Digital, Data Analytics, and Automation: Value Creation Through Digital E&P

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Optimizing Pressure Test with Artificial Intelligence

F.A.M. Bakeri, I.M. Gazali, H.H. Lee, M.I. Fadhil, S. Nurdyana, and T.A. Farhan

PETRONAS CARIGALI SDN BHD

PETRONAS

AGENDA

- Background
- Pain point
- Solution
- Result
- Future improvement

Drilling is an expensive business and significant cost spent on data acquisition. Hence, good quality data is critical to ensure return of investment to PETRONAS

Background

Pain Point

Solution

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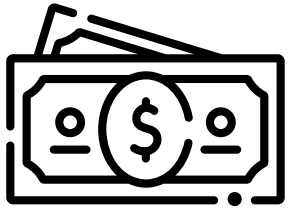
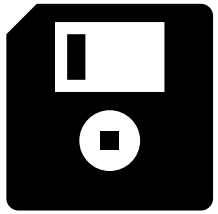
Moving Forward

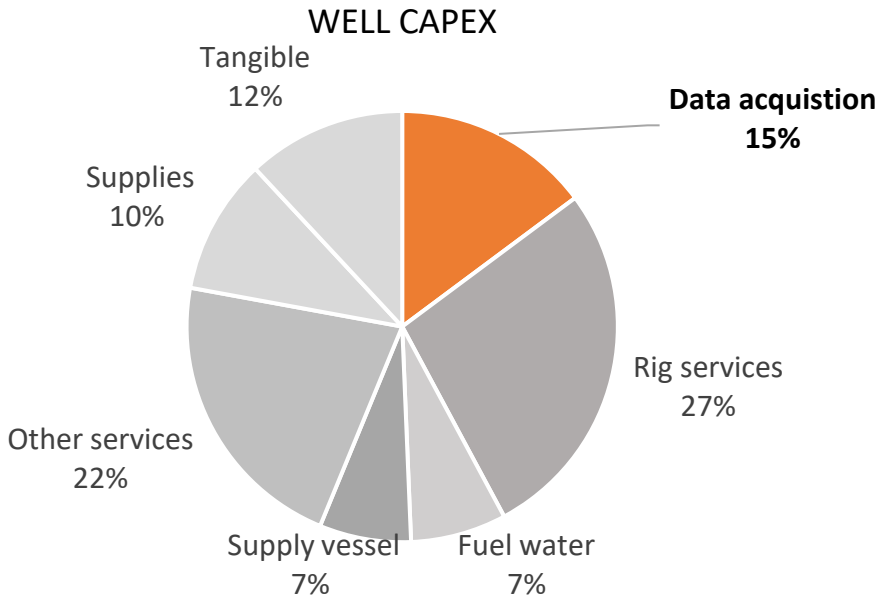




Significant amount of cost is incurred for drilling any new development well in PETRONAS

In average 10-15% spent for data acquisition.

Good quality data is important to subsurface team. Essential for understanding of our reservoir and develop plan to optimize & maximize oil and gas recovery for the company.



Formation pressure test is among the most important data acquisition in subsurface for evaluating reservoir. Historically the average success ratio is low ~60% for Field-A

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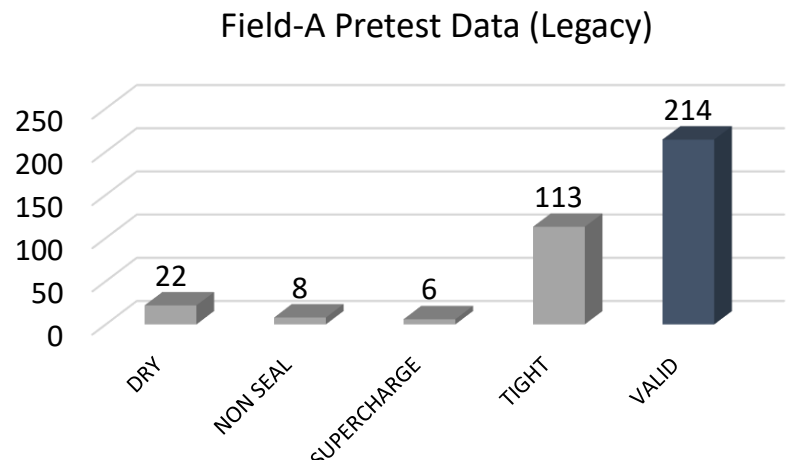
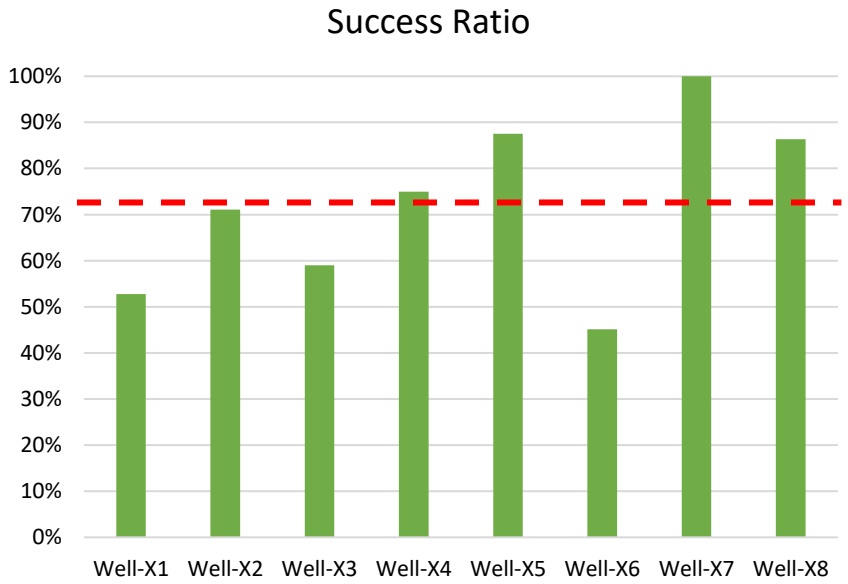
Formation pressures (Pretest) is among the critical data for subsurface. Crucial for confirming hydrocarbon presence in the reservoir



In our selected case study, Field-A, the historical success rate of pretest measurements is low. The average success ratio is only 60%

$$Success\ Ratio = \frac{Valid\ Test}{Valid\ Test + Invalid\ Test}$$



Team embarked on piloting Machine Learning prediction to help improve the pretest success ratio to 90%. Workflow is developed to ensure right data is trained, tested and deployed

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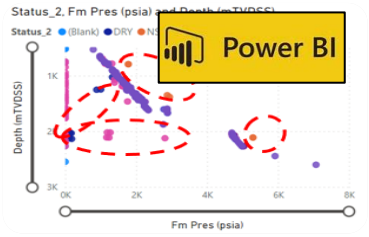
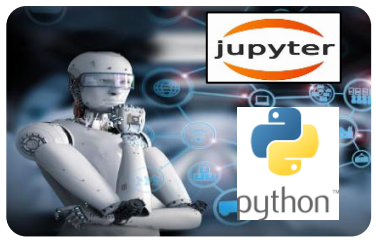
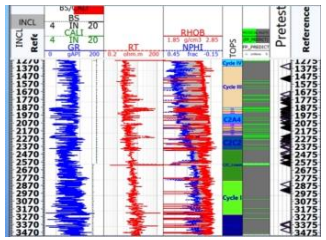
In-house ML solution was developed to predict validity of pretest point

Aiming to increase the success ratio from 60% to 90%







Data Preparation

- Utilization Generic Model to extract tabular data from legacy pdf report

QAQC

- 393 Data Points
- Power BI

Model Building

- Validity model
- Experimenting with Features
- ML Model Sensitivity
- Final model (Model accuracy, 80%)

Blind Test

- Pilot test on Field-B (Model accuracy, 87%)

Field-A Redev Campaign

- Deployment to 4 new wells
- Total 80 new pretest point acquired with Stethoscope (SLB tool)

Utilization of multiple digital and AI tools allows processing of large and unstructured subsurface data to generate new insight and accurate prediction.

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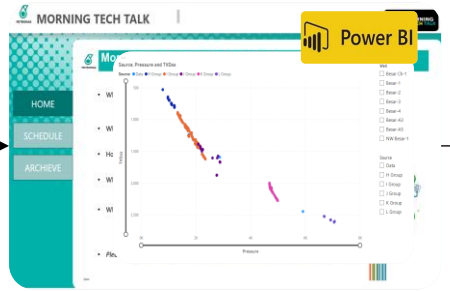
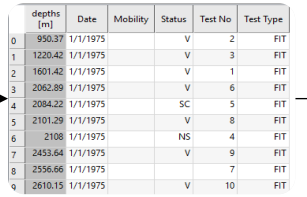
Unstructured Data from Legacy Report

Data QAQC and Labelling

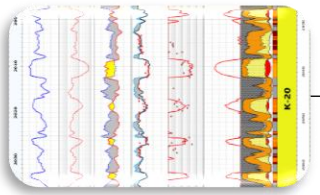


Clean Pretest Dataset



	depths [m]	Date	Mobility	Status	Test No	Test Type
0	950.37	1/1/1975		V	2	FIT
1	1220.42	1/1/1975		V	3	FIT
2	1601.42	1/1/1975		V	1	FIT
3	2062.89	1/1/1975		V	6	FIT
4	2084.22	1/1/1975		SC	5	FIT
5	2101.29	1/1/1975		V	8	FIT
6	2108	1/1/1975		NS	4	FIT
7	2453.64	1/1/1975		V	9	FIT
8	2556.66	1/1/1975			7	FIT
9	2610.15	1/1/1975		V	10	FIT

Wireline OH Data



Data Merge

Training & Test Data

Model Sensitivity

Model Transfered

Model Prediction Accuracy ~90%

Real time Ops Optimization

Model training stands as a pivotal element in the process of making machine learning predictions

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Train model

- Total dataset 333 points

	VALID	INVALID	TOTAL
Count of status	208	125	333

- Splitting 70:30 (stratification)

Sensitivity Analysis

Case	Model	Remark	Accuracy
1	Neural network	Base	0.61
2	Decision tree	Base	0.69
3 (a)	Random forest	Base	0.75
3 (b)		Add features (INCL)	0.76
3 (c)		Fine tuning parameter	0.79

Final Score Matrix

```
model = RandomForestClassifier( n_estimators=10,
                                random_state=2,
                                verbose=False)
```

```
model = RandomForestClassifier( bootstrap= True, max_depth= 30,
                                max_features= 'sqrt', min_samples_leaf= 4,
                                min_samples_split= 5, n_estimators= 50)
```

```
Number of features:  5

['GR', 'INC', 'NPHI', 'RHOB', 'RT']

[[48  9]
[11 27]]
              precision    recall  f1-score   support

   Valid 0.0       0.81      0.84      0.83        57
 Invalid 1.0       0.75      0.71      0.73        38

    accuracy                           0.79        95
   macro avg       0.78      0.78      0.78        95
weighted avg       0.79      0.79      0.79        95
```

Fine tune parameter

Field-B Pilot test

- Accuracy 87%

Example application in Well-Y2 shows good pressure validity prediction with high success ratio. Assist engineer to pick points through automated flagging.

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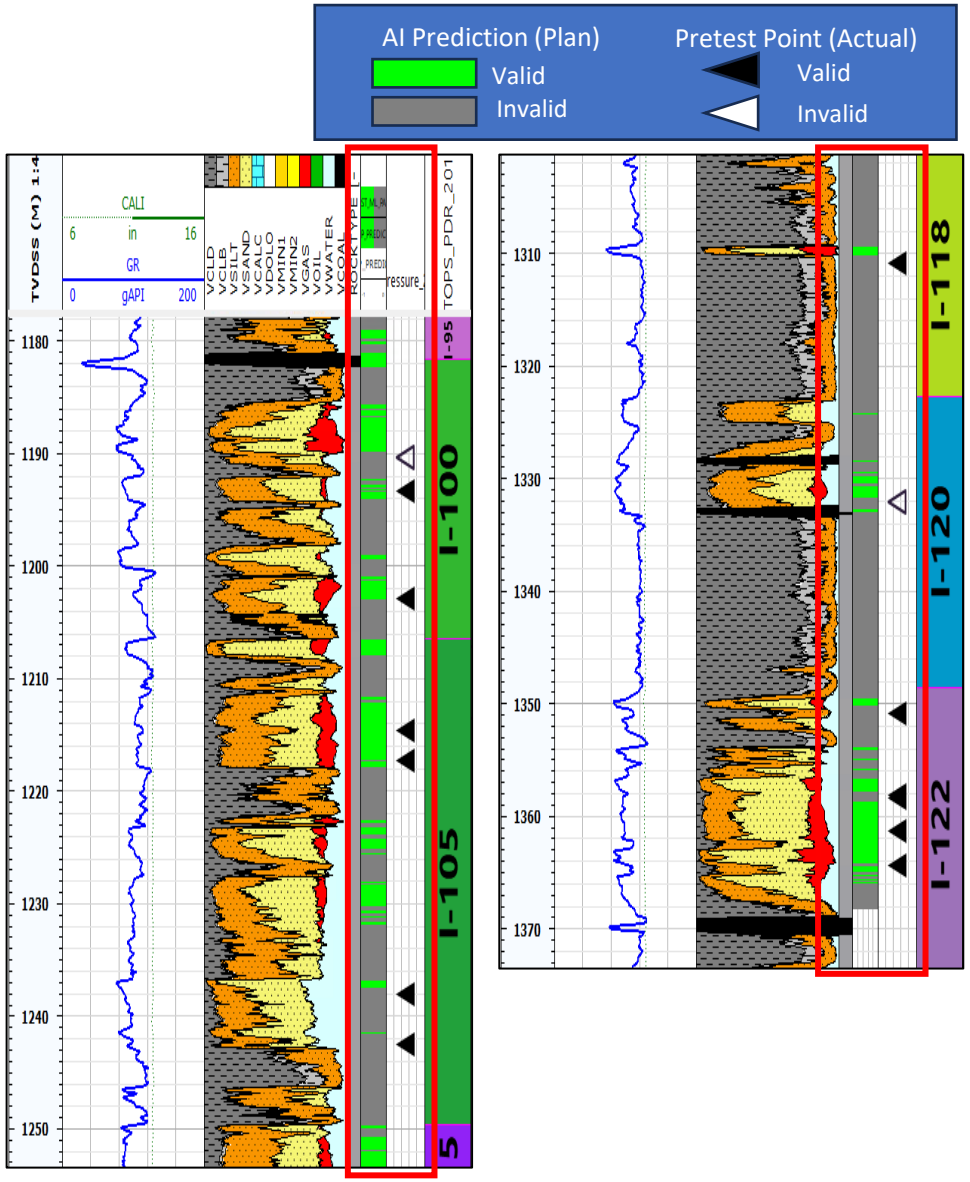
Field_Y2

Well	Depth (m MDDF)	TOPS	Pred Actual	AI Prediction	Correct Prediction
Y2	2006.53	I-95	1	1	YES
Y2	2082.76	I-100	0	1	NO
Y2	2091.99	I-100	1	1	YES
Y2	2120.2	I-100	1	1	YES
Y2	2155.94	I-105	1	1	YES
Y2	2164.06	I-105	1	1	YES
Y2	2227.56	I-105	1	1	YES
Y2	2241.25	I-105	1	1	YES
Y2	2413	I-118	1	1	YES
Y2	2449.44	I-118	1	1	YES
Y2	2513.76	I-120	0	1	NO
Y2	2571.16	I-122	1	1	YES
Y2	2593.21	I-122	1	1	YES
Y2	2593.7	I-122	1	1	YES
Y2	2602.84	I-122	1	1	YES
Y2	2611.95	I-122	1	1	YES

$$Actual\ Success\ Ratio = \frac{Valid\ Test}{Valid\ Test + Invalid\ Test} = \frac{14}{14+2} = 88\%$$



Summary of Success Ratio for all Field-A Redev wells (Y1,Y2,Y3 & Y4). In general, showing average improvement of 17% from previous campaign

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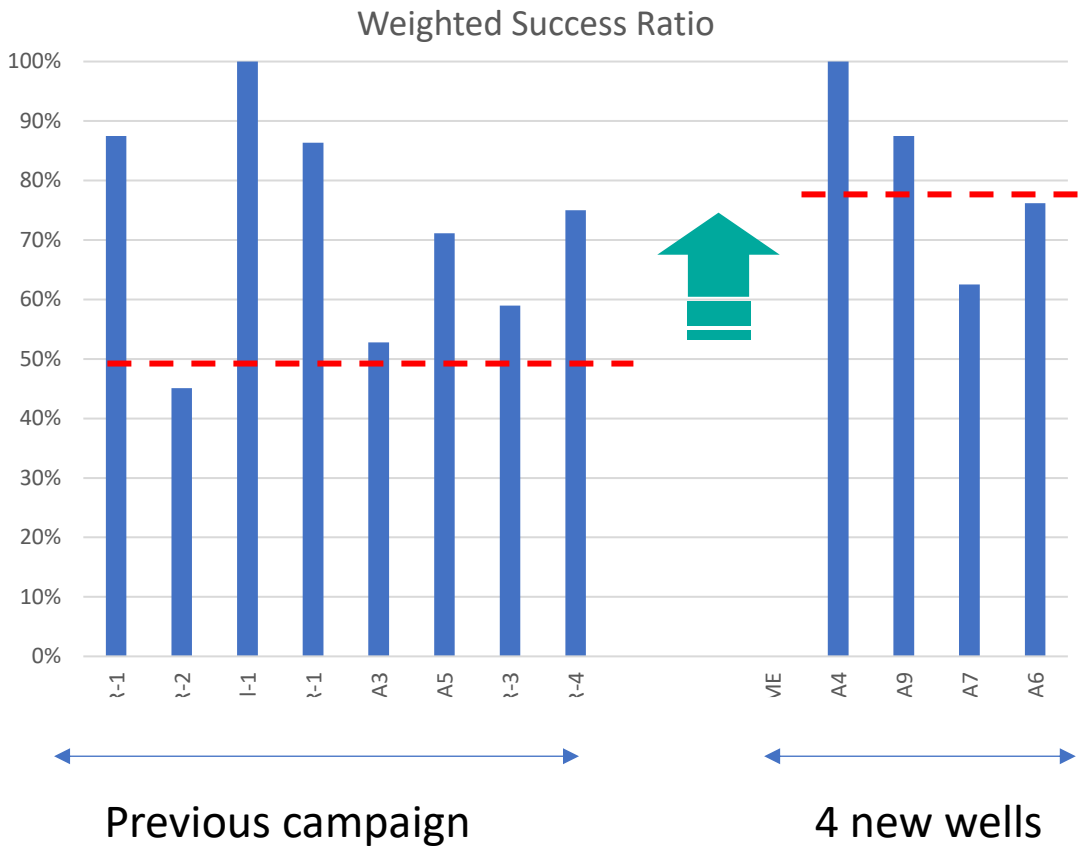
WELL	YEAR	VALID	INVALID	TOTAL	SUCCESS RATIO	WEIGHTAGE	WEIGHTED SUCCESS RATIO
X1	1975	7	1	8	88%	2.25%	59%
X2	1992	46	56	102	45%	28.73%	
X3	2004	20	0	20	100%	5.63%	
X4	2004	19	3	22	86%	6.20%	
X5	2017	38	34	72	53%	20.28%	
X6	2017	32	13	45	71%	12.68%	
X7	2010	46	32	78	59%	21.97%	
X8	2010	6	2	8	75%	2.25%	
				355		100.00%	

WELL	YEAR	VALID	INVALID	TOTAL	SUCCESS RATIO	WEIGHTAGE	WEIGHTED SUCCESS RATIO
Y1	2023	11	0	11	100%	13.75%	76%
Y2	2023	14	2	16	88%	20.00%	
Y3	2024	20	12	32	63%	40.00%	
Y4	2024	16	5	21	76%	26.25%	
				80		100.00%	



Multiple value generation from application in Field-A field. The technology has potential to be upscale and replicated to generate more value in Upstream business

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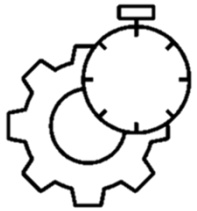

Increase pretest success ratio

17% increment in pretest success ratio for Field-A Redev campaign.

Cost saving through optimize operation

Cost savings MYR 260k from 4 wells. Saving achieved from avoidance of rig time and ops charge for invalid data points. Potential further cost savings > MYR 1 Mil through replication to other fields.

Safeguard Valuable Subsurface Data

Helps securing critical data for Field-A Redev development and meeting gas production target 62.5 MMscf/d

Success pressure test prediction application has unlocked other opportunity to further implement AI in Petronas Petrophysical workflow.

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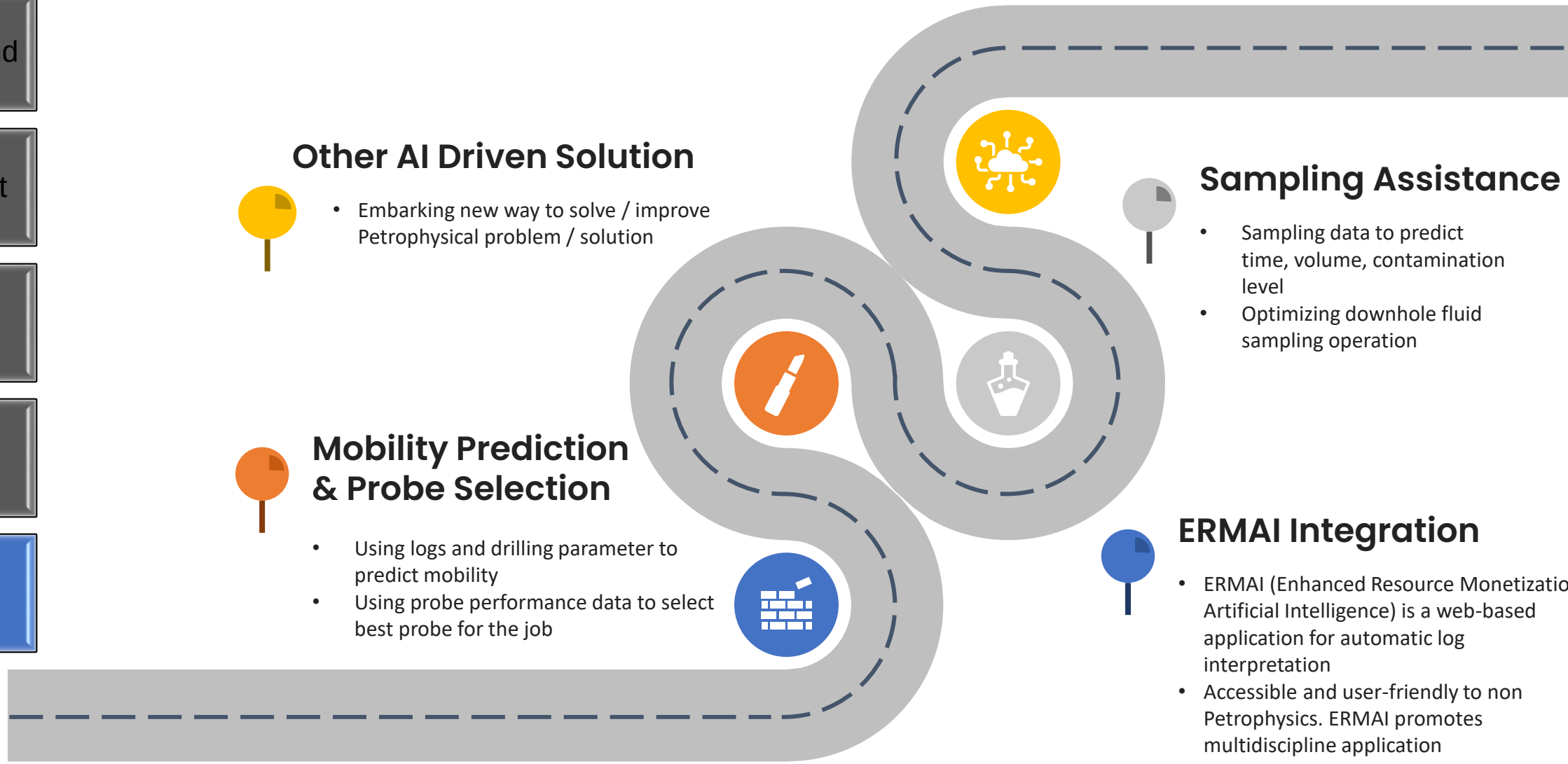

Other AI Driven Solution

- Embarking new way to solve / improve Petrophysical problem / solution

Sampling Assistance

- Sampling data to predict time, volume, contamination level
- Optimizing downhole fluid sampling operation

Mobility Prediction & Probe Selection

- Using logs and drilling parameter to predict mobility
- Using probe performance data to select best probe for the job

ERMAI Integration

- ERMAI (Enhanced Resource Monetizatio Artificial Intelligence) is a web-based application for automatic log interpretation
- Accessible and user-friendly to non Petrophysics. ERMAI promotes multidiscipline application

Acknowledgements/ Thank You/ Questions

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