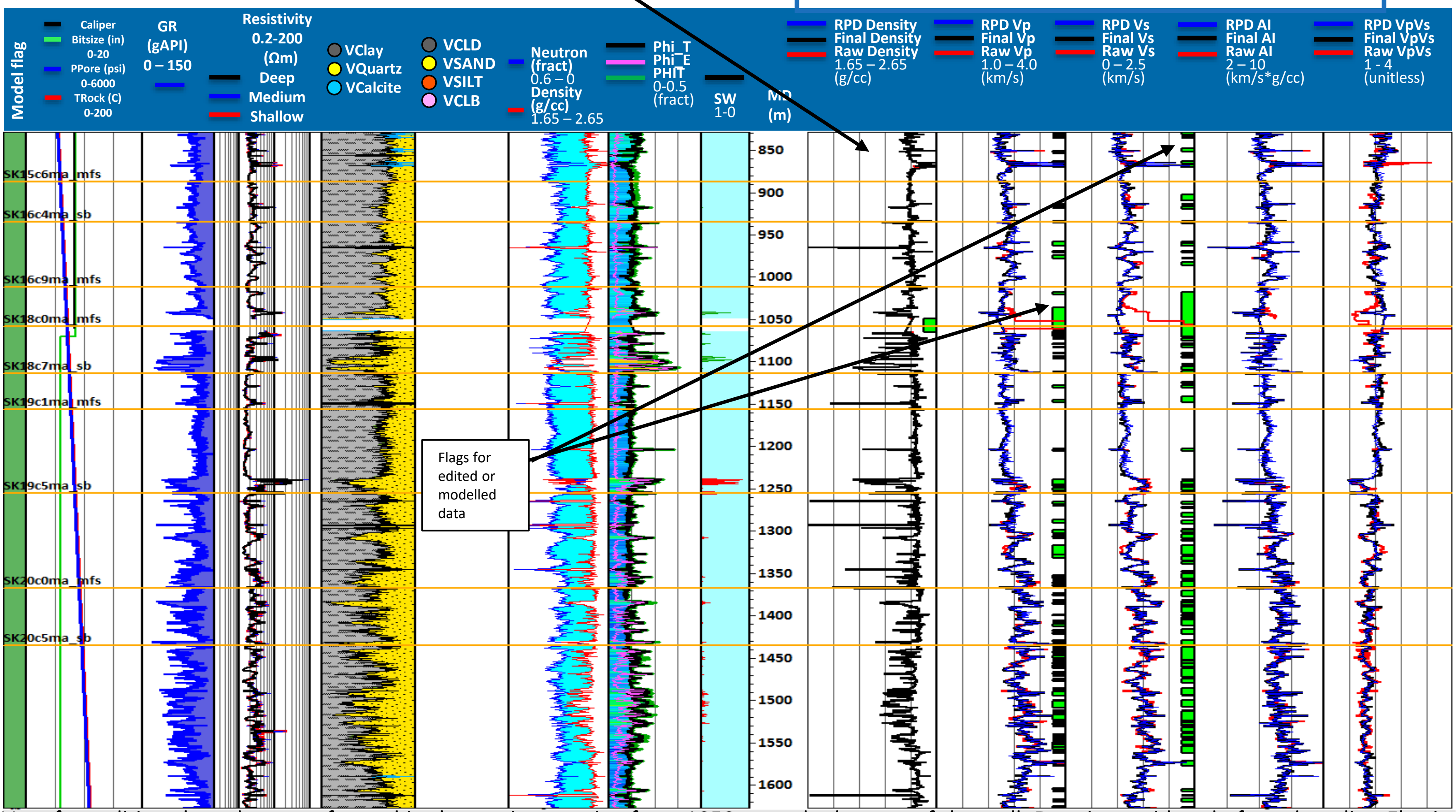
Gap editing was performed by simple interpolation taking care not to create any seismic event

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve

Final edited (Conditioned) curve

Original Raw (Raw) curve

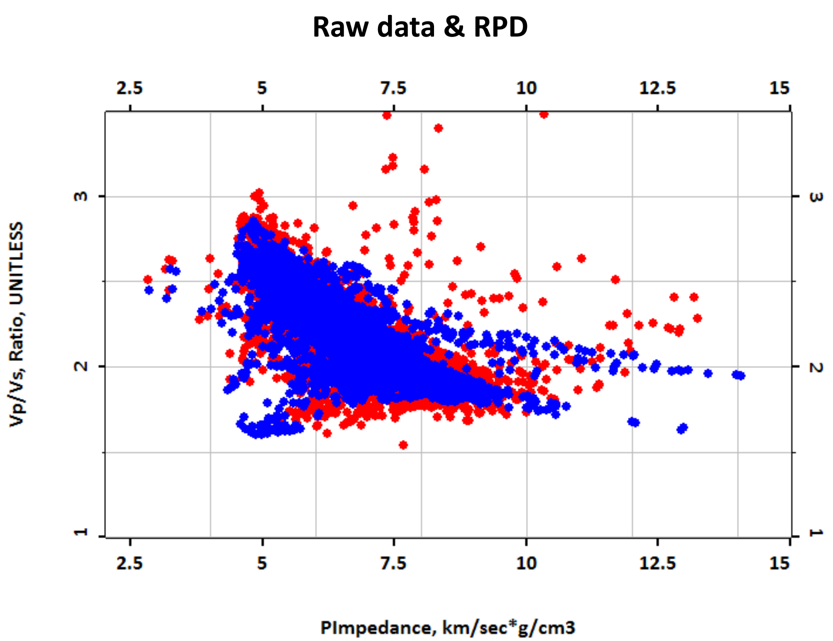


Very few editions have been performed in the section running from 1050 m to the bottom of the well. Data is considered of good quality. Elastic logs in the gap section at 1050 m have been linearly interpolated given there is no data available.

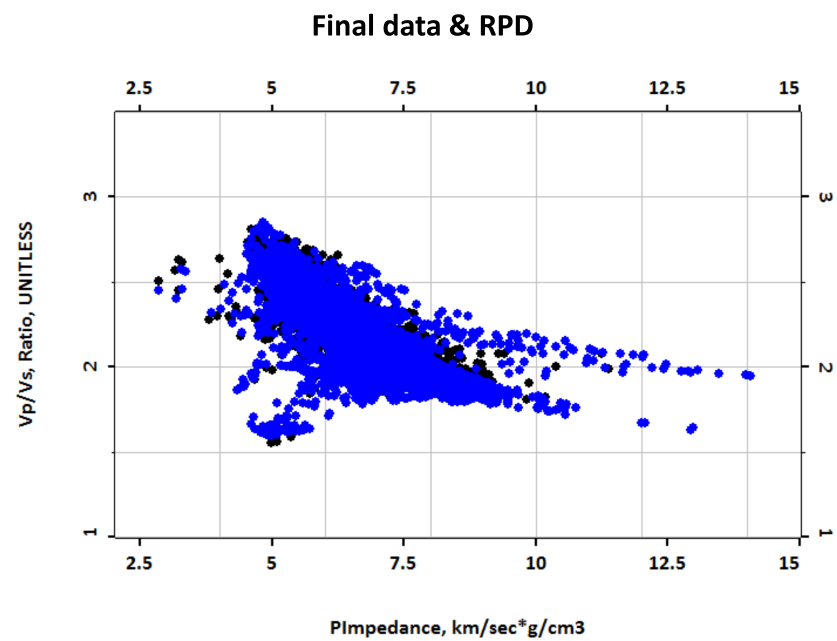
Rompin-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)

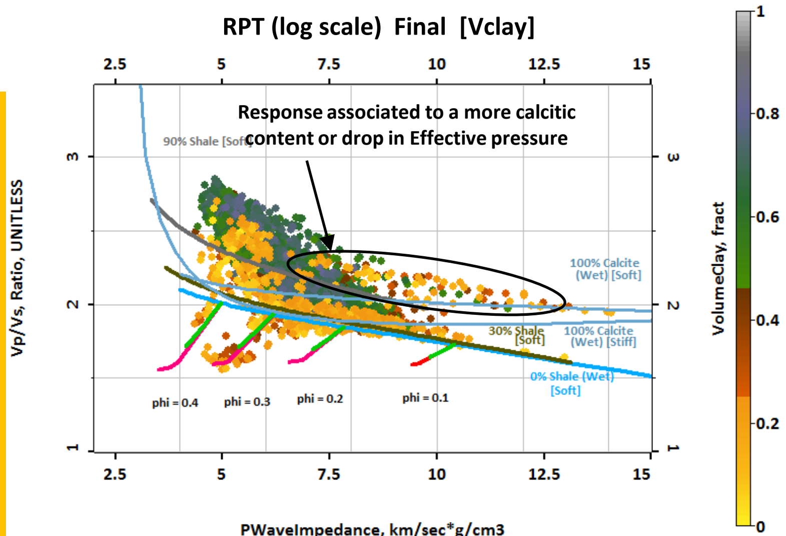


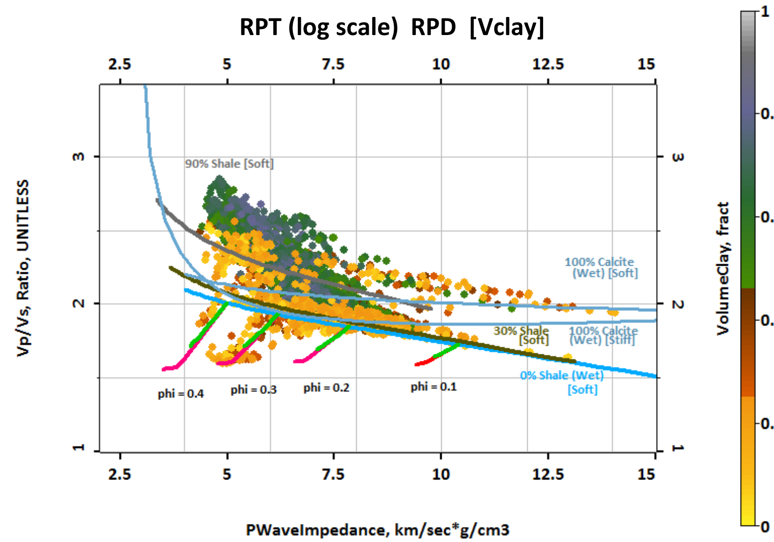
RPD (RPM)
Final (conditioned)

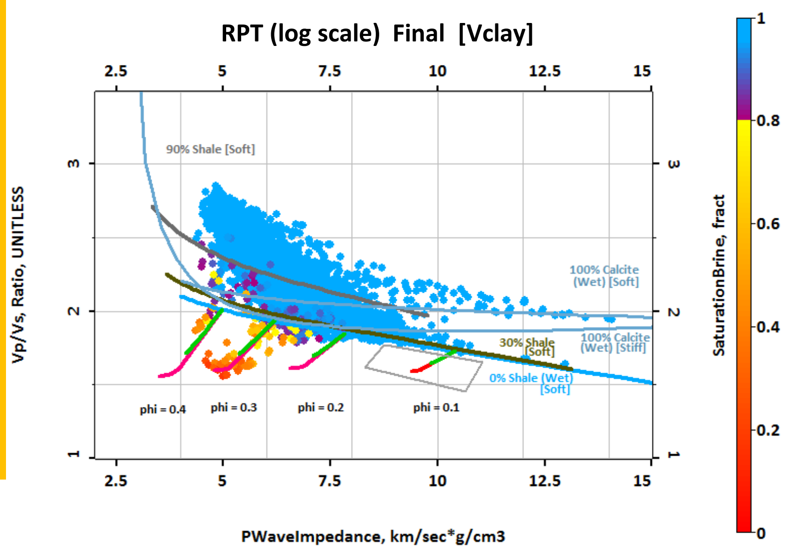
Rompin-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

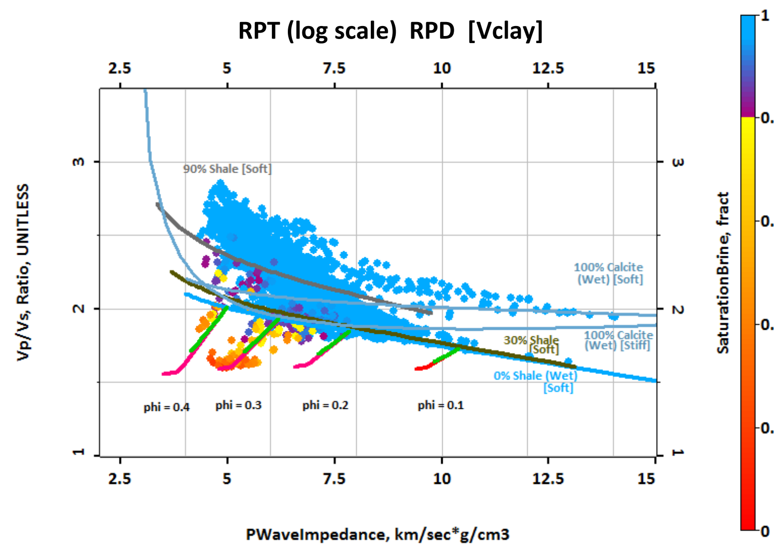
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Serunai-1

Serunai-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair to good and it has lower frequency content in compressional and shear velocities than those present in the density log. Elastic Data is available from around 2200m to 3600 m **.
- Density measurements are of good quality in general and was edited where it was determined it is affected by borehole conditions.
- Vp log quality is considered good, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies.
- Vs was not measured in this well and it was completely estimated using rock physics model.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities. Some other logs cover broader depth intervals, starting from 1200m.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The Serunai-1 well main targets were sands of cycle IV, Upper Cycle III and Cycle II, being the Limestones of Cycle I a secondary target. The interpreted section presents fair sand packages development, and a porosity reduction trend is observed with depth. The well presents low porosity values in general. Porosity values of up to 15% have been interpreted in shallower sections of the well. In general the values are below this value.

Volume of hydrocarbons:

- Several intervals in the carbonate section were interpreted as containing little amount of gas. The elastic responses agree more with the presence of gas, this may be due to the low porosity nature of the interval. Interpreted saturation of gas values does not exceed around 20%.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters and water resistivity were calculated by means of Pickett Plot analysis performed in estimated water bearing sands. The analysis gave the following results, a=1, m=2, n=2. Water resistivity used to interpret Sw: Rw=0.09 ohmm @ 242 F (for a salinity ~ 22,000 ppm).

** Depths referred in this report are MD.

Serunai-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies. The soft sediment model also was calibrated for the carbonate section of the well. Data from the clastic and carbonate sections that proved to be of good quality were used to calibrate the rock physics model better suited for this well. A variable depth shift on data used in the modeling was performed to align the measurements to eliminate as much noise as possible.

Fluid properties:

Water and hydrocarbon properties used in fluid substitution have been assumed to be the average of the area where the well was drilled. Water salinity was calculated using Pickett plot analysis. Main parameters used in fluid substitution are :

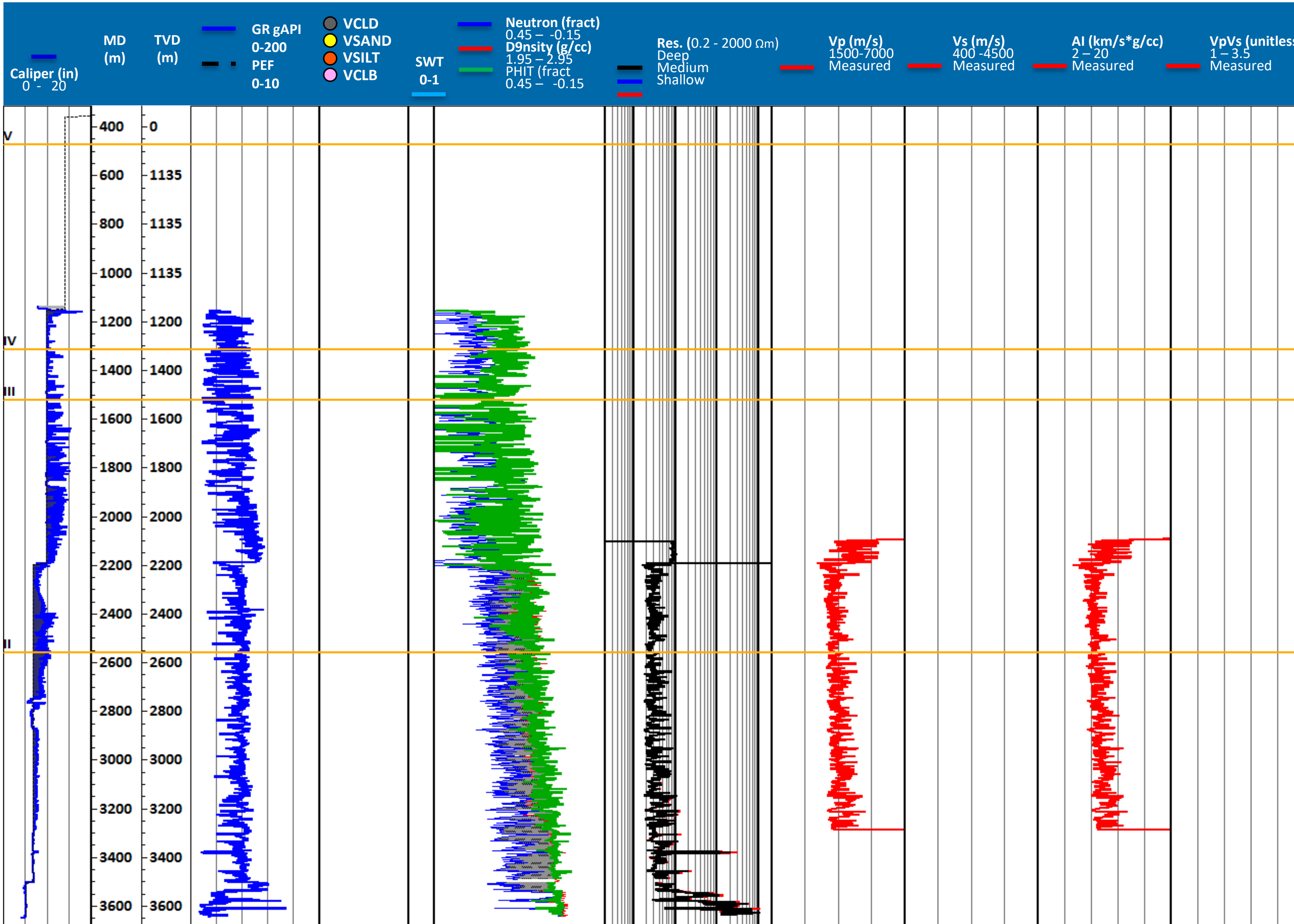
- Brine salinity: 22,000 ppm
- Gas gravity: 0.85 (PVT report SPAOH-1)
- Oil Gravity: 40 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in any of the sand packages appearing along the well. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Brie model.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As in the selected example, the sand package at 3450m (Water bearing sand in Cycle II) was gas substituted allowing the Water saturation to be reduced to 20%. Porosity was preserved for this exercise. This exercise showed lower values for VpVs ratio and lower values for Acoustic Impedance compared to the wet case.

** Depths referred in this report are MD

Input Logs – Serunai-1



Additional data includes mud weight data, pressure and temperature data and well reports. Shear slowness was not measured in this well

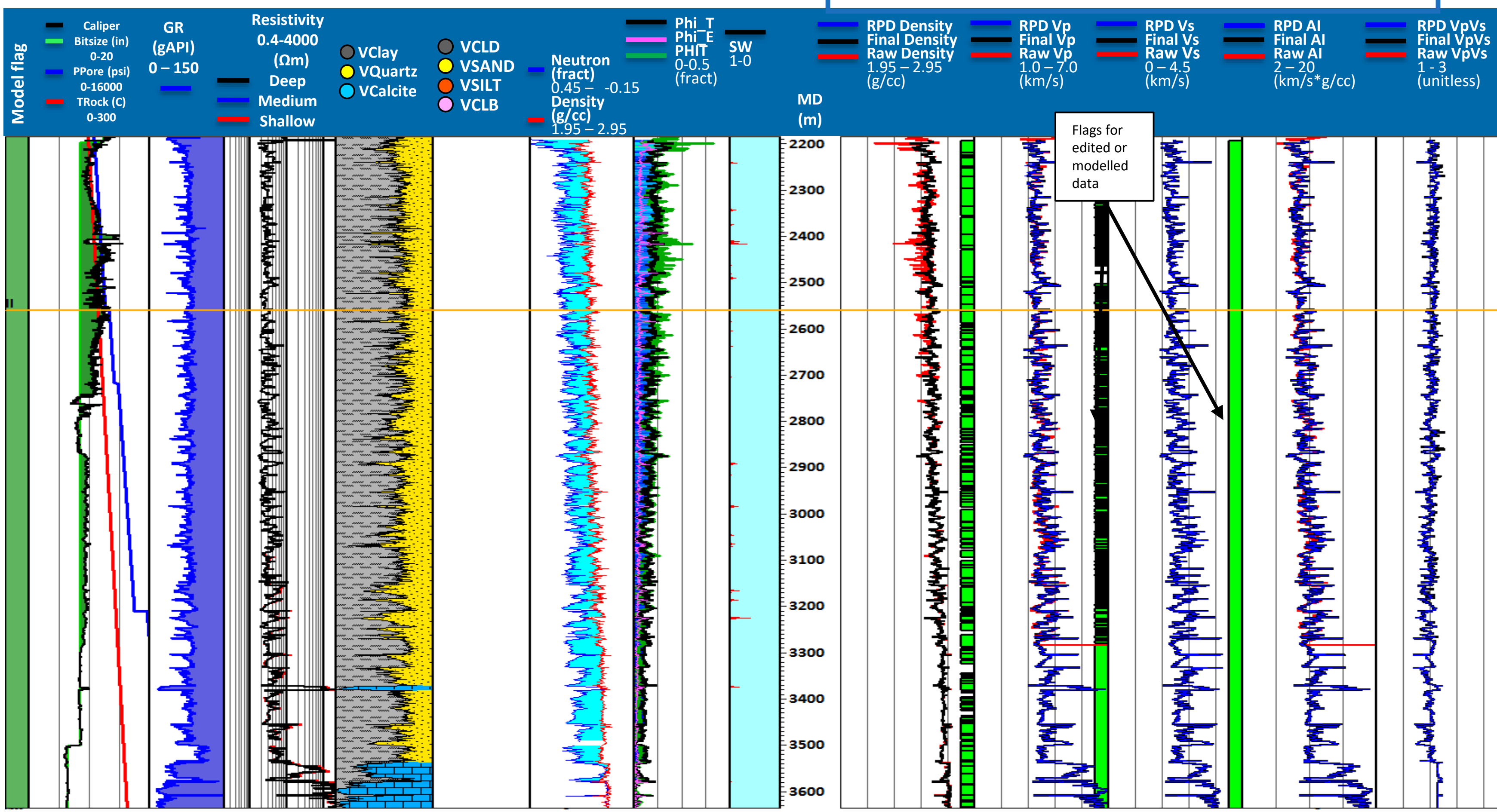
Serunai-1 Geophysical Well Log Analysis (GWLA)
Interval from 2190m to 3640 m

model type flag

Unconsolidated rock model
Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve
Final edited (Conditioned) curve
Original Raw (Raw) curve

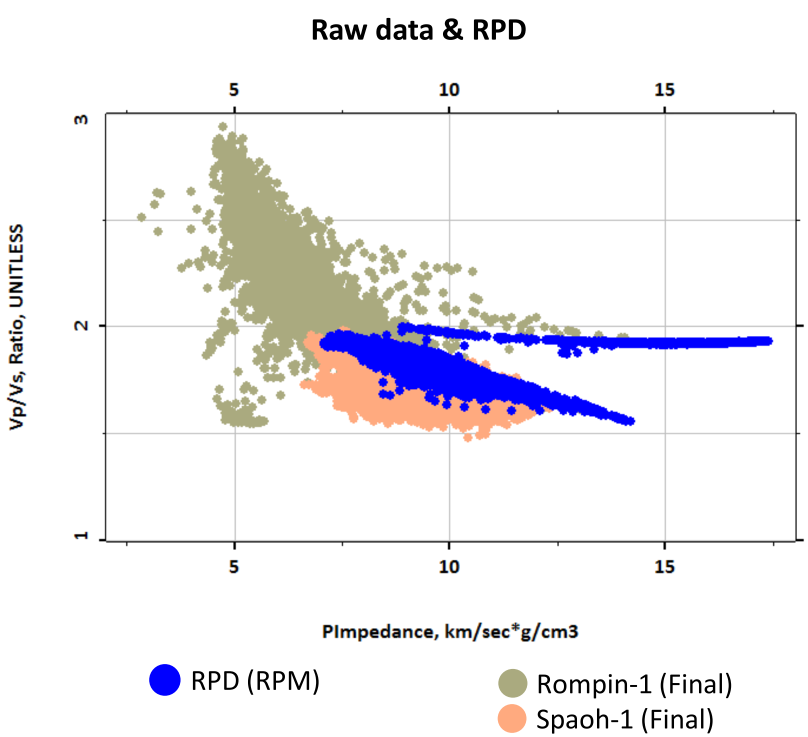


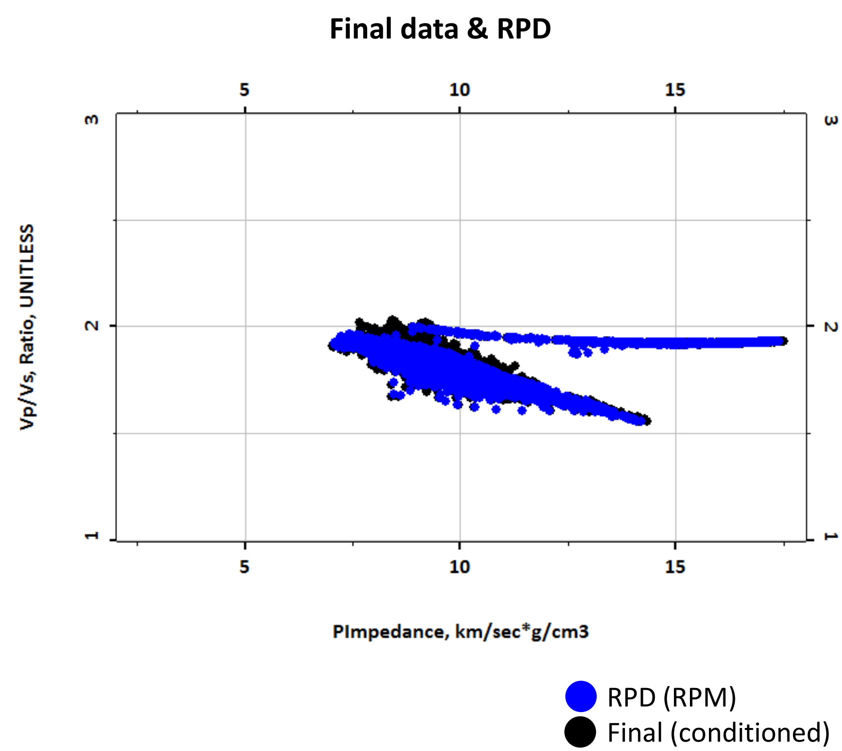
Well Serunai-1 interpretation results. Compressional velocities are of good quality in this interval. The edit flag in the compressional velocity track is indicating where the compressional velocities were depth shifted to align with other logs. The shear velocity was completely estimated. The density log is heavily affected by borehole conditions in shallower sections of the well.

Serunai-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data. Additional data is presented just for reference from wells Sikau North-1 and Rompin-1.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

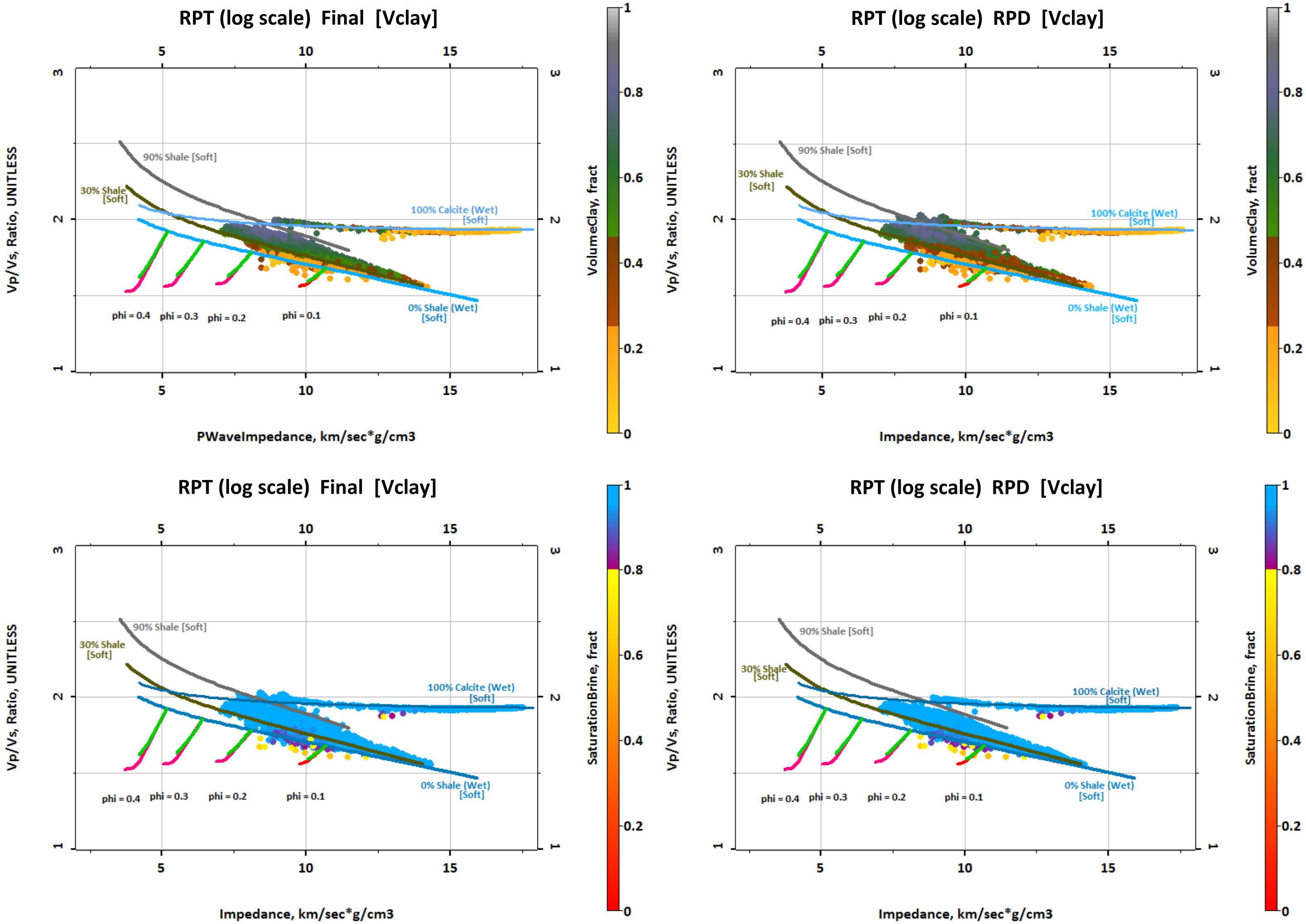




Serunai-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines (soft sediment model) compared to both the final elastic data to the left and the modelled data to the right, color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Sikau North-1

Sikau North-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited using the RPD in the interval(2500-3000m) due to a possible bad hole conditions(no caliber log available).
- Vs was spliced in the interval(2880-3200)with a separate run that match the full original trend (main run) and after VP was corrected in that interval using Greenberg-Castagna relationship.
- The hole encountered a sudden local over-pressure layers starting around 3200m MD causing sudden drop in the velocity, density and resistivity readings.
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight in some intervals with slightly calcareous cement in many intervals, distributed in lobe/channel complexes with come clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well were 100% brine saturated except some hydrocarbon saturation reached to about 50% in two intervals(2839-2843m and 2868-2875m).

Water saturation (Sw):

- Rw used in the well based on the salinity extracted from a nearby well's water sample(21000ppm), Rw found to be 0.11ohm at 212 degF. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=2.2 and Saturation exponent (n)=2 (assumed based on nearby well reports).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(1500m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

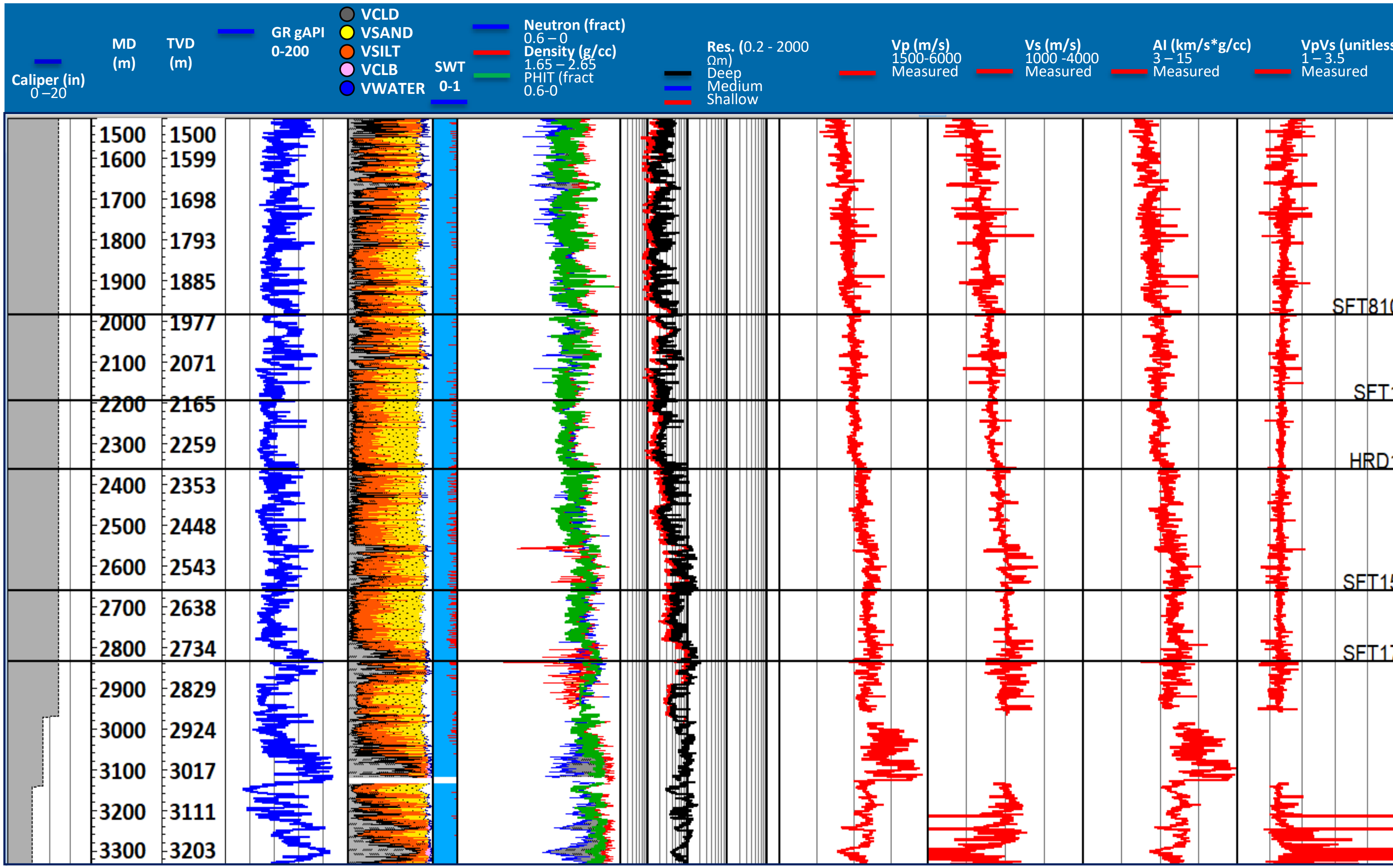
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 21000 ppm[based on nearby Rebab-1 well water sample]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- AVA class II was observed near the hydrocarbon sand @ 2888m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) all fluid cases shows a change to class IV AVO response.

Sikau North-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Sikau North-1 Geophysical Well Log Analysis (GWLA) – Top of elastic logs to 2400m(MD)

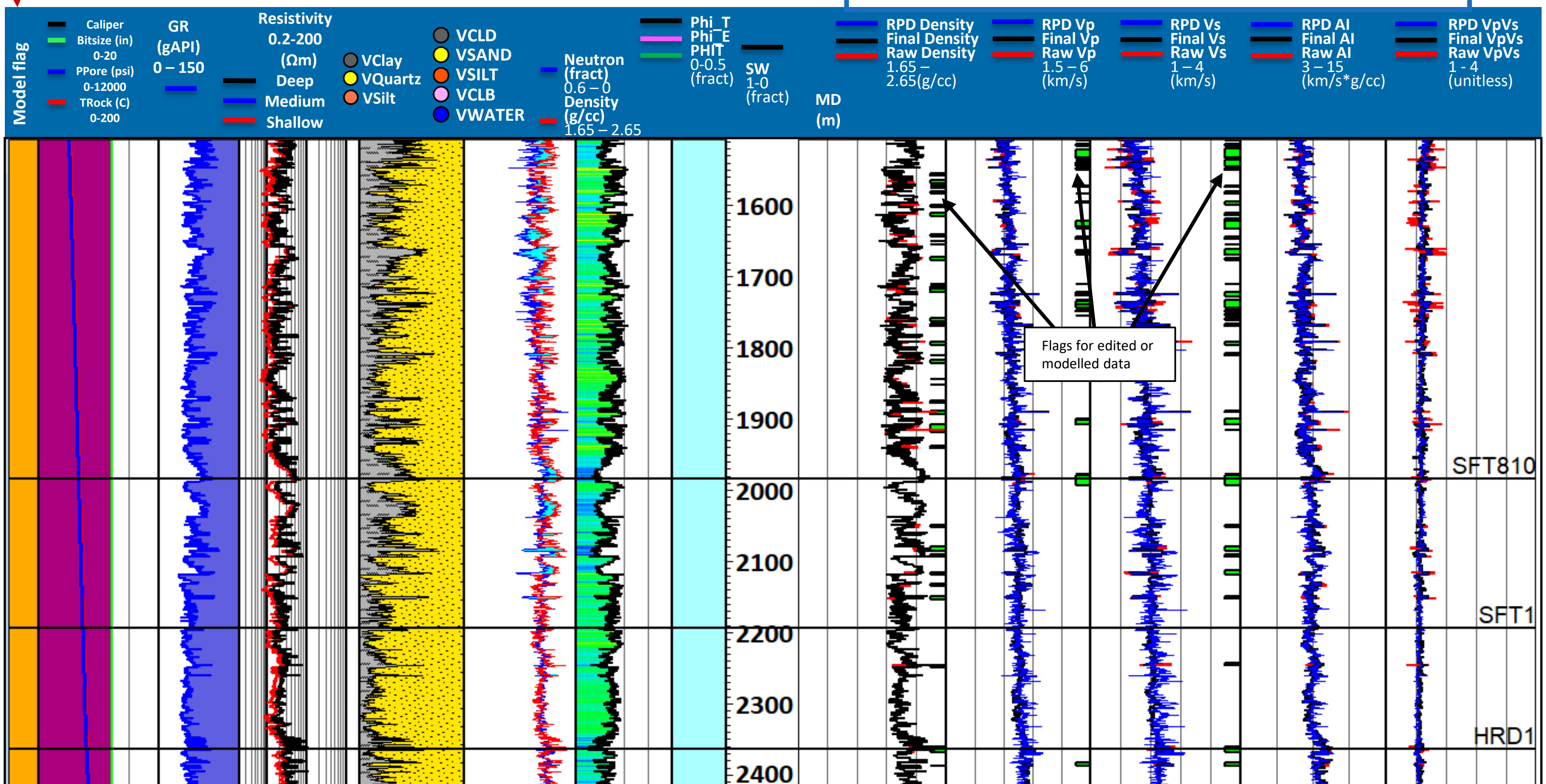
model type flag

- Soft rock model
- Stiff rock model

Above depth of 1500m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Sikau North-1 Geophysical Well Log Analysis (GWLA) – 2400m(MD) to the end of the elastic logs.

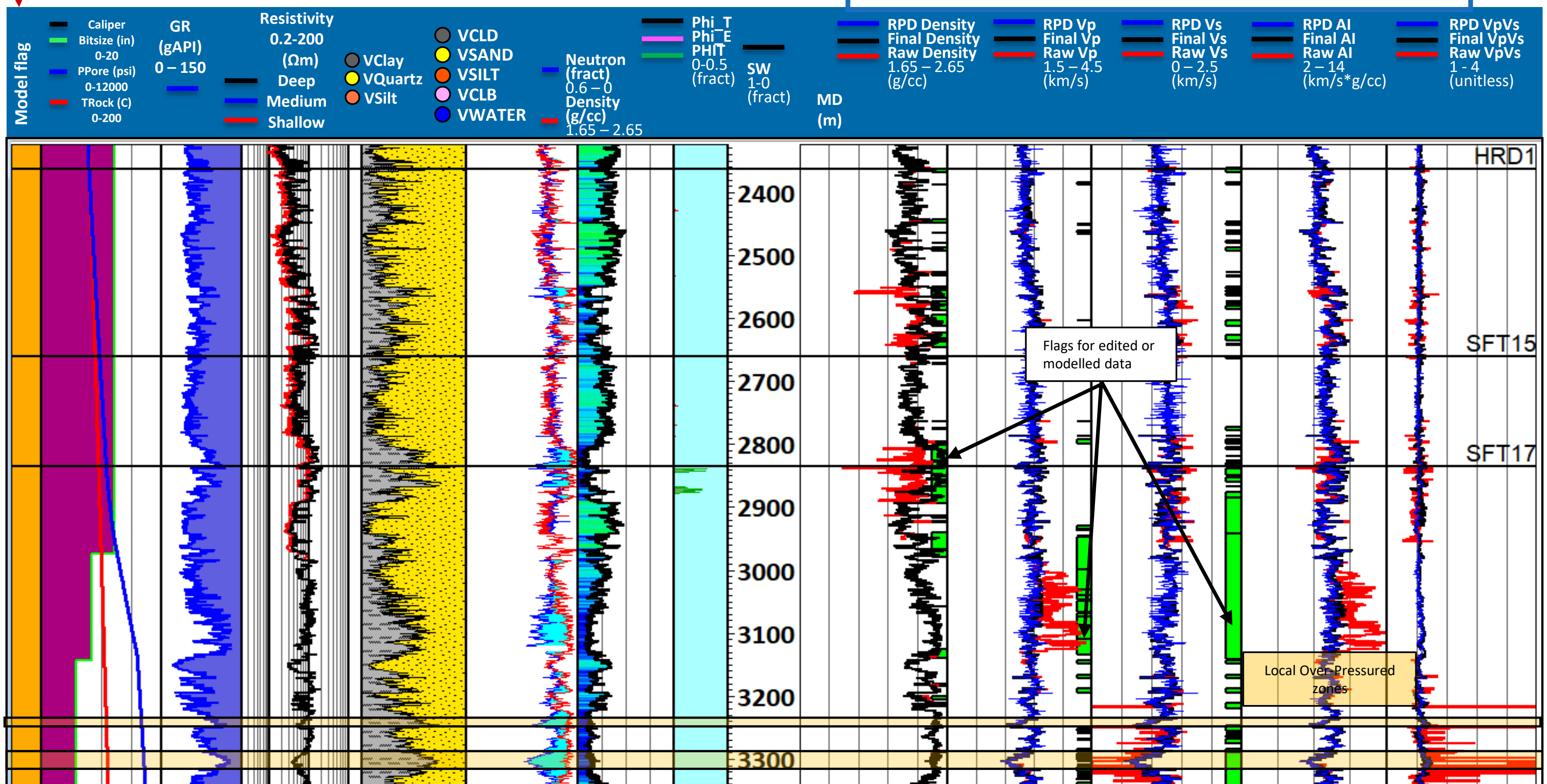
model type flag

- Soft rock model
- Stiff rock model

Above depth of 1500m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

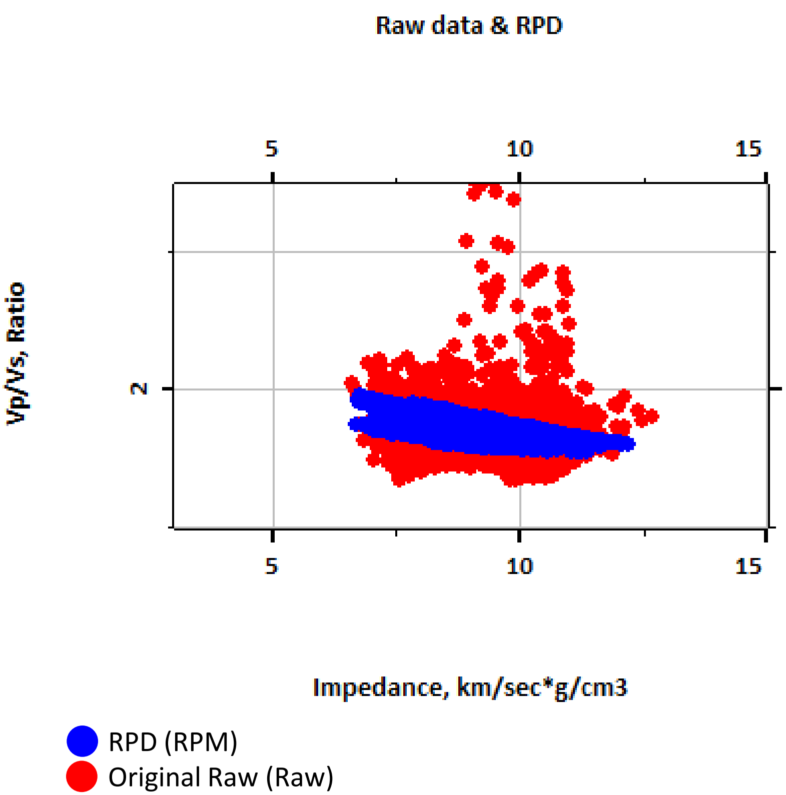


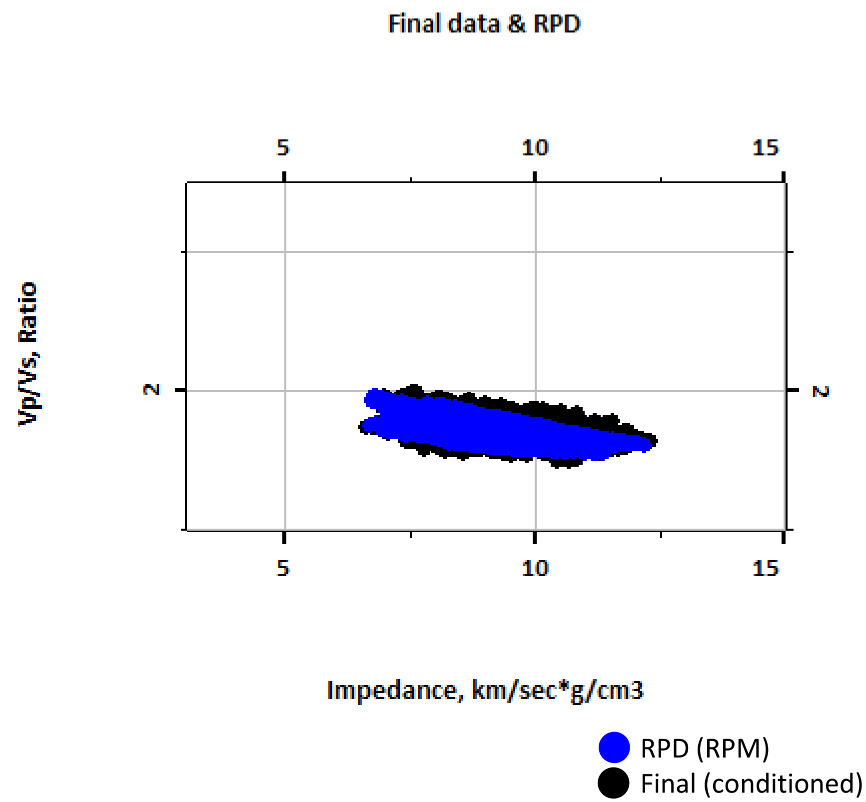
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Sikau North-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

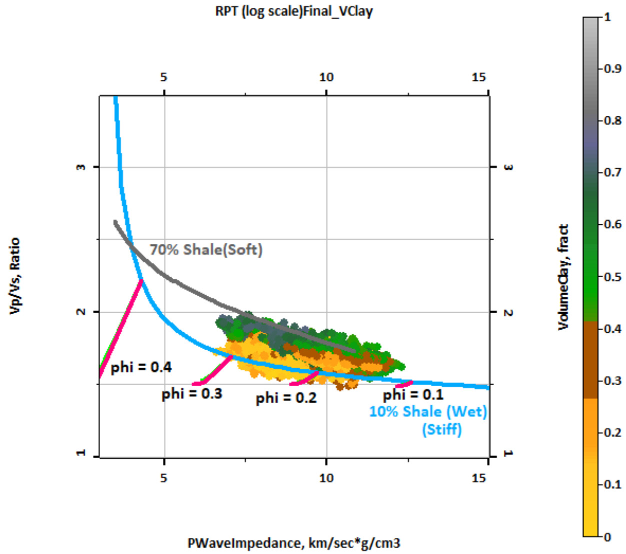


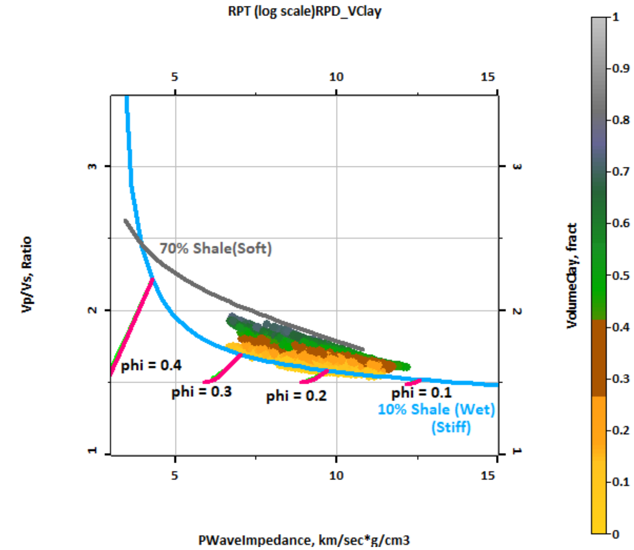


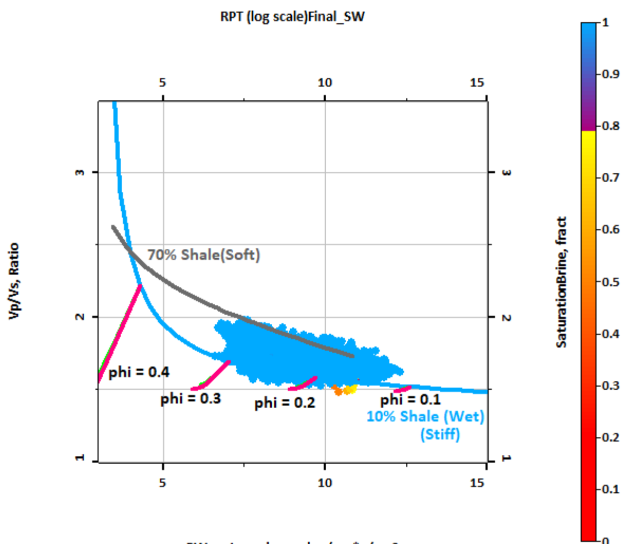
Sikau North-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

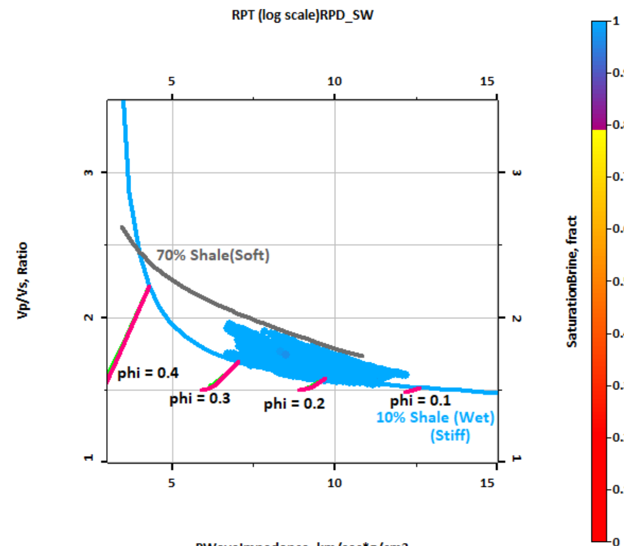
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Siwa-101

Siwa-101 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair and it has lower frequency content in compressional velocity log, than those present in the density log, this may introduce noise in the elastic variables obtained from the rock physics analysis. Most of the well log suites run from 960 m to 1800 m **.
- Density measurements are of good quality in general, minor edits were applied.
- Vp log quality is considered good, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies.
- Vs was not measured in this well and it was completely estimated using rock physics model.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities, and Photoelectric factor.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- There was not any report found for this well. In general the logged interval present many sand intervals, laminated in nature that span the entire well. The porosity variation ranges from about 17% to 25% in the upper sand packages.

Volume of hydrocarbons:

- Several sands in the well has been interpreted as gas bearing, starting in the upper Miri Formation. Gas saturation reach quite high values, reaching values of more than 60% in some intervals.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters and water resistivity were calculated by means of Pickett Plot analysis on several depth intervals, where it was assumed a water bearing rock. The results of the analysis is as follows:

1. Interval: 940m – 962m: a=1, m=n=2. Rw=1.06 ohmm @ 48 C (~ 6,500 ppm).
2. Interval: 1650m – 1663m: a=1, m=1.81, n=2. Rw=0.2941 ohmm @ 68.9 C (~ 25,000 ppm).
3. Interval: 1250m – 1258m: a=1, m=1.81, n=2. Rw=0.2941 ohmm @ 56.8 C (~ 25,000 ppm).

Siwa-101 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that two trends appear in this well. A softer rock interval present in the upper section of the well, going from 800m to about 1070m, and in the rest of the well the rock can be modeled with a Vclay weighted average between Stiff and Soft rock models. Editions were mainly performed to reconciliate frequency content between the density and compressional velocity log.

Fluid properties:

Water and hydrocarbon properties used in fluid substitution have been assumed to be the average of the area where the well was drilled. Water salinity was calculated using Pickett plot analysis. Main parameters used in fluid substitution are:

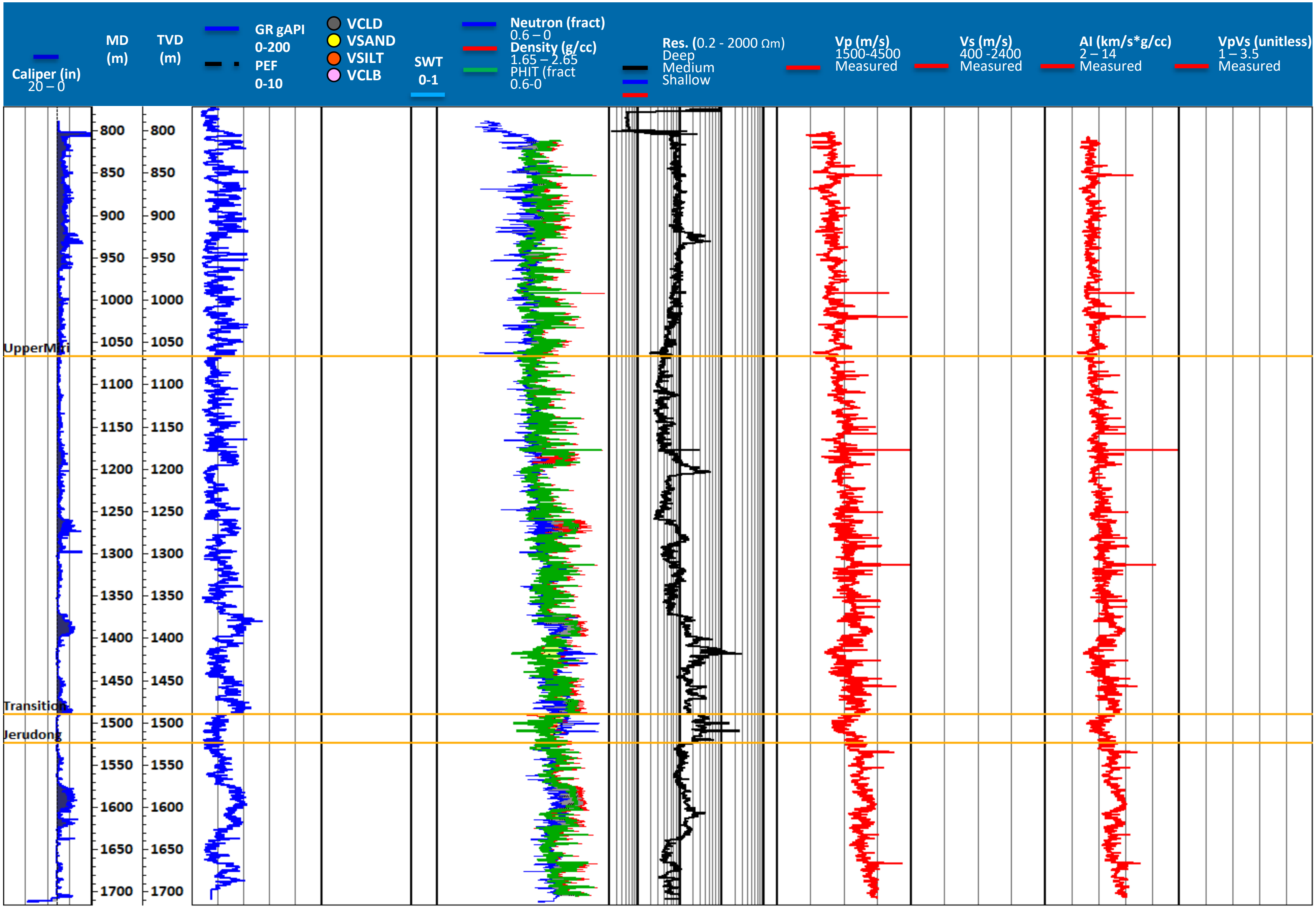
- Brine salinity: 25,000 ppm
- Gas gravity: 0.85 (PVT report SPAOH-1)
- Oil Gravity: 40 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in any of the sand packages appearing along the well. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Gassmann and Brie models.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As an example, the sand package at 1500m (Gas bearing sand in Transition Zone interval) was water substituted allowing the Water saturation to be increased to 100%. Porosity was preserved for this exercise. This exercise showed higher values for VpVs ratio and about the same values for Acoustic Impedance compared to the gas saturated sand (insitu conditions) case.

** Depths referred in this report are MD.

Input Logs – Siwa-101



Additional data includes mud weight data, pressure and temperature data and well reports. Shear slowness was not measured in this well

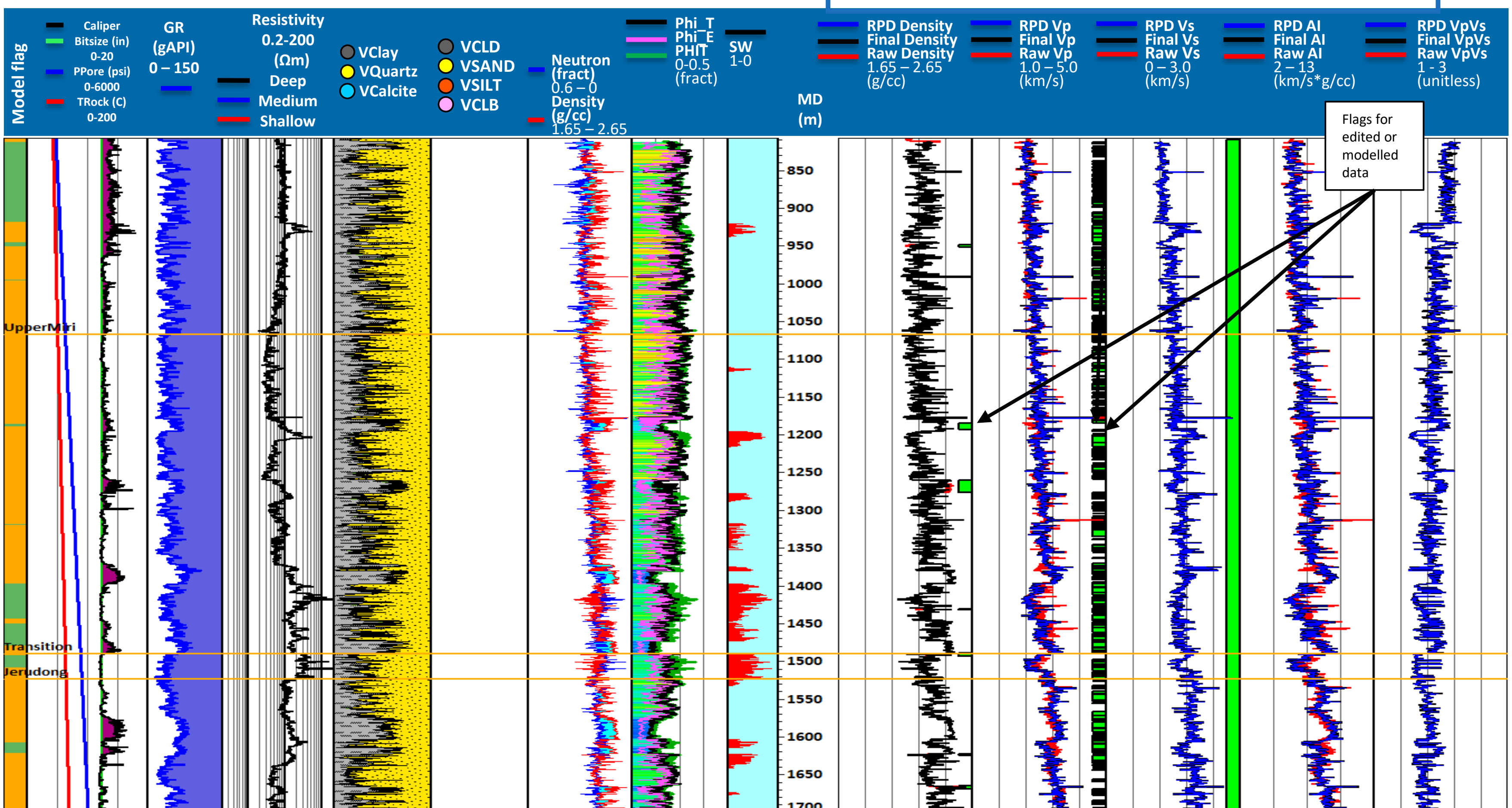
Siwa-101 Geophysical Well Log Analysis (GWLA) – Interval from 800 to 1720 m

model type flag

- Unconsolidated rock model
- Stiff and Soft Weighted averaged by VClay rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

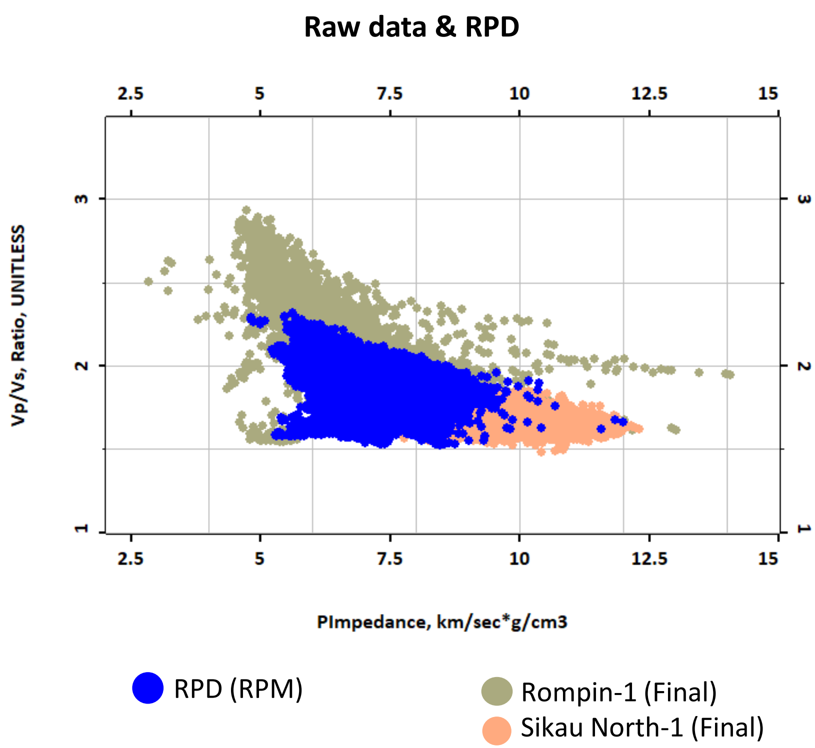


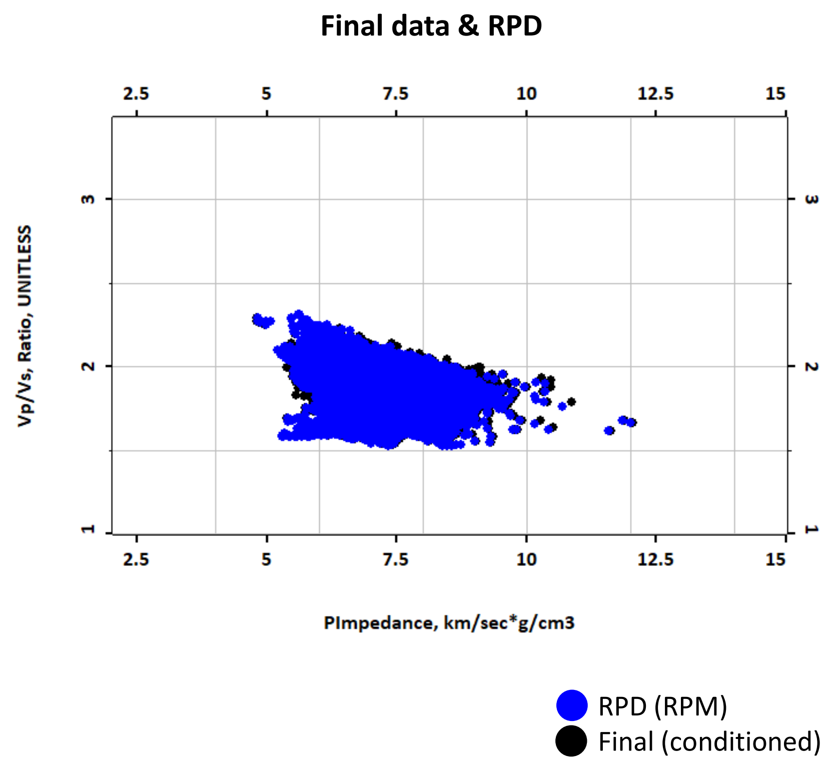
In general data quality is fair and it has lower frequency content in compressional velocity log, than those present in the density log. Editions in compressional velocities were mainly performed from the density log to recover the lost frequencies. Vs has been entirely modelled in the well.

Siwa-101, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data. Additional data is presented from nearby well Sikau North and Rompin-1, which is relatively far. Both wells show analog trends.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



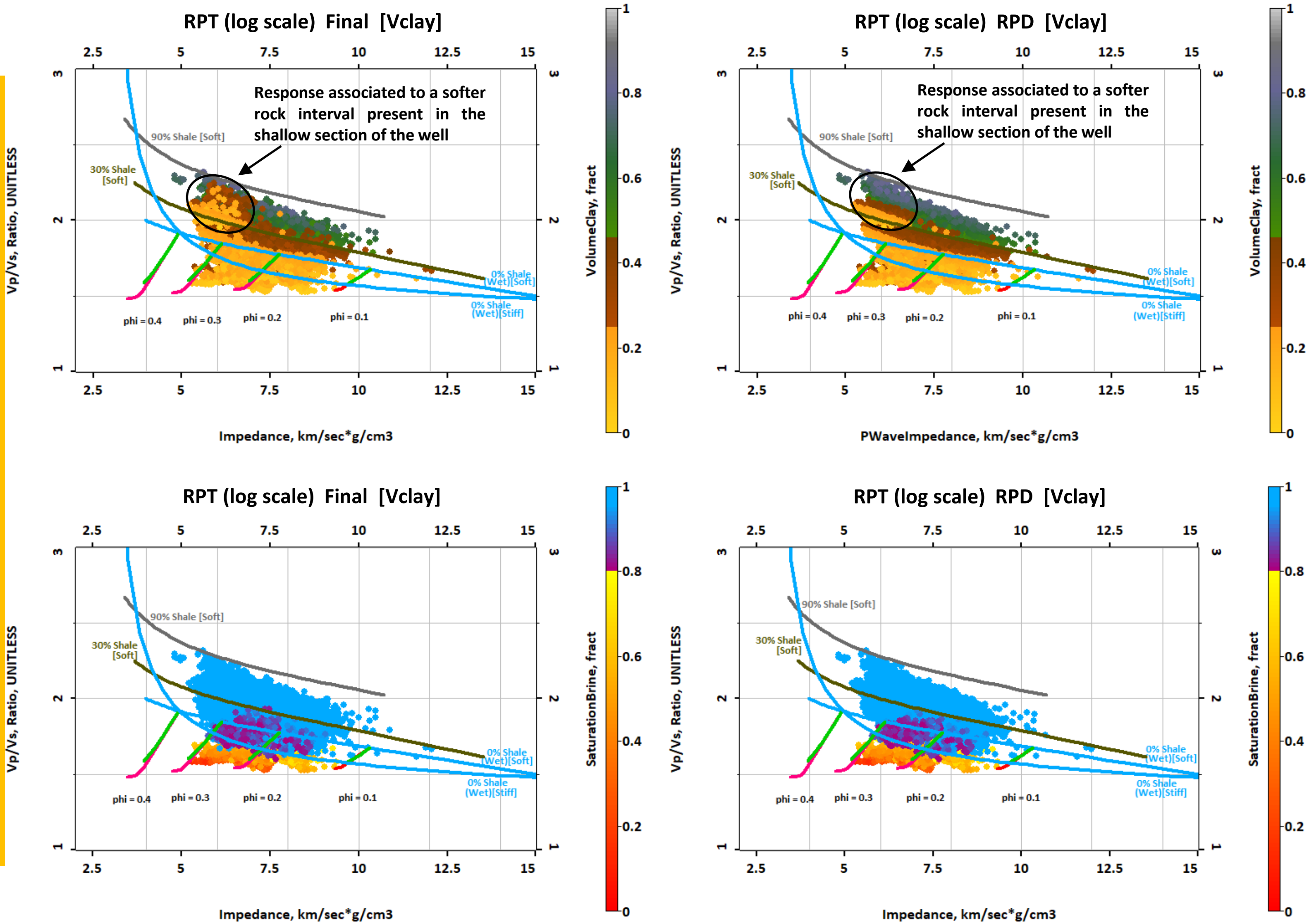


Open

Siwa-101, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right, color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Sook-1ST1

Sook-1ST1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference.
- Missing/bad VP, density and VS measurements were estimated using RPD.
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Intra cycle VI and VII sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes.

Volume of hydrocarbons:

- Some gas was interpreted in sands in 2248m-2276, 2571m-2634mm and 2755-2777m with an average of 15 -25 % gas saturation.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Water saturation was calculated using Simandoux's equation with RW of 0.046ohm, constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=2 yielding salinity value of~ 33000ppm (based on the well report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2180m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Faust model was used to estimate the VP data where RPD looks unreliable.

Fluid properties:

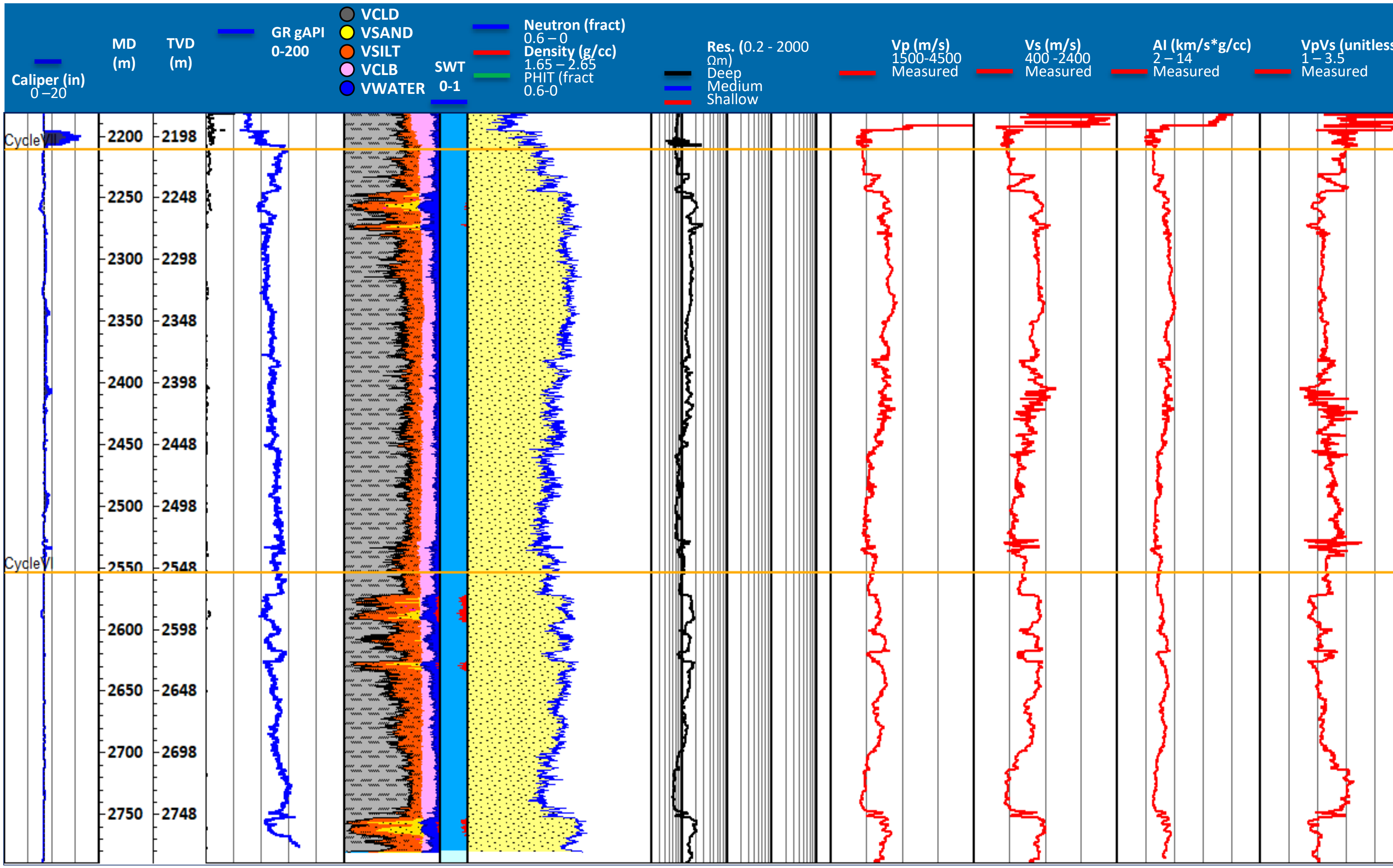
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 33000 ppm[Pickett plot]
- Gas gravity: 0.82[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of Intra cycle VII and VI using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II/IIP was observed near a good porosity sand @ 2750m for the hydrocarbon fluid cases at in situ reservoir conditions while AVA class I was observed for the wet scenario.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content), AVA class III is observed for the hydrocarbon scenarios.

Sook-1ST1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

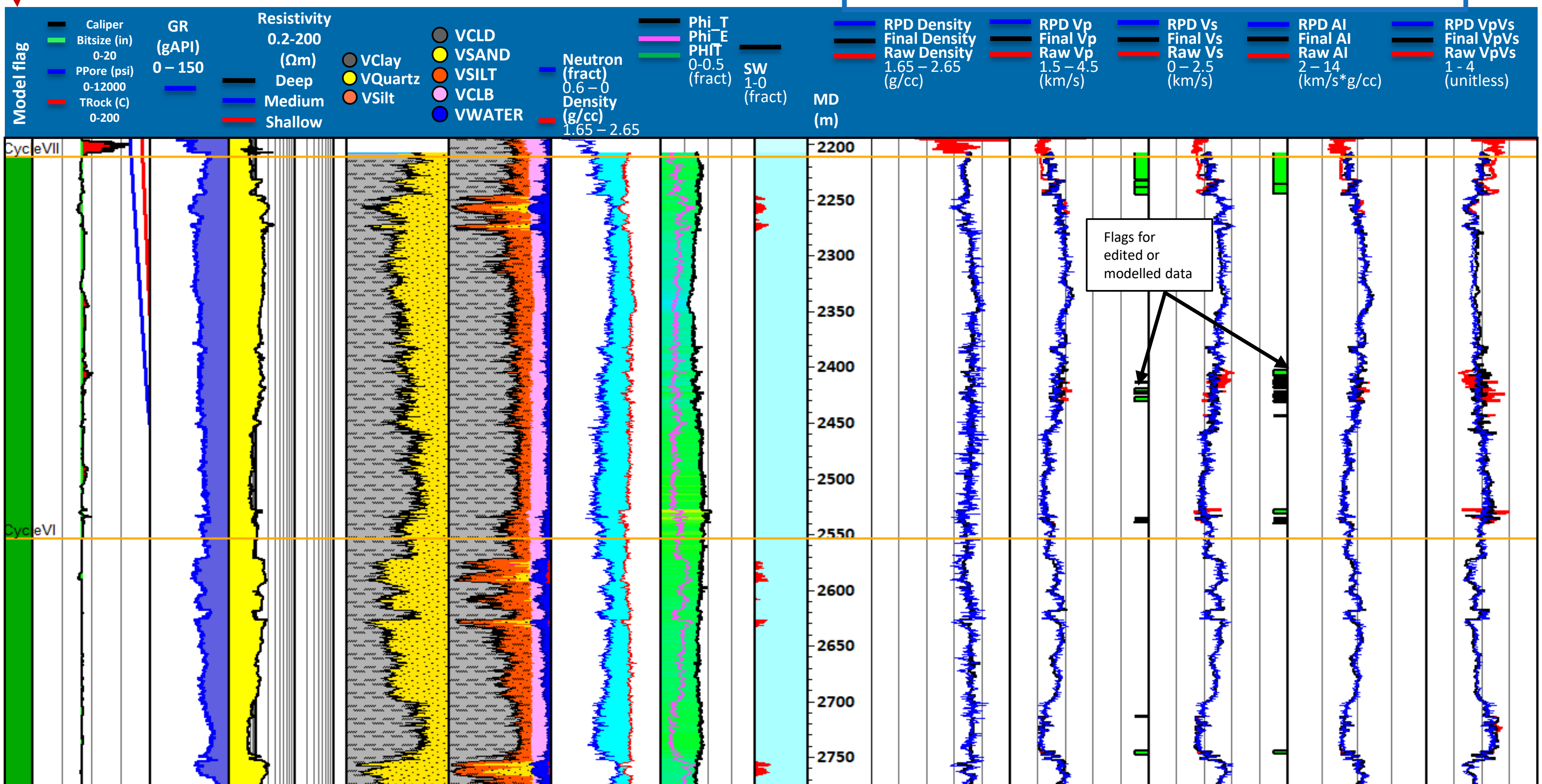
Sook-1ST1 Geophysical Well Log Analysis (GWLA) – Interval from 2180m to bottom of logs

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

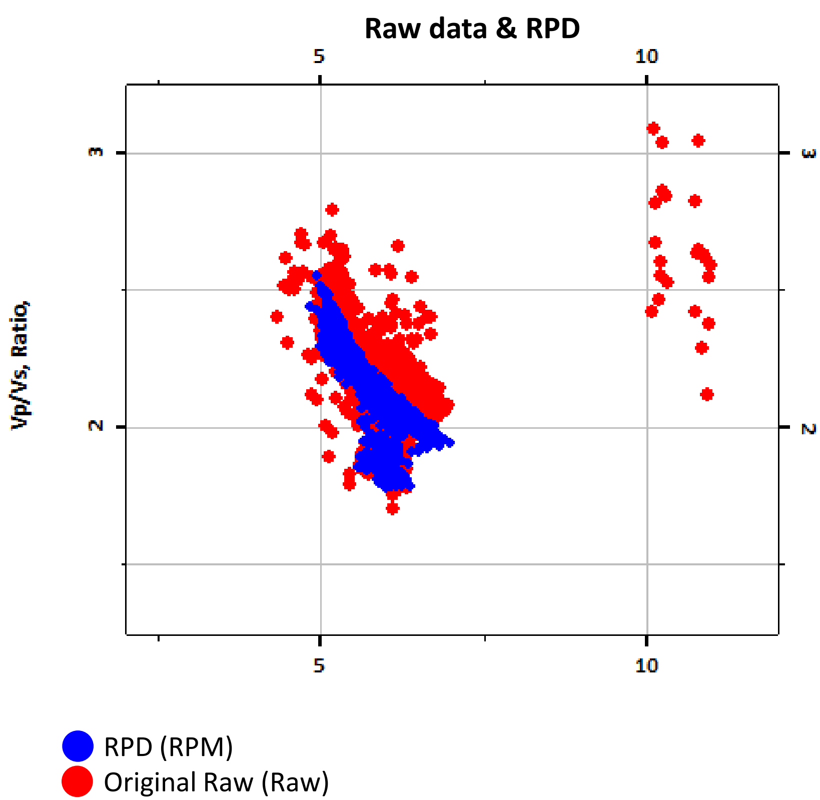


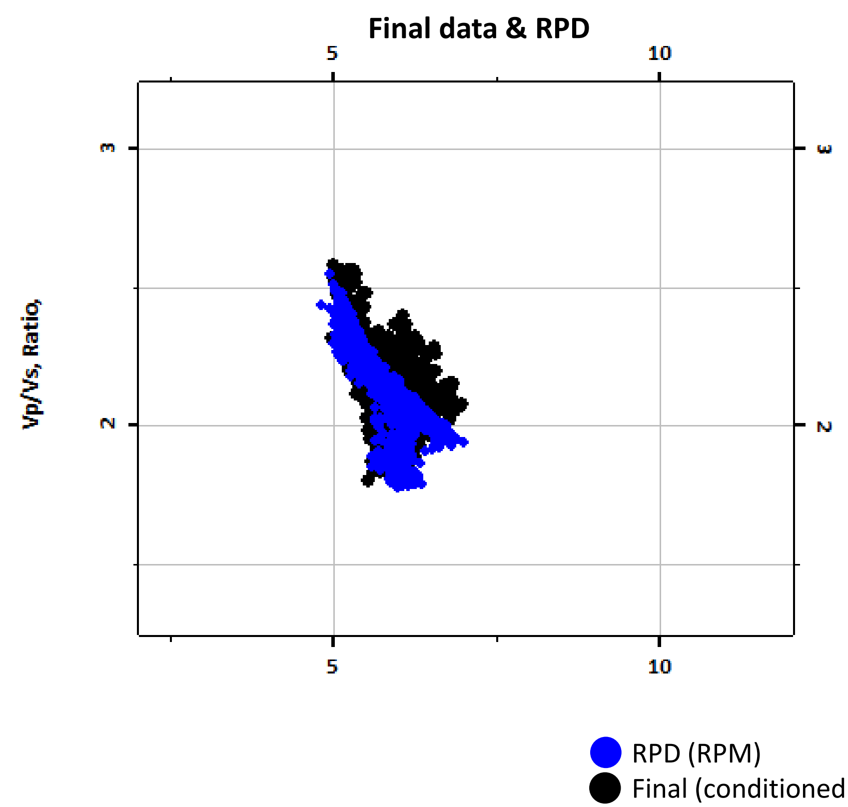
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Sook-1ST1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

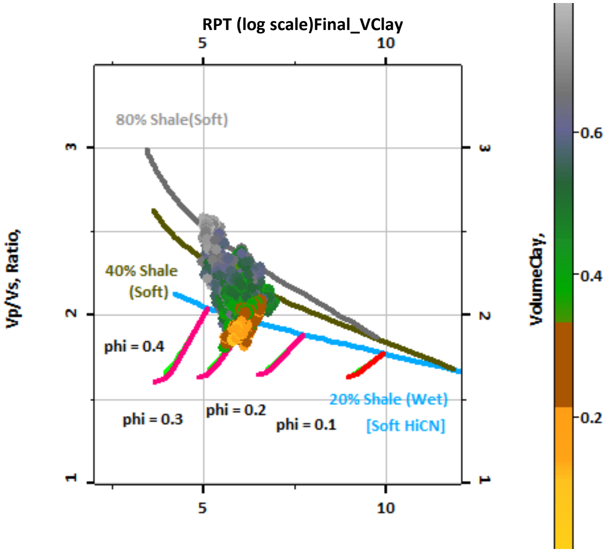


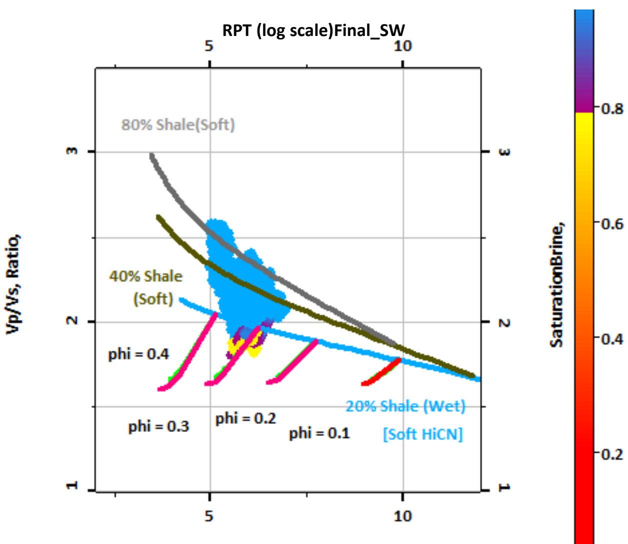


Sook-1ST1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

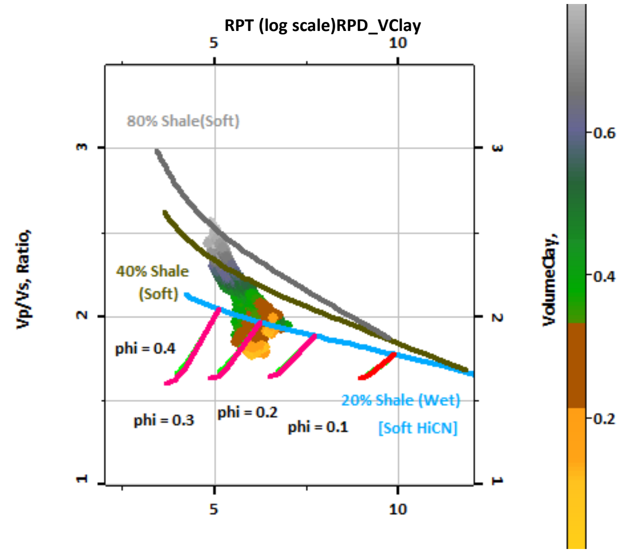
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

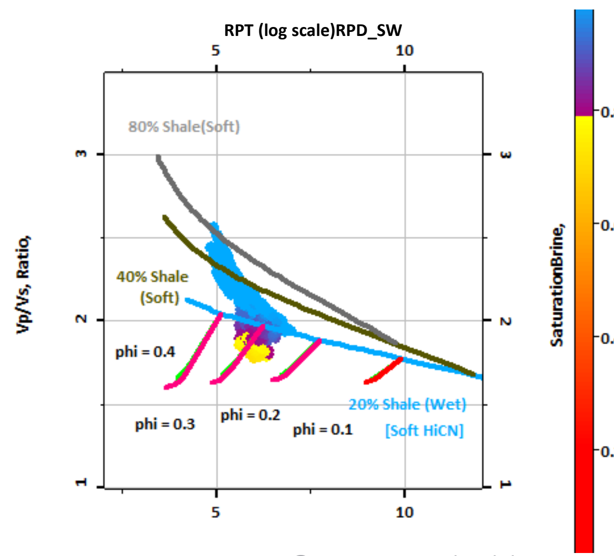
Final conditioned data





RPD(Modelled)data





Spaoh-1

Spaoh-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair and it has lower frequency content in compressional and shear velocities than those present in the density log. Most of the Vs data is unreliable. It was preserved as much as possible. Working data is available from 1430 m to 1800 m **. The density log is considered to be the most reliable log in this well. Density measurements are of good quality in general. No edits were done in the density with the exception of the gap present at 2800 m, here the density was linearly interpolated, due to lack of any kind of data.
- Vp log quality is considered good. Editions were mainly performed from the density log. A general variable depth shift needed to be applied since the compressional velocities were completely misaligned with the density log. Vp curve seems to be more reliable in this well. Editions were performed either where artefacts appeared in the log or to improve the frequency content of the log. Compressional velocities were completely estimated below 2800 m.
- Vs was heavily edited in the section above 2800 m. The Vs curve also required a complex depth shift to be performed on all the well depth, to minimize the noise and make the rock physics models to agree better. Shear velocities were completely estimated below 2800 m.
- Vp and Vs curves were replaced in Coal sections to eliminate inconsistencies in the measurements that lead to significant dispersion in the data in those intervals. Compressional and Shear velocities were completely estimated below 2008m using rock physics models.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The primary objective of Spaoh-1 well was to test hydrocarbon potential of Cycle II (primary objective) and deeper Cycle I clastics. In general the sand thickness are in the range between 10 to 45 meters and porosity varies between 12 and more than 20 %.

Volume of hydrocarbons:

- Several sands in the well has been interpreted hydrocarbon bearing, particularly in the Cycle II interval, at 2300 m and 2600 m. Saturations in these intervals show interpreted values of 80% or more. The well was plugged and abandoned as an oil and gas discovery.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters were assumed to be a=1, m=n=2. This parametrization coincides with values used for petrophysical estimation in the reports. Water resistivity used to interpret Sw: Rw=0.19 ohmm @ 289 F (8,000 ppm).

** Depths referred in this report are MD.

Spaoh-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies.

Fluid properties:

Hydrocarbon properties used in fluid substitution have been taken from PVT analysis of samples taken in a near by well (SPAOH-1), particularly the gas properties. Average values were taken from nearby wells for oil properties. Main parameters used in this modelling are:

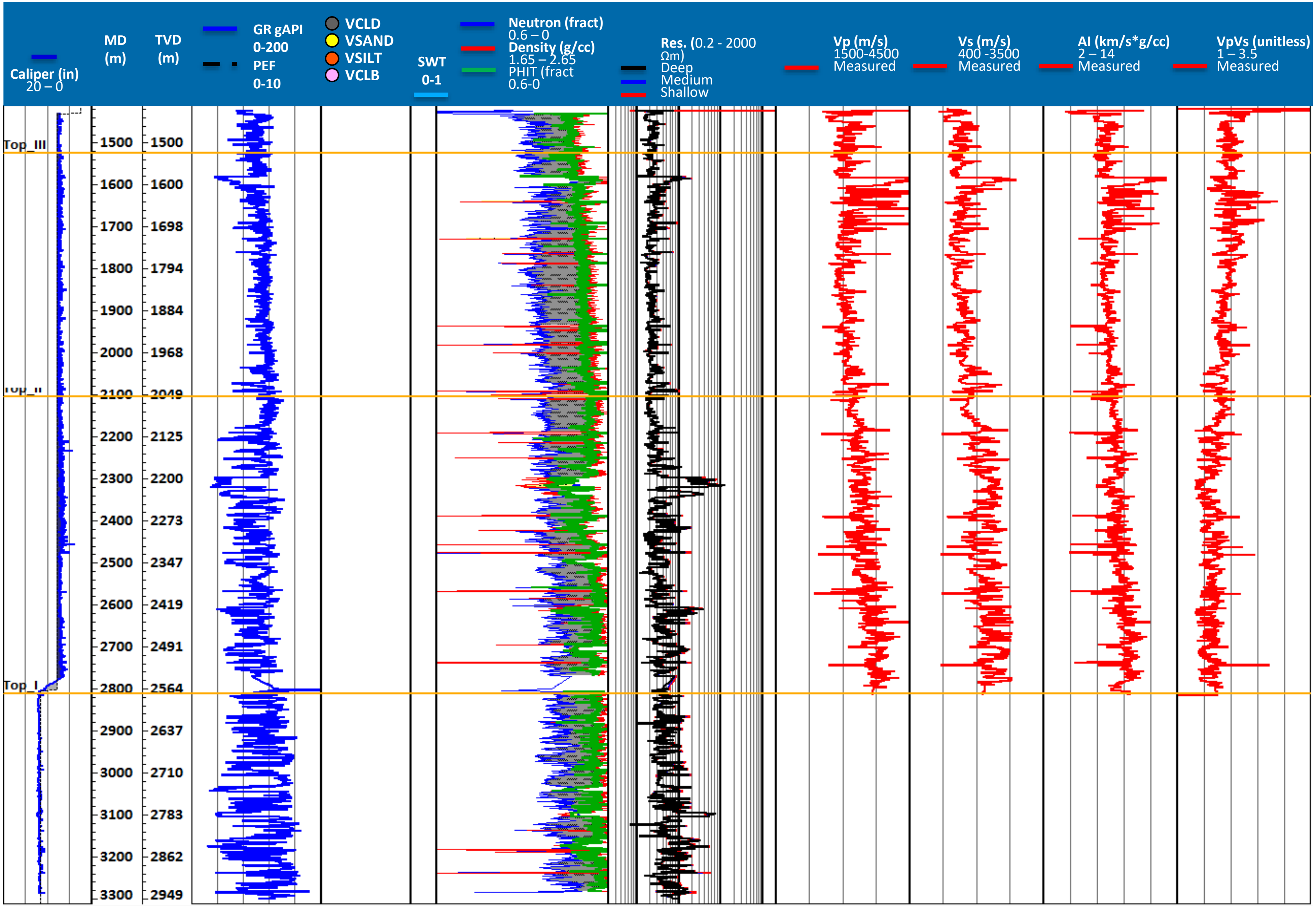
- Brine salinity: 8,000 ppm (Calculated from Picket analysis)
- Gas gravity: 0.7 (PVT report SPAOH-1)
- Oil Gravity: 44.4 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in sands appearing in Cycle II and Cycle 1 of the well. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Gassmann and Brie models.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As an example, the sand package at 2300m (Gas bearing sand in Cycle II) was water substituted allowing the Water saturation to be increased to 100%. Porosity was preserved for this exercise. This exercise showed higher values for VpVs ratio and about the same values for Acoustic Impedance compared to the gas saturated sand (insitu conditions) case.

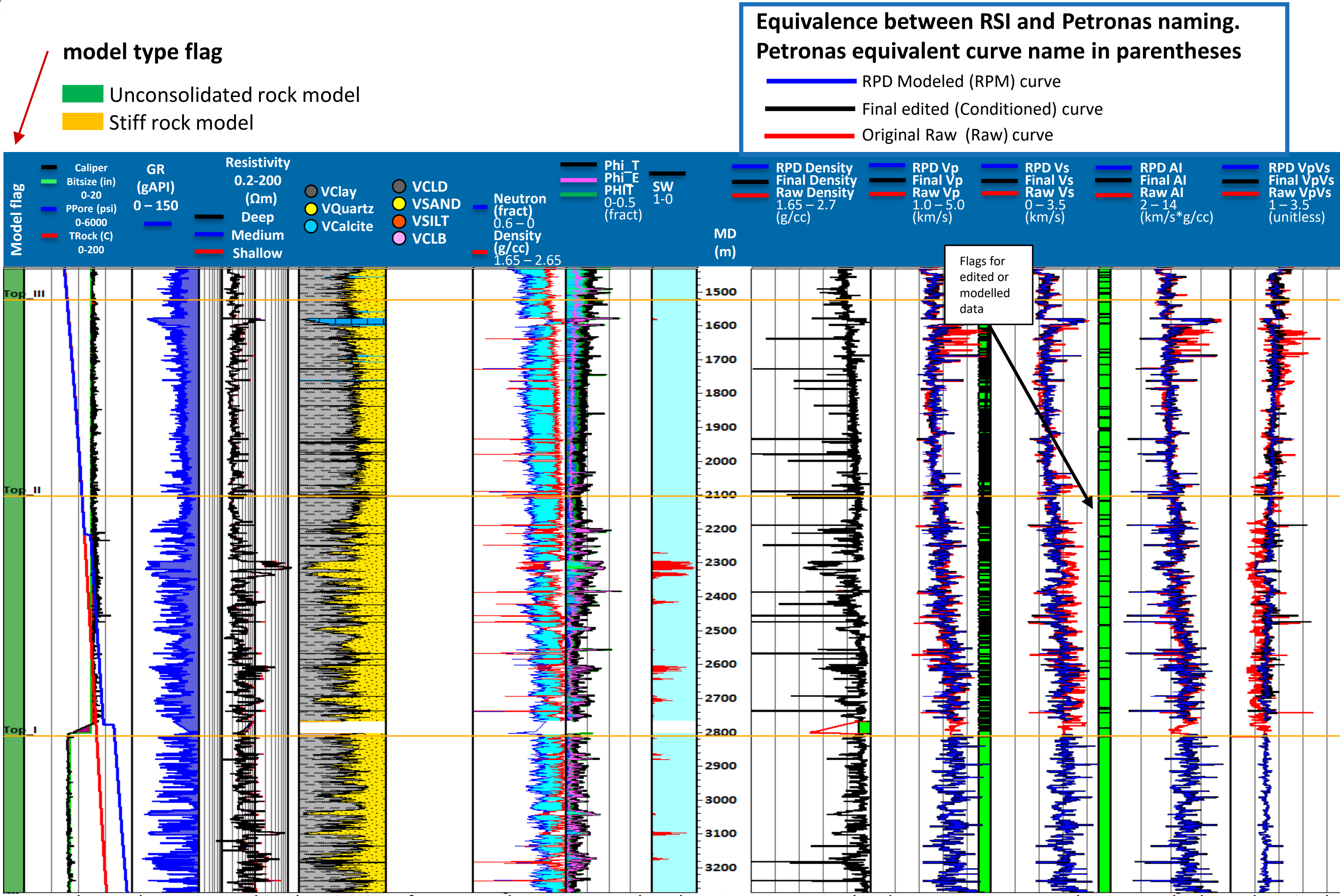
** Depths referred in this report are MD.

Input Logs – Spaoh-1



Additional data includes mud weight data, pressure data, petrography and well reports.

Spaoh-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m



Density has to be estimated in the vicinity of 2800 m, due to casing shoe locations a gap in the data was present in this interval. Elastic logs in the gap section at 2800 m were left unedited given there is no data available.

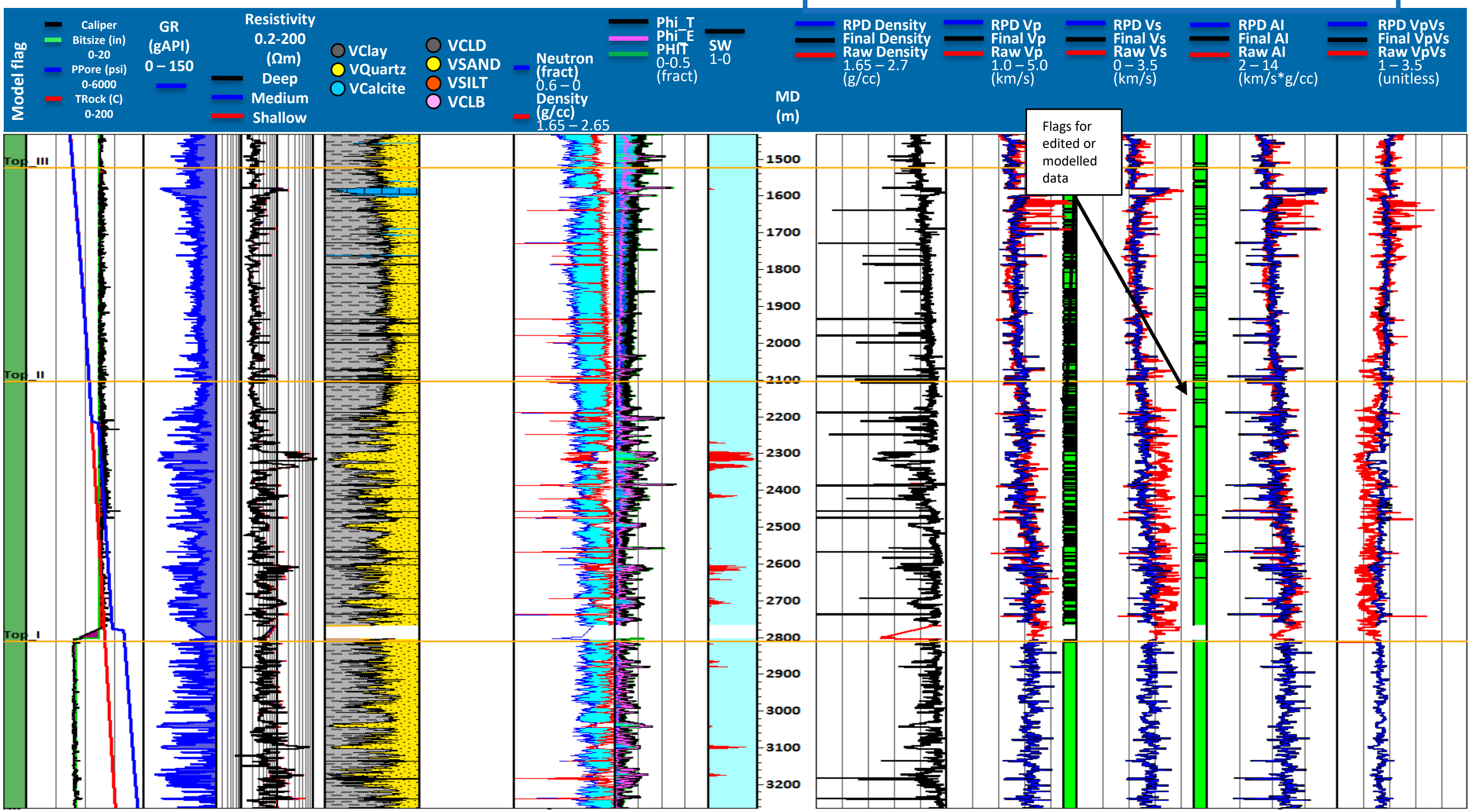
Spaoh-1 Geophysical Well Log Analysis (GWLA) – Interval from 460 to 1050 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

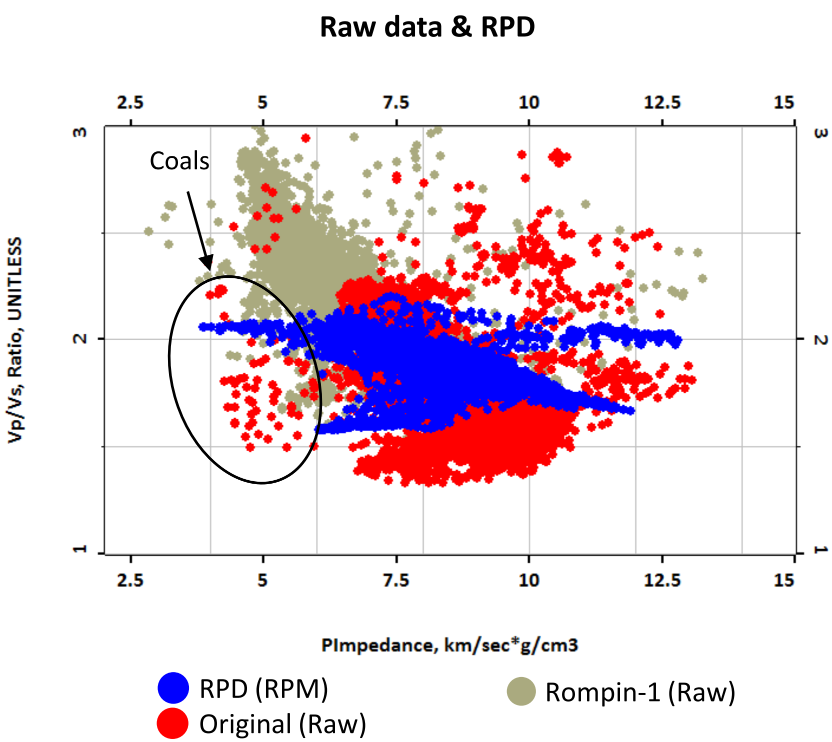


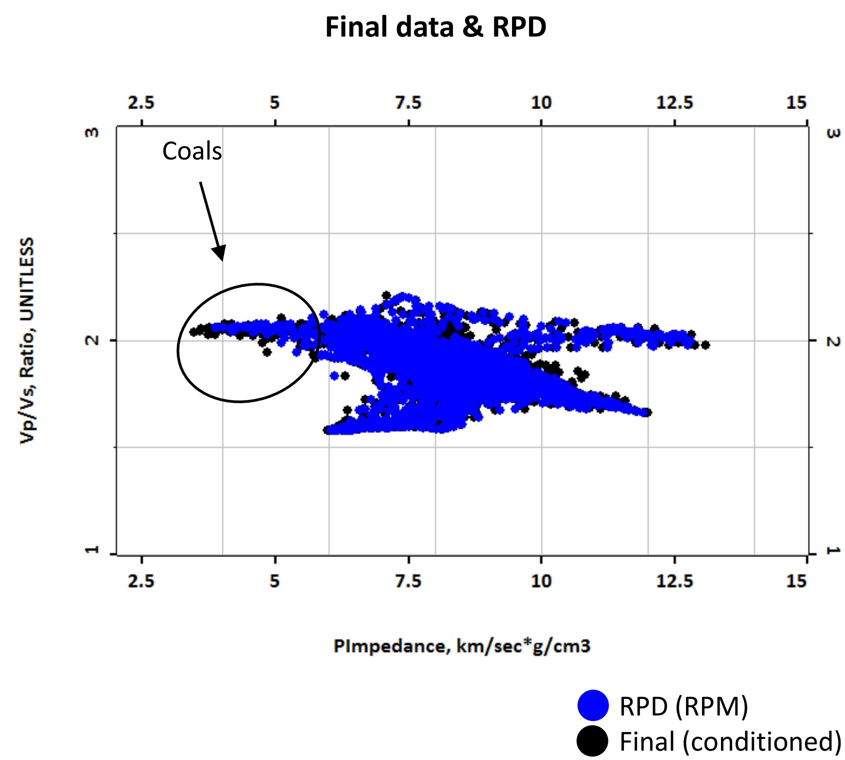
Density has to be estimated in the vicinity of 2800 m, due to casing shoe locations a gap in the data was present in this interval. Elastic logs in the gap section at 2800 m were left unedited given there is no data available.

Spaoh-1, Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data, along with elastic data from other wells, in this case well Rompin-1 raw data is presented. Spaoh-1 and Rompin-1 wells are in proximity.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

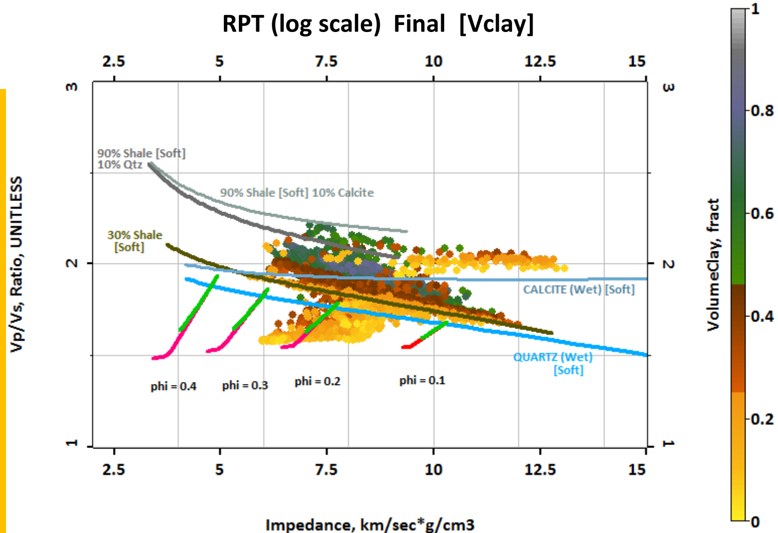


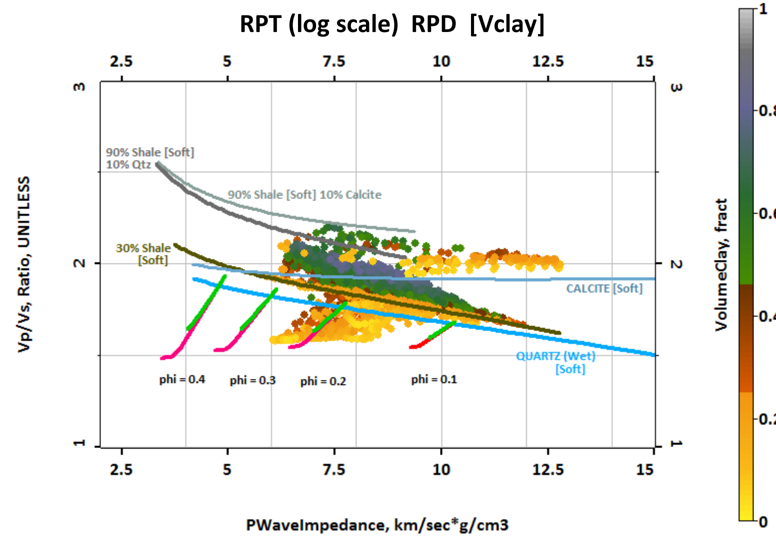


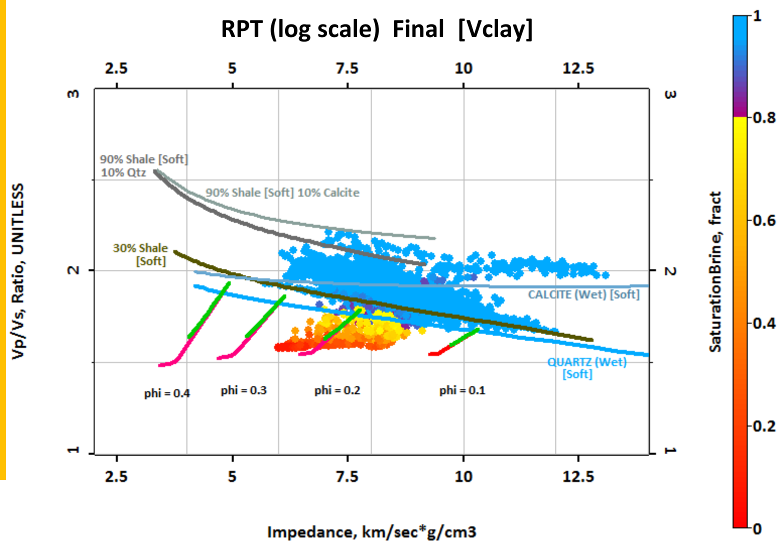
Spaoh-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

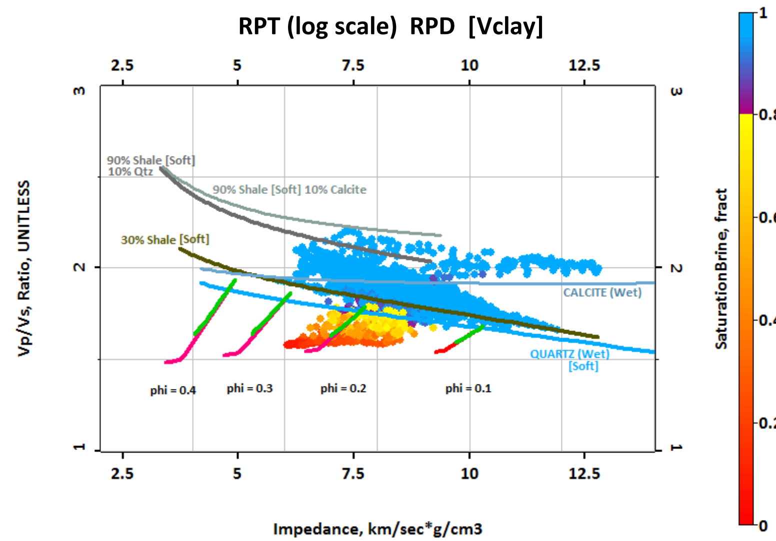
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

T3-2

T3-2 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair except the VS measurements were poor in many intervals. Client's petrophysical interpretation was not provided in that well. Density was heavily edited near the casing points using the RPD due to bad measurement.
- Invasion correction was applied for the density log in the gas saturated sands and the results were comparable to the clean wet sand intervals.
- Vs was heavily edited in some sections especially in the interval(1350-1850m).
- Other logs include Gamma, Neutron, Caliper, Deep and Medium Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the cycle IV and V sands. These are a series of turbiditic soft sands, distributed in lobe/channel complexes(coarsening upward sequences in many intervals) with decreasing porosity towards the base of the section.

Volume of hydrocarbons:

- Many sand reservoirs penetrated in the well were gas saturated that reached up to 60-70% in some sections especially above 700m(MD).

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the section the clean wet sand section(820-830m) yielded a formation water salinity of 29000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(1600m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

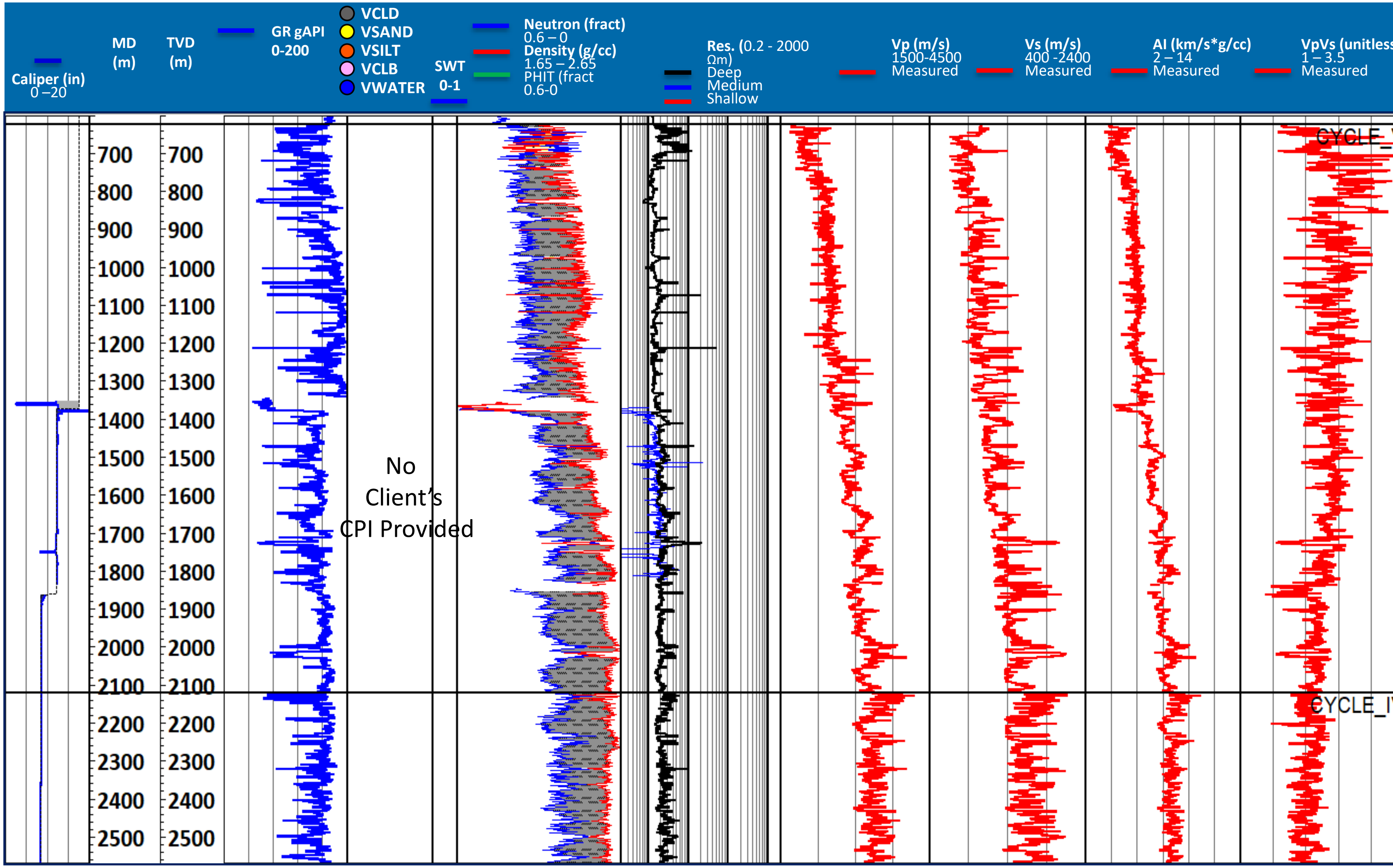
Fluid properties used in substitution have been assumed based well DST. Main parameters used in this modeling are:

- Brine salinity: 29000 ppm[Pickett plot]
- Gas gravity: 0.675[well DST]
- Oil Gravity: 38.1 API[Nuang-1 well test]
- Gas / Oil ratio: 263 (L/L) [Nuang-1 well test]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different sands of cycle IV and V using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class IIP was observed near a good porosity gas sand @ 1389m for all hydrocarbon cases while class I for the wet case(at in situ reservoir conditions).
- By downgrading the reservoir quality(decreasing porosity and increasing clay content) no significant change for the AVA class could be noticed except that the hydrocarbon cases started to behave more like class I response.

T3-2 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

T3-2 Geophysical Well Log Analysis (GWLA) – Interval Of Cycle V Down to 1600m

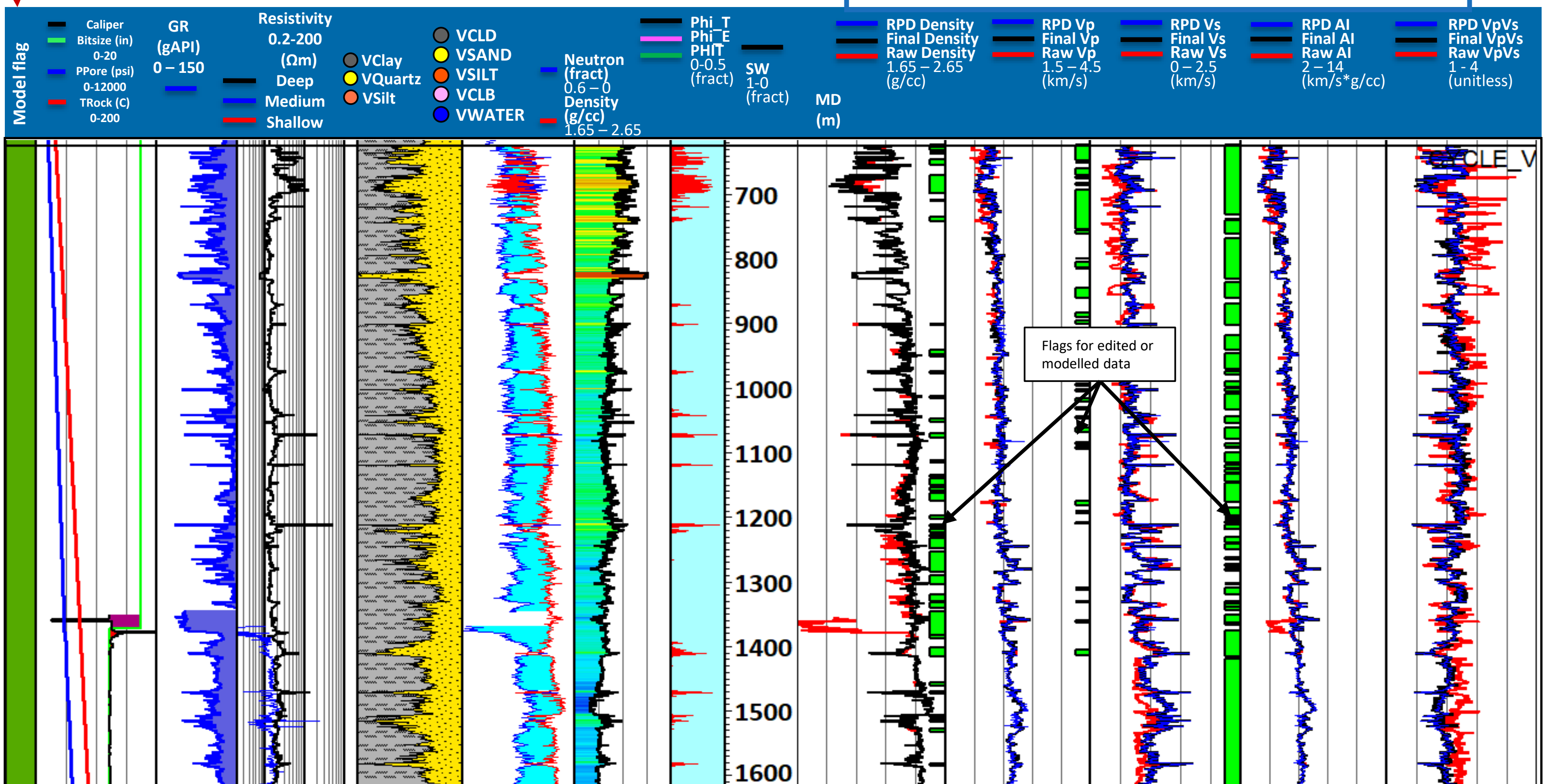
model type flag

- Soft rock model
- Stiff rock model

Above depth of 600m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

T3-2 Geophysical Well Log Analysis (GWLA) – Interval From 1600m To The End Of The Elastic Logs

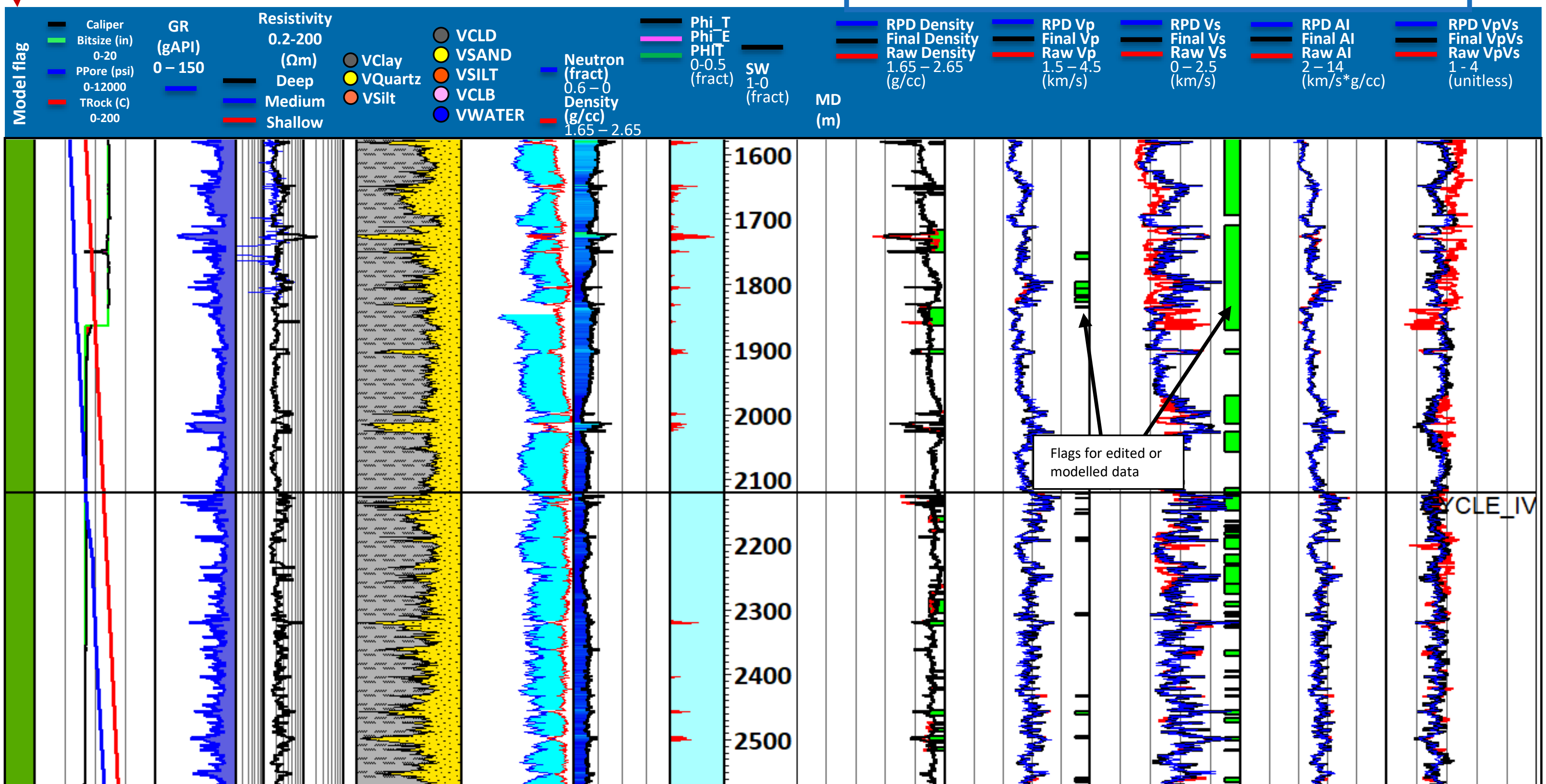
model type flag

- Soft rock model
- Stiff rock model

Above depth of 1600m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

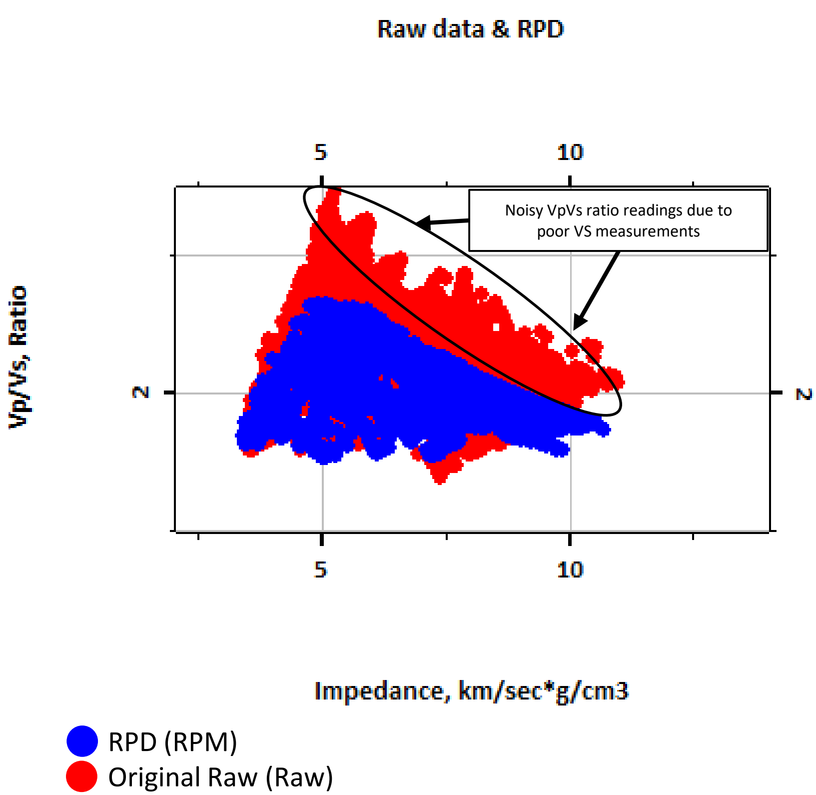


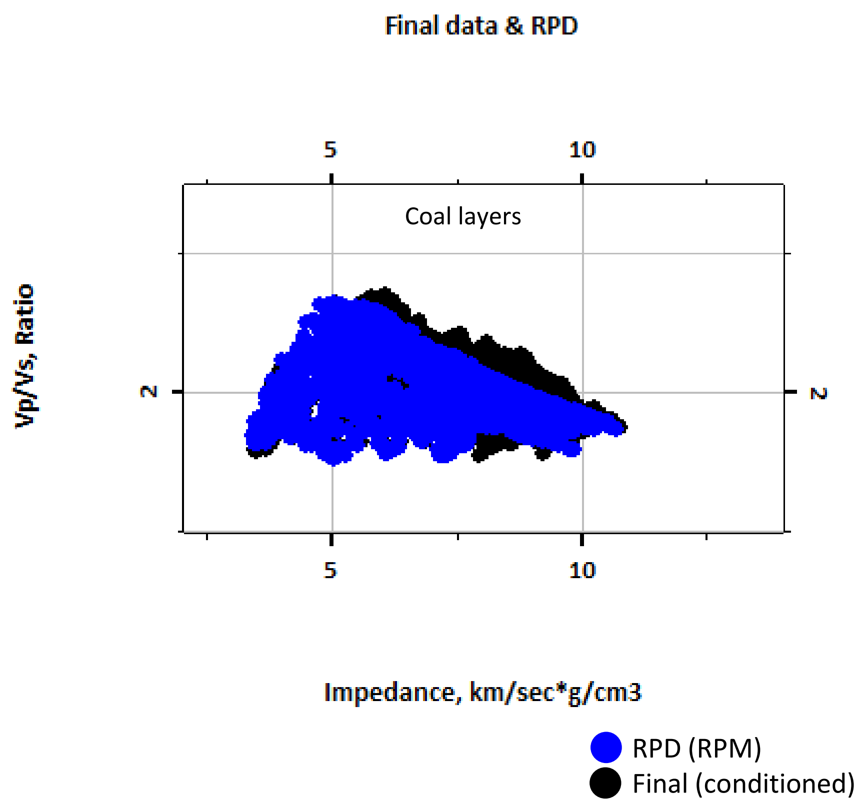
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

T3-2,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

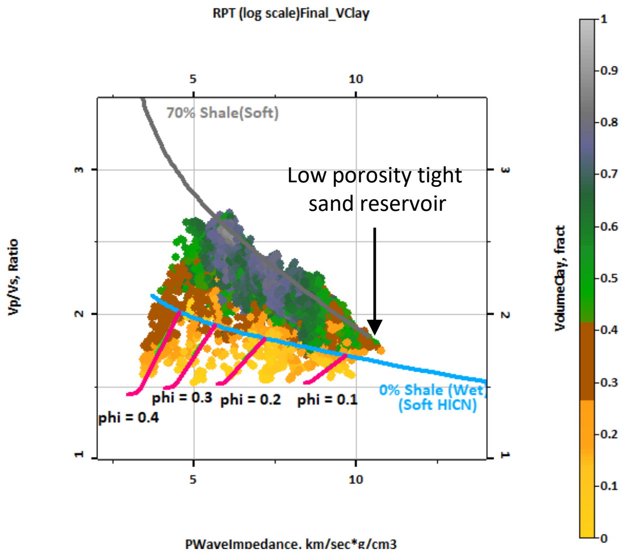


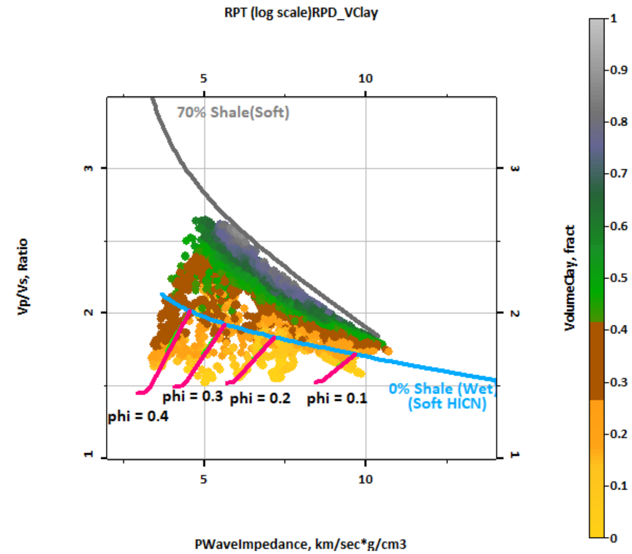


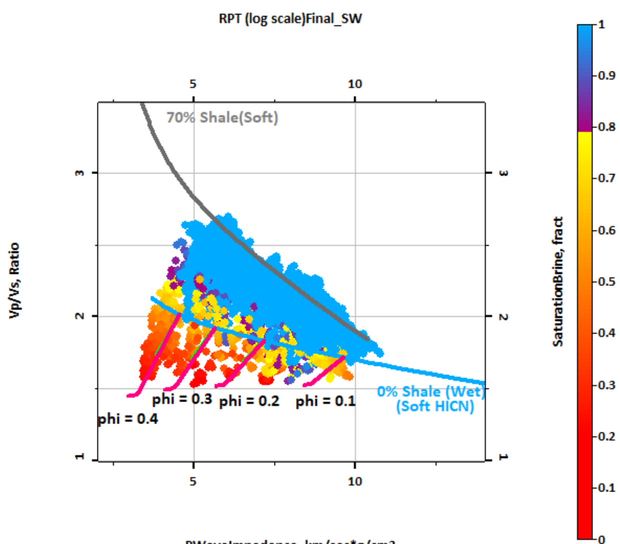
T3-2,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

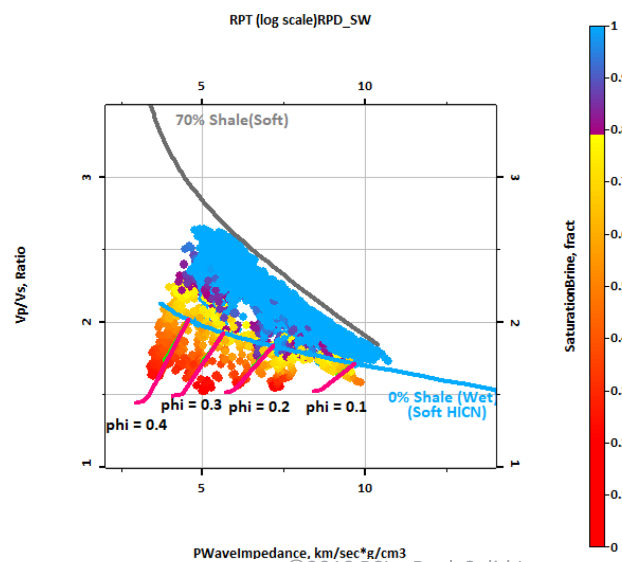
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Tahan-1

Tahan-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is fair, but the data availability is very limited since we have full elastic coverage for only the section(2700-2810m) while the density covers to shallower interval(up to 1650m). Client's petrophysical interpretation was provided for this well except water saturation.
- Shear wave velocity(VS)was fully modelled in the well from 1675m to the point where the shear measurement was available(2700m) using the RPD after the model was carefully calibrated based on the offset well(Mawar-1R1S1, Nuang-1 and Dayung-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby wells(especially Nuang-1).
- Due to the bad hole conditions in some intervals, density was corrected using the RPD as in the interval(2722-2737m).
- Vp was also was fully modelled in the well from 1675m to the point where the compressional measurement was available(2700m) using the RPD after the model was carefully calibrated based on the offset well(Mawar-1R1S1, Nuang-1 and Dayung-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby wells(especially Nuang-1).
- Based on the provided final well report the main gas sand section encountered in the well was no covered by any elastic logs so it was excluded from the study.
- Other logs include Gamma, Caliper, Deep resistivity and Neutron which all run for the full logging run to the T.D.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands(Cycle II). These are a blocky tight sands with some calcareous cement.

Volume of hydrocarbons:

- Most of the section covered by the available logs in the well was for the main shale section of cycle and the well just penetrated short section of the tight sand of cycle II which was 100% brine saturated except some residual gas saturation.

Water saturation (Sw):

- Water salinity used in the well based on the final petrophysical report of provided by client and reflected RW of about 0.17ohmm @ 166 degF. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2 (based on final petreophysical report).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that from the point where the full elastic log suite started(1650m) down to the T.D. the soft sediment model(with high coordination number) proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.

Fluid properties:

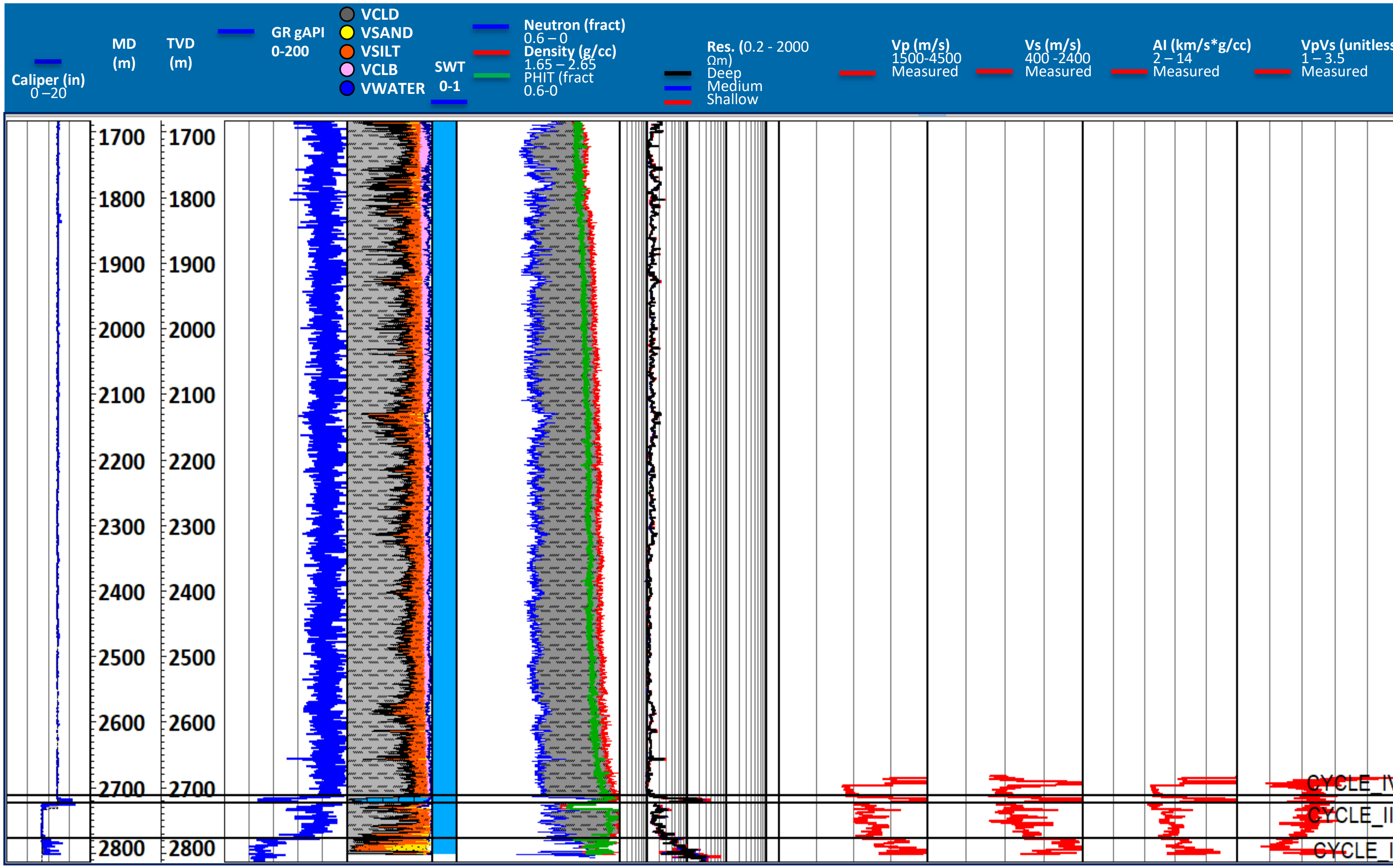
Fluid properties used in substitution have been assumed based on nearby area information. Main parameters used in this modeling are:

- Brine salinity: 16300 ppm[Pickett plot]
- Gas gravity: 0.827[assumed]
- Oil Gravity: 38.9 API[assumed]
- Gas / Oil ratio: 500 (L/L) [assumed]

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(cycle II) using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with good discrimination with the brine sands.
- AVA class II was observed near the top sand of cycle II @ 2777m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity) the brine scenario changed to class IV while the hydrocarbon scenarios into class III.

Tahan-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

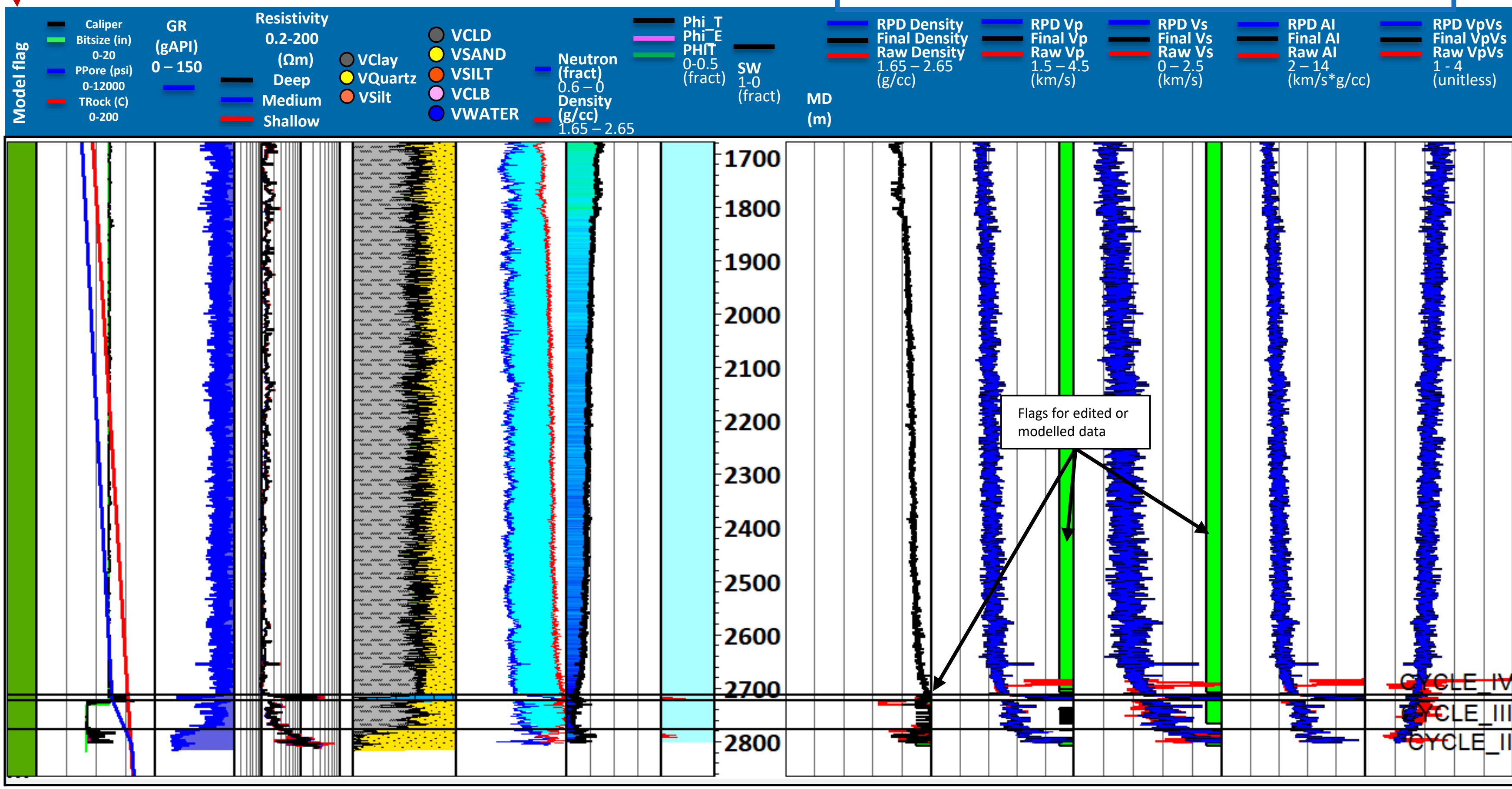
Tahan-1 Geophysical Well Log Analysis (GWLA) – All Well Interval

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

model type flag

- Soft rock model
- Stiff rock model

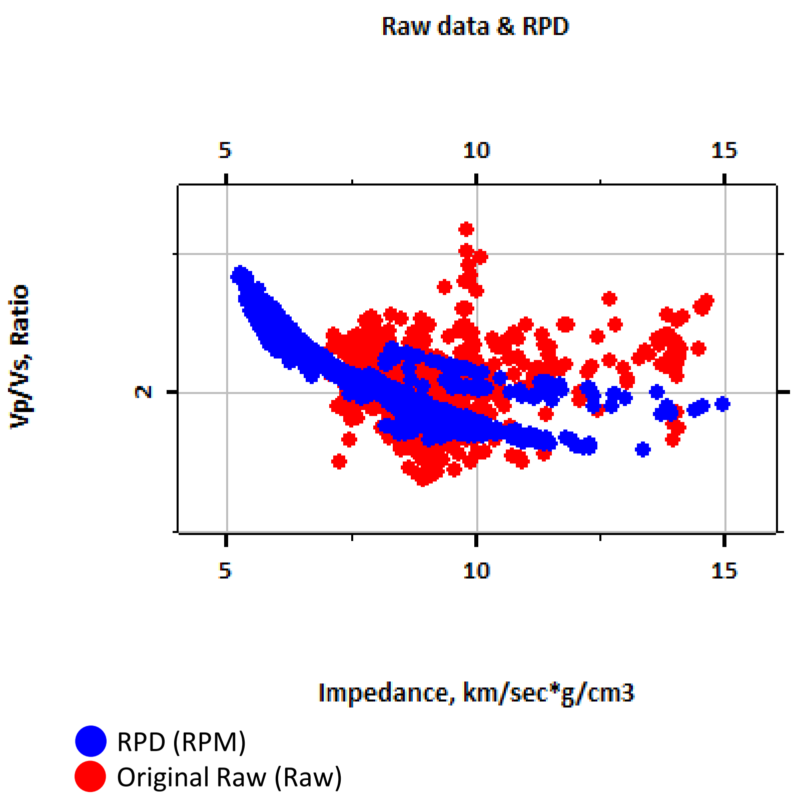


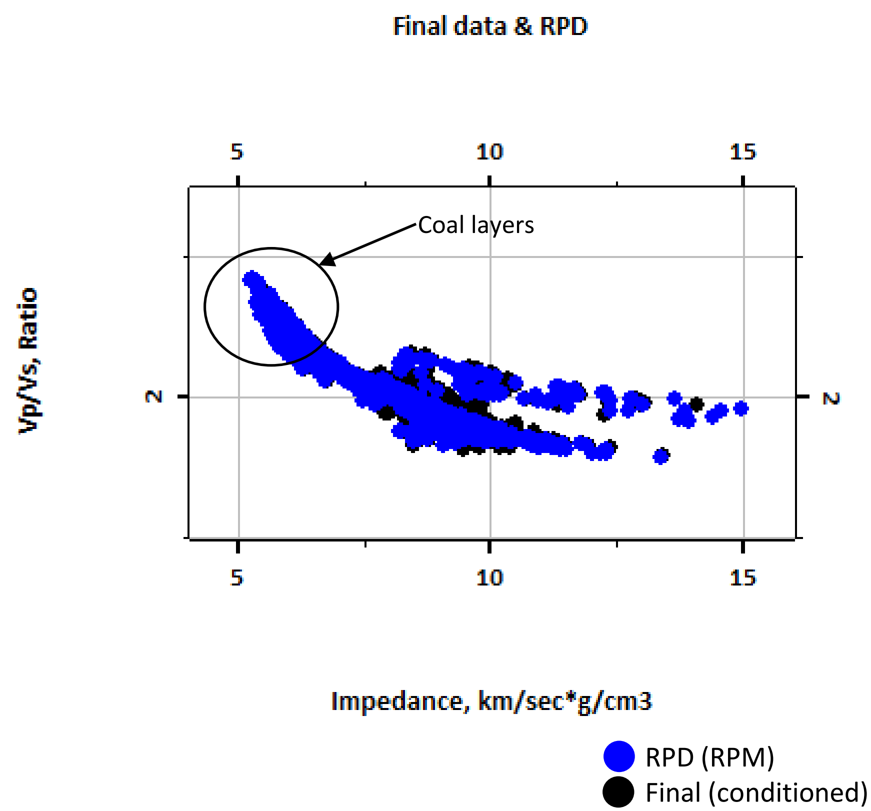
Some edits to the measured data and model calibration is strong. Granular media model (soft sand with high coordination number) was used for all elastic curves prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Tahan-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

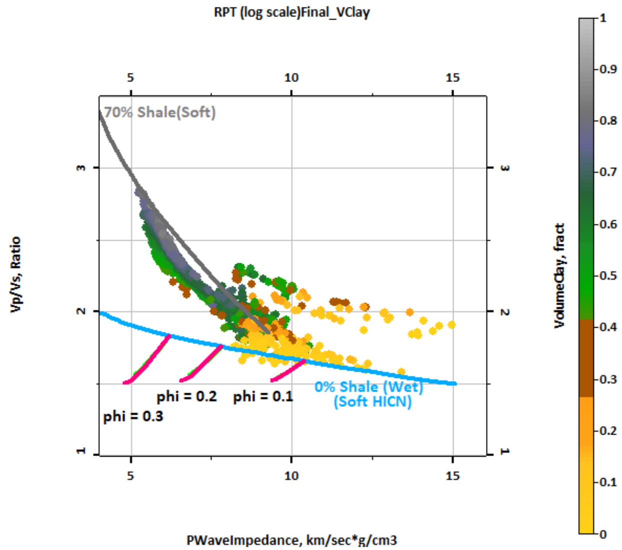


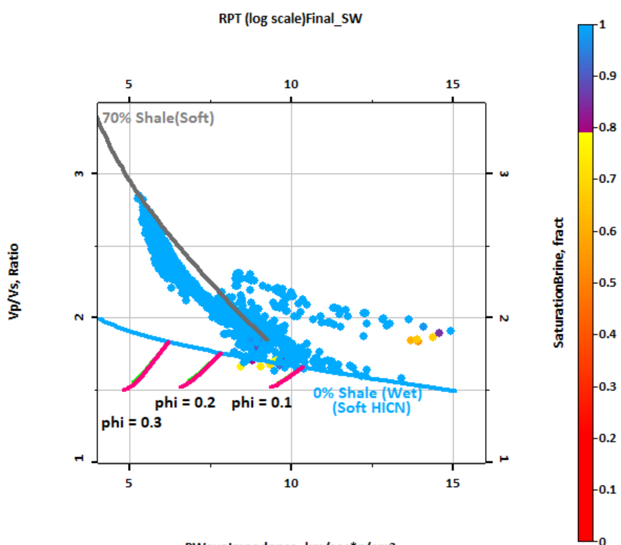


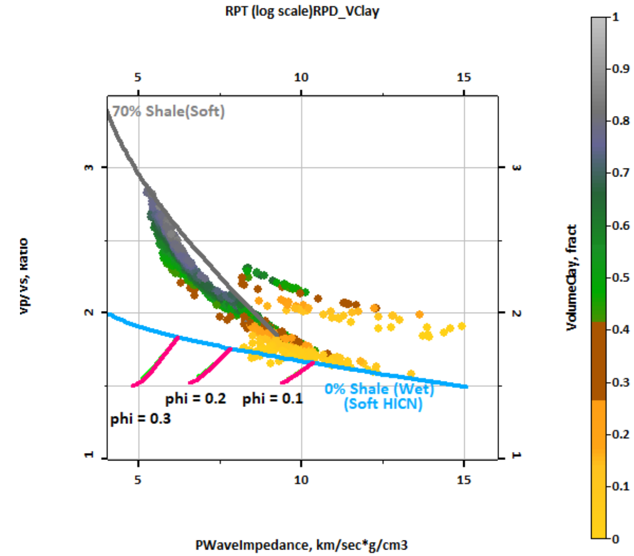
Tahan-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

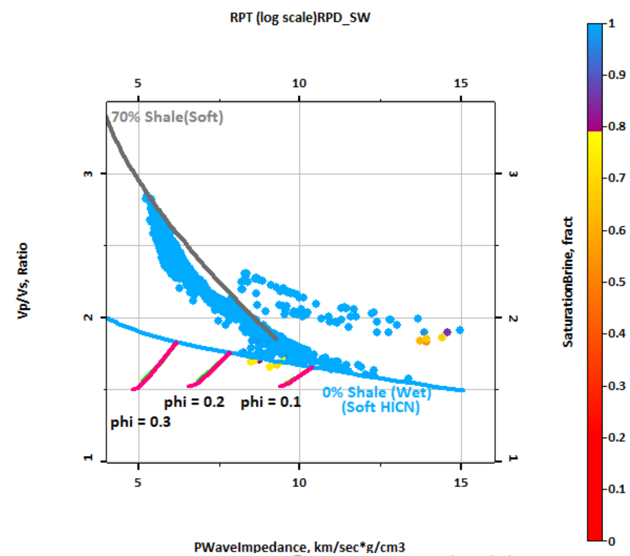
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Talang-1

Talang-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality is strong. Density, compressional and shear velocities are available from 2048m-3698m. Client's volume shale, total porosity, and total water saturation were provided as a reference.
- Vp was acquired from 2048m-3698m. The measurement is high quality, only some rare erroneous measurements have been edited using the RPD model.
- Similar to Vp the Vs is acquired from 2048m-3698m. Vs was only edited at some casing gaps and for rare bad measurements.
- Density is available from 2048m-3698m and is high quality. Measurements are strong, the only edits are in the casing gaps. All edits are made using the RPD.
- Other logs used in the analysis include Gamma, Caliper, and deep resistivity run from 1246m – 3698m, and Neutron run over the same interval as density.

Clay volume (VClay):

- This volume was derived from a combination of the linear Gamma Ray and Neutron/Density crossplot methods.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the sandstones interbedded with claystones in intervals III and II. Some calcite stringers are also present.

Volume of hydrocarbons:

- Interpreted gas saturation is present starting at interval III with saturations as high as 80%.

Water saturation (Sw):

- Rw is derived from Pickett plot analysis. Assuming Archie parameters are (a)=1, Cementation exponent (m)=2 and Saturation exponent (n)=2, at the wet sand at 3550m the Rw is 0.067 Ωm, at 288° F NaCl is 25000ppm. Water saturation was calculated using Simandoux's equation.

Talang-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for both sand rich and clay rich intervals when compared to the measured data and also when compared to good measured data in the nearby reference wells. Despite the significant difference in water depth Jelawat-1 ST1 appears a strong analog well for comparing elastic response.

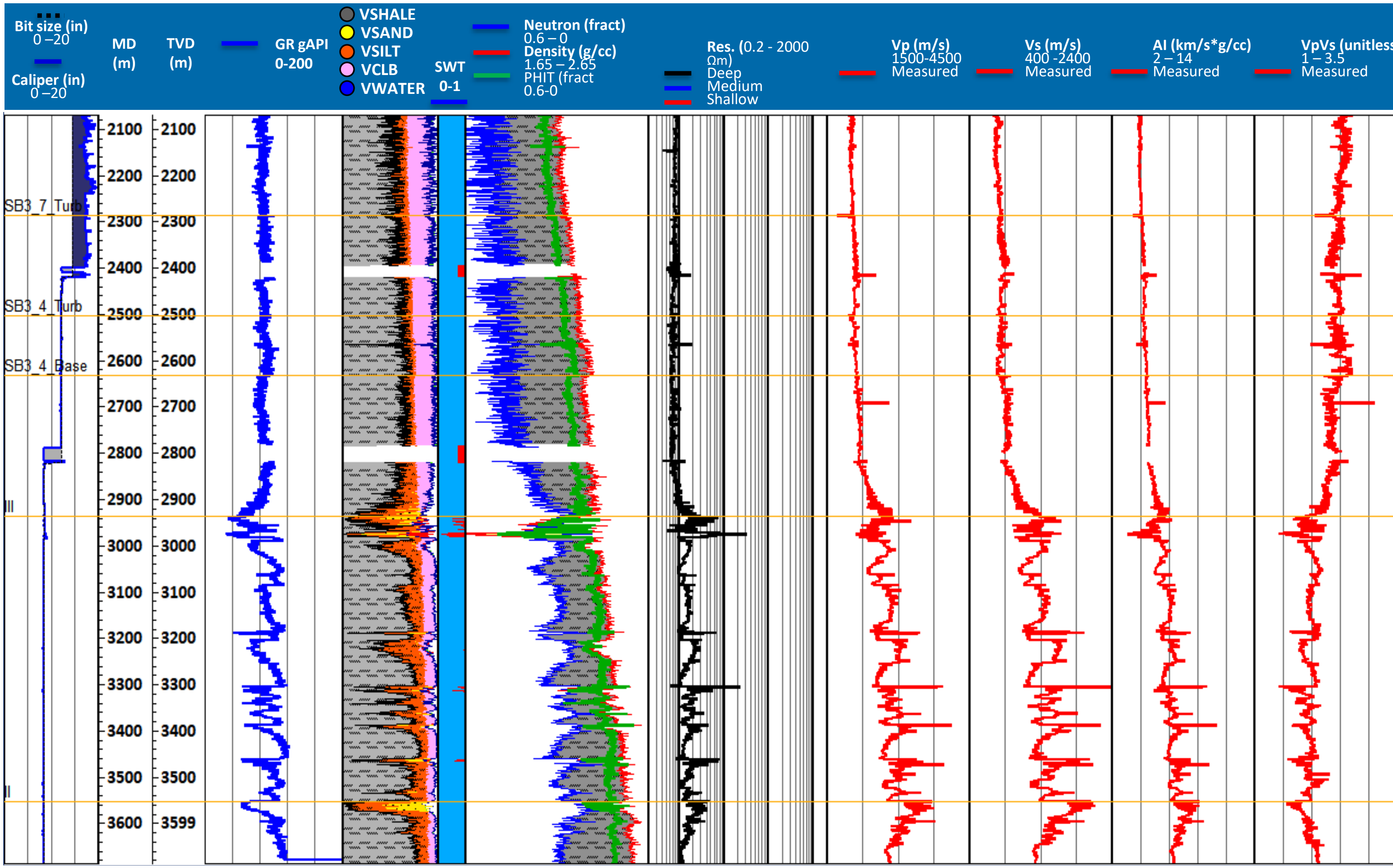
Fluid properties:

- Fluid properties used in substitution have been taken from nearby Jelawat-1 properties. Main parameters used in this modeling are:
- Brine salinity: 25000 ppm [Rw]
- Gas gravity: 0.82
- Oil Gravity: 38.9° API
- Gas / Oil ratio: 500 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the interval III and II reservoir sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale and upscaled domains with good discrimination with the brine sands.
- At in situ conditions the III interval shows a Class IV or Class III AVA response, strong negative intercept with flat or weakly positive gradient, with good fluid discrimination. Increasing porosity leads to a more negative intercept and stronger positive gradient and better fluid discrimination. Reducing porosity leads to a near zero intercept and gradient with no fluid sensitivity.

Talang-1 Input Logs



Additional data includes pressure, temperature data, cuttings descriptions, and final geological report.

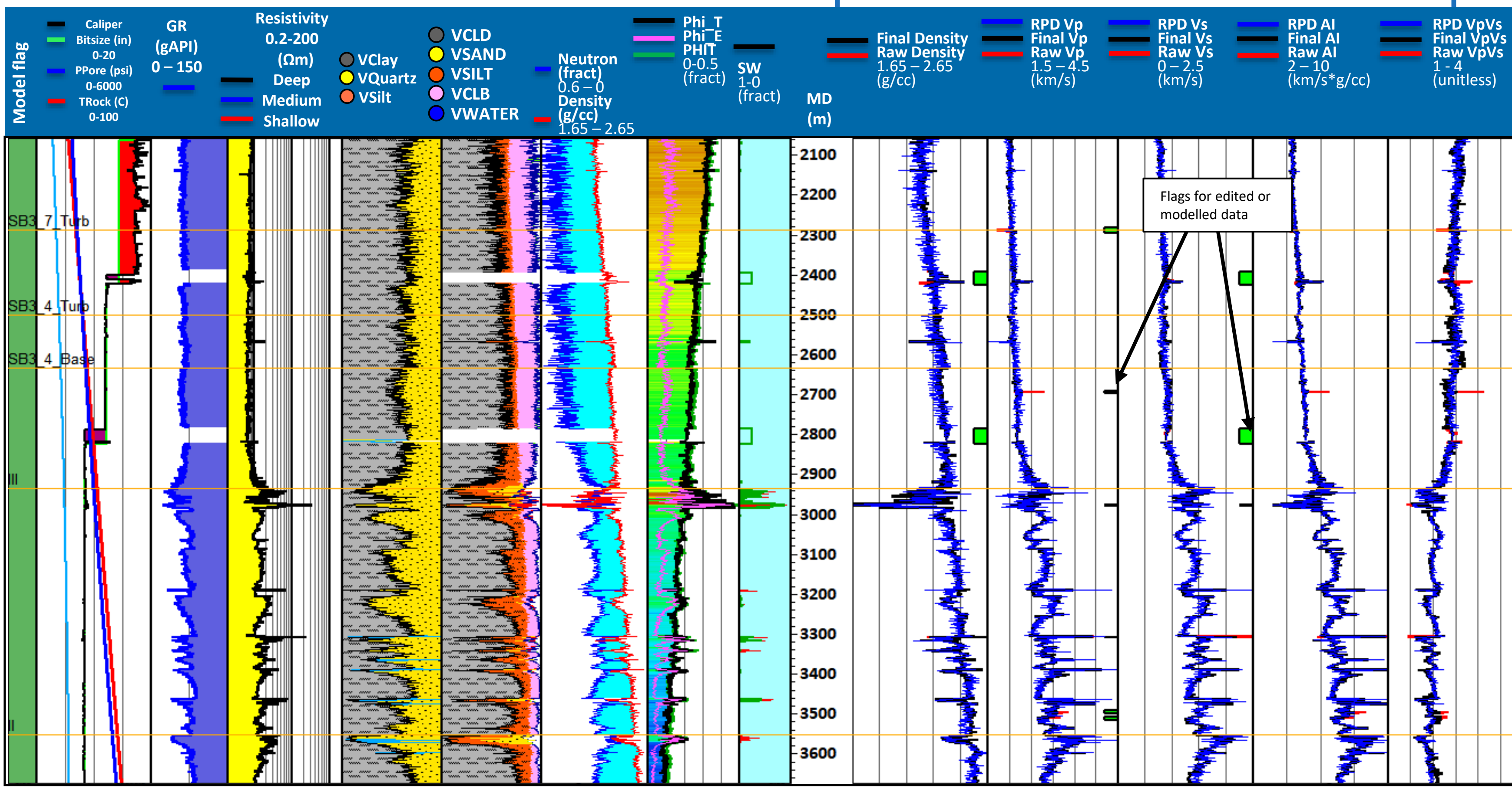
Talang-1 Geophysical Well Log Analysis (GWLA) – Interval from Top of logs to 2810m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

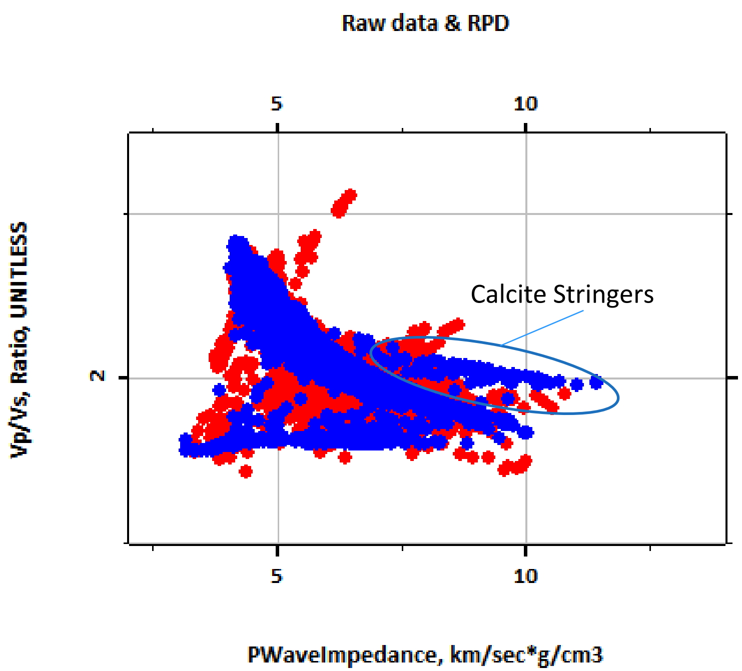


Some minor edits to all logs for casing gaps and other troubles. Granular media model (soft sand with variable Coordination Number) was used for all elastic curves prediction (Rhob, Vp and VS) with good correlation with the measured data.

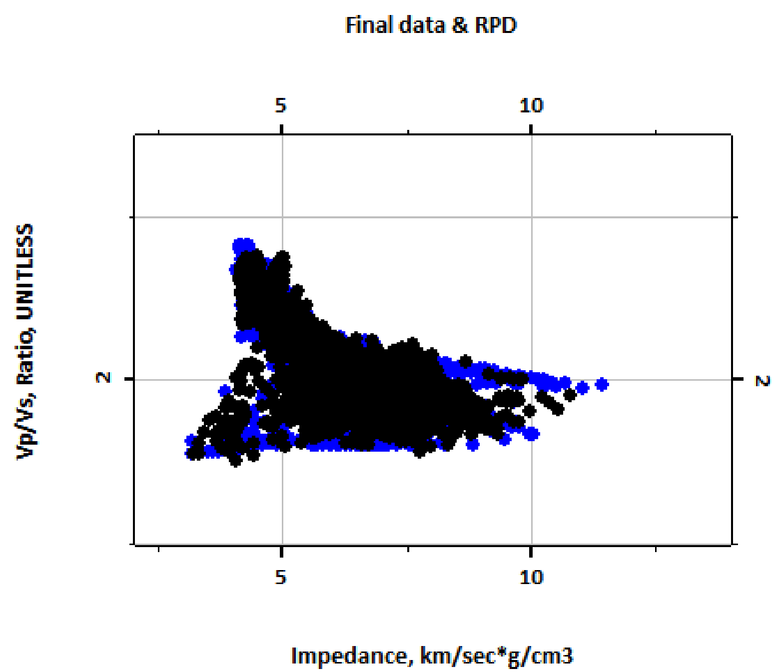
Talang-1,Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.



RPD (RPM)
Original Raw (Raw)

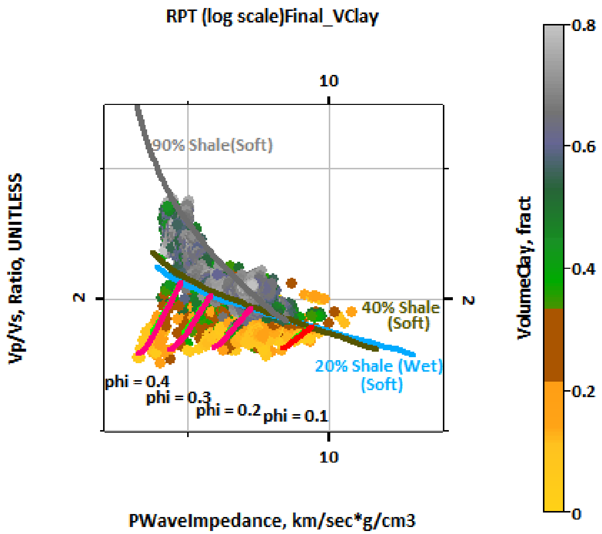


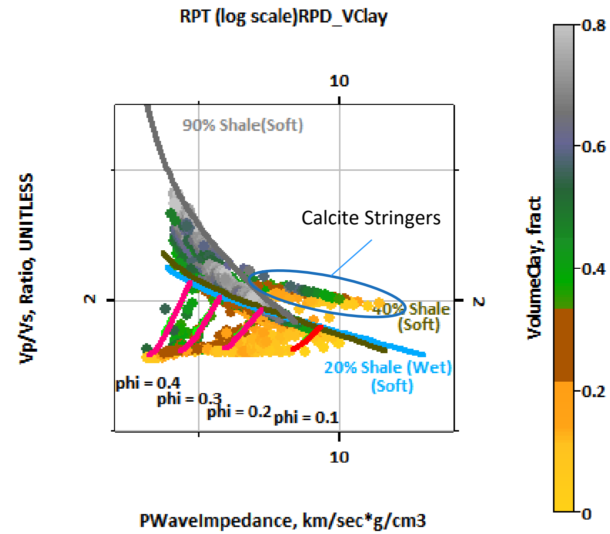
RPD (RPM)
Final (conditioned)

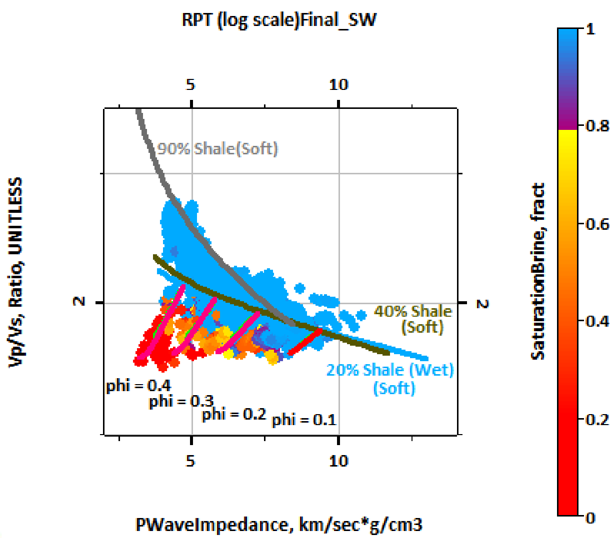
Talang-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

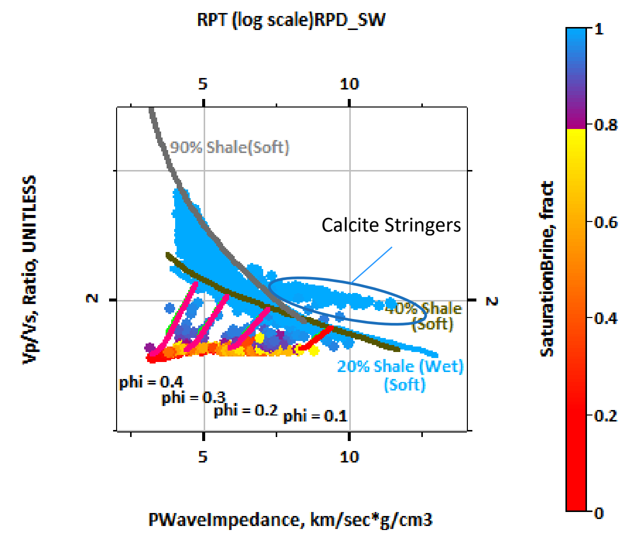
RPT cross plot shows the correlation between the rock physics model lines(soft sediment model) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Tanjak-1

Tanjak-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general data quality is fair to good and it has lower frequency content in compressional and shear velocities than those present in the density log. Elastic Data is available from around 750m to 3000 m **.
- Density log is heavily affected by borehole conditions, especially in the shallower section of the well, corresponding to the shallower log run set. Density log also appears to be affected in the middle section of the well corresponding to the second log run.
- Vp log quality is considered of better quality, and suffers from low frequency content. Editions were mainly performed from the density log to recover the lost frequencies where it was possible. Modified Faust model and synthetically estimated compressional velocities where used in few depth intervals. The compressional velocities where recovered using multi linear regression in the gap present between the first and second log run.
- Vs was not measured in this well and it was completely estimated using rock physics modeling.
- Other logs include, Neutron, Caliper, Deep and Shallow resistivities. Most of logs cover a depth interval from 400m to 3000m. Although there are measurements from 400m, there is only usable data for rock physics modeling from around 750m, top of the V geological marker.

Clay volume (VClay):

- This volume was estimated using mostly the Linear Gamma Ray method and the Neutron-Density crossplot approach. Petronas Vclay interpretation has also been a useful resource when revisiting the clay interpretation.

Reservoir characteristics:

- The Tanjak-1 well main targets were clastics and carbonates of Cycle IV and Cycle III, being the upper sandstones of Cycle V a secondary target. The interpreted section presents fair to good development of sand packages in Cycle V, averaging porosities between 20% and 30%. General reduction in porosity is observed below 1550m. There is less sandstone developments below that interval as well. Porosity values are usually below 15% in this interval.

Volume of hydrocarbons:

- The intervals in this well were interpreted as water bearing. Tanjak-1 well was Plugged and Abandoned as dry hole with gas shows.

Water saturation (Sw):

- Water saturation was estimated using Modified Simandoux's equation. Archie's parameters and water resistivity were calculated by means of Pickett Plot analysis performed in estimated water bearing sands. The analysis gave the following results, a=1, m=2, n=2. Water resistivity used to interpret Sw: Rw=0.09 ohmm @ 177 F (for a salinity ~ 30,000 ppm).

** Depths referred in this report are MD.

Tanjak-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore and indicated that the soft sediment model proved to be the best to predict the different elastic curves (RHOB, VP and VS) for both clay rich and sand facies. The soft sediment model also was calibrated for the carbonate section of the well. Data from the clastic and carbonate sections that proved to be of good quality were used to calibrate the rock physics model better suited for this well. Modified Faust model and linear regression method was used to perform some minor editions in the clastic interval, where the compressional velocity log seemed to have anomalous measurements. The linear regression method was used to reconstruct the compressional velocity log in the gap present between the first and second log runs.

Fluid properties:

Water and hydrocarbon properties used in fluid substitution have been assumed to be the average of the area where the well was drilled. Water salinity was calculated using Pickett plot analysis. Main parameters used in fluid substitution are :

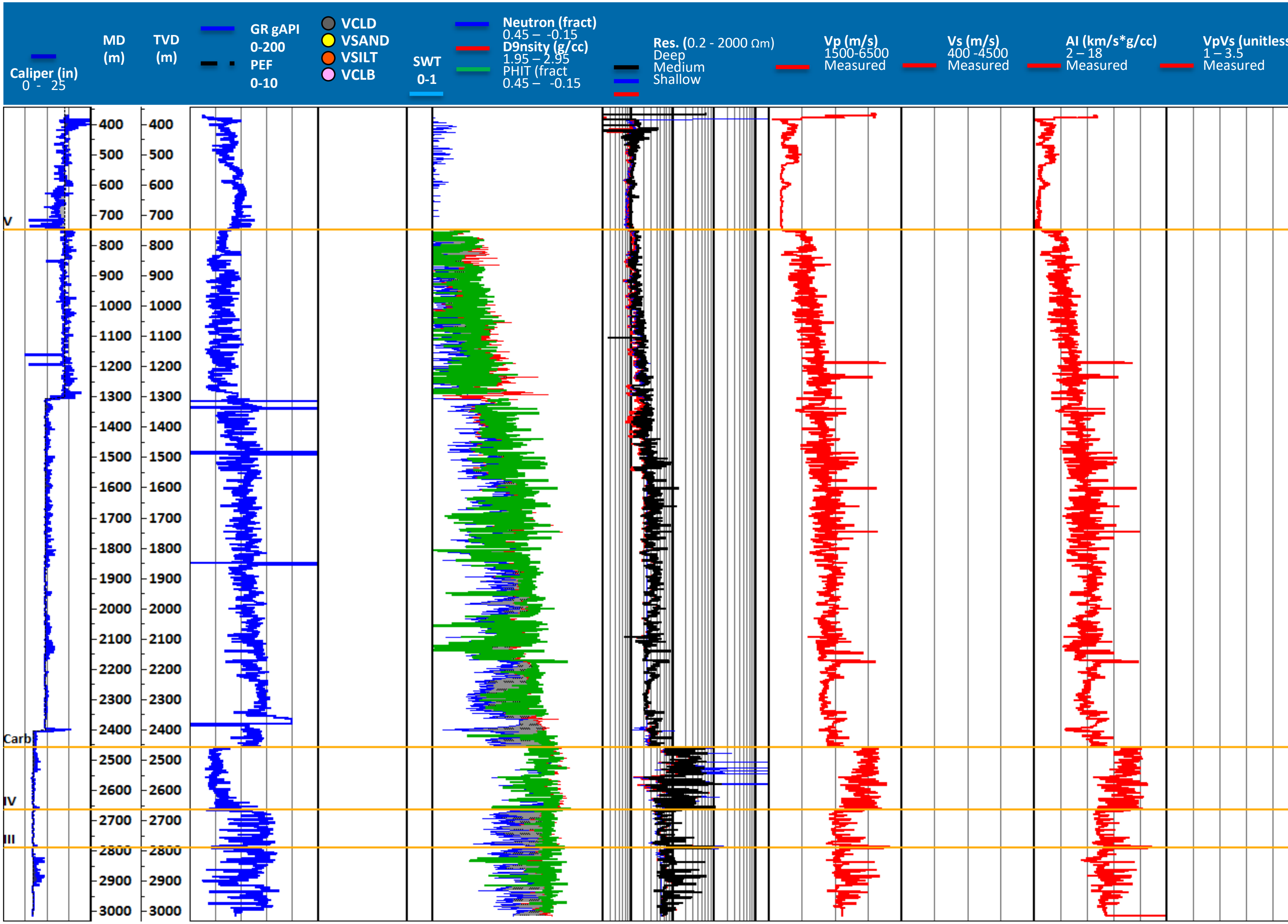
- Brine salinity: 30,000 ppm
- Gas gravity: 0.85 (PVT report SPAOH-1)
- Oil Gravity: 40 API (Average value based on nearby data)
- Gas / Oil ratio: 194 (L/L) (Average value based on nearby data)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling can be performed in any of the sand packages appearing along the well. Perturbational modelling calculates the effect in elastic properties due to changes in porosity, volume of clay, and fluid content of the rock. In general, gas saturated sands show lower Vp/Vs ratios and lower p-wave impedance (AI) values than wet sands at log scale.
- Fluid substitution is performed via Brie model.
- Particular AVO responses will depend on the selected modeling interval, porosity and fluid content of the rock. As in the selected example, the sand package at 2900m (Water bearing sand in Cycle III) was gas substituted allowing the Water saturation to be reduced to 20%. Porosity was preserved for this exercise. This exercise showed lower values for VpVs ratio and lower values for Acoustic Impedance compared to the wet case.

** Depths referred in this report are MD.

Input Logs – Tanjak-1



Additional data includes mud weight data, pressure and temperature data and well reports. Shear slowness was not measured in this well

Tanjak-1 Geophysical Well Log Analysis (GWLA)
Upper section, Interval from 750m to 2000 m

model type flag

Unconsolidated rock model

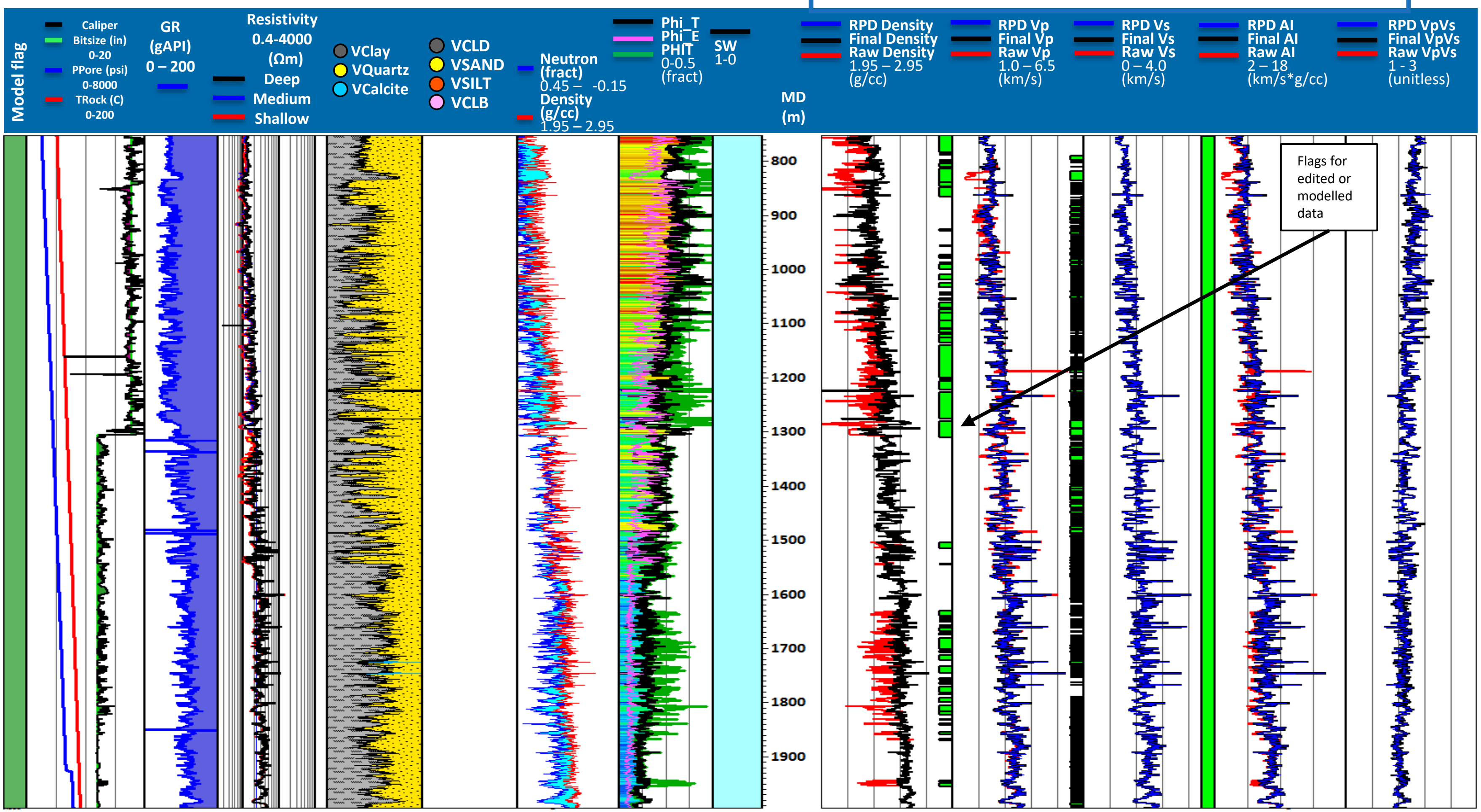
Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

RPD Modeled (RPM) curve

Final edited (Conditioned) curve

Original Raw (Raw) curve



Clastic section of the well Tanjak-1. Compressional velocities are of good quality in this interval. The edit flag in the compressional velocity track is indicating where the compressional velocities were depth shifted to align with other logs. The shear velocity was completely estimated.

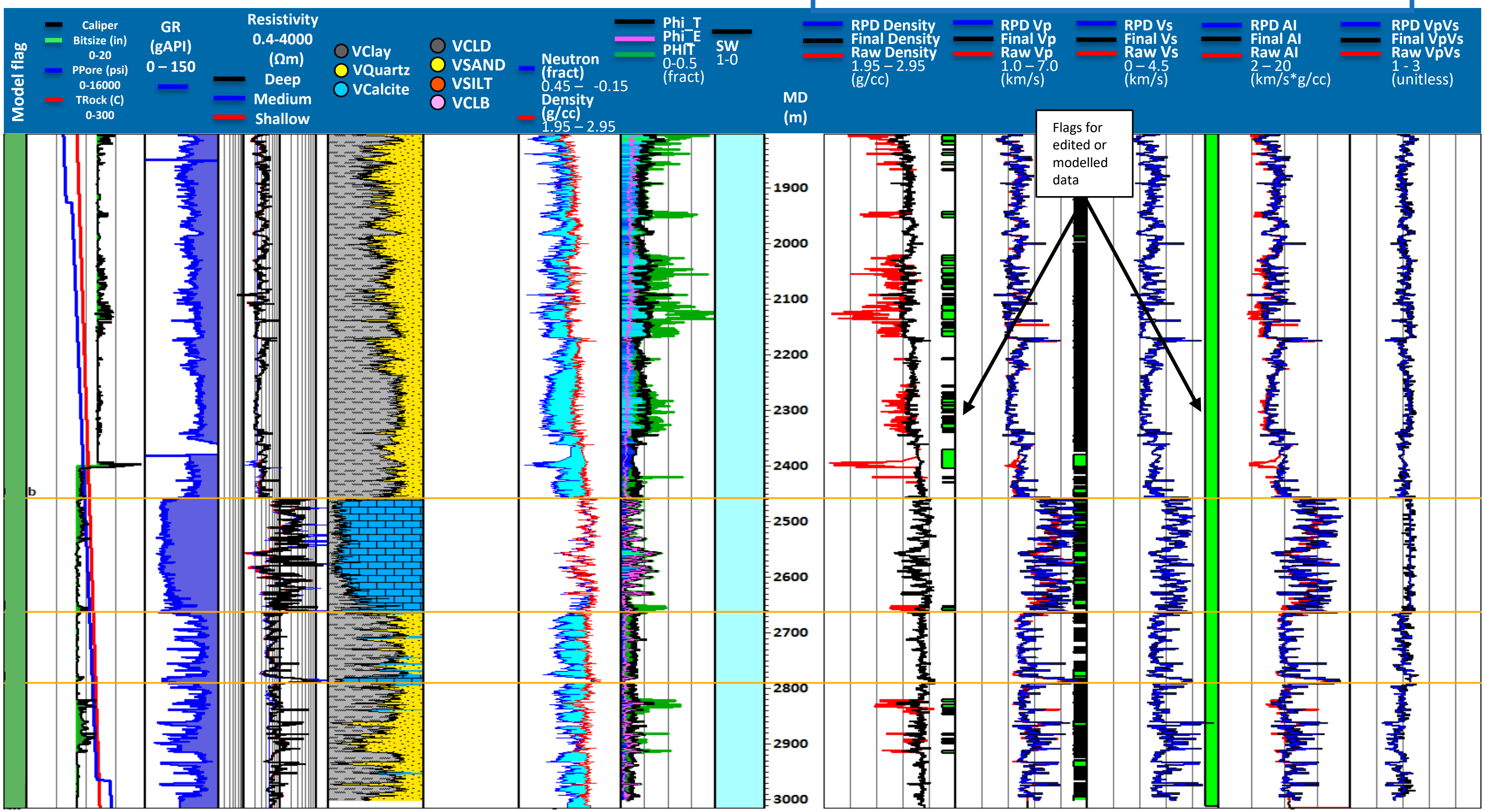
Tanjak-1 Geophysical Well Log Analysis (GWLA)
Lower section, Interval from 1800m to 3000 m

model type flag

- Unconsolidated rock model
- Stiff rock model

Equivalence between RSI and Petronas naming. Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

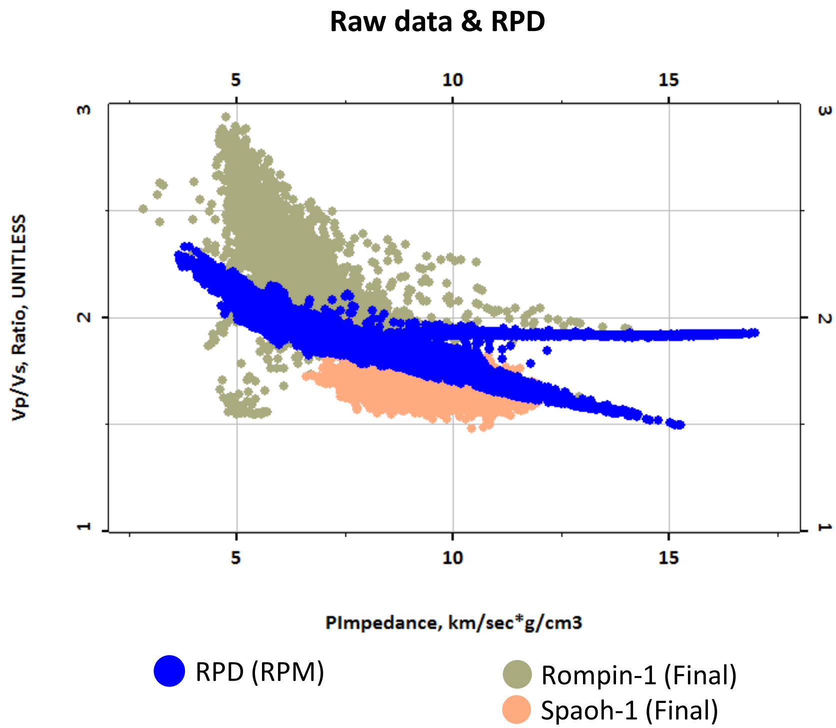


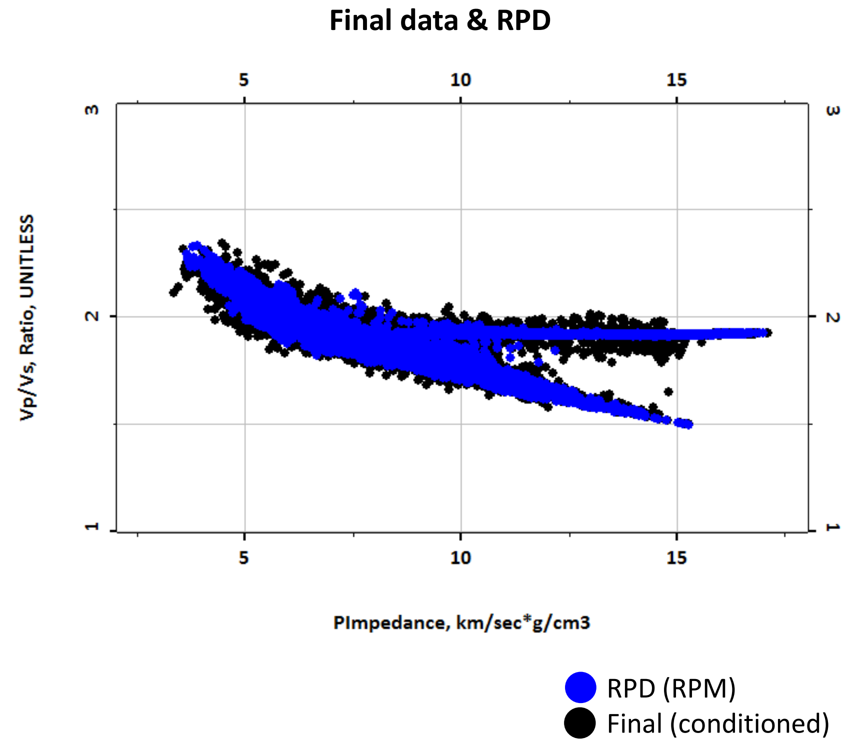
Carbonate section of the well Tanjak-1. Density log is of good quality in this interval. The edit flag in the density track is indicating where the density log was depth shifted to align with other logs. The shear velocity was completely estimated.

Tanjak-1, Rock Physics Diagnostics (RPD)
Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original (raw) data. Additional data is presented from nearby well Sikau North and Rompin-1, which is relatively far.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

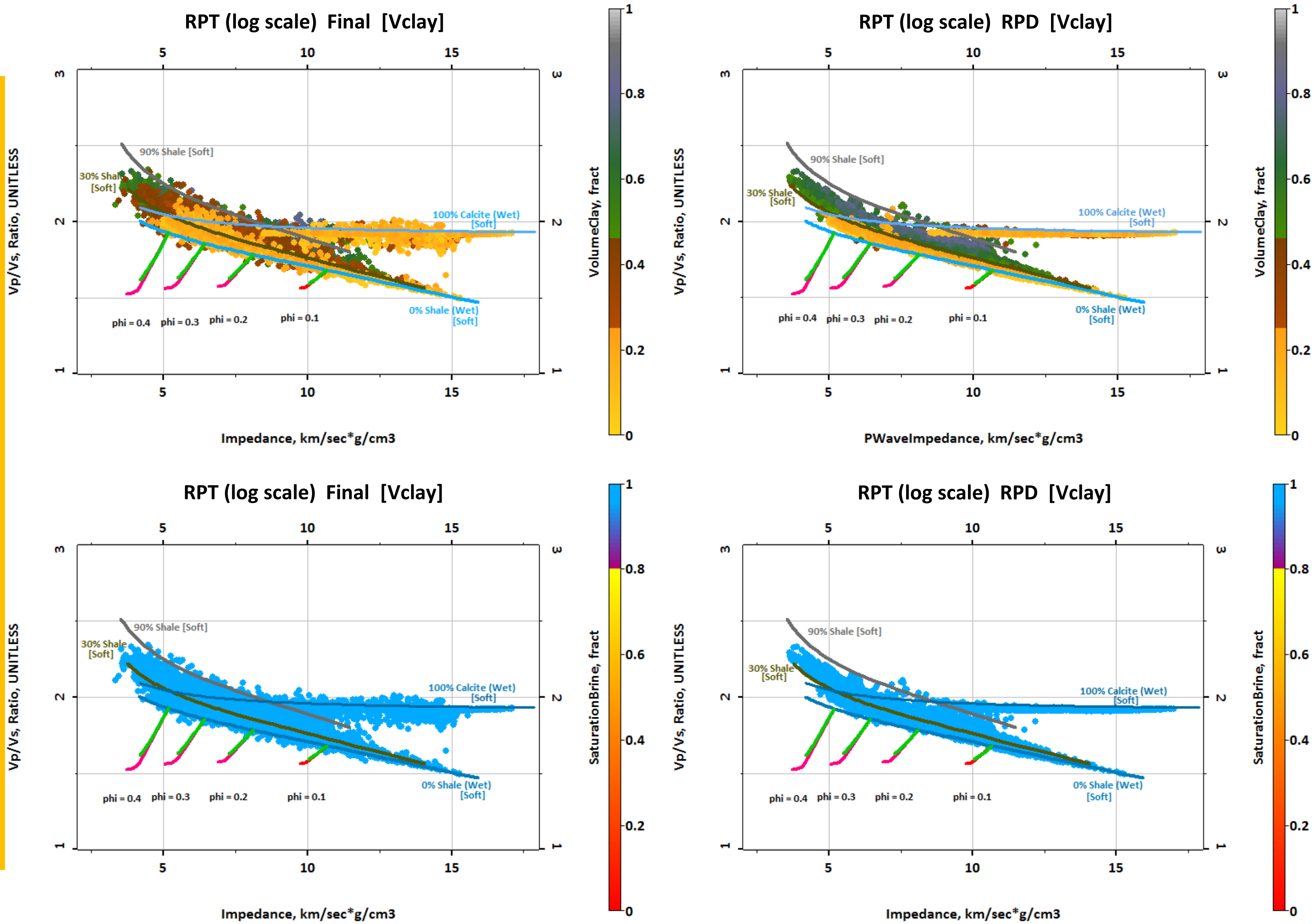




Tanjak-1, Rock Physics Diagnostics (RPD)
Rock Physics Models, Clastic Section (2000m-3610m)

RPT cross plot shows the correlation between the rock physics model lines (soft sediment model) compared to both the final elastic data to the left and the modelled data to the right, color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

Tanjung Baram-1

Tanjung Baram-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference but without lithology interpretation(just porosity and water saturation). Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts(expected since no Caliber log was provided).
- Shear wave velocity(VS)was fully modelled in the well using the RPD after the model was carefully calibrated based on the offset well(Tukau Timur West-1) which behaves elastically similar to the well and also using the VP-Rhob relation to predict best model to use. The resulted modelled VPVS ratio and P-wave impedance follow the trend of the measured data in the nearby well(Tukau Timur West-1)
- Other logs include Gamma, Neutron and deep resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands(Cycle V). These are a series of turbiditic sands with fair to good porosity and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with some clay rich interbeds.

Volume of hydrocarbons:

- As per the information found in the final well report for the well provided by the client, the well tested oil and gas. High gas saturation encountered starting from depth 3522m(MD) to the T.D with calculated gas saturation up to 70%, while the oil leg encountered starting from depth about 3000m down to 3522m(MD) with oil saturation reached to 65%.

Water saturation (Sw):

- Salinity used in the well based on the information provided in the well final geological report as 30000ppm. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.85 and Saturation exponent (n)=1.85 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2900m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB and VP) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- Elastic behavior for the well was carefully calibrated with the nearby wells honoring the same elastic trend for the well(P-Wave impedance depth trend) And concluded that the well elastically behaves (VP-RHOB wise) same to Tukau Timur West-1 well, so S-wave velocity completely modelled in the well based on the same model which resulted in a matched trend with the calibrated nearby well and very well behaved model when compared to the modelled results in the other wells in the area.

Fluid properties:

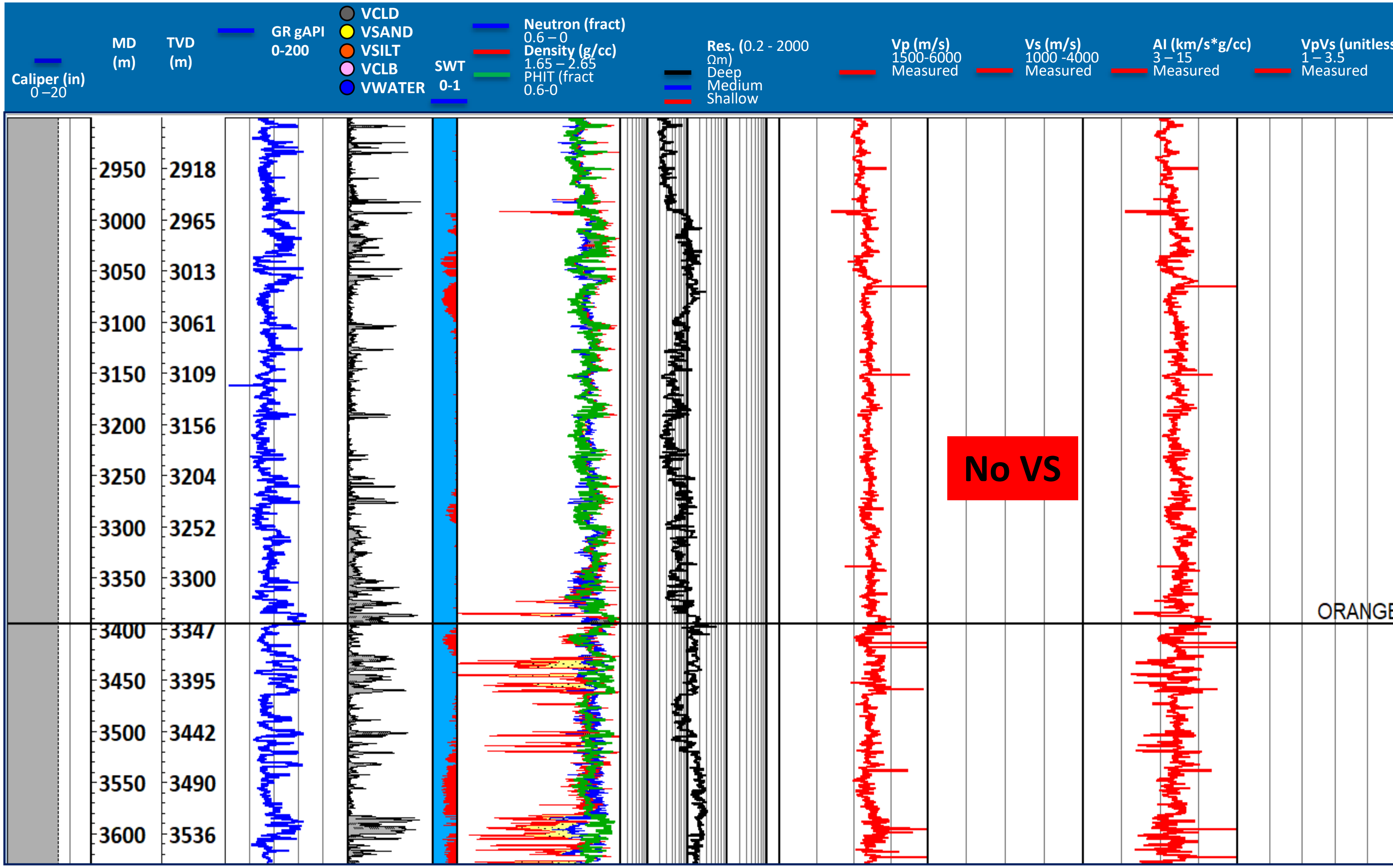
Fluid properties used in substitution have been assumed based well DST#3/3A. Main parameters used in this modeling are:

- Brine salinity: 30000 ppm[Final geological report]
- Gas gravity: 0.74
- Oil Gravity: 35 API
- Gas / Oil ratio: 985(L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands(Cycle V) using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with poor to fair discrimination with the brine sands.
- AVA class IV was observed near the oil sands @ 3025m for all fluid cases at in situ reservoir conditions with poor separation between the different fluid cases.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no noticeable change for the AVO class was observed but the discrimination between the wet and the hydrocarbon cases enhanced a lot.

Tanjung Baram-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

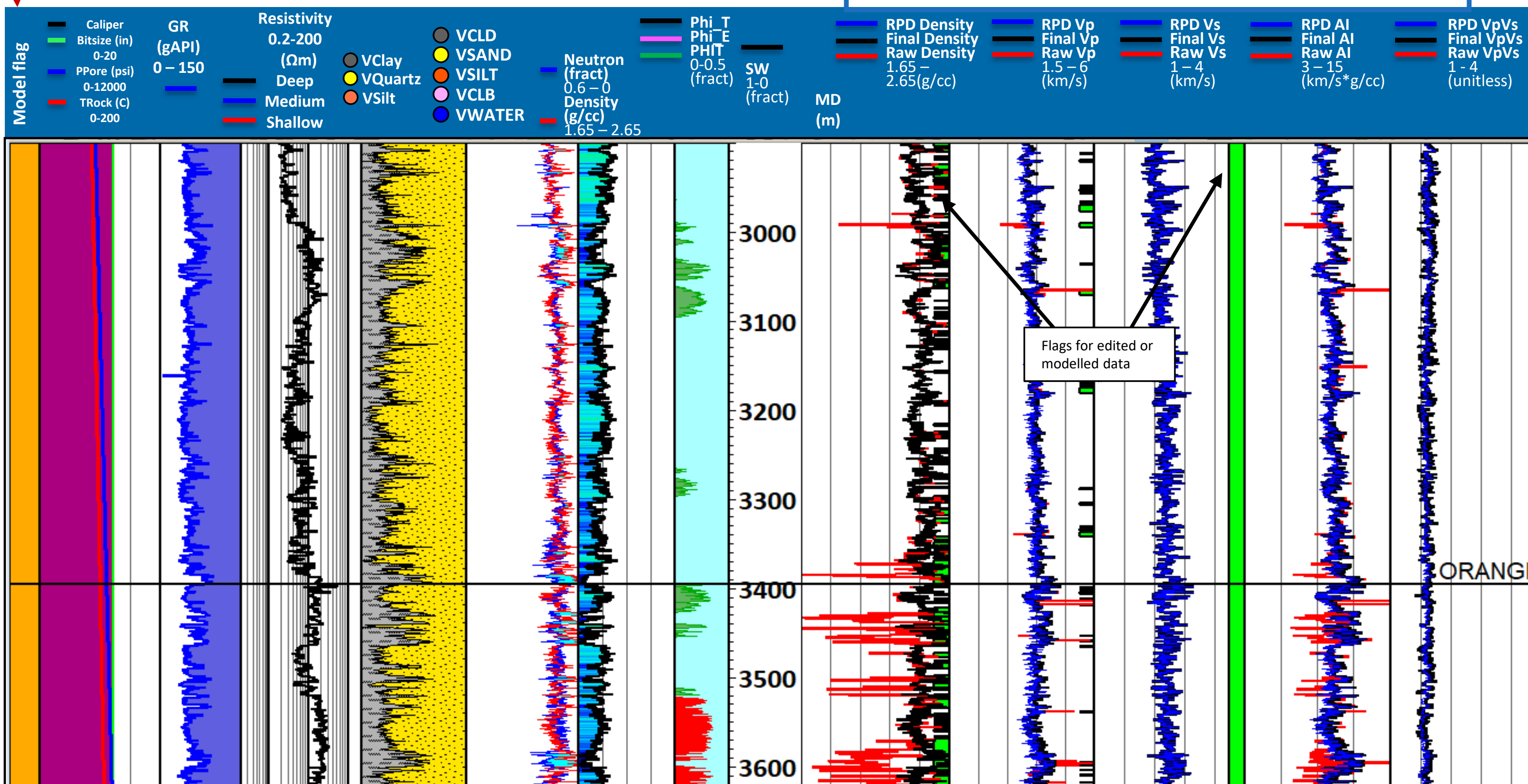
Tanjung Baram-1 Geophysical Well Log Analysis (GWLA)
Top of Available Elastic Logs To The End Of The run

model type flag

- Soft rock model
- Stiff rock model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

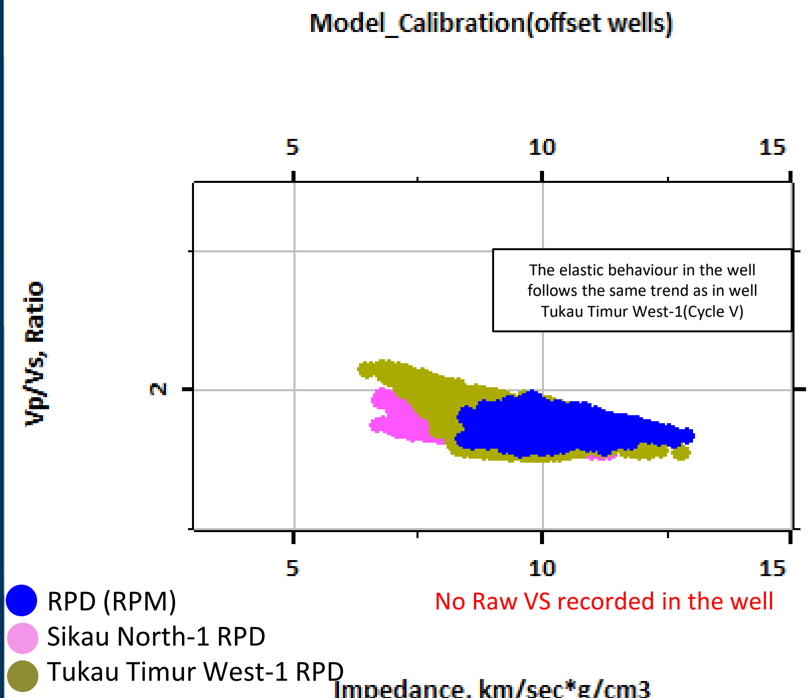
- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



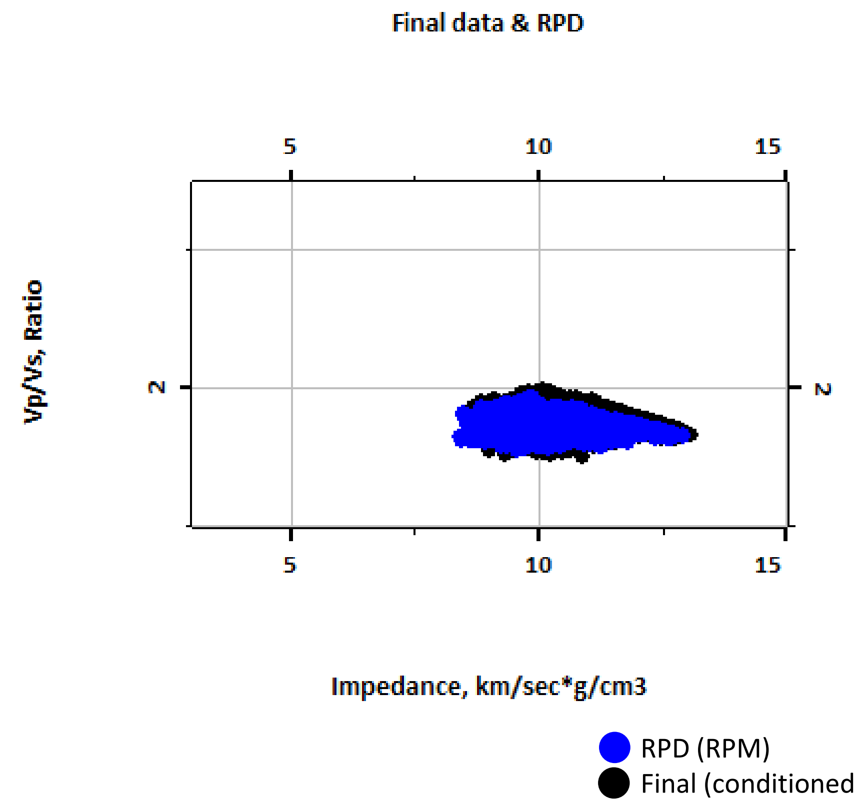
Many edits to the measured data(especially Rhob) and model calibration is strong where reliable measured data occurs. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data and with the nearby reference well Tukau Timur West-1.

Tanjung Baram-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the good calibration for the Tanjung Baram-1 well RPD with the nearby well Tukau Timur West -1 and Sikau North-1.



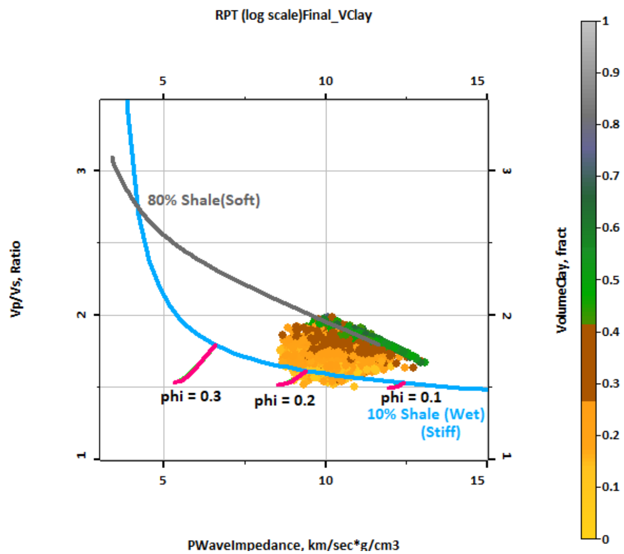
P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data(Rhob and Vp ere conditioned while VS is totally modelled).

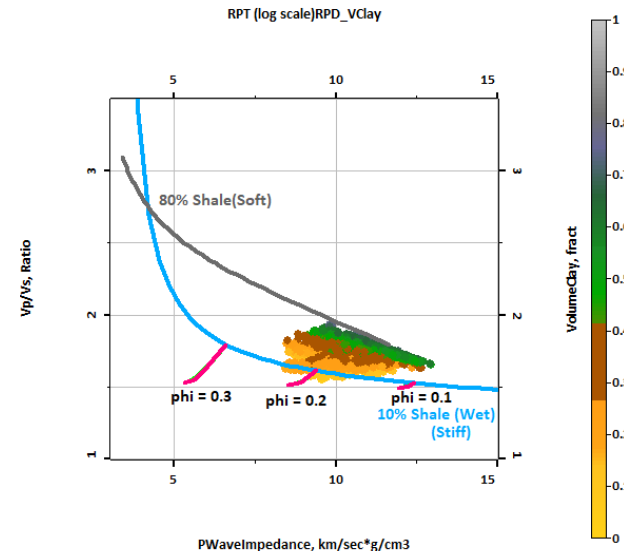


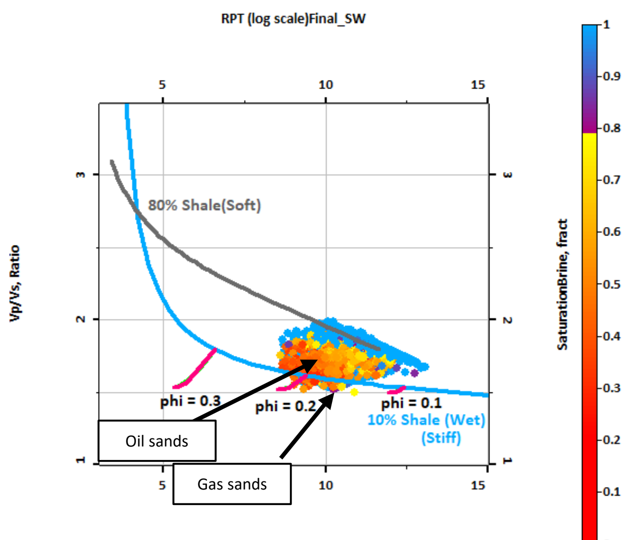
Tanjung Baram-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

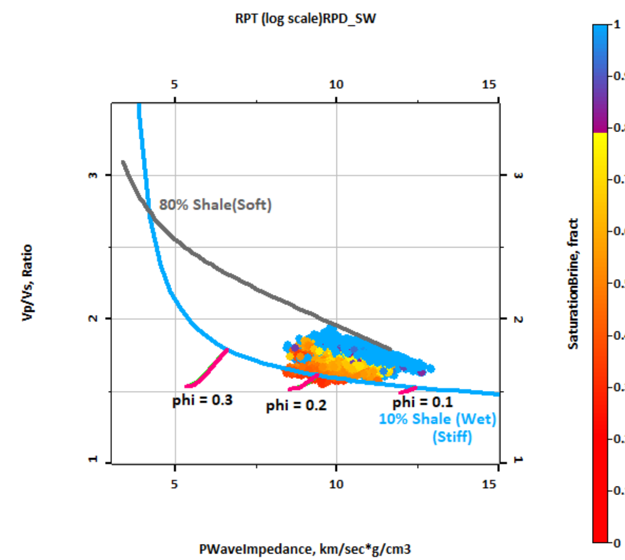
RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data









RPD(Modelled)data

Tukau Timur West-1

Tukau Timur West-1 Geophysical Well Log Analysis and Rock Physics Modelling Summary

Log data availability and quality:

- In general, data quality and availability is fair. Client's petrophysical interpretation was fully provided as a reference. Density was heavily edited using the RPD in the intervals where the borehole was greatly affected by the washouts.
- Invasion correction was applied for the density log in the gas saturated sands and the results were aligned with the porosity provided by Petronas for reference.
- Vs was heavily edited in the shallower section of the measurement(2000m-2150m).
- Other logs include Gamma, Neutron, Deep and shallow Resistivity, which all run for the full logging run.

Clay volume (VClay):

- This volume was derived from linear Gamma Ray method.

Reservoir characteristics:

- In terms of lithology the primary reservoir targets are the Miocene sands. These are a series of turbiditic sands tight and with minor calcareous cement in some intervals, distributed in lobe/channel complexes with some clay rich interbeds.

Volume of hydrocarbons:

- All the sand reservoirs penetrated in the well from top to about 3100m(MD) were 100% brine saturated while most of the sands penetrated below that depth were gas saturated with saturation reached to 80% in many intervals especially H790, H800 and H830.

Water saturation (Sw):

- Pickett plot analysis assisted in the Rw interpretation. Particularly, the clean wet sand section(3045-3050m) yielded a formation water salinity of 13000 PPM. Water saturation was calculated using Simandoux's equation with constants used were (a)=1, Cementation exponent (m)=1.8 and Saturation exponent (n)=1.8 (assumed).

Rock physics diagnostics (RPD):

- This was performed from top to bottom of the wellbore, and indicated that from the point where the full elastic log suite started(2000m) down to the T.D. the stiff sand model proved to be the best to predict the different elastic curves(RHOB, VP and VS) for quartz rich intervals while the soft sediment model is the best to match the measured data in the clay rich intervals when compared to the well measured elastic logs.
- This well behaves very similar to the elastic trend in the southern area of Sabah basin(Samarang wells) where same model was applied.

Fluid properties:

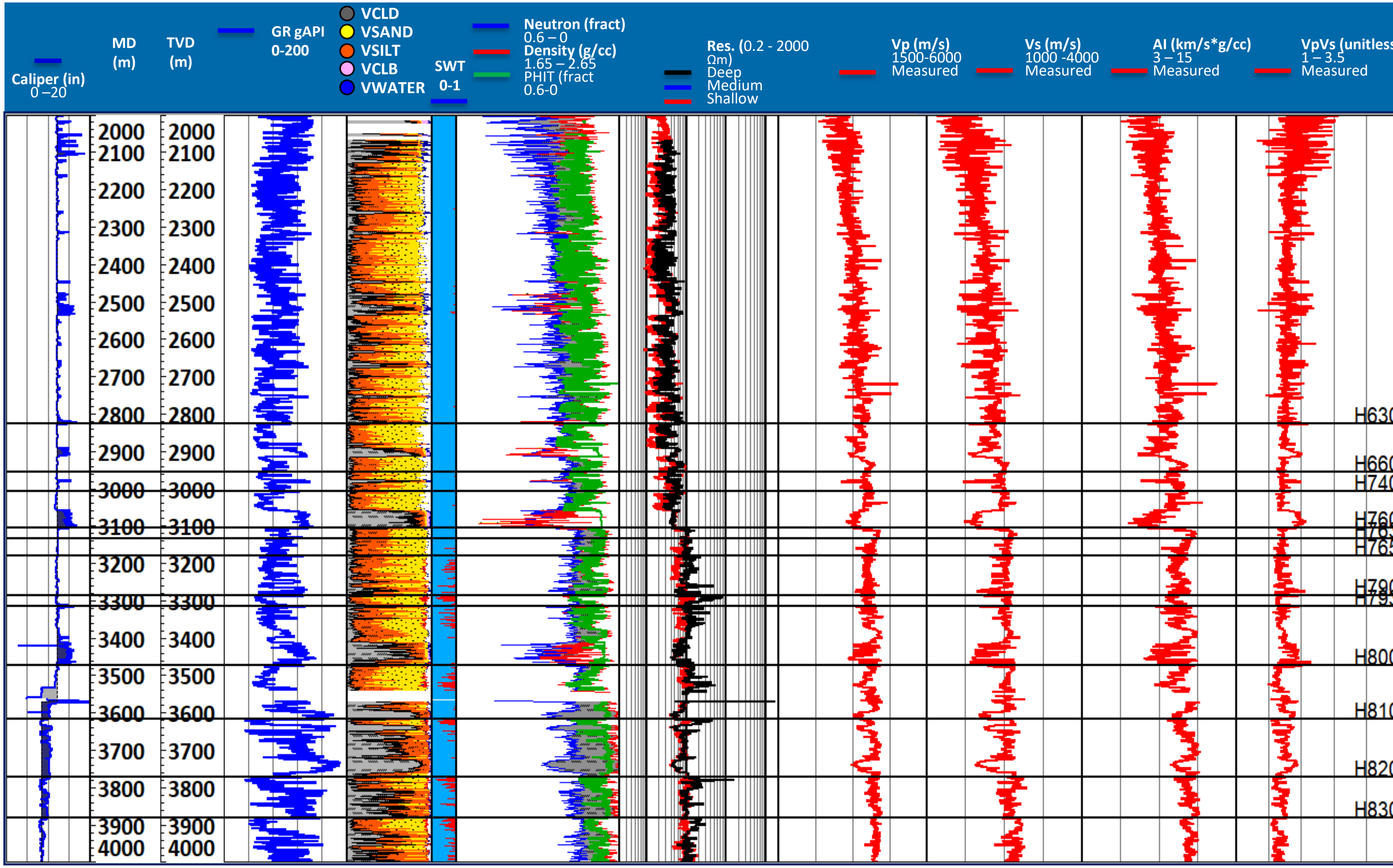
Fluid properties used in substitution have been assumed based well production test. Main parameters used in this modeling are:

- Brine salinity: 13000 ppm[Pickett plot]
- Gas gravity: 0.68
- Oil Gravity: 47.6 API
- Gas / Oil ratio: 50 (L/L)

Rock physics modelling (lithology, fluid and porosity):

- Perturbational modelling was performed in the different Miocene sands using the final modelled elastic curves as an input.
- Gassmann's fluid substitution method was used to perturb the different Modeling scenarios
- Perturbational modelling showed the effect of changing porosity, volume clay, and fluid on the elastic properties. Gas saturated sands showed lower Vp/Vs ratio and lower p-wave impedance (AI) values than wet sands at log scale with fair discrimination with the brine sands.
- AVA class IV was observed near the H800 gas sands @ 3500m for all fluid cases at in situ reservoir conditions.
- By upgrading the reservoir quality(increasing porosity and decreasing clay content) no noticeable change for the AVO class was observed.

Tukau Timur West-1 Input Logs



Additional data includes pressure, temperature data and cuttings descriptions (Final geological report).

Tukau Timur West-1 Geophysical Well Log Analysis (GWLA)
Top of elastic logs to 3000m(MD)

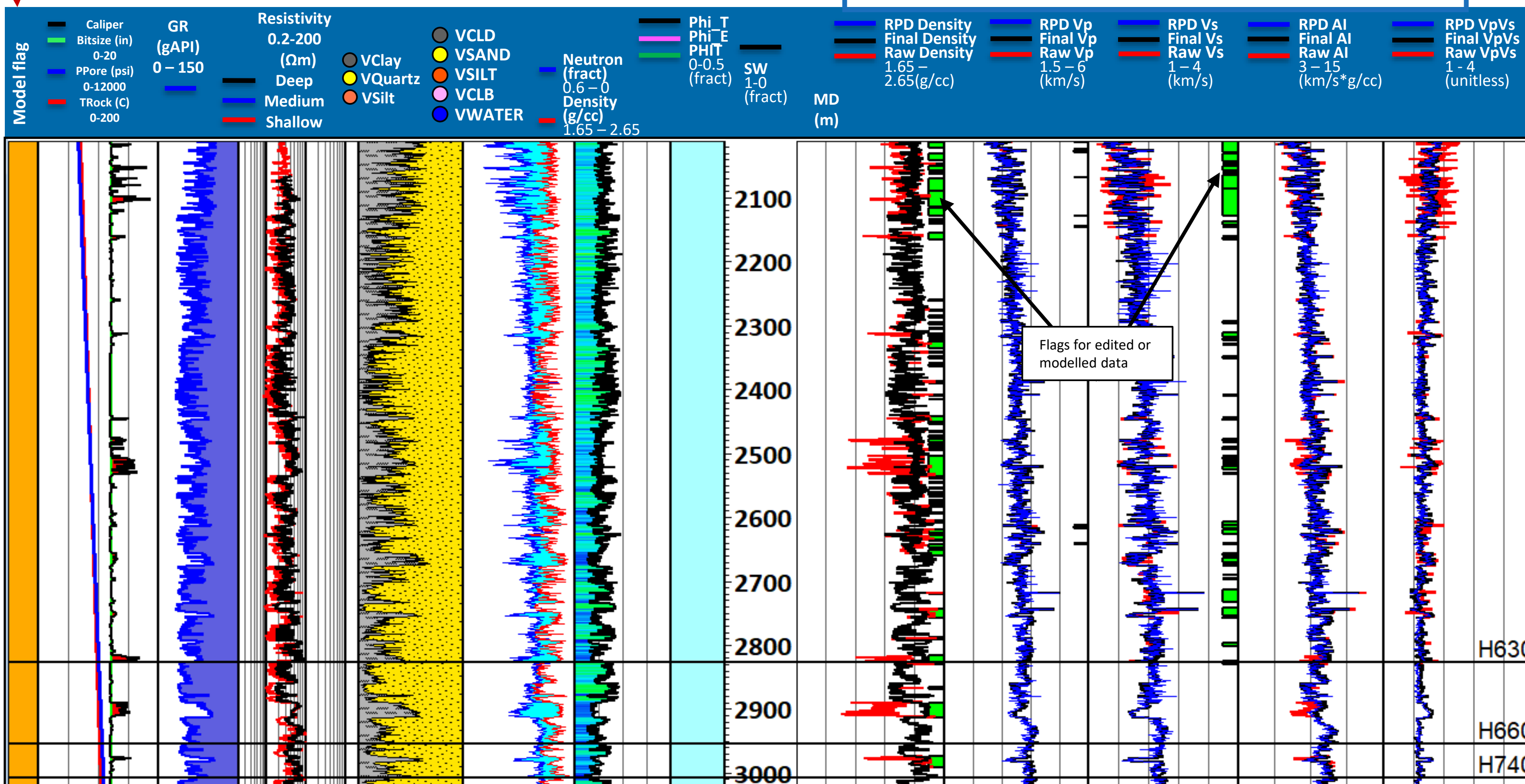
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2000m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve



Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Tukau Timur West-1 Geophysical Well Log Analysis (GWLA) 3000m(MD) to the end of the elastic logs.

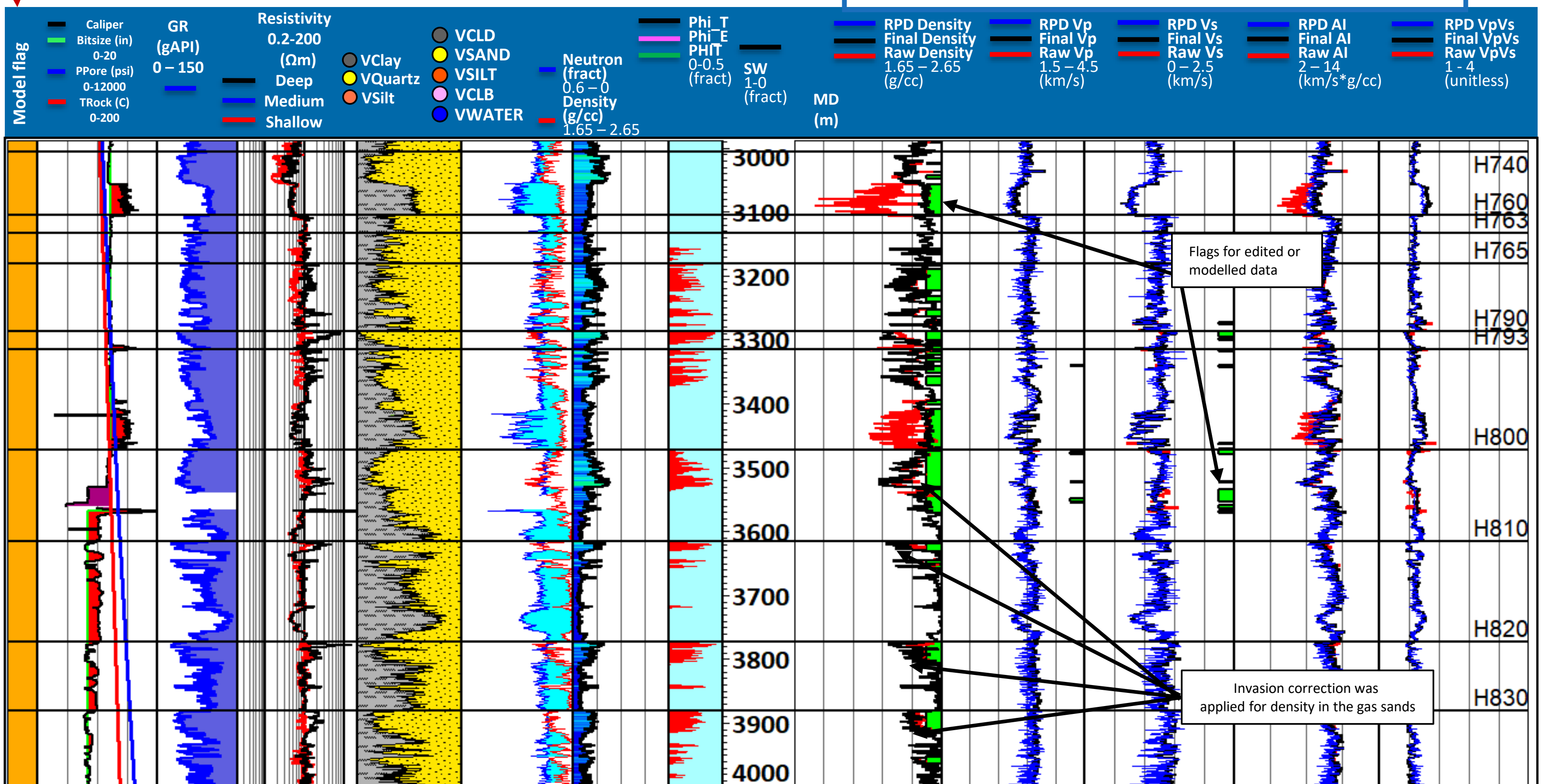
model type flag

- Soft rock model
- Stiff rock model

Above depth of 2000m(MD) no reliable logs were available to establish a rock physics model

Equivalence between RSI and Petronas naming.
Petronas equivalent curve name in parentheses

- RPD Modeled (RPM) curve
- Final edited (Conditioned) curve
- Original Raw (Raw) curve

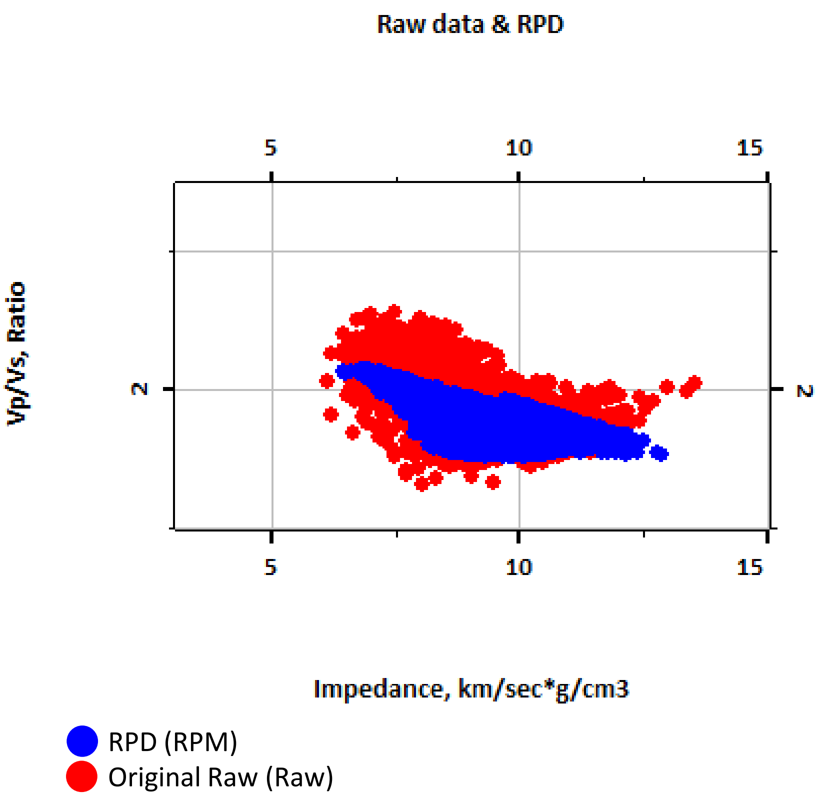


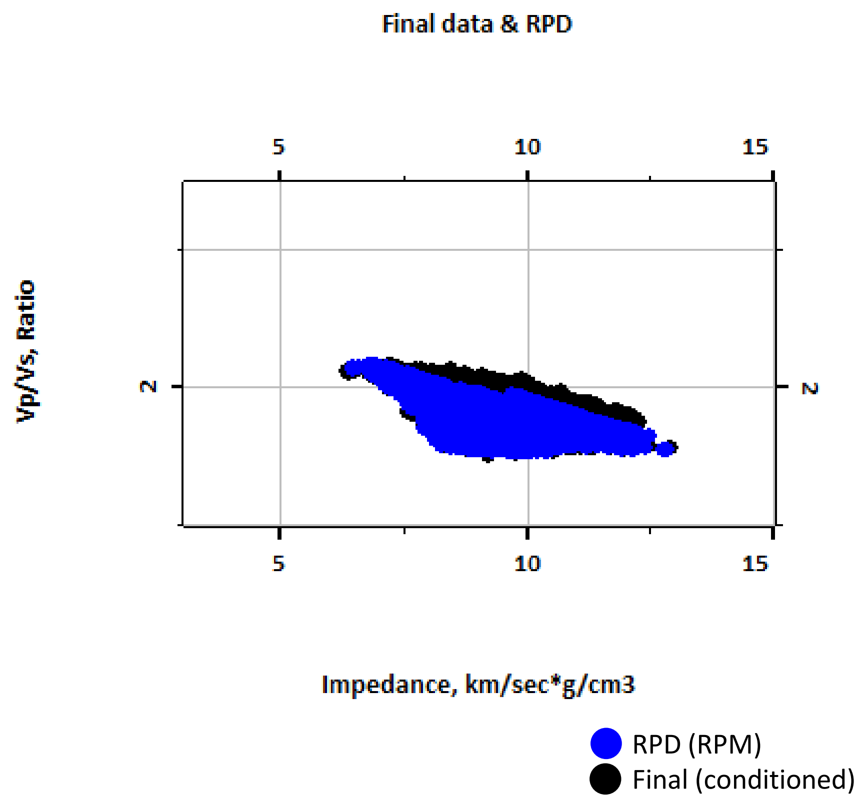
Some edits to the measured data and model calibration is strong. Granular media model (stiff sand) was used for all elastic curves' prediction (Rhob, Vp and VS) in the clean reservoir rocks while(soft sediment model)for the clay rich intervals with good correlation with the measured data.

Tukau Timur West-1,Rock Physics Diagnostics (RPD) Measured, conditioned and modelled data

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the original un-edited measured data.

P-Impedance vs. Vp/Vs plot showing the overlay between the RPD model estimated elastic variables over the final conditioned data.

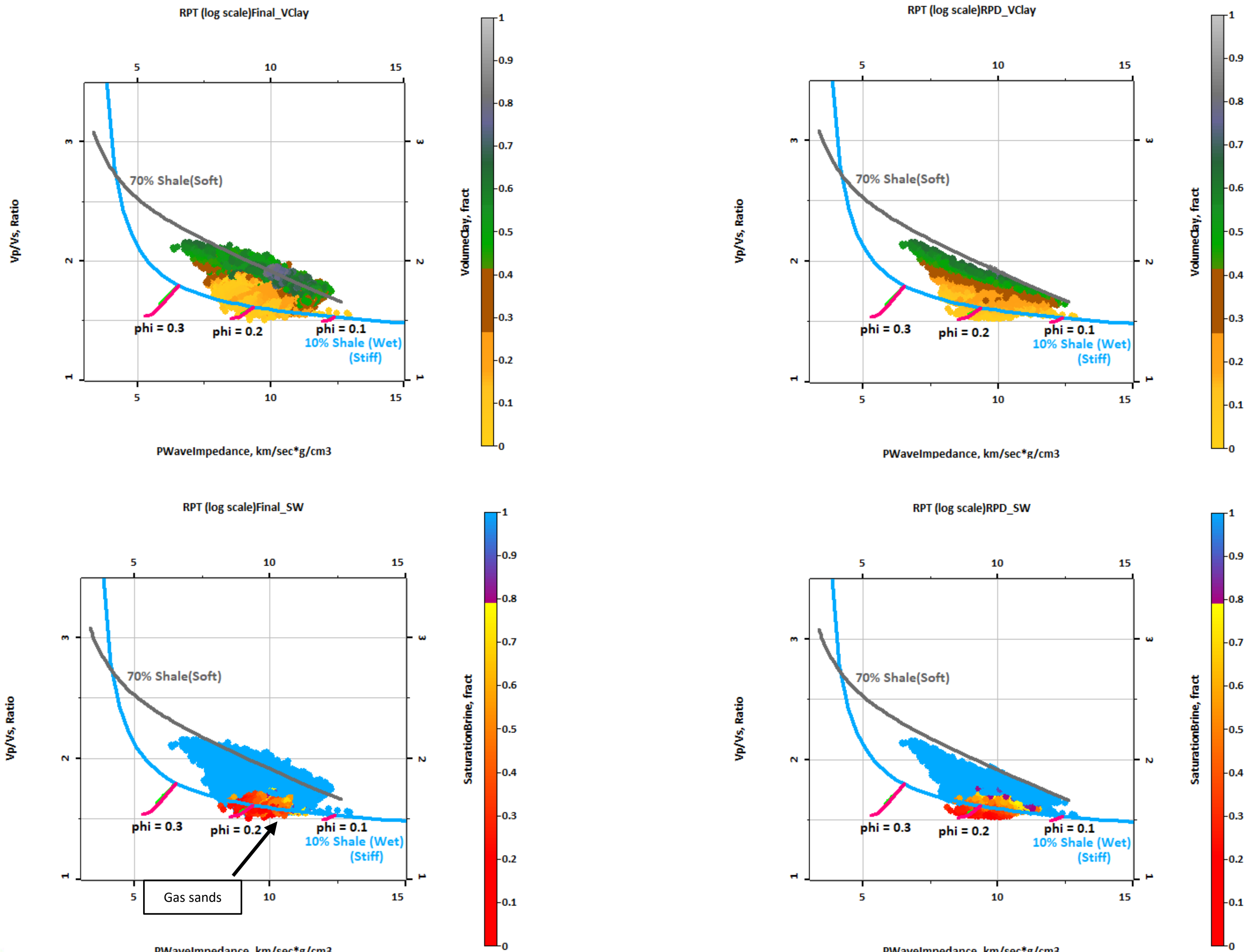




Tukau Timur West-1,Rock Physics Diagnostics (RPD)
Rock Physics Models, Full Well

RPT cross plot shows the correlation between the rock physics model lines(soft and stiff models) compared to both the final elastic data to the left and the modelled data to the right color coded by clay volume and water saturation.

Final conditioned data



RPD(Modelled)data

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