AI FOR WELL LOG PROCESSING & MACHINE PREDICTED LITHOLOGY

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INTRODUCTIONS

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AGENDA

- INTRODUCTION TO SOFTSERVE
- WELL LOGS DATA AND AI
- AUTOMATION OF WELL LOGS PROCESSING AND ENHANCEMENT
- MACHINE LEARNING FOR LITHOLOGY PREDICTION
- EXPLORATION DATA PLATFORM
  a single place to work with wells, well logs and other subsurface documentation
- SUMMARY & Q&A

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THE FUTURE STARTS NOW

STABILITY

More than

27 YEARS

of award-winning service

EXPERIENCE

10,000+

complex projects completed

TRUST

Our

77 NPS

leads the industry

STRENGTH

9,000+

Consultants, Engineers & Designers

INDUSTRY EXPERTISE

15+

Industry Leading Energy Brands trust in SoftServe

PARTNERSHIP

OSDU

Forum Member

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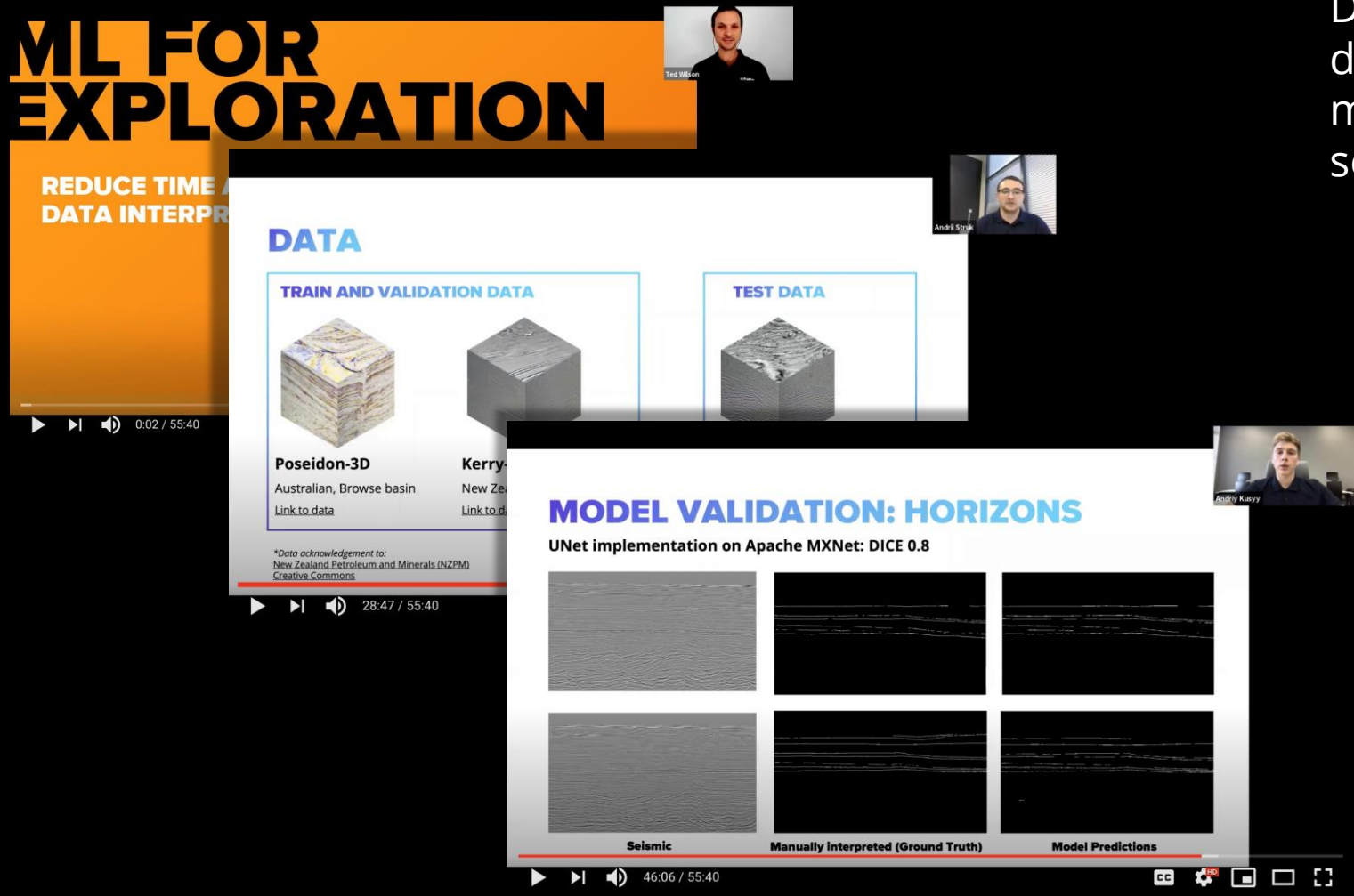
WEBINAR SERIES



During the webinar in June we demoed techniques for applying machine learning algorithms to seismic data interpretation.

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KEY DRIVERS IN THE EXPLORATION LIFECYCLE

Reduce time
to first oil

High-grade acreage
and prospects

Reduce risk
& improve safety

G&G Documents management and knowledge mining → **Well Logs Processing, Lithology Prediction** → **Seismic Processing, Interpretation, & Modeling** → **Reservoir Simulation & Field Development Planning**

Exploration Data Platform

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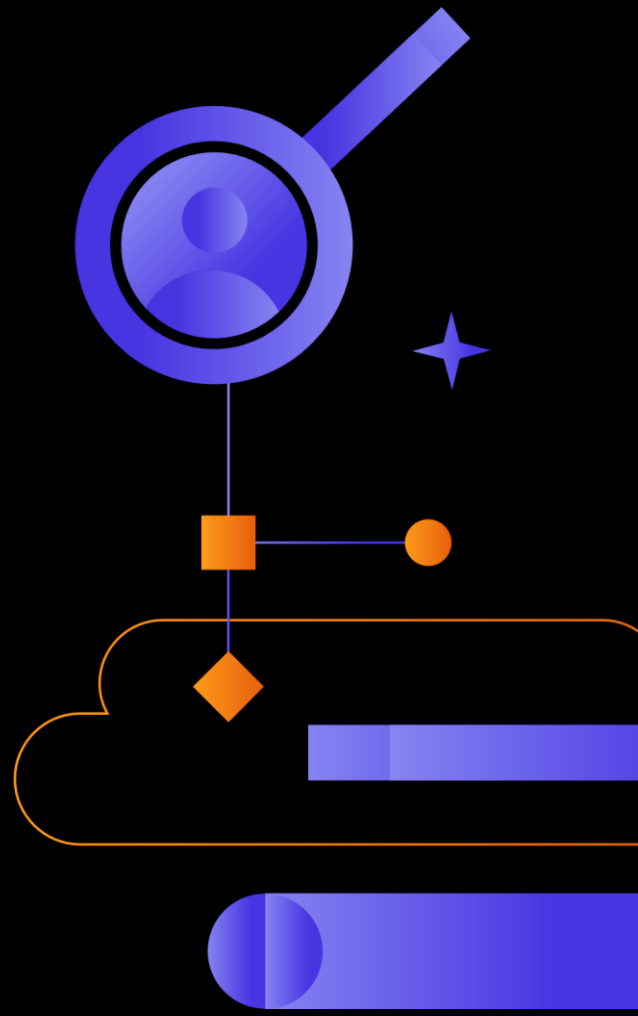
POLL 1



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WELL LOGS DATA AND AI

ANDRII STRUK
Business Analyst, SME, Energy, Oil & Gas

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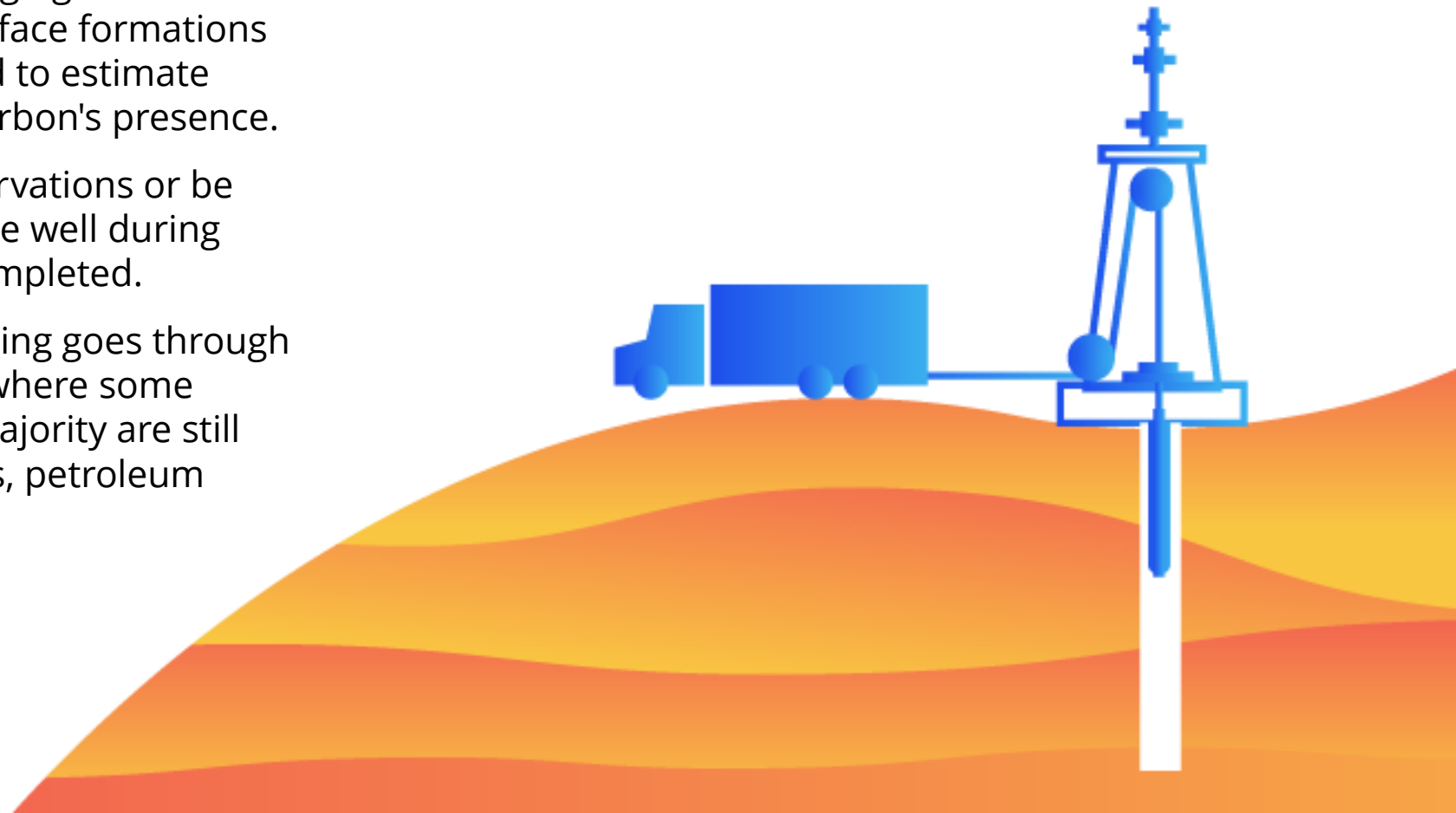
WHAT IS WELL LOGGING DATA

The oil and gas industry uses well logging to obtain a detailed continuous record of subsurface formations rock properties, which is further used to estimate reservoir characteristics and hydrocarbon's presence.

The methods can include visual observations or be made by instruments lowered into the well during drilling or after drilling operations completed.

All the data obtained during well logging goes through processing and interpretation steps where some operations are automated, but the majority are still performed manually by geophysicists, petroleum engineers, geologists.



CHALLENGES WORKING WITH WELL LOGS DATA

DATA AND QUALITY

- Large amounts of well logging and other related G&G data companywide from different regions and periods.
- Difference in data quality
- Data management and usability
- Data readiness for AI interpretation

TIME AND COST

- Data search and navigation
- Low quality data enhancement and enrichment
- Data structuring and analysis
- Data preparation for further interpretation

OPINION AND PITFALLS

Different people view the same data differently and may end up with diverse interpretations.

Broad picture view – more data better interpretation

Limited scalability as it based on available human resources

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WITH AI WE CAN AUTOMATE...

DATA PROCESSING & MANAGEMENT

- Well Logs Header parsing and values extraction
- Mnemonics grouping by method
- Mnemonics merging
- Geolocation and G&G documents tie to its source of origin

DATA ENHANCEMENT & ENRICHMENT

- Noisy curves filtering
- Units fixing
- Bad and missing data restoration
- Headers enrichment

DATA INTERPRETATION

- Clear zone picking
- Lithology prediction
- Reservoir characterization
- Well-to-Well correlation
- Well to seismic tie

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AUTOMATION OF WELL LOGS PROCESSING AND ENHANCEMENT

TARAS HNOT
Lead Data Scientist

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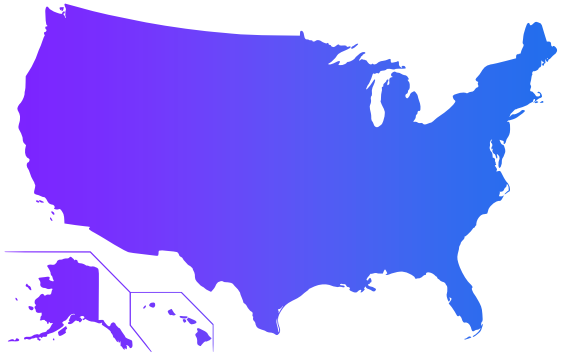
DATA



USA

1220 .las files

UNITED KINDOM

1560 .las files

AUSTRALIA

160 .las files

IN TOTAL – 2940 .LAS FILES

Data sources:
http://www.kgs.ku.edu/index.html
https://data-ogauthority.opendata.arcgis.com/
https://nopims.dmp.wa.gov.au/Nopims/

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WHAT .LAS FILE LOOKS LIKE

```
~Version Information Section
VERS.          2.0                            : CWLS LOG ASCII Standard
WRAP.          NO                             : One line per depth step
CREA.          03/27/19                       : LAS Creation Date
~Well Information Section
STRT.ft        319.5000                       : Start Depth
STOP.ft        12604.0000                     : Stop Depth
STEP.ft        0.5000                         : Step
NULL.          -999.2500                      : Null Value
COMP.          MOBIL                          : Company
WELL.          9/13a-50                       : Well
FLD .          BERYL                          : Field
LOC .          NORTH SEA                      : Location
LOC1.          -                              : Location (UTM)
CTRY.          UK                             : Country
PROV.          UKCS                           : Province
UWI .          11891                          : UWI Number
API .          -                              : API Number
SECT.          -                              : Section
TOWN.          -                              : Township
RNGE.          -                              : Range
PDAT.          MSL                            : Perm Datum
EPD .ft        0.0                            : Elevation
LMF .          KB                             : Log Measured From
DMF .          KB                             : Drill Measured From
APD .ft        86.0                           : Above Perm Datum
EKB .ft        86.0                           : Elev-Kelly Bushing
EDF .ft        85.0                           : Elev-Drill Floor
EGL .ft        -384.0                         : Elev-Ground Level (Water Depth)
TDD .ft        14634.00                       : Total Depth (Driller)
TDL .ft        14670.00                       : Total Depth (Logger)
SRVC.          ATLAS                          : Service Company
LATI.          59 36 04.62 N                  : Latitude
LONG.          01 33 42.56 E                  : Longitude
DATE.          01-OCT-1990-22-FEB-1991        : Logging Date
PROJ.          UKCS                           : Project
SET .          COMP WIRE                      : Set
```

~Version Information Section

```
~Curve Information Section
DEPTH.ft                                      : Depth Curve
AC.us/ft                                      : Acoustic Travel Time
CALI.in                                       : ZDL Caliper
CNC.pu                                        : Compensated Neutron Porosity
GR.gAPI                                       : Gamma Ray
GRD.gAPI                                      : Density Gamma Ray
K.Unknown                                     : Potassium concentration
KTH.gAPI                                      : Uranium Stripped Gamma Ray
PE.b/e                                        : Photoelectric factor
RFOC.ohmm                                     : Logarithmic Resistivity from CFOC
RILD.ohmm                                     : Deep Induction Resistivity
RILM.ohmm                                     : Medium Induction Resistivity
TH.ppm                                        : Thorium concentration
U.ppm                                         : Uranium concentration
ZCOR.g/cc                                     : ZDL Density correction
ZDEN.g/cc                                     : ZDL Bulk density
```

~Curve Information Section

```
~ASCII Log Data Section
  319.5000      -999.2500      -999.2500      -999.2500        8.5692      -999.2500      -999.2500
  320.0000      -999.2500      -999.2500      -999.2500        8.2174      -999.2500      -999.2500
  320.5000      -999.2500      -999.2500      -999.2500        8.5243      -999.2500      -999.2500
  321.0000      -999.2500      -999.2500      -999.2500        8.3304      -999.2500      -999.2500
  321.5000      -999.2500      -999.2500      -999.2500        7.5455      -999.2500      -999.2500
  322.0000      -999.2500      -999.2500      -999.2500        8.1665      -999.2500      -999.2500
  322.5000      -999.2500      -999.2500      -999.2500        9.6605      -999.2500      -999.2500
  323.0000      -999.2500      -999.2500      -999.2500        9.4083      -999.2500      -999.2500
  323.5000      -999.2500      -999.2500      -999.2500        7.7944      -999.2500      -999.2500
  324.0000      -999.2500      -999.2500      -999.2500        6.5221      -999.2500      -999.2500
  324.5000      -999.2500      -999.2500      -999.2500        6.2341      -999.2500      -999.2500
  325.0000      -999.2500      -999.2500      -999.2500        6.7665      -999.2500      -999.2500
  325.5000      -999.2500      -999.2500      -999.2500        7.1638      -999.2500      -999.2500
  326.0000      -999.2500      -999.2500      -999.2500        6.9005      -999.2500      -999.2500
  326.5000      -999.2500      -999.2500      -999.2500        6.5159      -999.2500      -999.2500
  327.0000      -999.2500      -999.2500      -999.2500        6.7415      -999.2500      -999.2500
  327.5000      -999.2500      -999.2500      -999.2500        7.6315      -999.2500      -999.2500
  328.0000      -999.2500      -999.2500      -999.2500        8.6105      -999.2500      -999.2500
```

~Log Data Section

DEEPER LOOK ON CHALLENGES

```
LMF .          KB                              : Log Measured From
DMF .          KB                              : Drill Measured From
APD .ft        86.0                            : Above Perm Datum
EKB .ft        86.0                            : Elev-Kelly Bushing
EDF .ft        85.0                            : Elev-Drill Floor
EGL .ft        -384.0                          : Elev-Ground Level (Water Depth)
TDD .ft        14634.00                        : Total Depth (Driller)
TDL .ft        14670.00                        : Total Depth (Logger)
SRVC.          ATLAS                           : Service Company
LATI.          59 36 04.62 N                   : Latitude
LONG.          01 33 42.56 E                   : Longitude
DATE.          01-OCT-1990-22-FEB-1991         : Logging Date
PROJ.          UKCS                            : Project
SET .          COMP WIRE                       : Set
```

Coordinates are not in float format

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LIST OF CURVES AND NAMES ARE NOT STANDARDIZED

```
~Curve Information Section
DEPTH.ft                                    : Depth Curve
AC.us/ft                                    : Acoustic Travel Time
CALI.in                                     : ZDL Caliper
CNC.pu                                      : Compensated Neutron Porosity
GR.gAPI                                     : Gamma Ray
GRD.gAPI                                    : Density Gamma Ray
K.Unknown                                   : Potassium concentration
KTH.gAPI                                    : Uranium Stripped G
PE.b/e                                      : Photoelectric fact
RFOC.ohmm                                   : Logarithmic Resist
RILD.ohmm                                   : Deep Induction Res
RILM.ohmm                                   : Medium Induction R
```

```
~Curve Information Section
DEPTH.ft                                    : Depth Curve
CALCM.in                                    : Acoustic Caliper Corrected Memory
DTC.us/ft                                   : Delta-T Compressional
DTS.us/ft                                   : Delta-T Shear
GRAFM.gAPI                                  : Gamma Ray Apparent (Filtered) Memory
RACHM.ohmm                                  : Resistivity (AT) Borehole Corrected 2MHz Memory
RACLM.ohmm                                  : Resistivity (AT) Borehole Corrected 400kHz Memory
RPCHM.ohmm                                  : Resistivity (PD) Borehole Corrected 2MHz Memory
RPCLM.ohmm                                  : Resistivity (PD) Borehole Corrected 400kHz Memory
```

The same curves could have different names and descriptions

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UNITS ARE ALSO NOT STANDARD

ORIGINAL NAME	STANDARDIZED NAME
BARN	B/E
BARN/E	B/E
BARNS/ELECT	B/E
BE	B/E
B/E	B/E
OHM	OHM*M
OHM*M	OHM*M
OHM-M	OHM*M

Barns / electrons

Electrical unit of resistance

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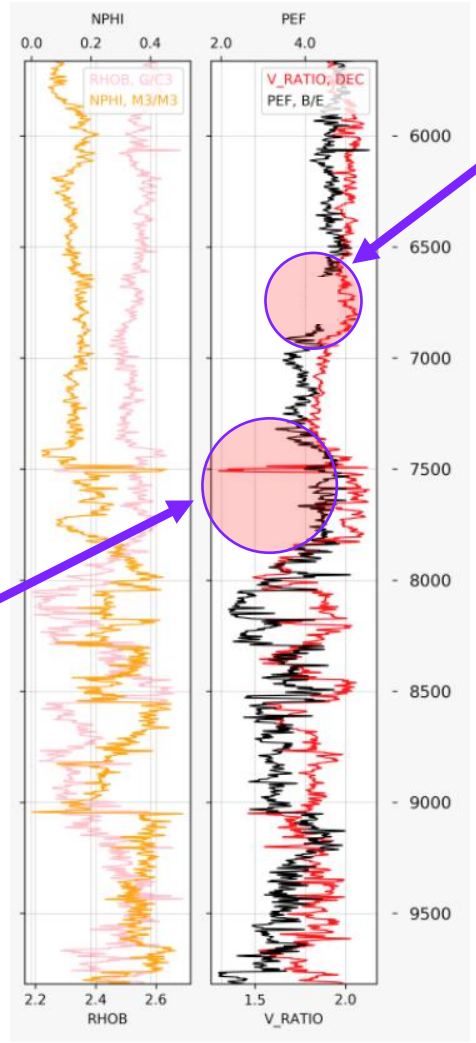
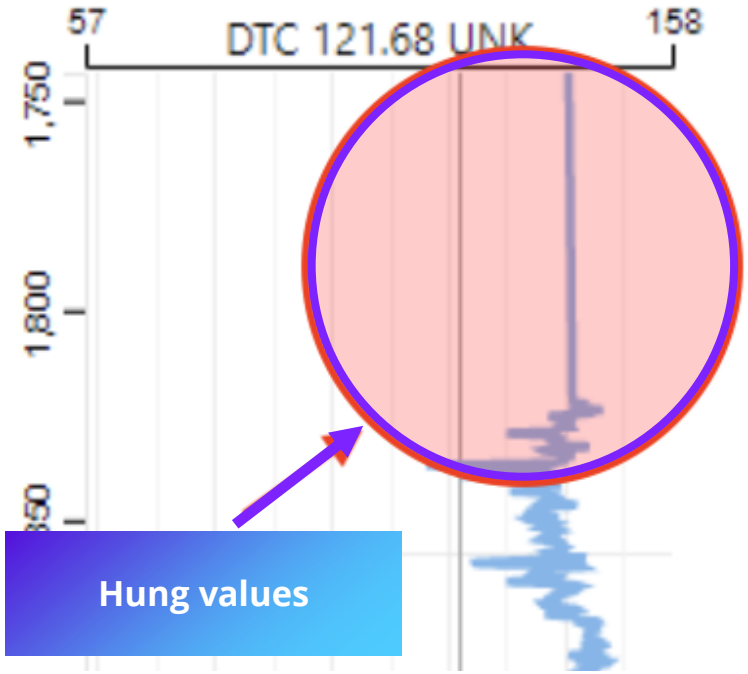
MISSING & CORRUPTED VALUES AND CURVES



Outliers, corrupted/noisy data

Missed data points



Hung values

...AND MUCH MORE

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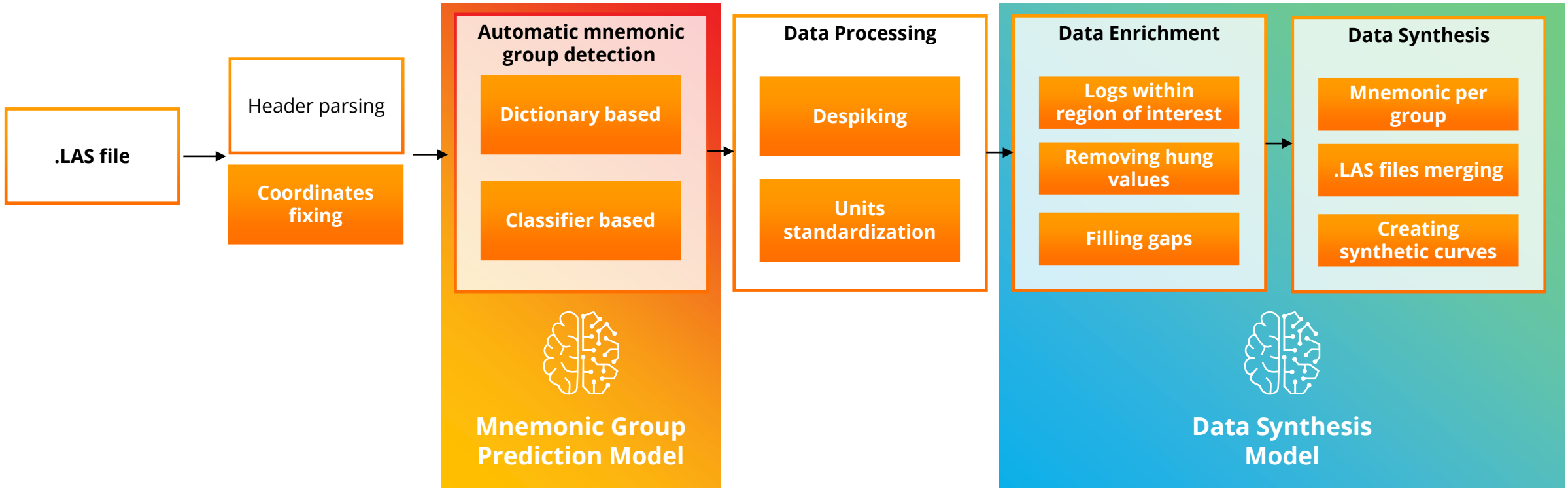
WELL LOGS PREPROCESSING BUILDING BLOCKS



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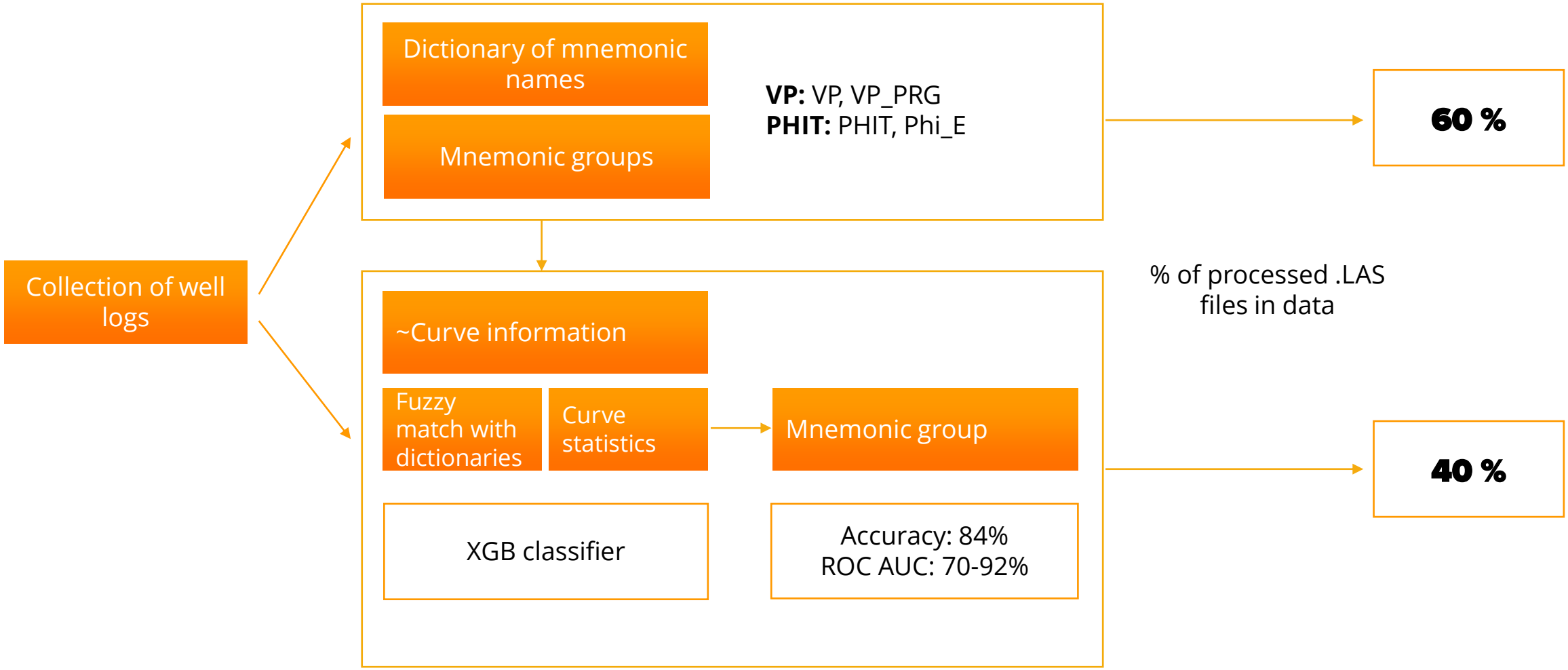
AUTOMATIC MNEMONIC GROUP DETECTION



MNEMONIC DICTIONARY

RHOB	SP	GR	POR	Neutron	DEPTH	PERM	SON	CAL	PEF	RES
CORR	SPBR	AG110	CDPD	LSN	DEPC	MPRM	ACCM	ACBH	PE	ARTA
CORR2	SPBRDH	API	CDPF	LSNR	DEPTH	MPRMA2	DT24F	ARAD	PE2	ARTB
DEN	SPCH	AU198	CDPI	NEU	DEPM	MPRMA3	DT24N	ARAD1	ZU	DFRM
DEN2	SPCHDH	BHKGR	CDPL	HSIG	FEET32	MPRMA4	DTDL	ARAD2	ZU2	DLRM
DNC	SPSB	CR51	CDPN	SIGB	FEET	MPRMA5	DTDS	ARAD3	PE	DP1A
DNC2	SPSBDH	GR1	CDPP	SIGF	DEPTH	SPRM	PKSQR	ARAD4	DPE	DP1B
FDDP	SPW	GR2	CDPS	LSN	FDEP	SPRMA2	PKSQT	ARADS3	PE	DP2A
FDDR	SPWDH	GR3	CDPT	LSNR	SDEP	SPRMA3	PKSXR	ARADS5	PELC	DP2B
FDN	SPBD	GR4	CN	SSN	WF5D	SPRMA4	PKSXT	ARADS7	PEU	DP3A
GDENC	SPCD	GRSL	CNC	SSNR	WF6D	SPRMA5	PKSYR	AVCAL	HLEF	DP3B
GDENM	SPDH	GRSLC	CNCDL	NF0	WF7D	MPA2	PKSYT	BCSA	PEFL	DP4A
GRADEN	SPWD	GRU	CNCF	NF1	WF8D	MPA3	SLOWF	BCSAW	HPEF	DP4B
SSDEN	SP	I131	CNCFDL	NFA	WF9D	MPA4	SLOWN	BHA	PEF	DP5A
TFDEN	SPDH	IR192	CNCFLS	NN0	WF1D	MPA5	DTFT	BHDCB	U8	DP5B
ZCOR	SPDH15	KAPI	CNCFSS	NN1	WF2D	SPM2	DTNT	BIT	UMA_HILT	DP6A
ZCOR2	SPDHEA	KAPIC	CNCLS	NNA	WF3D	SPM3	PSMQ	BRAD	UZ	DP6B
ZDEN	SPDHEAH	PFC	CNCSS	FDSN	WF4D	SPM4	PSMX	BRADW	U8	DPRM
ZDEN2	SPDHH	PH	CPP	NDSN	WF5D	SPM5	PSMY	BRIT	UMA_HILT	LLRM
ZDNC	SPH	QGR1	CPP2	A1EP	WF6D	MPRM	SLOF	C01M	UZ	M0R1
ZDNC2	SPHU	QGR2	CPPC2	A2EP	WF7D	PERM	SLON	C02M	U8	M0R2
COR2	SPS2	QGR3	CPPZ	AFEC	WF8D	KBFV	DT	C03M	UMA_HILT	M0R3
GDNC	SPS3	QGR4	CPPZ2	AFTC	WF9D	KCMR	DT1	C04M	UZ	M0R6
GDNM	SPU	SB124	CPPZC	ANEC	FTD	KCMR_SL	DT12	C05M	HULS	M0R9
GDEN	SPSB	SC46	CPPZC2	H1EP	RFPD	KSDR	DT12F	C06M	ULDS	M0RX
SSDN	SPSBDH	THAPI	DCBW	H2EP	RFSD	KSDR_SL	DT12N	C07M	DPEM	M1R1
TDEN	SP	THAPIC	DIFE13	HFCR		KTIM	DT2	C08M	DPEX	M1R2
ZCR2	SPBD	UAPI	DIFE23	HFEC		KTIM_SL	DT24	C09M	PEB	M1R3
ZDN2	SPBR	AG	DIFE24	HNEC			DT24A	C10M	PEB_RT	M1R6
ZDC2	SPBR	AU	MCBW	CFTC			DT24AF	C11M	PEF	M1R9

Mnemonic	Number of Values in Dictionary
OTHER	1092
RES	792
POR	577
CAL	393
SON	316
GR	159
PRESS	156
T	152
RHOB	137
NPHI	106
Volume	61
DTC	59
SP	41
DTS	38
Neutron	34
ISO	30
PEF	29
PERM	26
DEPTH	19
Saturation	17

MNEMONIC GROUP CLASSIFICATION MODEL

filename	group	min_val	q5_val	q50_val	q90_val	max_val	std_val	CAL_SIM	RHOB_SIM	SON_SIM	GR_SIM	NPHI_SIM	RES_SIM	SP_SIM	PEF_SIM	OTHER_SIM	POR_SIM	ISO_SIM
well_logs_data/LAS/UK/02_05-10_DATACO_JWDL_QC.las	CAL	6.914100	11.070300	12.195300	16.023450	22.625000	2.396249	1	0	0	0	0	0	0	0	0	0	0
well_logs_data/LAS/UK/02_05-10_DATACO_JWDL_QC.las	RHOB	-0.075200	-0.004400	0.020000	0.075700	0.246100	0.032587	0	1	0	0	0	1	0	0	0	0	0
well_logs_data/LAS/UK/02_05-10_DATACO_JWDL_QC.las	RHOB	1.306600	1.770250	2.156300	2.445300	2.793000	0.216465	0	1	0	0	0	0	0	0	1	0	0
well_logs_data/LAS/UK/02_05-10_DATACO_JWDL_QC.las	SON	42.187500	75.991565	110.562500	146.375000	227.500000	24.484211	0	0	1	0	0	0	0	0	0	0	0
well_logs_data/LAS/UK/02_05-10_DATACO_JWDL_QC.las	GR	25.828100	37.906300	58.500000	84.687500	168.000000	16.818734	0	0	0	1	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

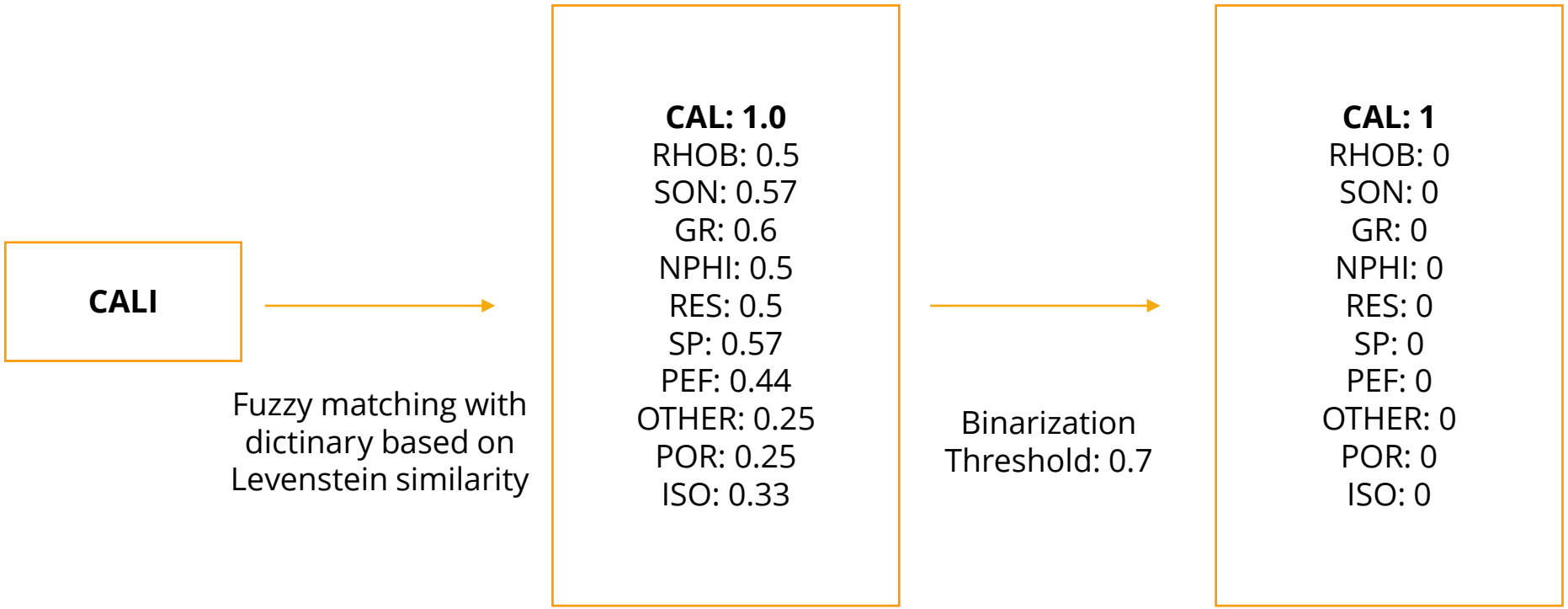
Curves characteristics

Fuzzy-matching with dictionaries

Target variable

Features

EXAMPLE:
FUZZY-MATCHING WITH DICTIONARIES



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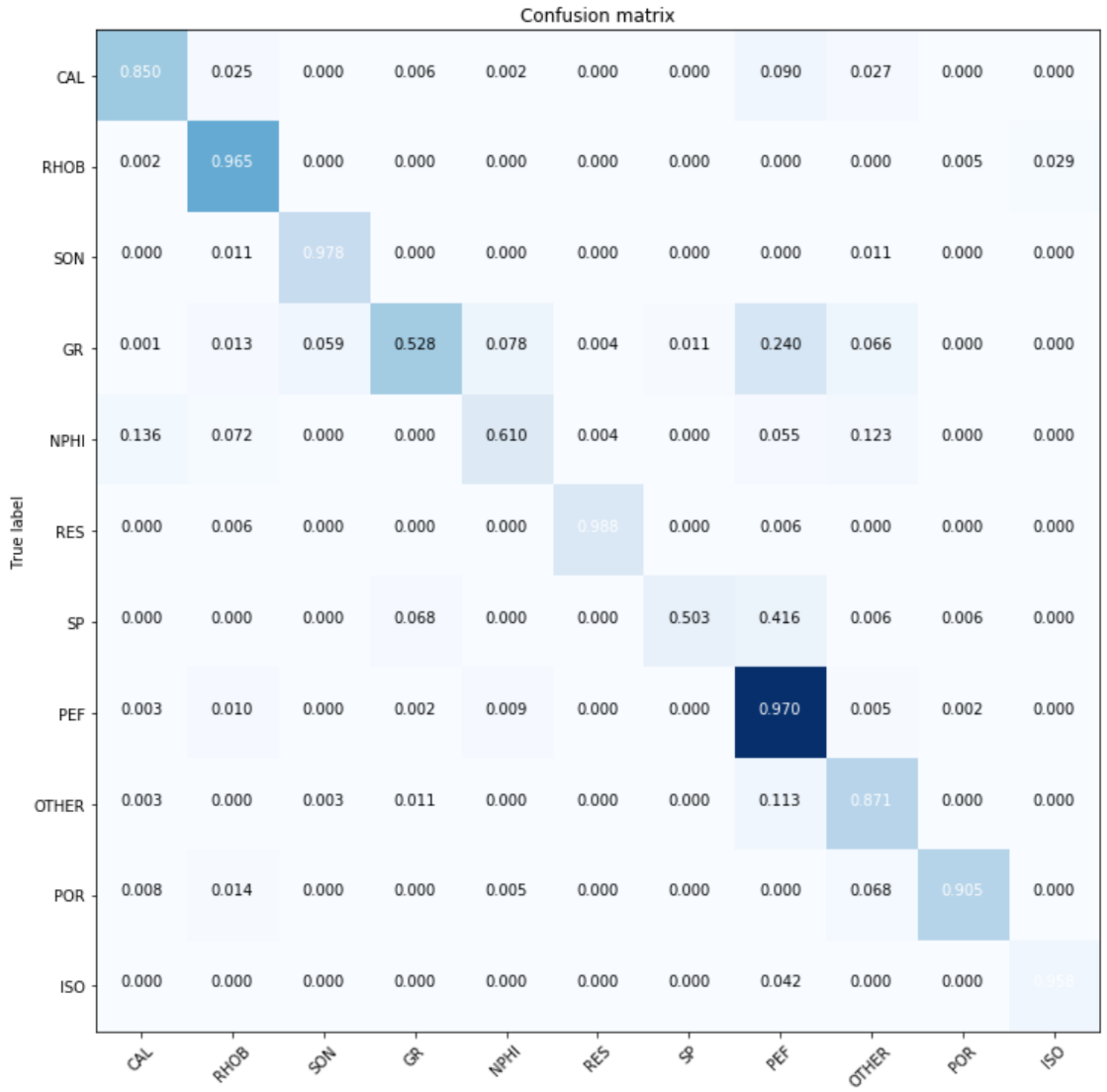
MNEMONIC GROUP PREDICTION MODEL

Model predicts one out off 12 standardized groups for each mnemonic based curves statistics and mnemonic name

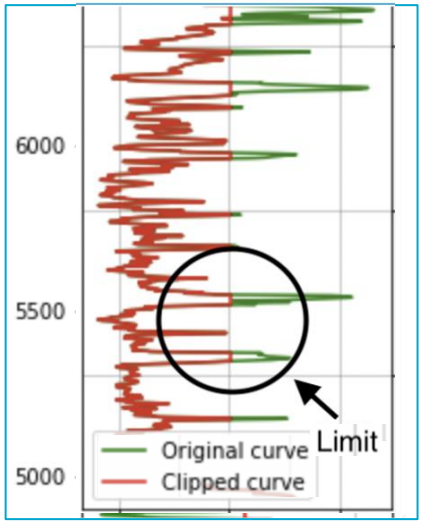
Accuracy: **0.84**	ROC AUC: **0.7-0.92**



DATA PROCESSING

Despiking/clipping

MNEMONIC	UNIT	Lower	Upper
GR	GAPI	0	400
CAL	IN	2	24
CAL	CM	5	60
RES	OHM*M	0	1000
RHOB	G/CM3	1.1	3.1



Units Standardization

Unit	Standard Unit
B/E	B/E
BARN	B/E
BARN/E	B/E
BARNS/ELECT	B/E
BE	B/E
%	DEC
DEC	DEC
DECP	DEC
FRAC	DEC
FRACTION	DEC
P	DEC
PCT	DEC
PE	DEC
PERC	DEC
PERCENT	DEC
U	DEC
DEG	DEG
G/C3	G/CM3
G/CC	G/CM3
G/CM3	G/CM3
K/M3	G/CM3
AAPI	GAPI
API	GAPI

Processing is done using dictionaries and physics rules.

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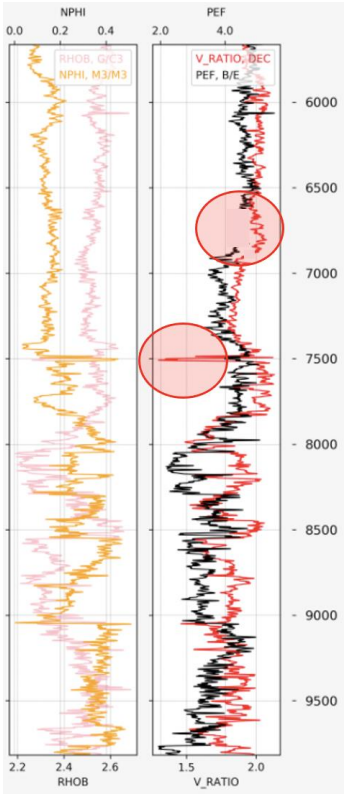
DATA ENRICHEMENT & SYNTHESIS

2 problems:

- Missing data points (e.g., hung values)
- Missing curves

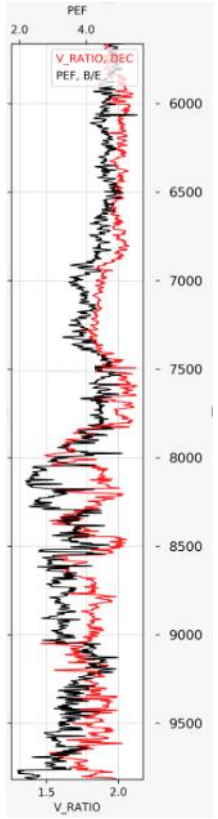
generation of the partially missing data in the given curves
generation of the completely missing curves



ML regression model

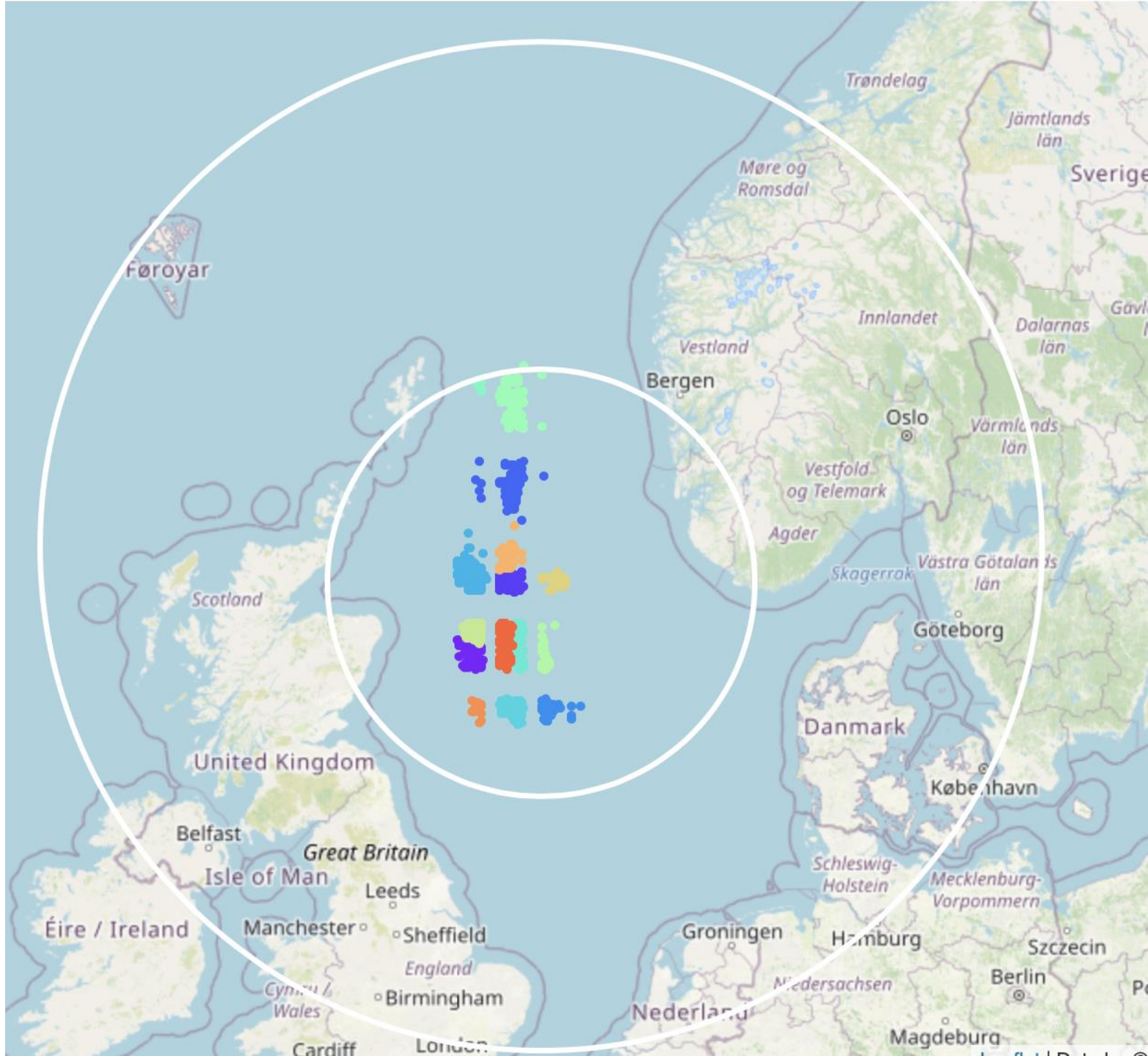
- XGBoost models
- LSTM Auto encoders

- Statistical features (window, outliers)
- Physically related curves
- Normalization is important !



GEOGRAPHIC REGION OF INTEREST

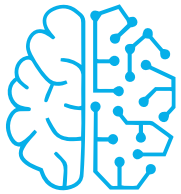
UK North Sea region clusters



CURVES SYNTHESIS

Caliper
Gamma-Ray
Density Curves
Porosity
Neutron Porosity
Resistivity
Photoelectric Effect

‘Features’ curves



Model

Synthetic Sonic

Synthesized curve

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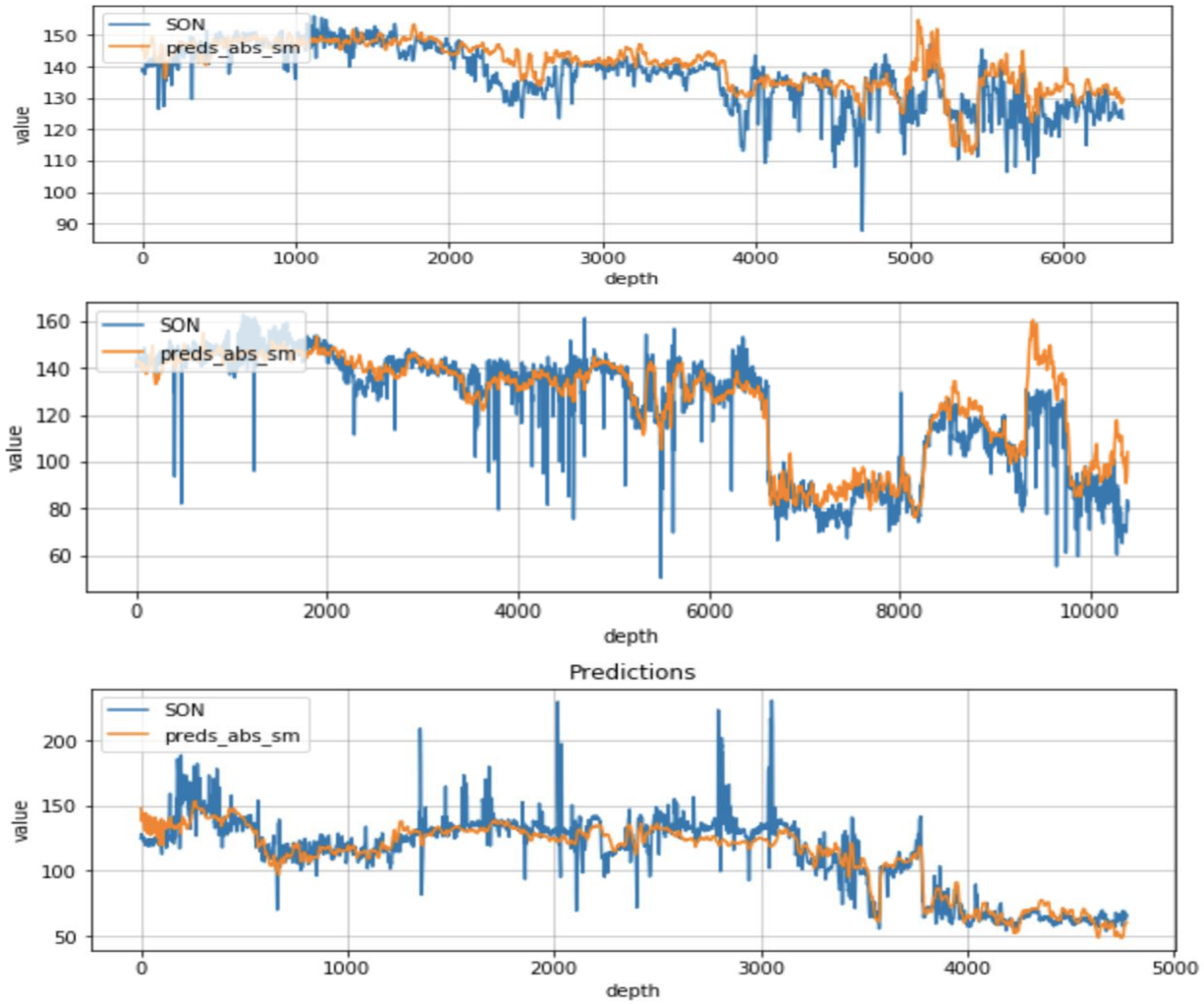
SONIC CURVES SYNTHESIS



Examples of model inferences on testing data

- Original curve
- Synthesized curve

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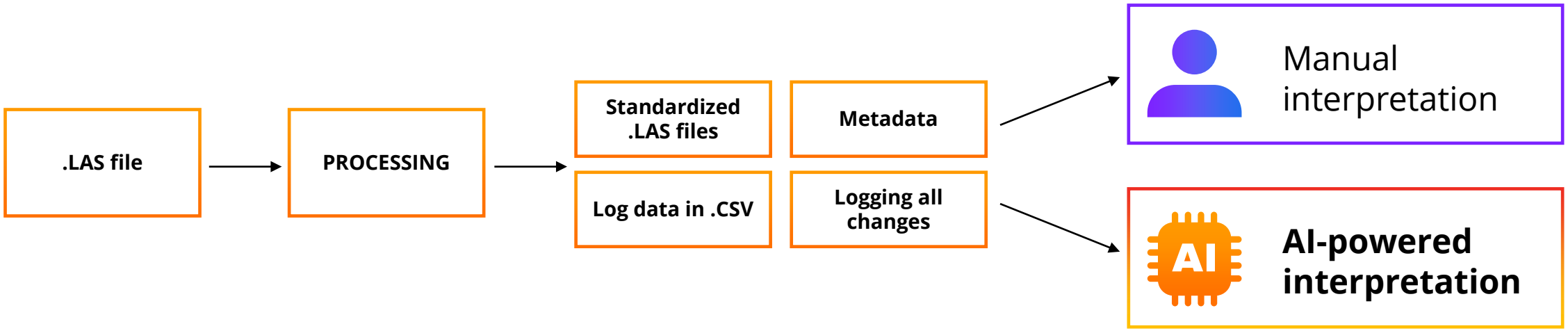
PROCESSING PIPELINE



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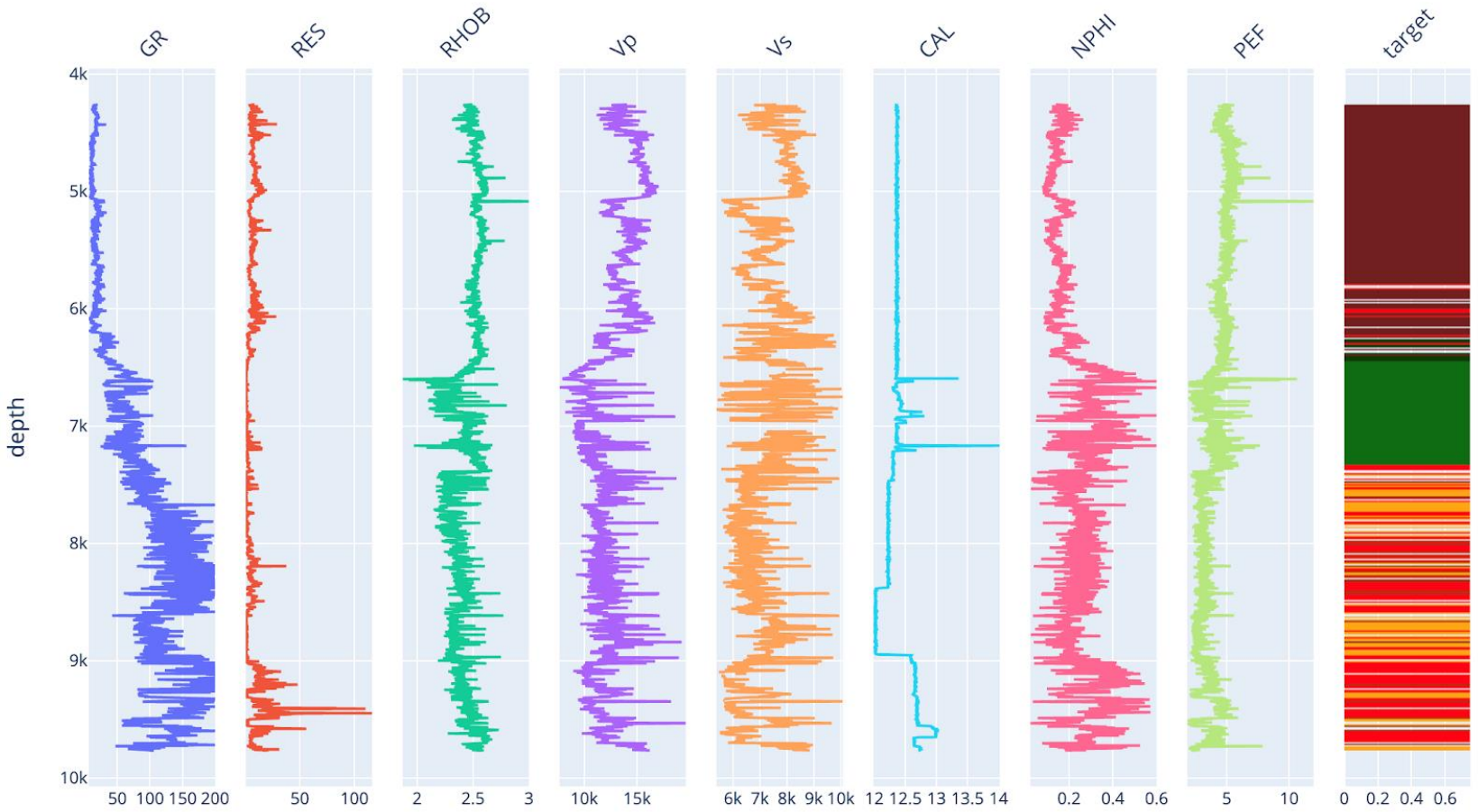
AI-POWERED LITHOFACIES PREDICTION

FACIES DETECTION PROBLEM



- Limestone
- Badhole
- Claystone
- Sandstone
- Marlstone
- Siltstone

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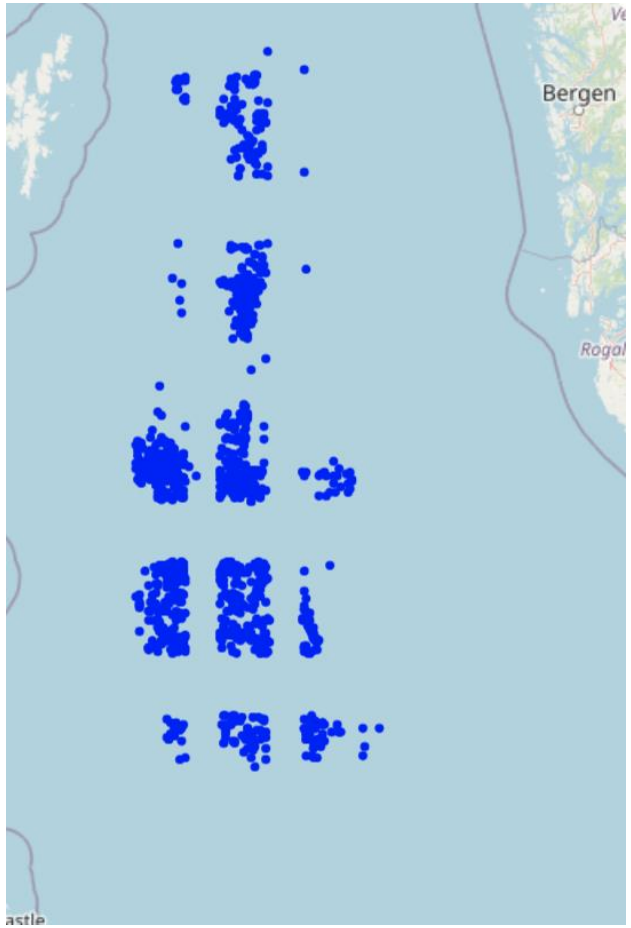
TRAINING APPROACH 1

Generalize to all wells in the field
maximize accuracy across the field



TEST SET (RANDOM)

TRAIN SET 1-FOLD

TRAIN SET 2-FOLD

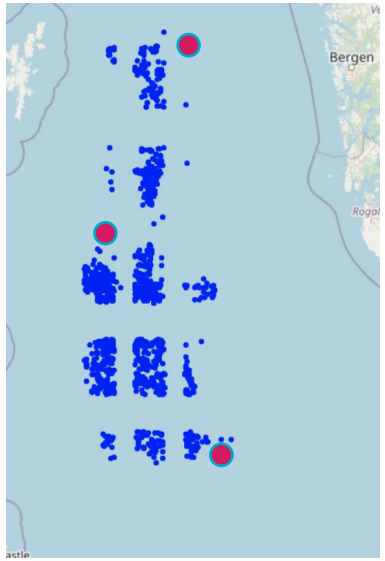
...

TRAIN SET K-FOLD

Test & Evaluate

Train & Validate split per well

Model



Inference on any well in the field

1. Do not need a lot of training samples
2. Accuracy may vary from well to well

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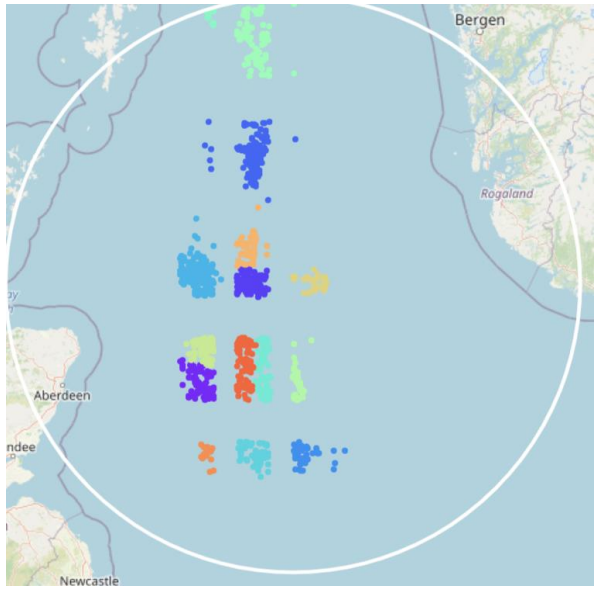
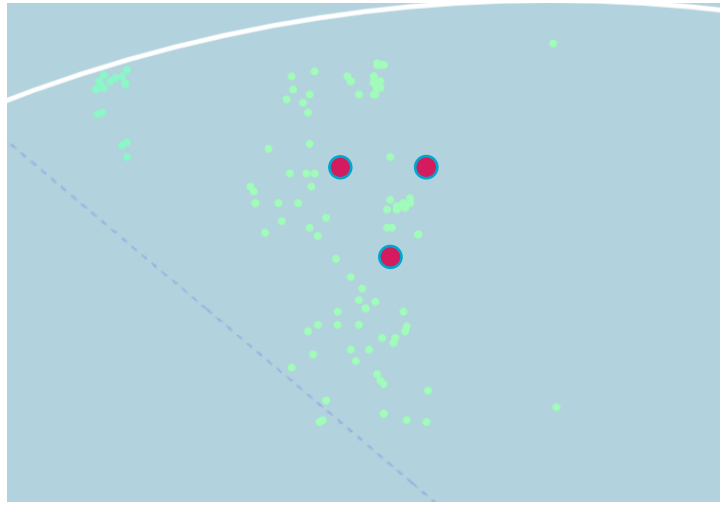
TRAINING APPROACH 2

Maximize accuracy on some specific wells





Test Set (random)

Test & Evaluate

Train Set 1-fold

Train Set 2-fold

...

Train Set K-fold

Train **hundreds** of models on different splits

Select models with the best performance on well from the subregion of interest

Inference on wells from subregion

Average predictions

N x Models

1. Need training samples from each subregion
2. Accuracy on specific well would be higher

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DATA

Wells data from North Sea basin (90-100 labeled wells)

depth	CAL	GR	NPHI	RES	RHOB	Vp	Vs	PEF	target	well
6012.25	8.5625	34.5051	0.3102	0.8110	2.0999	9841.986900	5349.344277	1.9740	1.0	13-26a-5
6013.25	8.5625	33.7100	0.2943	0.8153	2.0856	9816.991642	5288.061883	2.0452	1.0	13-26a-5
6013.75	8.5625	34.7091	0.2983	0.8109	2.0809	9841.735059	5238.772786	2.0432	1.0	13-26a-5
6313.75	8.5625	40.9212	0.2199	1.5261	2.2519	11747.347449	6820.026325	2.3141	1.0	13-26a-5
2590.25	8.6250	12.7817	0.1774	5.1499	2.4802	13508.292741	6732.669268	5.1392	7.0	13-26a-5

FEATURES ENGINEERING

SME feature engineering

```
# rescale RHOB and NPHI cols to start with 0 and end with 1 based on rock-physic rules and calculate their cross-plot
RHOB_sc = las_df['RHOB'].apply(lambda x: (x - 1.5) / (3 - 1.5))
NPHI_sc = las_df['NPHI'].apply(lambda x: (x - 0.6) / (-0.15 - 0.6))
las_df['RHOB_NPHI_cross-plot'] = RHOB_sc - NPHI_sc
'''
Description:
------------
lambd - 1st Lame parameter
mu    - Shear modulus
E     - Young's modulus
K     - Bulk modulus
v     - Poisson's ratio
M     - P-wave modulus
'''

las_df['V_ratio'] = las_df['Vp'] / las_df['Vs']
las_df['lambd'] = las_df['RHOB'] * (las_df['Vp'] ** 2 - 2 * las_df['Vs'] ** 2)
las_df['mu'] = las_df['RHOB'] * las_df['Vs'] ** 2
las_df['E'] = (las_df['mu'] * (3 * las_df['Vp'] ** 2 - 4 * las_df['Vs'] ** 2)) / (
        las_df['Vp'] ** 2 - las_df['Vs'] ** 2)
las_df['K'] = las_df['RHOB'] * (las_df['Vp'] ** 2 - (4 / 3) * las_df['Vs'] ** 2)
las df['v'] = (las df['Vp'] ** 2 - 2 * las df['Vs'] ** 2) / (2 * (las df['Vp'] ** 2 - las df['Vs'] ** 2
```

FEATURES ENGINEERING

Non-linear interactions of features, polynomial features

```
poly = PolynomialFeatures(degree=2)
poly_df = pd.DataFrame(poly.fit_transform(las_df[coef_cols]),
                       columns=poly.get_feature_names(coef_cols),
                       index=las_df.index).iloc[:, 9:]
```

CAL	RHOB
GR	Vp
NPHI	Vs
RES	PEF

RHOB
Vp
Vs

```
poly_three = PolynomialFeatures(degree=3)
poly_df_three = pd.DataFrame(poly_three.fit_transform(las_df[coef_cols_three]),
                             columns=poly_three.get_feature_names(coef_cols_three),
                             index=las_df.index).iloc[:, 4:]
```

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FEATURES ENGINEERING

Sequence data features:
trends, rolling statistics

```
# rolling windows statistics
rolling_cols = ['NPHI', 'PEF', 'RES_log', 'RHOB', 'Vp', 'Vs']


statistics = [
    (np.min, 'rolling_min'),
    (np.mean, 'rolling_mean'),
    (np.max, 'rolling_max'),
    (np.median, 'rolling_q_50'),
    (np.std, 'rolling_std'),

]
```

```
las_df[rolling_cols].rolling(window=30, center=True, min_periods=5).apply(func_name[0], raw=True)
```

```
# logGR, PE, Vp, Vs, Vp / Vs

GR_log_lr = windows_lr_new(las_df[['GR_log', 'DEPT']].fillna(0), window=12)
PE_lr = windows_lr_new(las_df[['PEF', 'DEPT']].fillna(0), window=12)
V_ratio_lr = windows_lr_new(las_df[['V_ratio', 'DEPT']].fillna(0), window=12)
Vp_lr = windows_lr_new(las_df[['Vp', 'DEPT']].fillna(0), window=12)
Vs_lr = windows_lr_new(las_df[['Vs', 'DEPT']].fillna(0), window=12)
```

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FEATURES SELECTION

USING STATISTICAL METHODS	For every feature, the influence on the target is evaluated by a **univariate test** and the **p-Value** is calculated. The methods that calculate the p-values are called feature selectors. Afterwards the **Benjamini Hochberg procedure** which is a multiple testing procedure decides which features to keep and which to cut off (solely based on the **p-values**).
MODEL FEATURE IMPORTANCE FILTERING	**XGBoost** model is built and its feature importance is used for further feature selection, leaving only the most significant features.

At this step 68 features were filtered out

```
The following 29 features were selected
['PEF_rolling_max', 'PEF', 'PEF_rolling_mean', 'PEF_interc.',
'Vp_rolling_max', 'PEF_rolling_min', 'GR_log_interc.', 'Vs_rolling_min',
'NPHI_rolling_max', 'v', 'RHOB^3', 'Vs^3', 'GR_log', 'Vp_interc.',
'NPHI_rolling_q_50', 'RES_log', 'NPHI', 'Vs_interc.', 'RES_log_rolling_max',
'Vp*Vs^2', 'PEF_rolling_q_50', 'RHOB_NPHI_cross-plot', 'RES_log_rolling_q_50',
'Vp_rolling_mean', 'Vp_rolling_q_50', 'CAL', 'Vs_rolling_max',
'NPHI_rolling_mean', 'DEPT']
```

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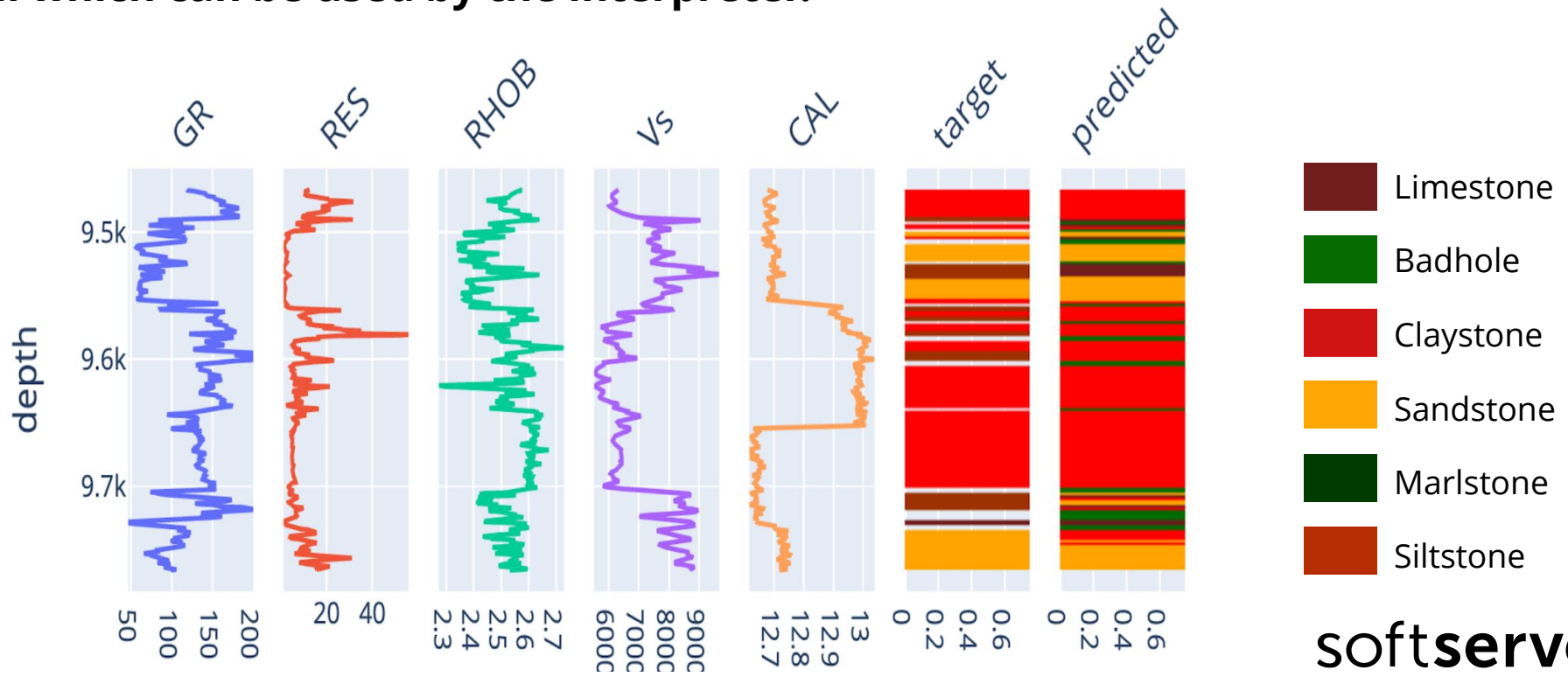
ML MODEL SELECTION

Multinomial classification problem with unbalanced classes.
Therefore, the decisions were made based on the weighted f1-score metric.

model	test_accuracy	test_f1_macro	test_f1_micro	test_f1_weighted	test_f1_weighted_mean	test_f1_weighted_std
XGB	0.721+-0.160	0.531+-0.183	0.721+-0.160	0.696+-0.192	0.696	0.192
RF	0.695+-0.153	0.491+-0.148	0.695+-0.153	0.682+-0.188	0.682	0.188
LR__0.001	0.698+-0.171	0.481+-0.189	0.698+-0.171	0.674+-0.206	0.674	0.206
LR__0.1	0.688+-0.125	0.446+-0.079	0.688+-0.125	0.668+-0.176	0.668	0.176
LR__0.0001	0.678+-0.164	0.396+-0.095	0.678+-0.164	0.649+-0.194	0.649	0.194
LR__0.01	0.640+-0.140	0.419+-0.112	0.640+-0.140	0.614+-0.177	0.614	0.177
LinearSVC	0.618+-0.145	0.373+-0.093	0.618+-0.145	0.587+-0.189	0.587	0.189
SVC	0.606+-0.163	0.349+-0.159	0.606+-0.163	0.549+-0.229	0.549	0.229

ML MODEL TEST PREDICTION

The actual data and the predicted lithofacies for the bottom 300 feet of the test well which can be used by the interpreter.



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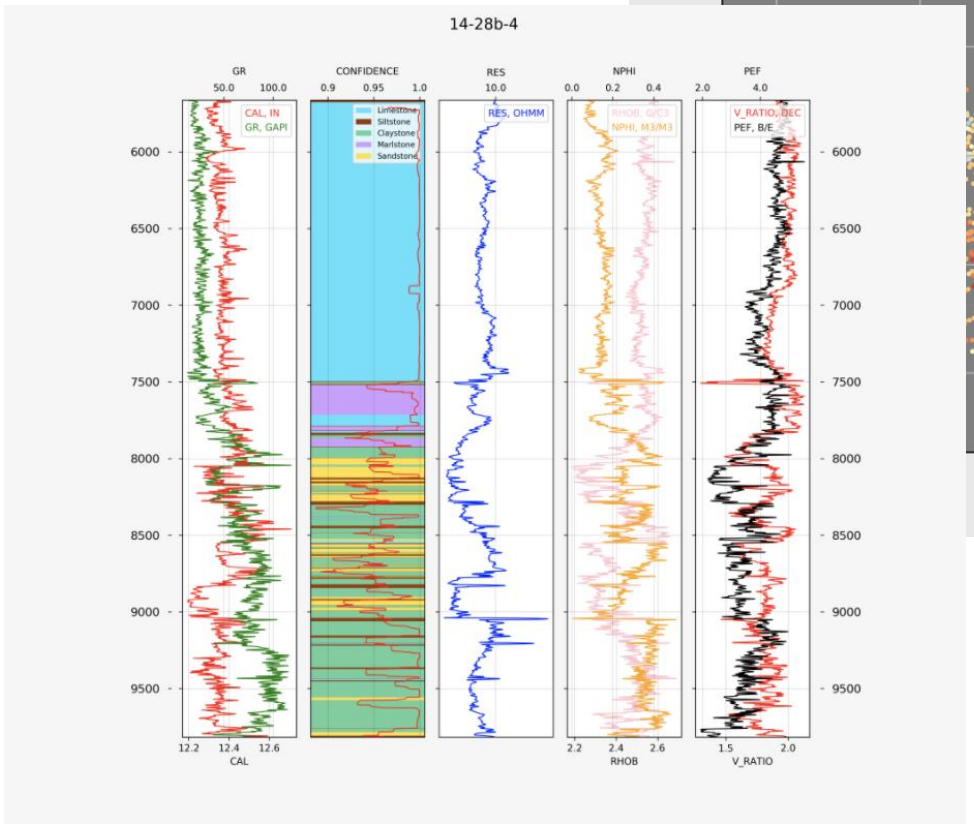
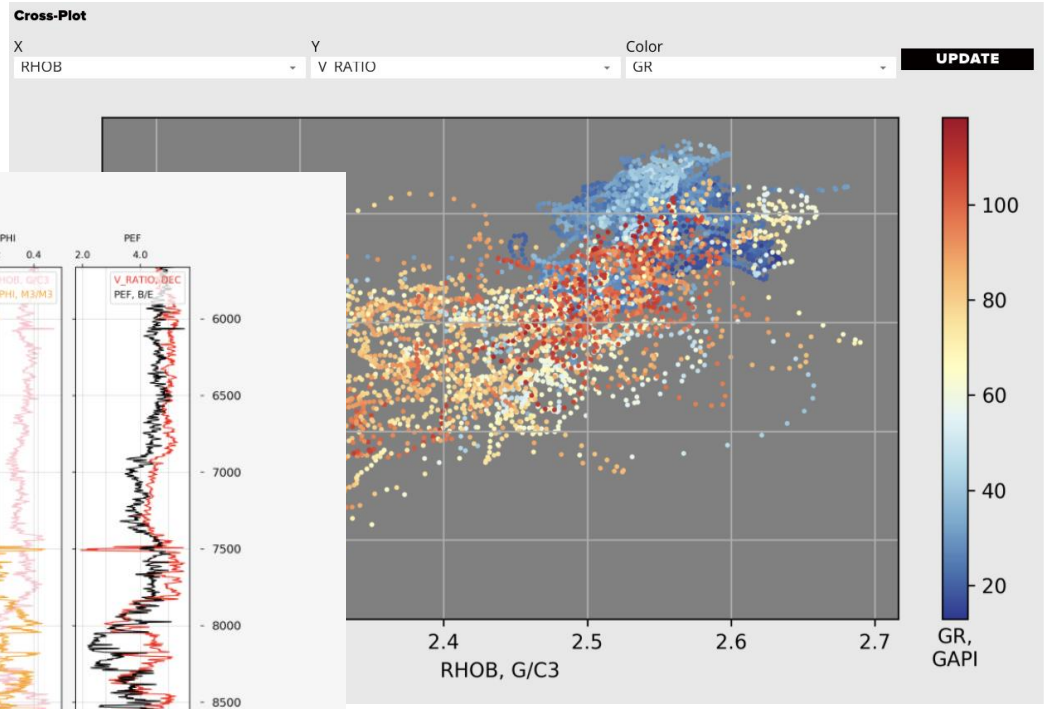
FACIES DETECTION DEMO

- CLAYSTONE
- MARLSTONE
- SANDSTONE
- SILTSTONE
- LIMESTONE
- DOLOSTONE
- OTHER ROCK TYPES





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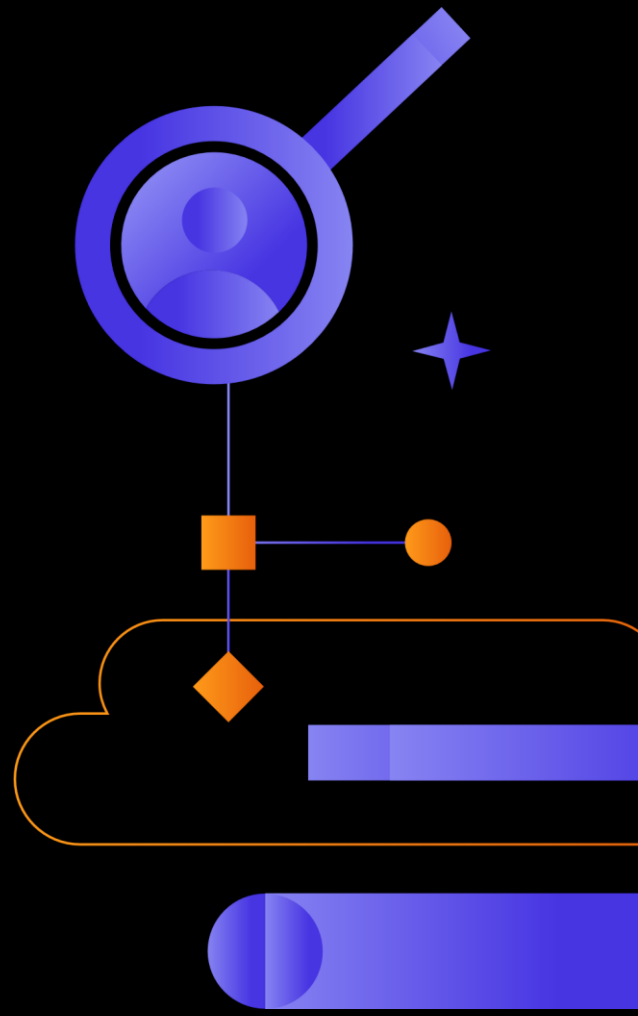
POLL 2



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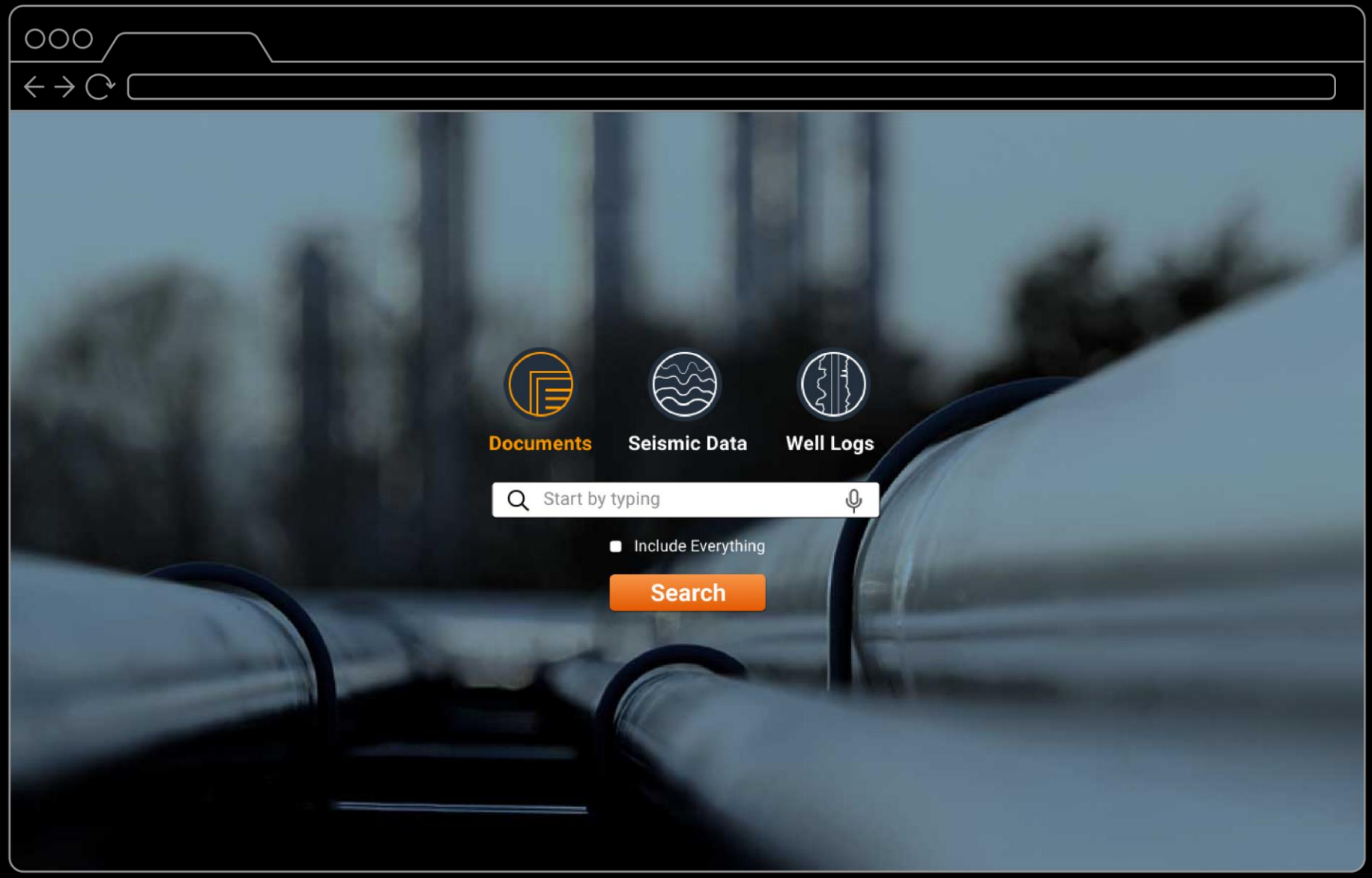
EXPLORATION DATA INTERPRETATION PLATFORM

ANDRII STRUK
SME, Energy, Oil & Gas SoftServe

softserve



Searchable and navigable platform for unstructured and semi-structured exploration and production documents.

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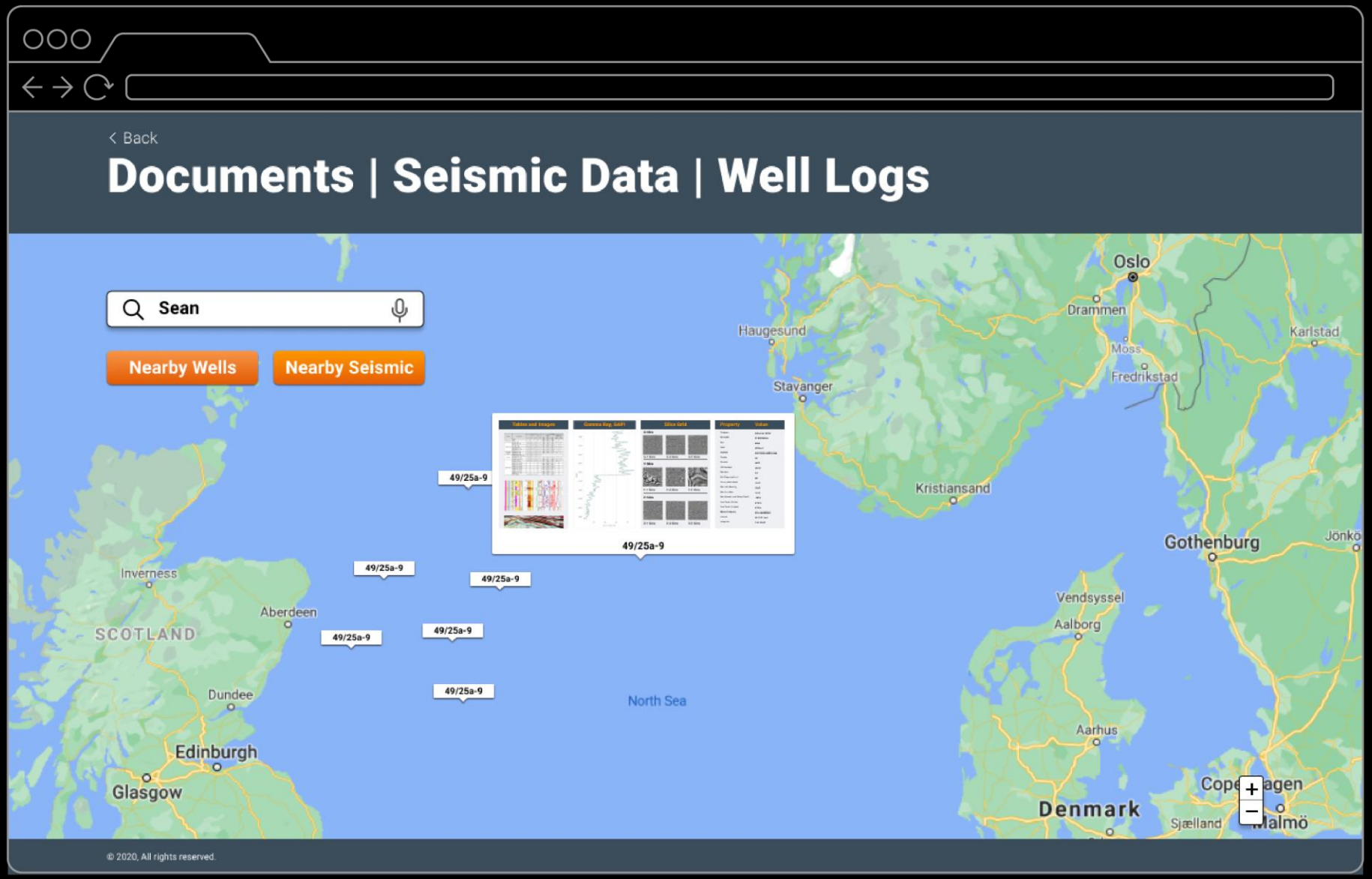

With the ability to extract, classify, and index domain-specific information as well as geolocate and tie information to its source of origin.

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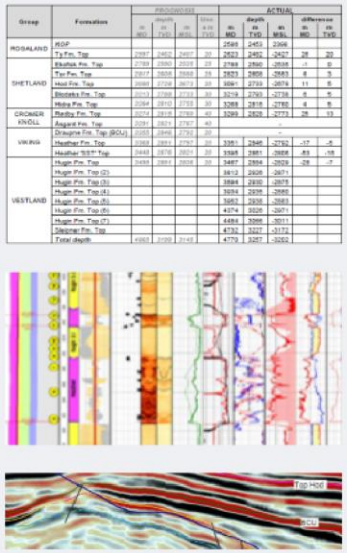
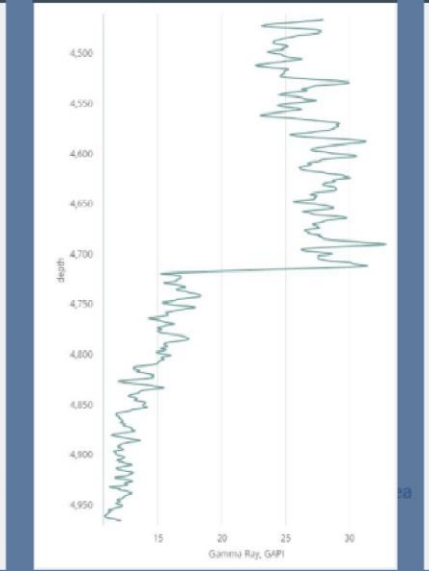
Documents | Seismic Data | Well Logs

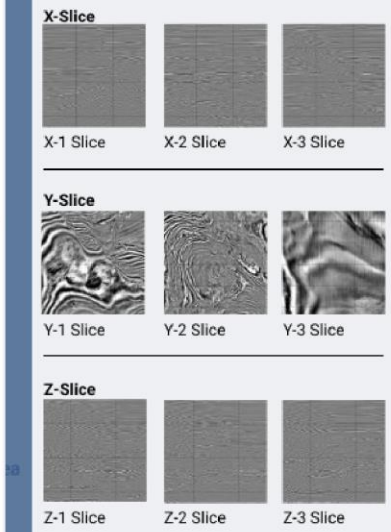
Tables and Images



Gamma Ray, GAPI



Slice Grid



Property / Value

Property	Value
Company	SHELL UK EXPRO
RIGNAME	SF BRITANNIA
Well	SEAN
Field	49/25a-9
Location	SOUTHERN NORTH SEA
Country	UK
Province	UKCS
UWI Number	22312
Elevation	0.0
Drill Measured From	KB
Above perm Datum	115.0
Elev-Kelly Bushing	115.0
Elev-Drim floor	115.0
Elev-Ground Level (Water Depth)	-100.0
Total Depth (Driller)	8730.0
Total Depth (Logger)	8730.5
Service Company	SCHLUMBERGER
Latitude	53 12 37.76 N
Longitude	2 55 19.6 E

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DOCUMENTS SEARCH

Search for documents, seismic and well-log data with custom built Knowledge Graph powering map-based search.

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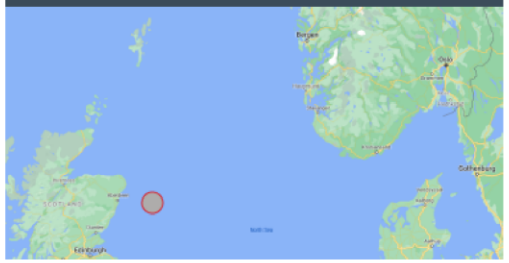
Documents

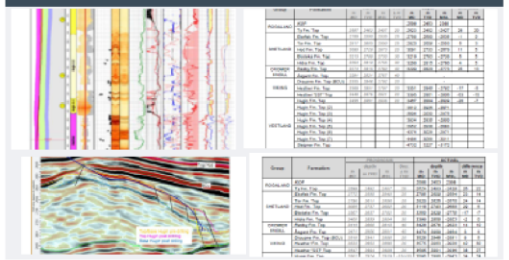
mudlogging unit blackout

- End of well report. Hobby North 14/26a-9.pdf
- Composite Well Log: 14/26a-9.pdf
- Final Well Report Well NO 15/9-F-11...Volve Field.pdf
- OGA 21st CXRM- Southwest of Britain Project.pdf
- Final Well...NO 15/9-F-11 A, NO 15/9-F-11 B.pdf
- Composite Well Log: 15/9f-11.pdf

Geolocation



Tables and Images



Key Values

Late Oligocene	Maastrichtian / Chalk
Middle Oligocene	Late Campanian / Chalk
Middle Eocene	Midde Campanian / Chalk
Early Eocene	Albian? Sinemurian
Middle Paleocene	Hettangian
Danian / Chalk	Norian to Early Rhaetic

Knowledge Graph

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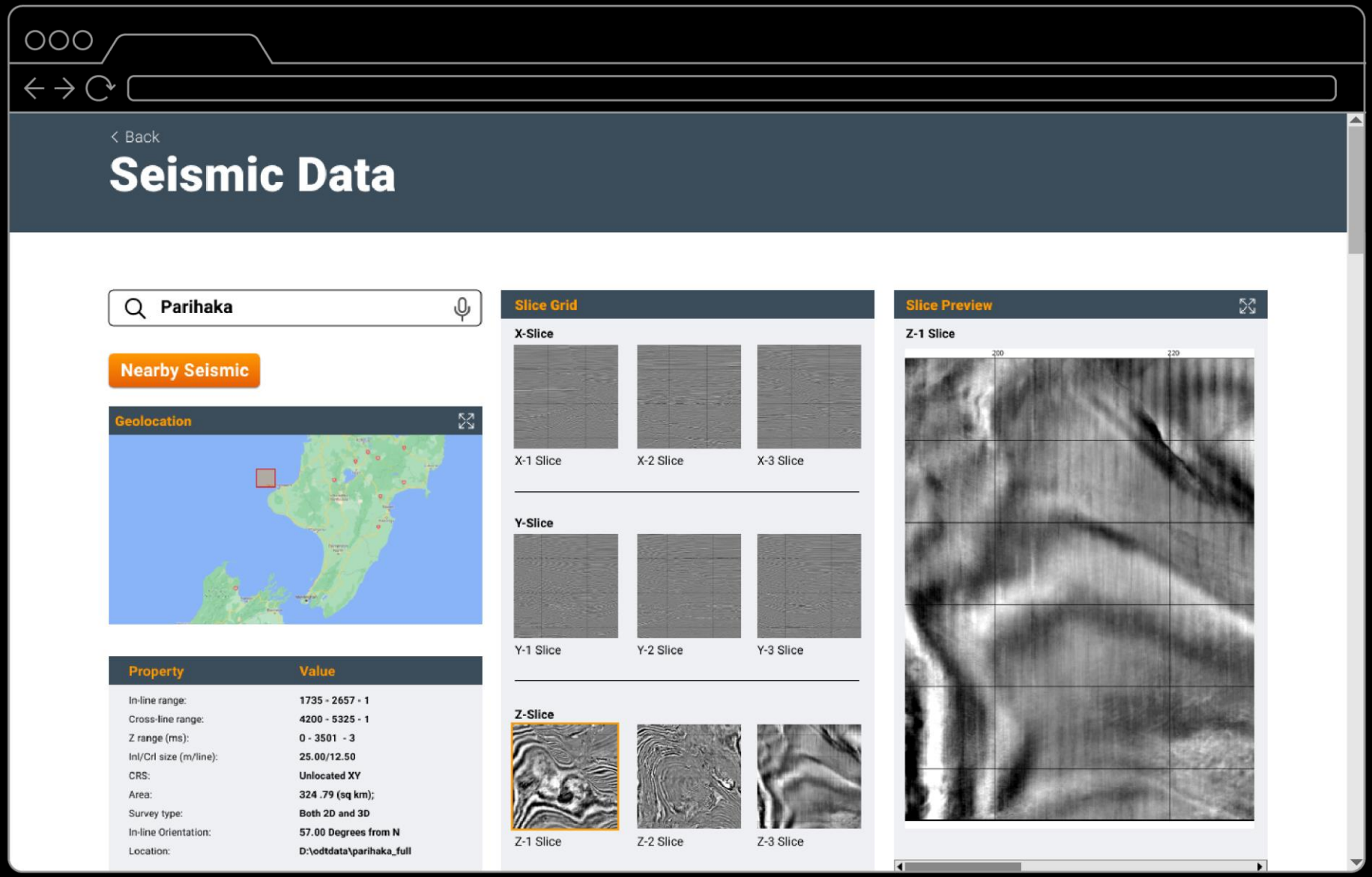

SEISMIC DATA INTERPRETATION

Process seismic data and predict faults, channels, and horizons.

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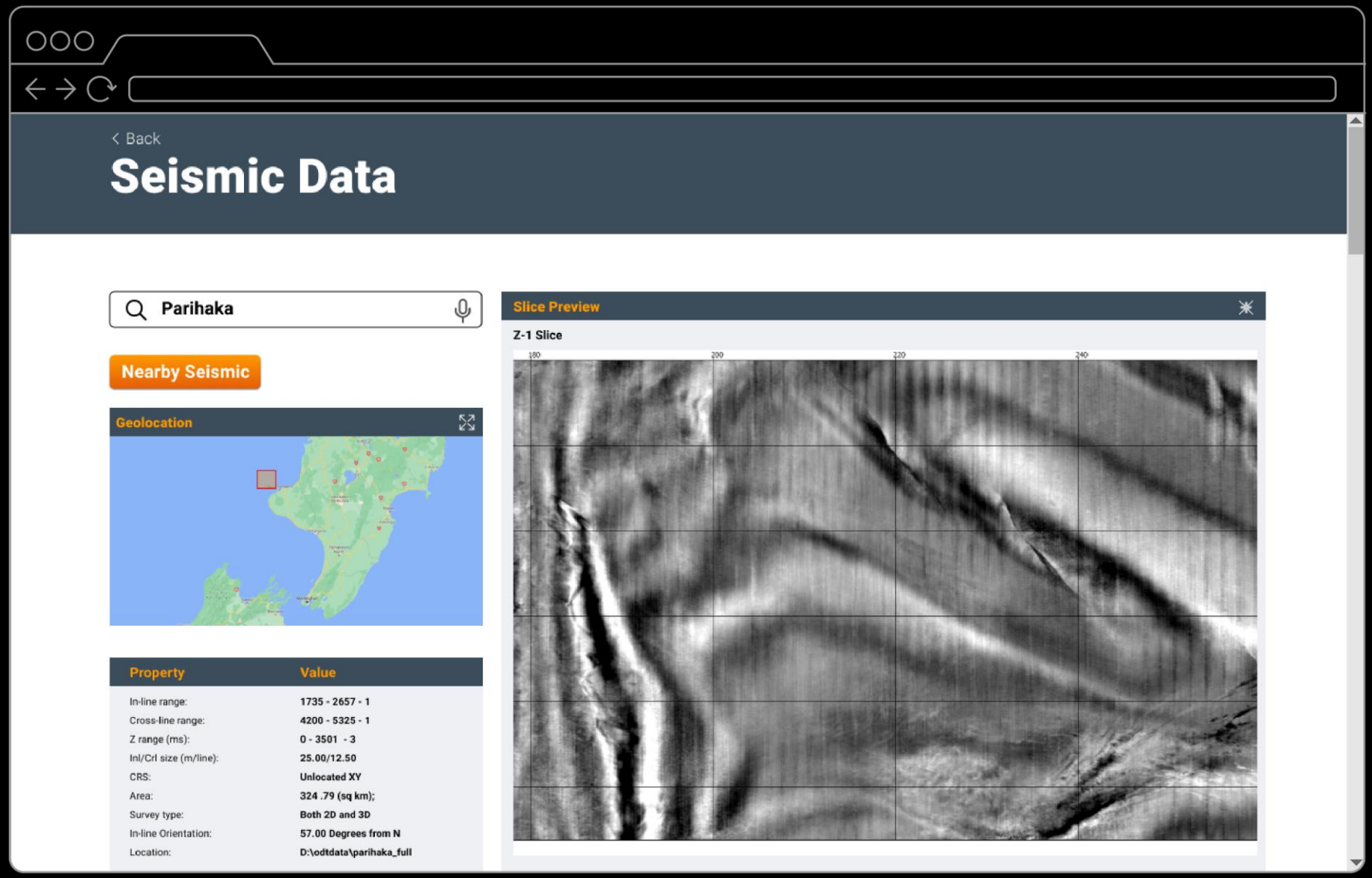
SEISMIC DATA INTERPRETATION



Process seismic data and predict faults, channels, and horizons.

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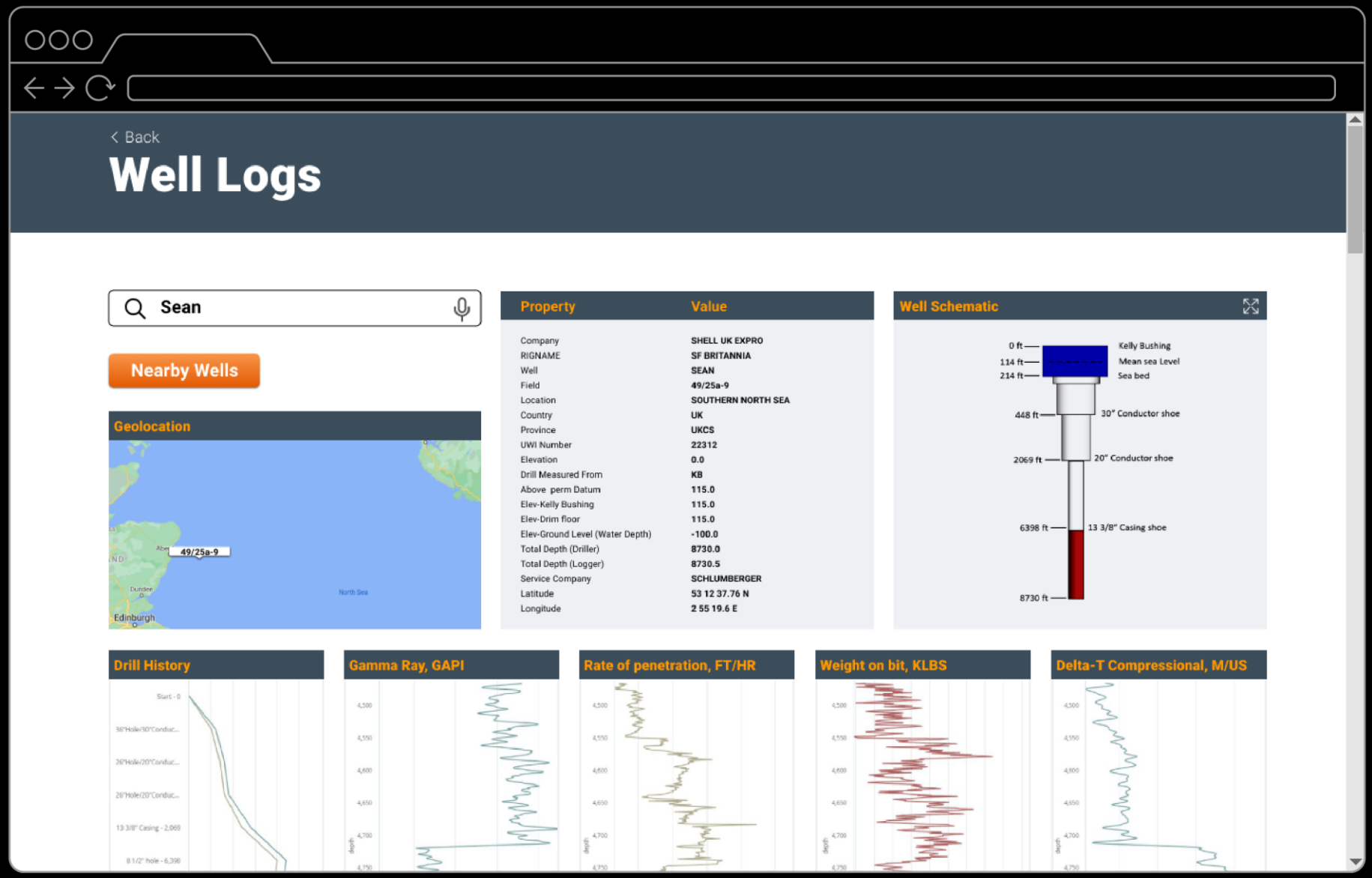
WELL LOGS AND LITHOLOGY

Process well-log data and label lithology.



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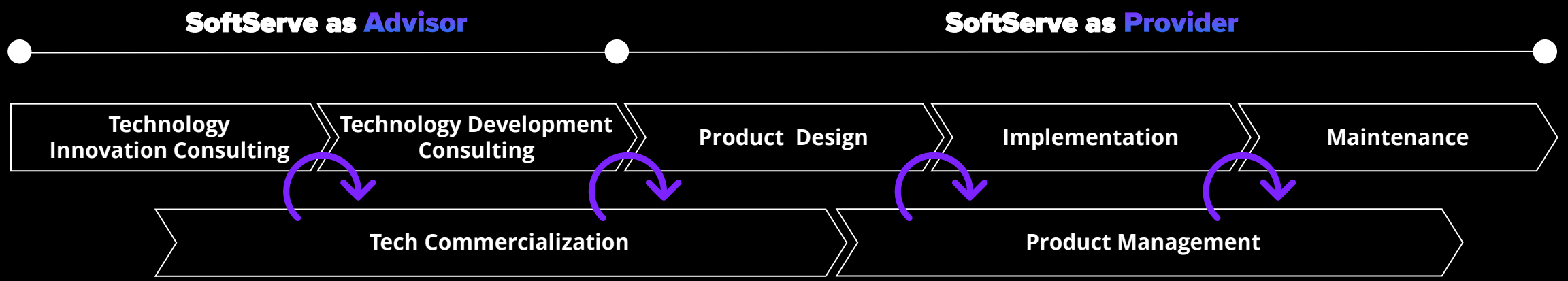
THE SOFTSERVE APPROACH



I have a Business and I need help in defining my deep tech strategy and aligning it with my business strategy

I have a technology Idea/ Opportunity/Problem/ identified. How do I validate it rapidly? What is next?

I have the technology in mind. How can I make value of it? How do I build the Product/Solution?

Are we ready for effective implementation of Product/Solution? How would we do that?

Are there any issues with current Solution/Product? How could we prevent possible issues?

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O&G BUSINESS PRIORITIES ADDRESSED THROUGH DIGITAL APPLICATIONS

BUSINESS PRIORITIES	 Intelligent Exploration	 Development/ Engineering	 Production O&M Excellence	 Connected Supply Chain	 Smart HSE
DIGITAL SOLUTIONS	combined artificial intelligence(AI)/machine learning, Big Data analytics, supercomputing power and cloud-based platforms	integrated AI/machine learning, Big Data analytics and a centralized cloud-based data management platform	Linked manufacturing execution systems (MES) to AI/ML, Big Data analytics and cloud-based platforms, that run distributed control systems and ERP applications.	integrated AI/machine learning, smart track-and-trace technologies, Big Data analytics and cloud-based platforms with ERP applications	combined AI/machine learning, MES, Big Data analytics, autonomous technologies (robots, drones and digital twins), Internet-of-Things platforms and cloud-based applications
VALUE	Advanced interpretation of seismic data and reservoir models, reduced exploration costs, faster data acquisition and discovery.	Improved production operations and maintenance excellence through advances in process digitization that drive integrated resource planning, manufacturing scheduling and maintenance execution.	Optimized value chain and operations & management (O&M) performance across integrated upstream and downstream activities.	Enhanced supplier interactions, warehousing and logistics with advances such as digital category management, smart replenishment and shipment transparency.	Reduced human exposure to hazardous operations, improving risk management and energy efficiency management, monitoring of emissions and meeting sustainability targets with smart health, safety, security and environmental (HSSE) applications.

by Strategy& (PwC), 2020 Digital Operations study for energy

WHAT'S NEXT

- WEBINAR VIDEO RECORDING
- WELL-LOGS DATA PROCESSING AND LITHOFACIES PREDICTION WHITEPAPER
- AI WELL-TO-WELL CORRELATION PROTOTYPE
- G&G DOCUMENTS MANAGEMENT AND KNOWLEDGE MINING ACCELERATOR/MVP

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QUESTIONS?

WE'VE GOT THE ANSWERS.

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THANK YOU!

LET'S GET IN TOUCH

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