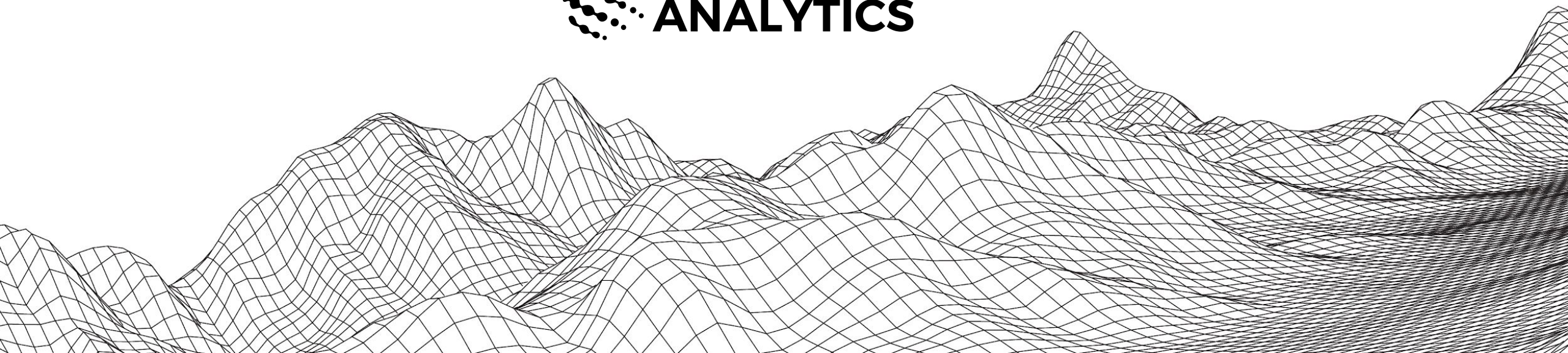


Looking up the AI maturity curve in E&P; opportunities, challenges and the impact on geoscience work

Eirik Larsen, Stephen J. Purves, Dimitris. Economou and Behzad Alaei



20 years ago

Conference Paper

Porosity, Permeability and TOC Prediction from Well Logs Using a Neural Network Approach

June 1999

DOI: 10.3997/2214-4609.201407849

Conference: 61st EAGE Conference and Exhibition

Project: [Seismic Modeling](#)

A. Bhatt ·  Hans B. Helle

Conference Paper

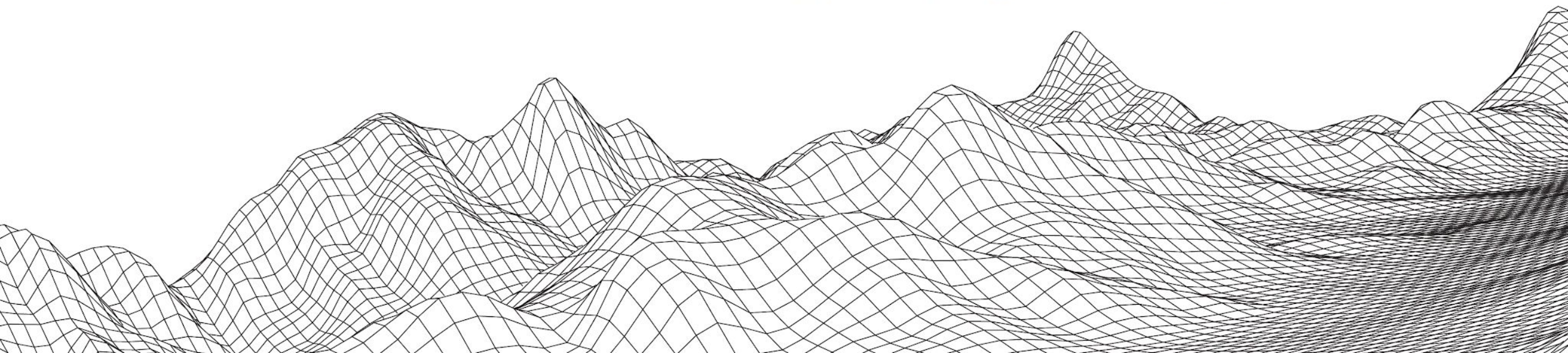
Full-text available

The Geometry and Facies Anatomy of Regressive Fan-Deltaic Wedges in an Open-Marine Graben: the Neogene Köprü Basin, Southwestern Turkey

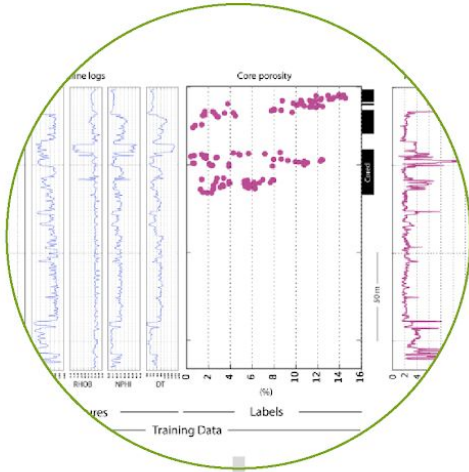
June 2001

Conference: AAPG Annual Meeting 2001 AAPG Search and Discovery Article #90906©2001 · At: Denver · Volume: AAPG Search and Discovery Article #90906©2001 AAPG Annual Convention, Denver, Colorado

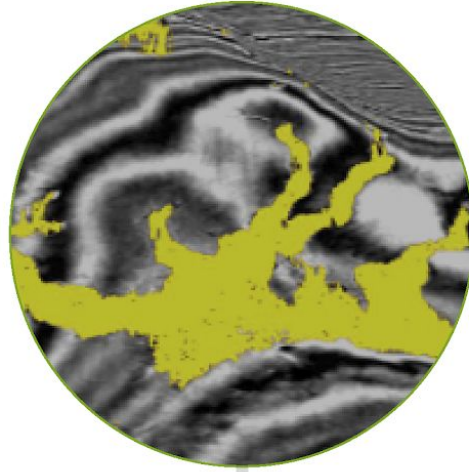
 Eirik Larsen · T Dreyer ·  Wojciech Nemec · T-R Ellingsen



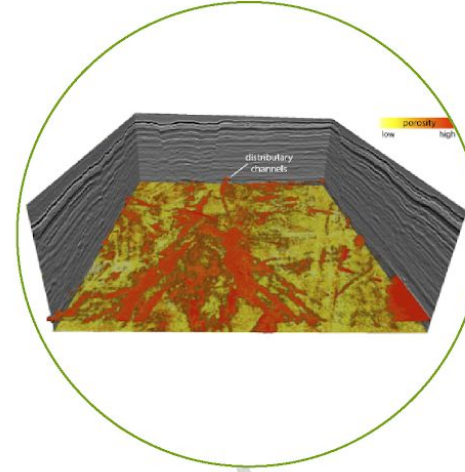
AI-assisted
well-data analysis



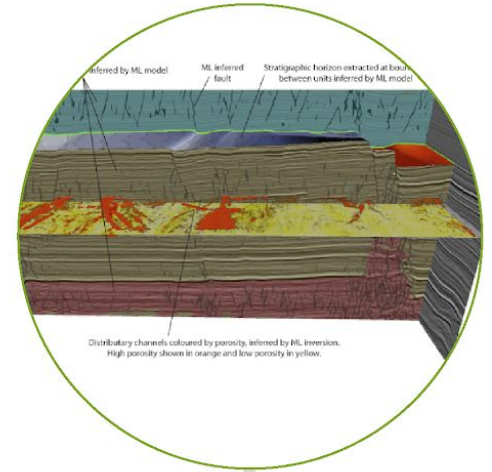
AI-assisted
seismic interpretation



AI-assisted
seismic inversion



AI-assisted
geomodelling



1950's

1960's

1970's

1980's

1990's

2000's

2010's

Early artificial intelligence
stirs excitement



**ARTIFICIAL
INTELLIGENCE**

Machine learning begins
to flourish

**MACHINE
LEARNING**

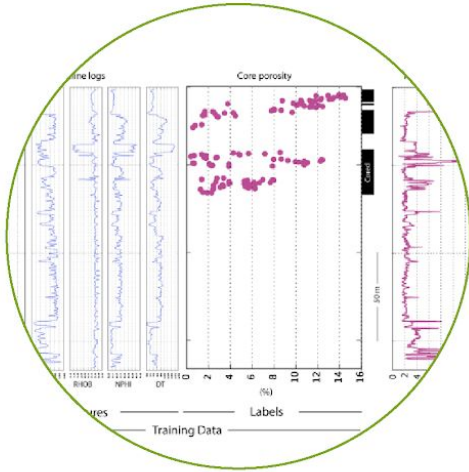


Deep learning breakthroughs
drive AI boom

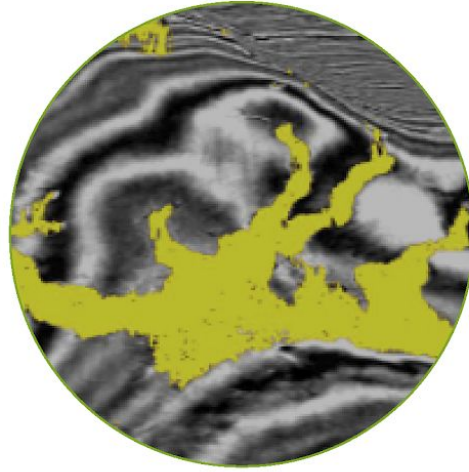
**DEEP
LEARNING**



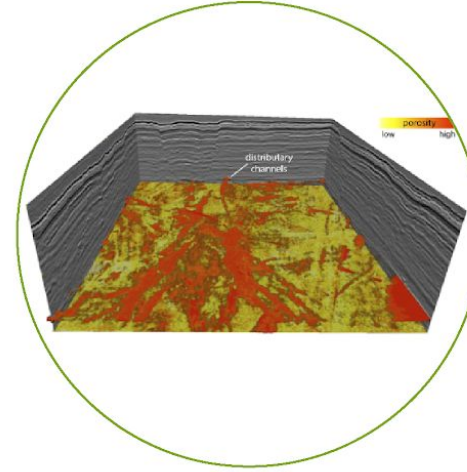
AI-assisted
well-data analysis



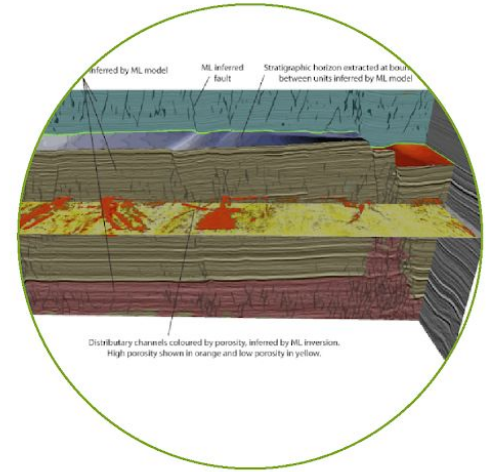
AI-assisted
seismic interpretation



AI-assisted
seismic inversion



AI-assisted
geomodelling



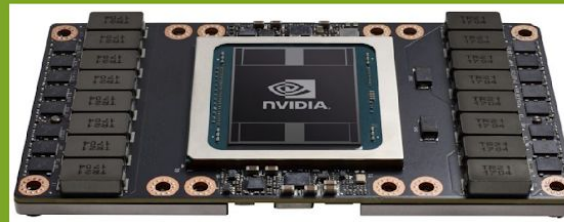
Enablers



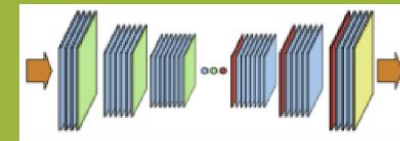
**Democratization of
Sub-Surface Data**



**Open Source
Libraries**



**GPU Enabled High
Performance Computing**

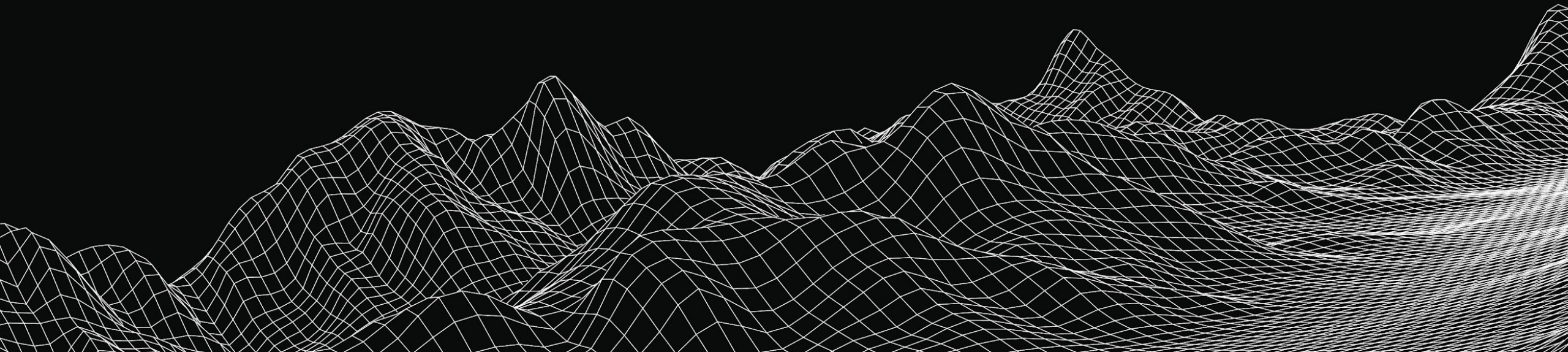


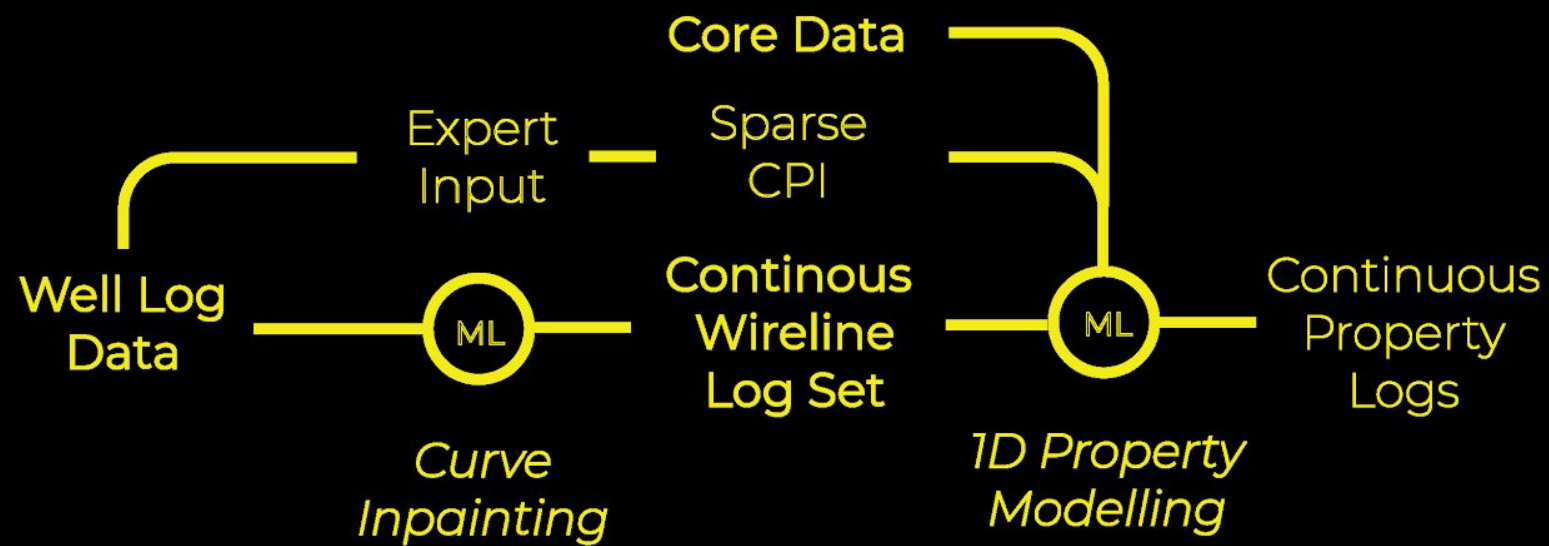
**Algorithmic
Development**



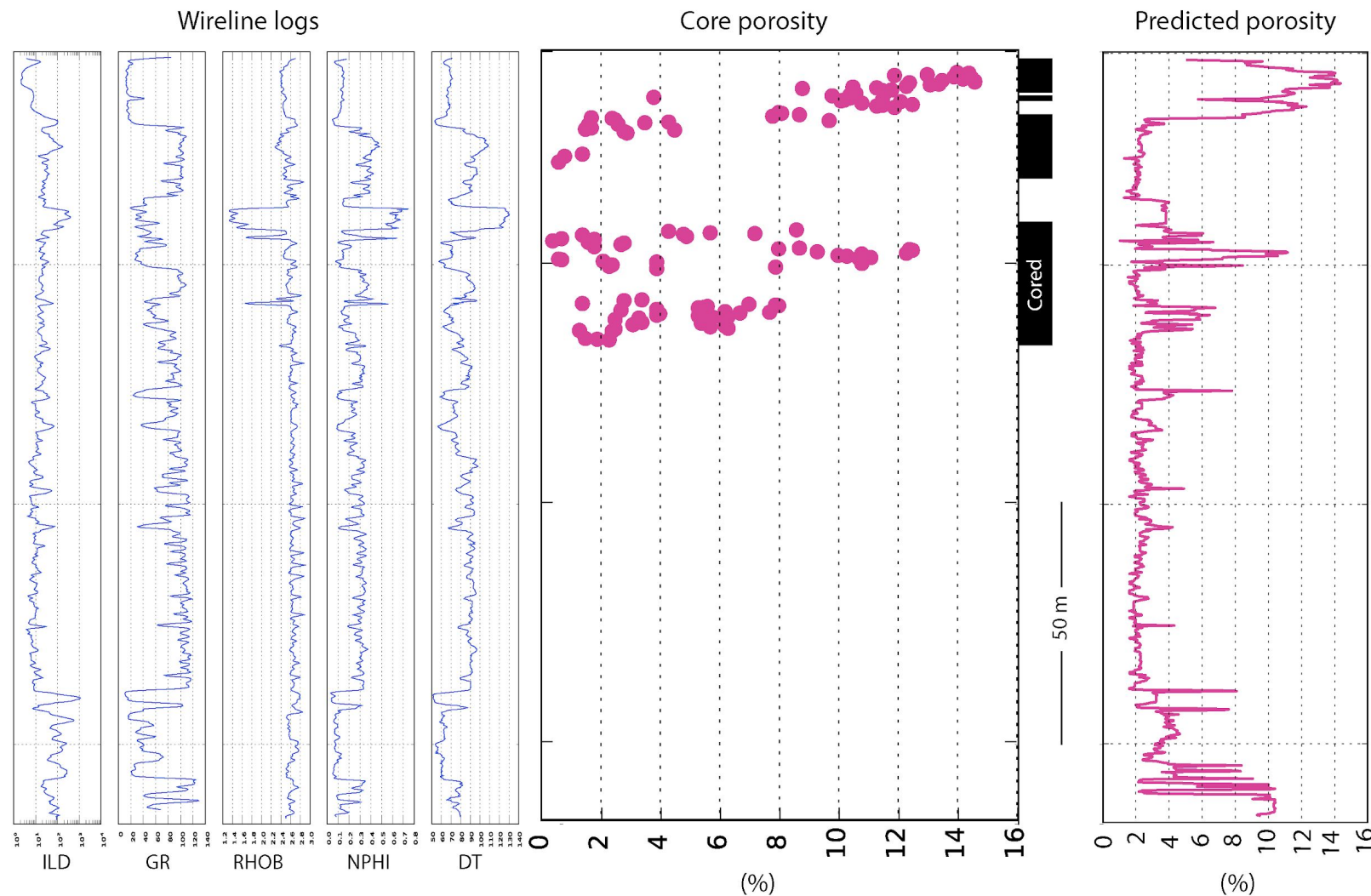
**Data Analytics
Platforms**

AI is Changing Geoscience Work





Predicting rock- and fluid-property curves



Features: wireline logs

Labels: core porosity

Prediction: porosity log

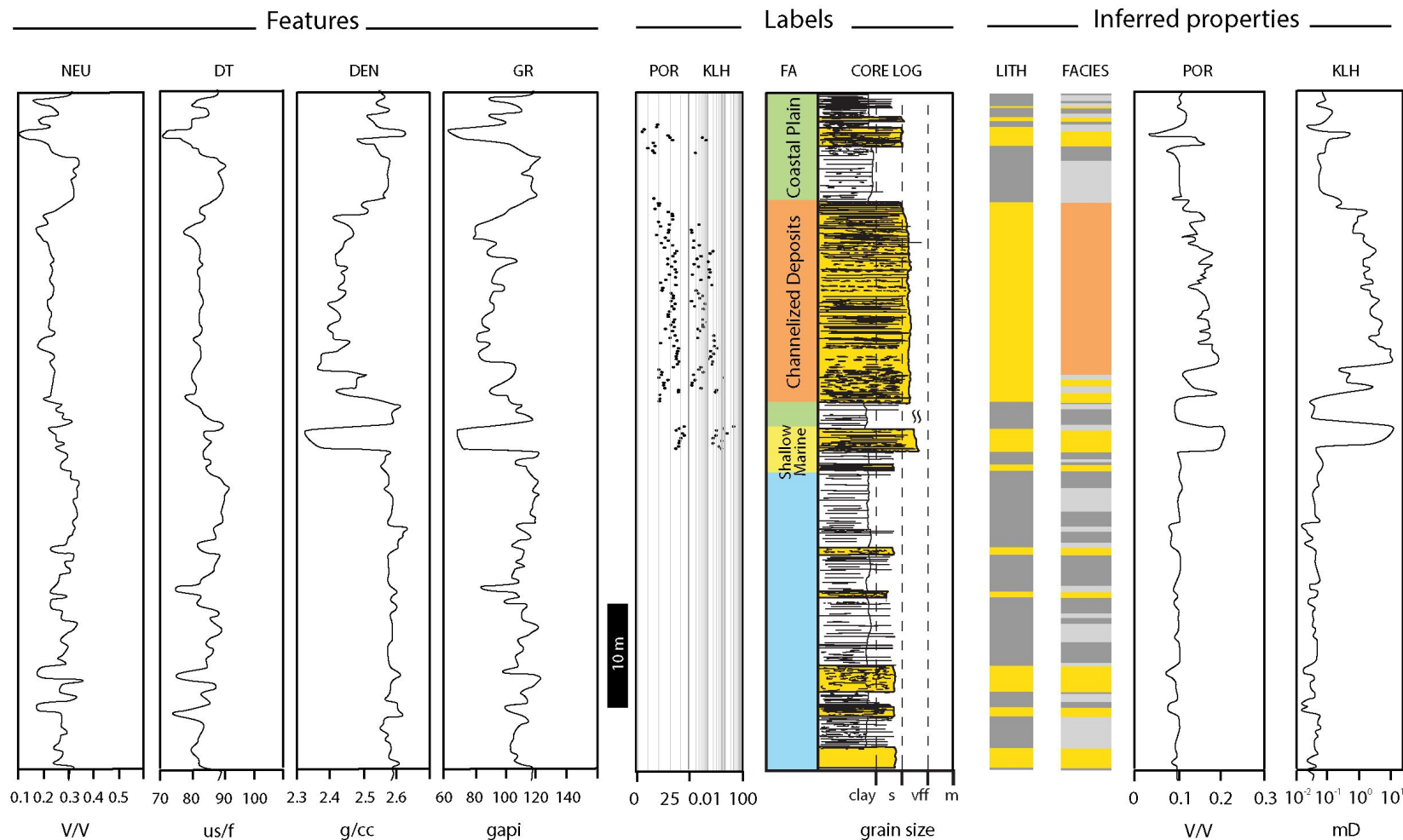
Features

Labels

Training Data

Prediction

The changing face of well-data analysis



Efficient ML model building

enables prediction of multiple
rock and fluid properties for
large datasets

The changing face of well-data analysis

EarthNET ▾

Data Management ▾

Machine Learning

Workers

Models

demo ▾

demo ▾

Wells

7222/11-1

7222/11-2

7222/6-1 S

7223/5-1

7224/6-1

7224/7-1

7225/3-1

7225/3-2

7226/11-1

7226/2-1

7227/10-1

7228/1-1

7228/2-1 S

7228/7-1 A

7228/9-1 S

7321/7-1

7321/8-1

7321/9-1

7324/10-1

7324/7-1 S

7324/7-2

7324/8-1

7324/9-1

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Groups

Formations

FRUHOLMEN FM

FUGLEN FM

HAVERT FM

HEKKINGEN FM

ISBJØRN FM

KLAPPMYSS FM

KNURR FM

KOBBE FM

KOLJE FM

KOLMULE FM

KVITING FM

NAUST FM

NO FORMAL NAME

NORDMELA FM

POLARREV FM

RØYE FM

SNADD FM

STØ FM

TORSK FM

ML Features

DEN

DT

GR

NEU

RDEP

RELPOS

RMED

HC

OIL

GAS

BRINE

Labels:

DTS

Augmentation

Regressor:

XGBoost

Search Parameters

Flags:

Groups

Log Range Filters

Get Histograms

Active Workers

✓ Add New Worker

t2.micro@eu-west-2a

DTS = XGR(DEN,DT,GR,NEU,RDEP,RELPOS,RMEI

CV Folds:

3

CV per wells

Split Data:

60

Blind Test

Do ML

- 1) Set up model
- 2) Train on cloud instance



3D Seismic
Offset Stacks

3D Pre-Stack
Seismic

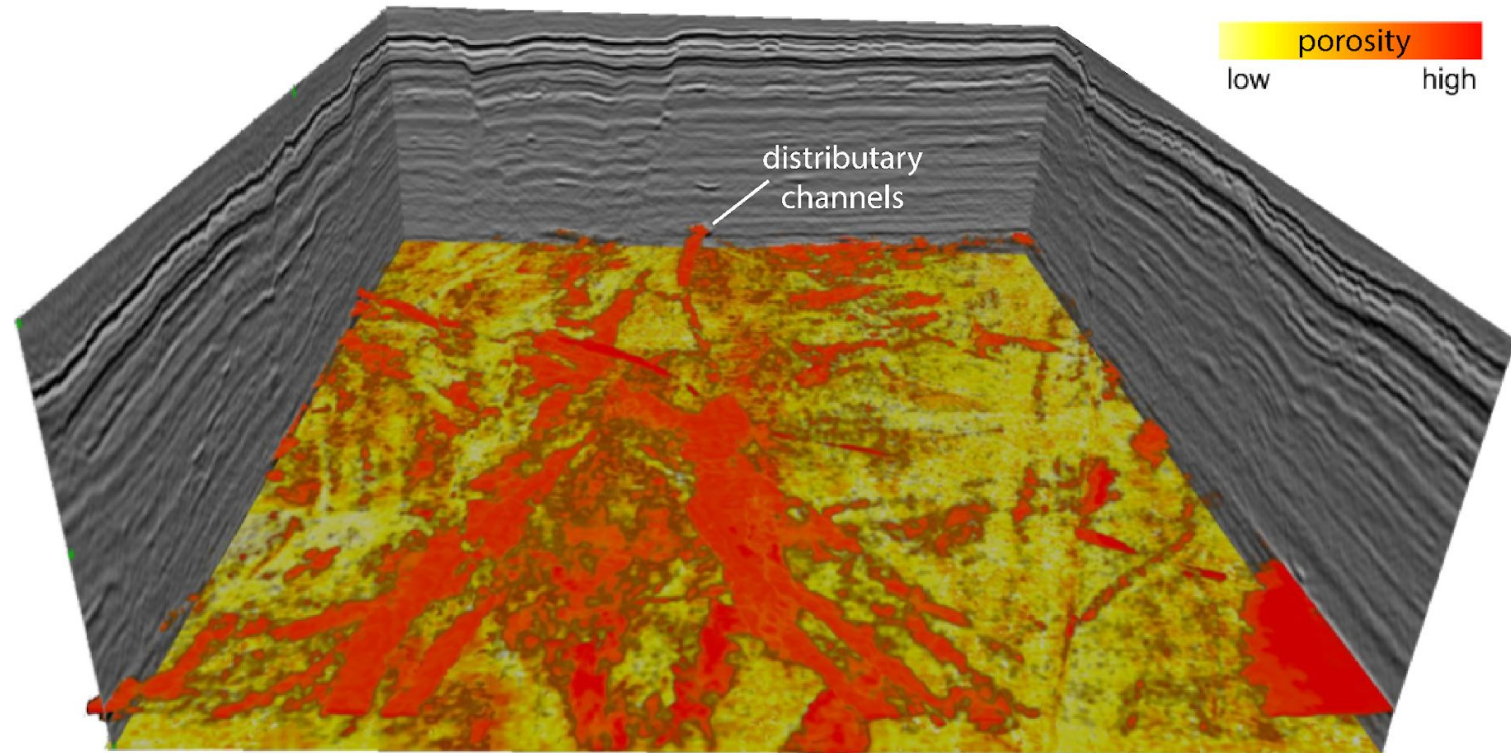
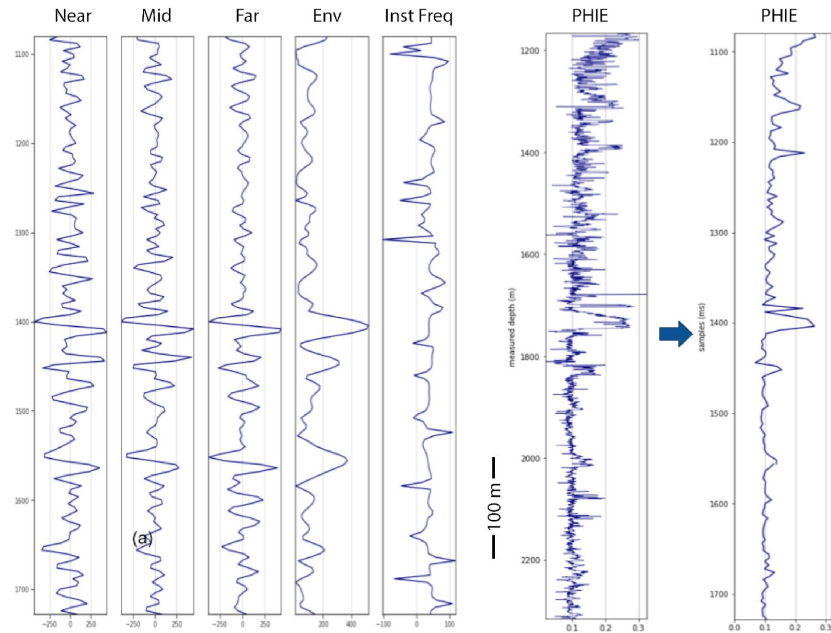
Continuous
Property
Logs

Seismic Scale
Property Cubes

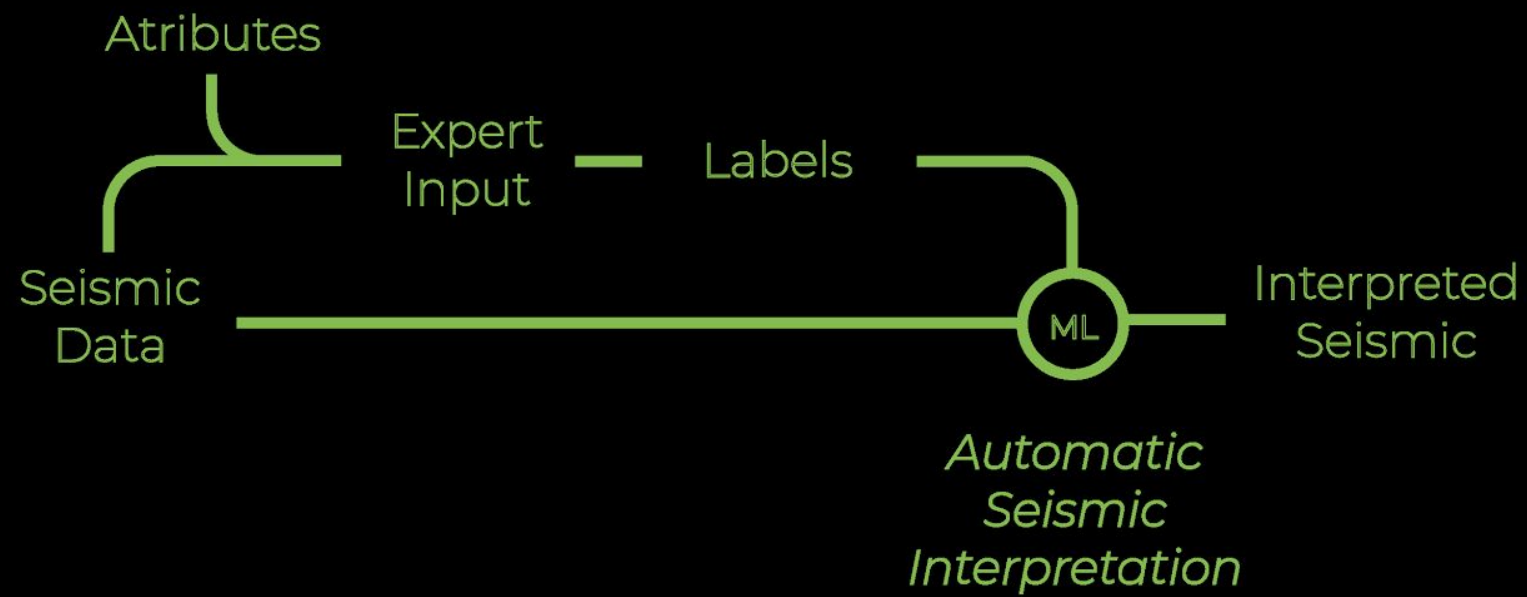


*3D Property
Modelling*

The changing face of 3D rock & fluid property prediction

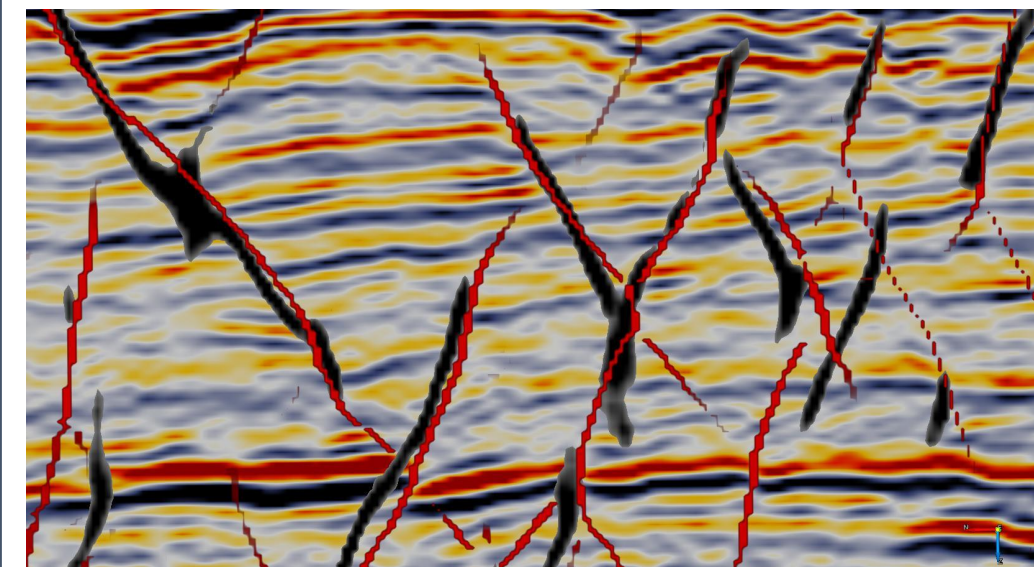
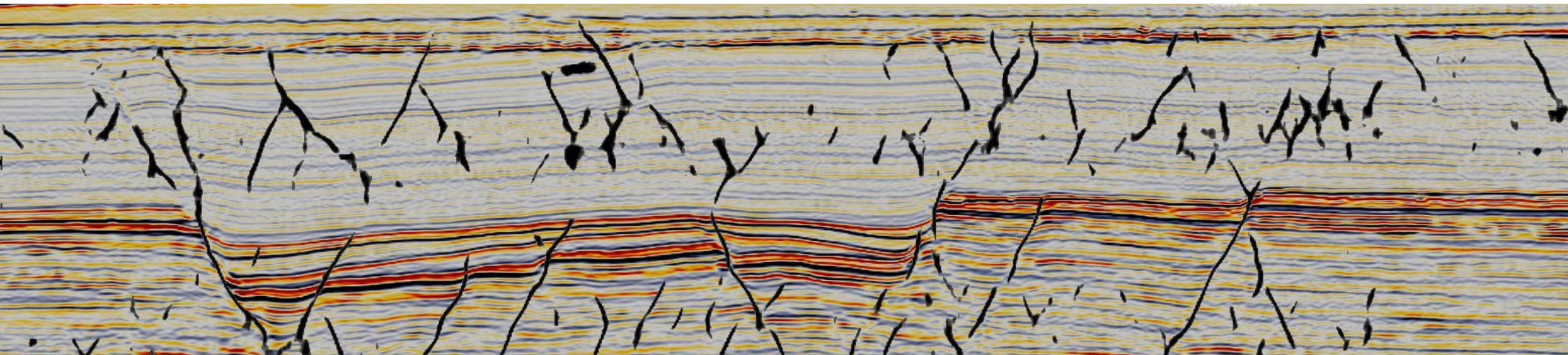


ML-derived 3D porosity model
inferred from seismic traces;
near, mid, far and seismic attributes

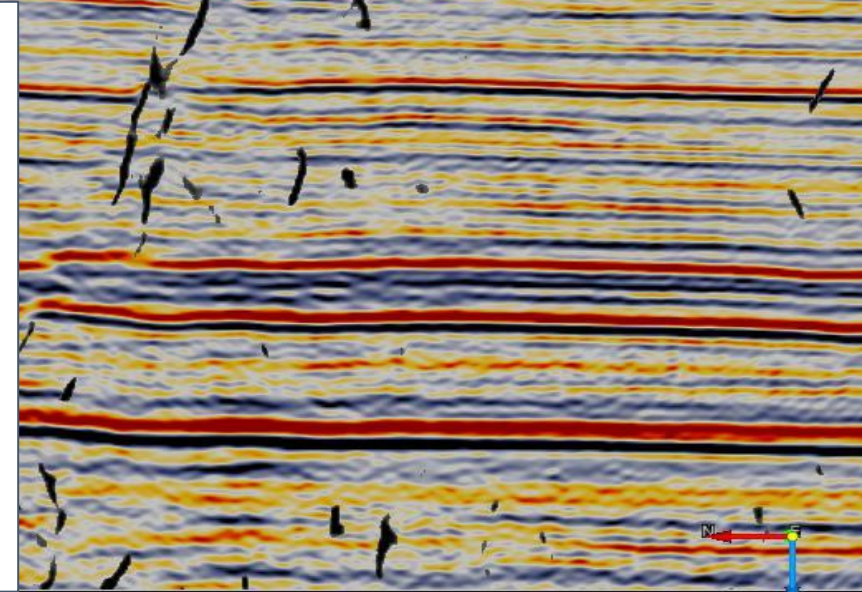


The changing face of seismic interpretation

fault interpretation

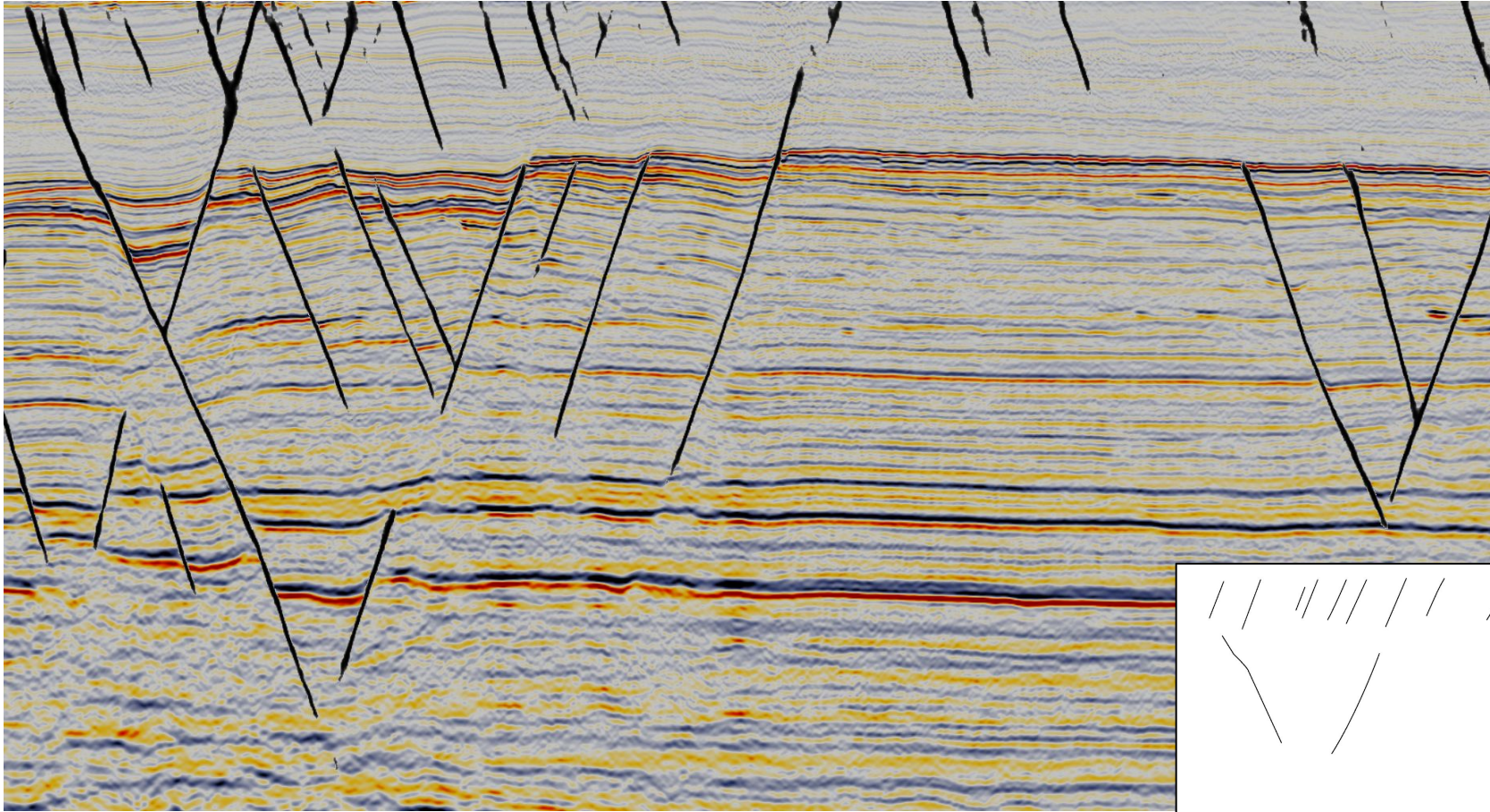


Deep Learning Model
trained on
seismic attributes



The changing face of seismic interpretation

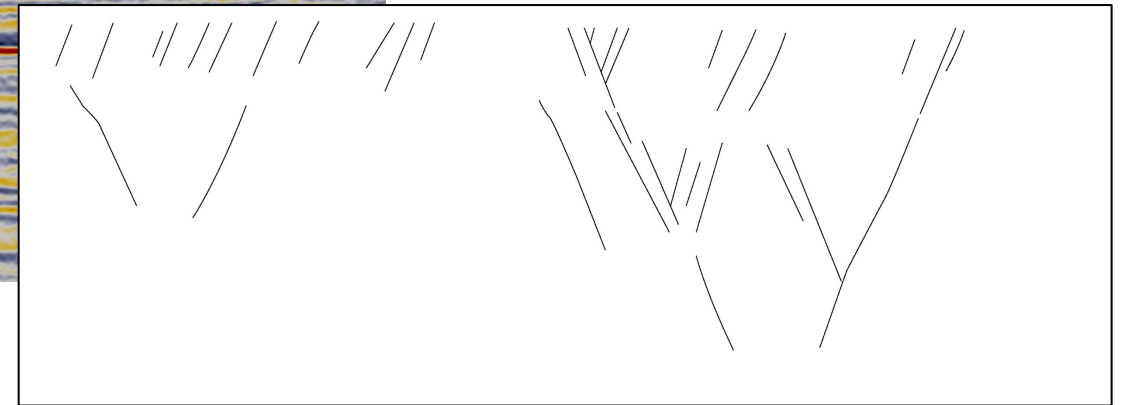
fault interpretation



Deep Learning Model

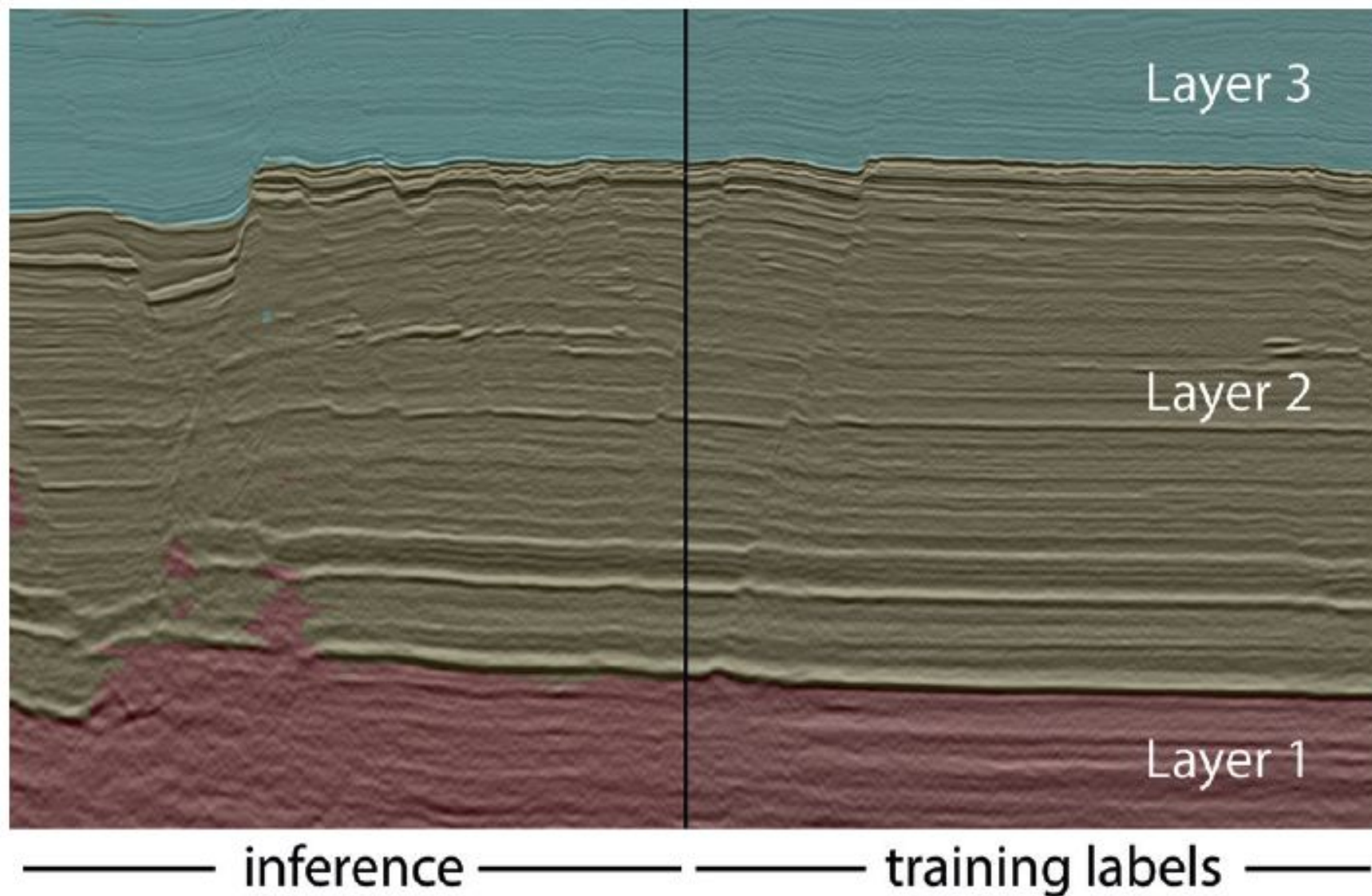
trained on manual
fault picks on 15 inlines

(below) representative
labels from a different
line



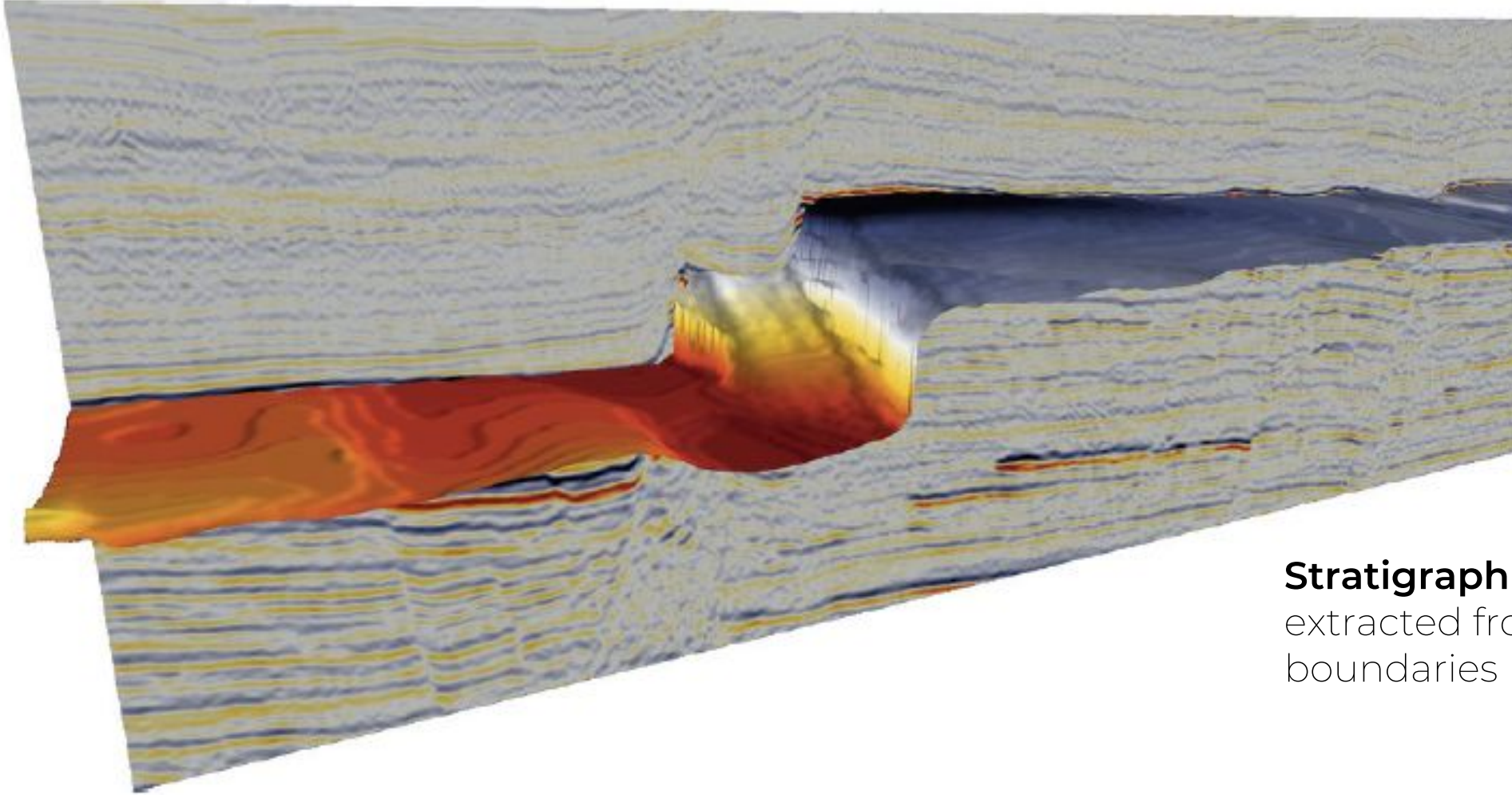
The changing face of seismic interpretation

stratigraphic interpretation



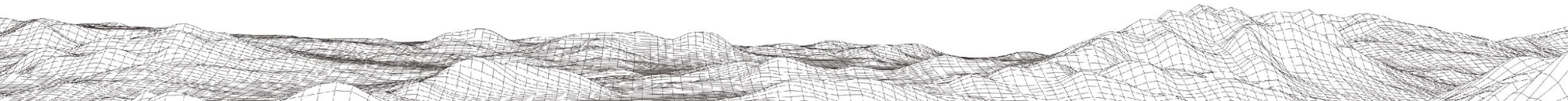
The changing face of seismic interpretation

stratigraphic interpretation



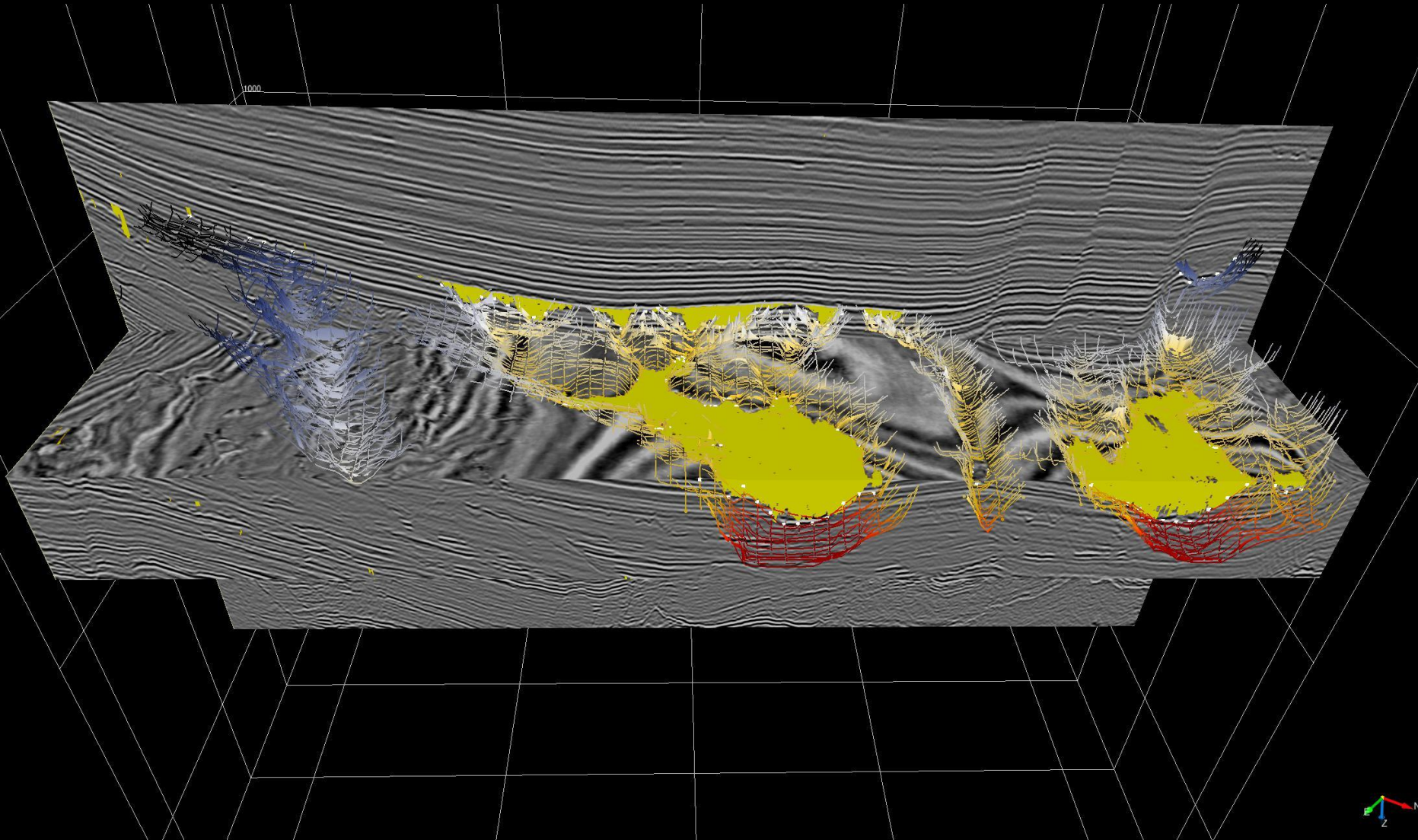
Stratigraphic horizons

extracted from layer
boundaries

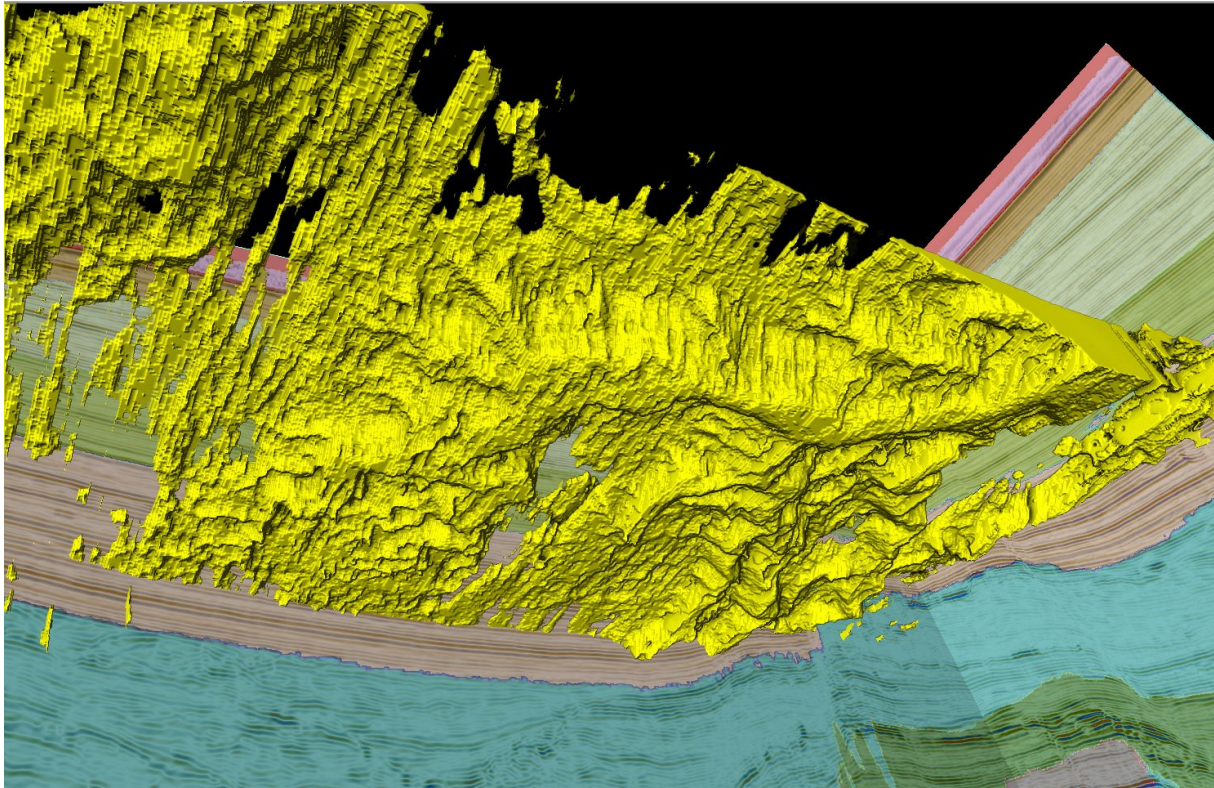


The changing face of seismic interpretation

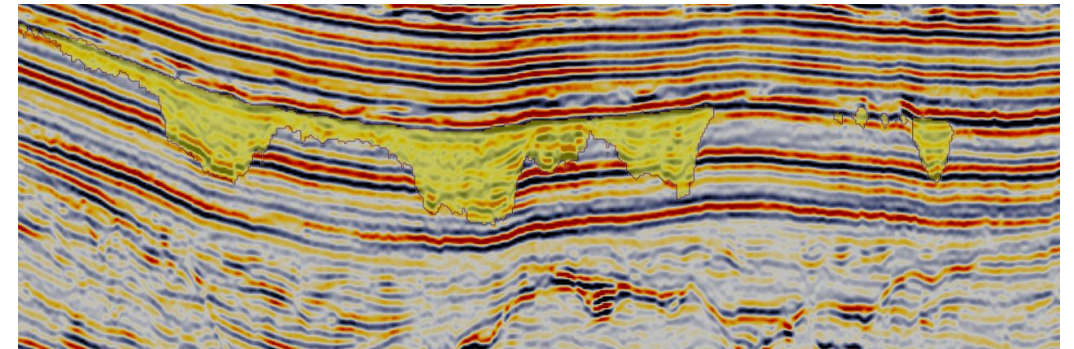
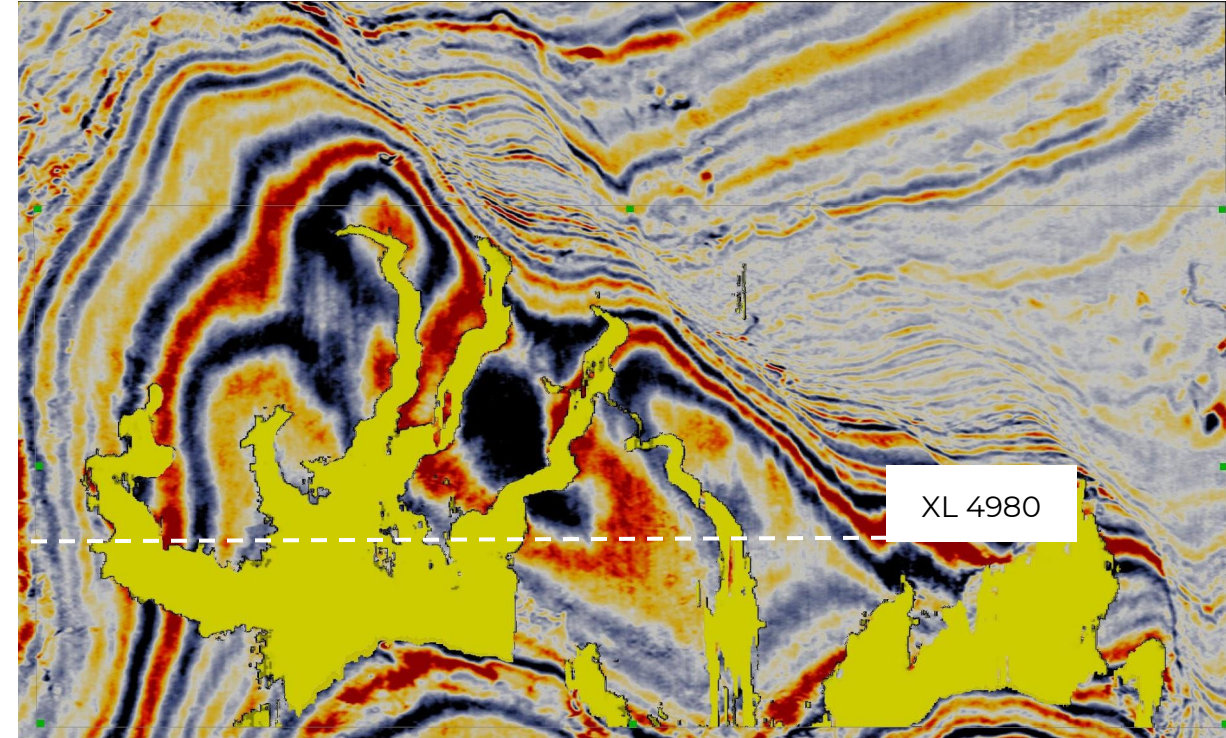
3D geobody interpretation



Volume based predictions are detailed, quick to produce

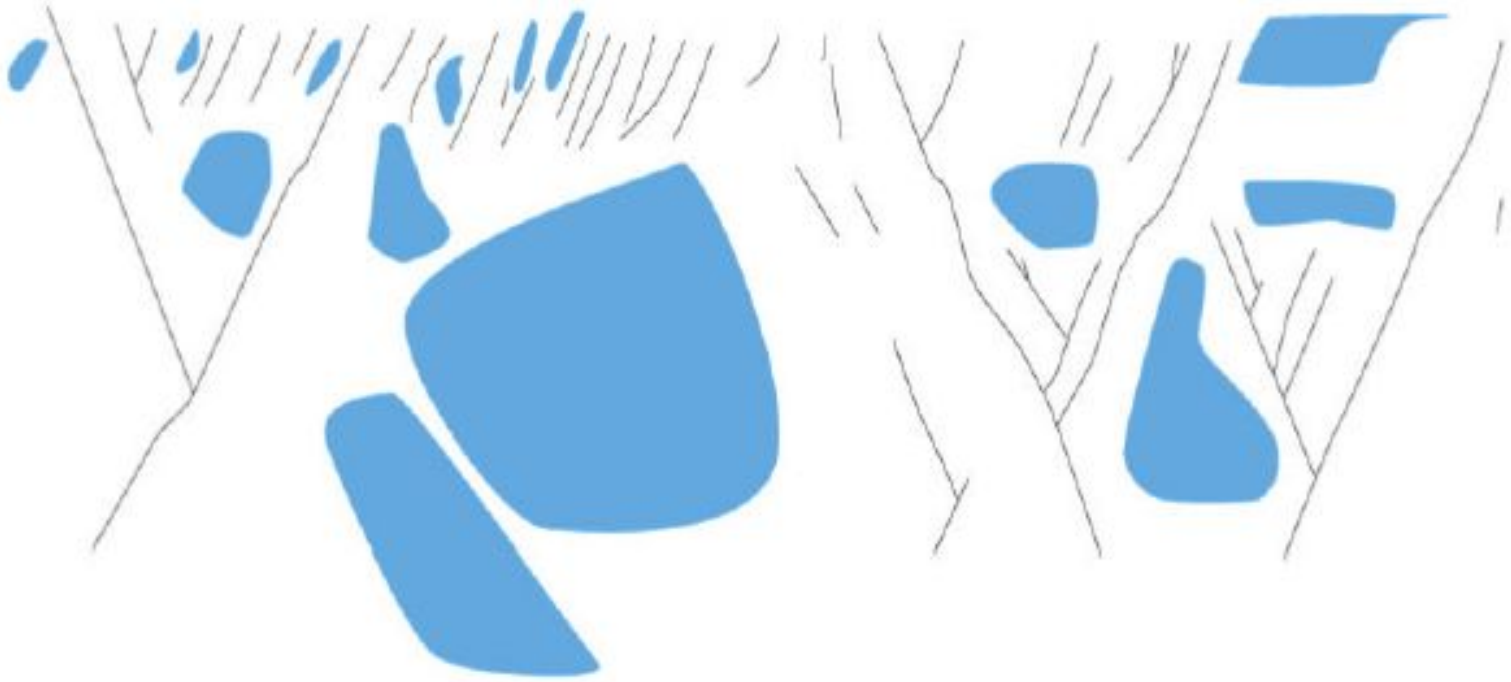


Single realisation of a complex gully geobody produced using a deep learning model trained using labels that were manually picked on inline sections only



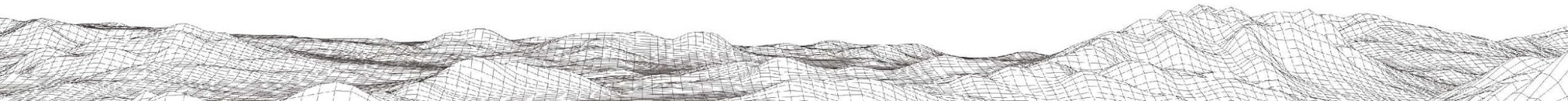
XL 4980

The changing role of the subsurface expert

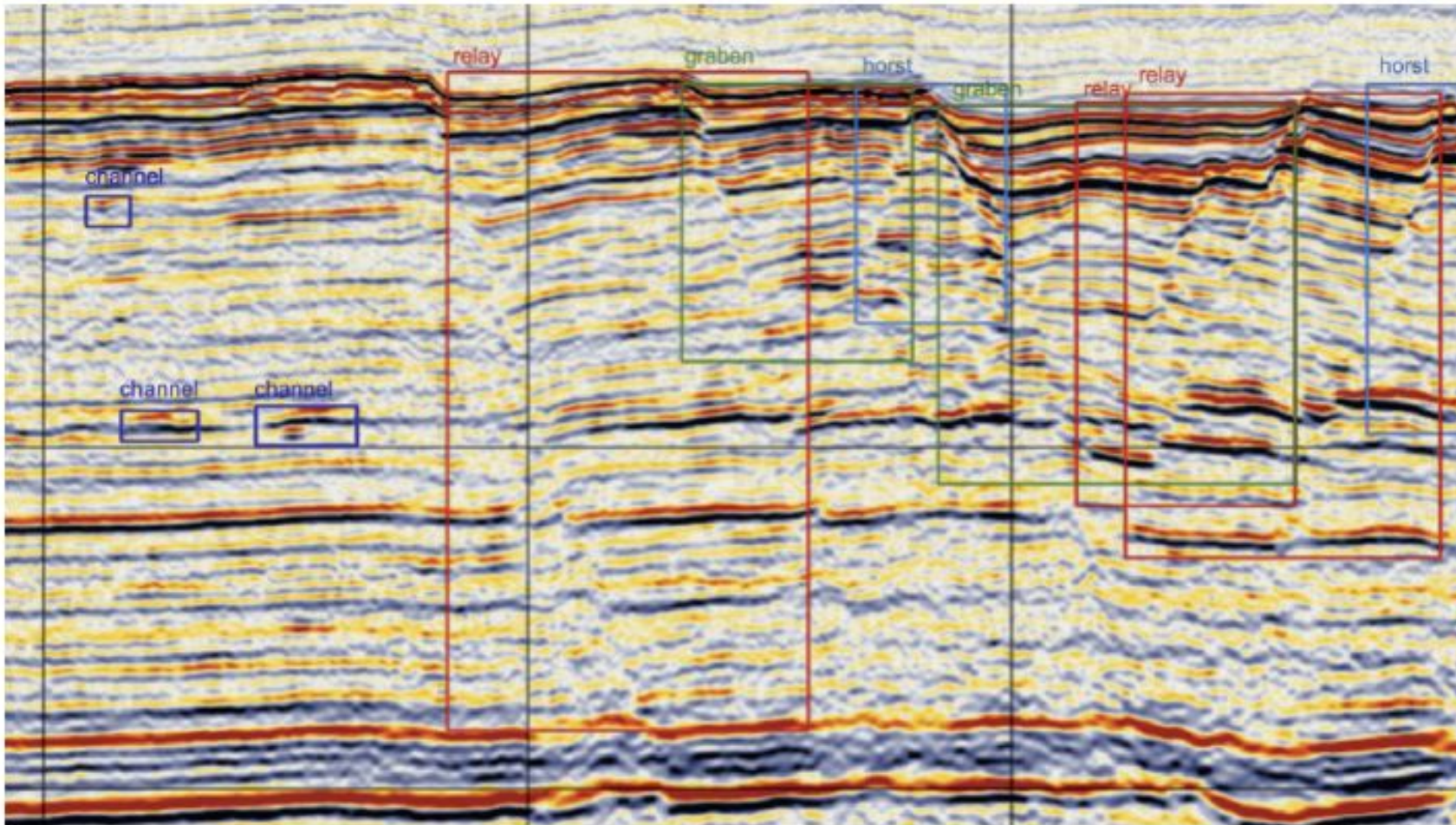


**Labelling and embedding
knowledge**

labelling faults and non-faults

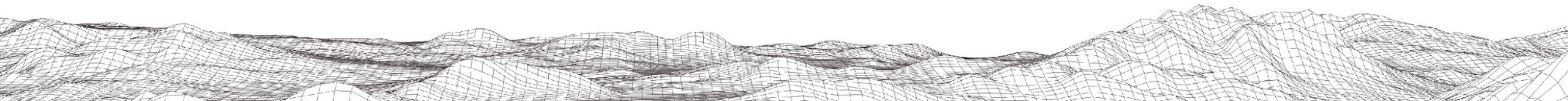


The changing role of the subsurface expert

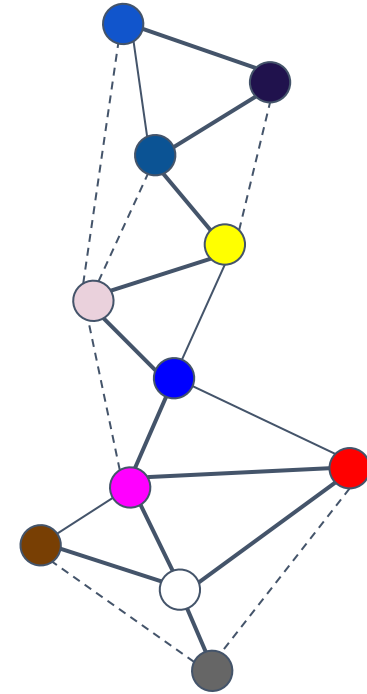
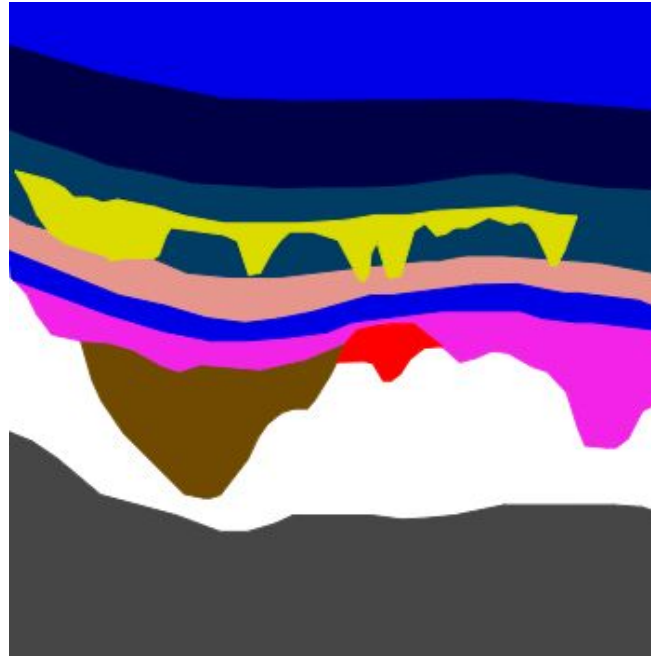
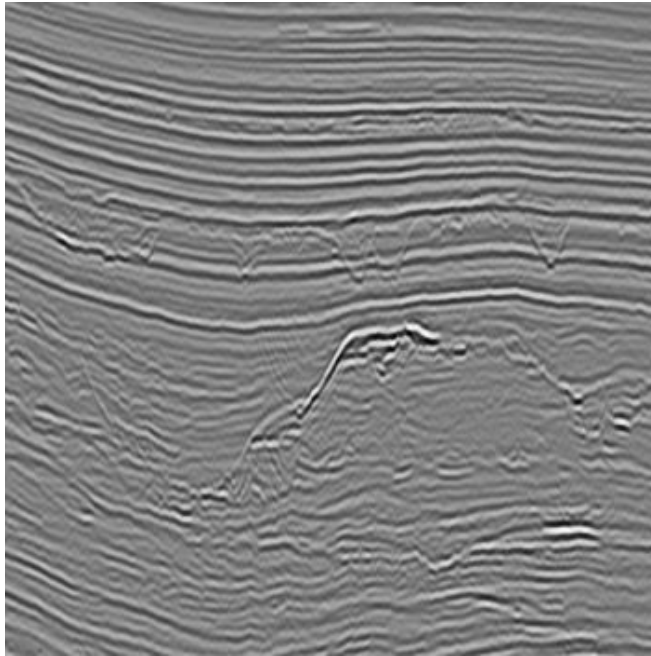


**Labelling and embedding
knowledge**

labelling bounding boxes

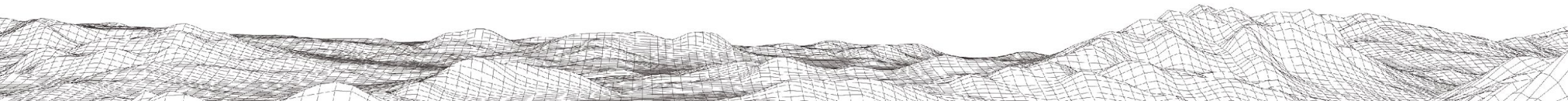
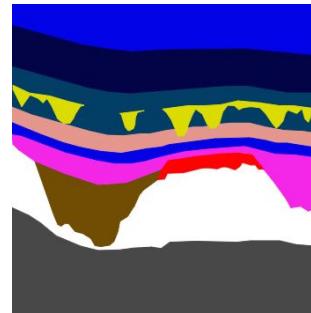
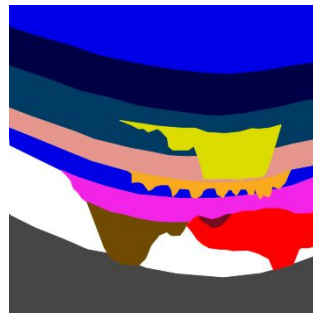
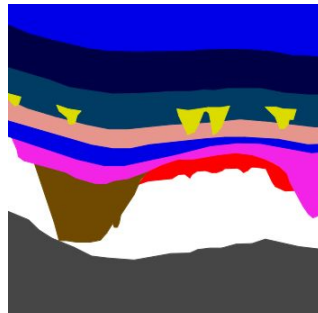
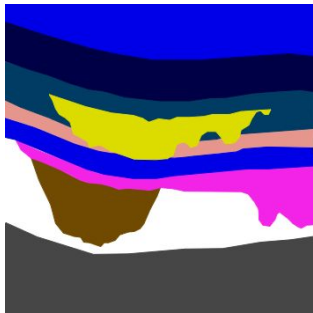


The changing role of the subsurface expert



Labelling and embedding knowledge

labelling seismic stratigraphic/
geomorphological units



Continuous
Property
Logs

Seismic Scale
Property Cubes

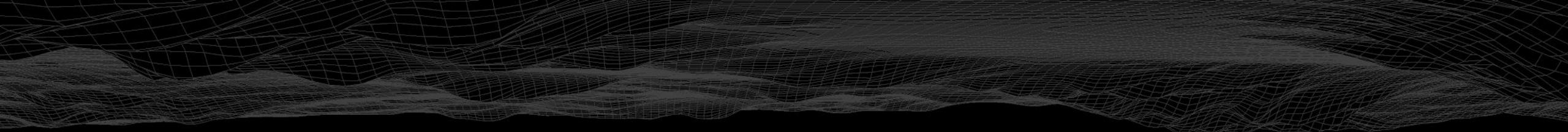
Interpreted
Seismic

MC

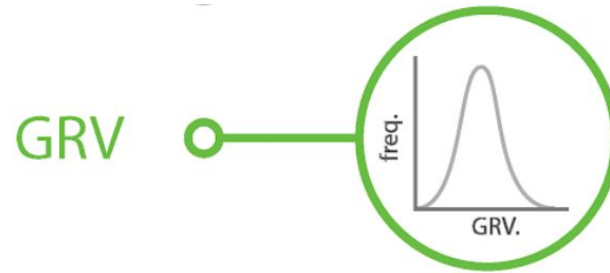
Probabilistic
Volumetrics

Monte
Carlo
Simulation

Flow
Simulation
Models

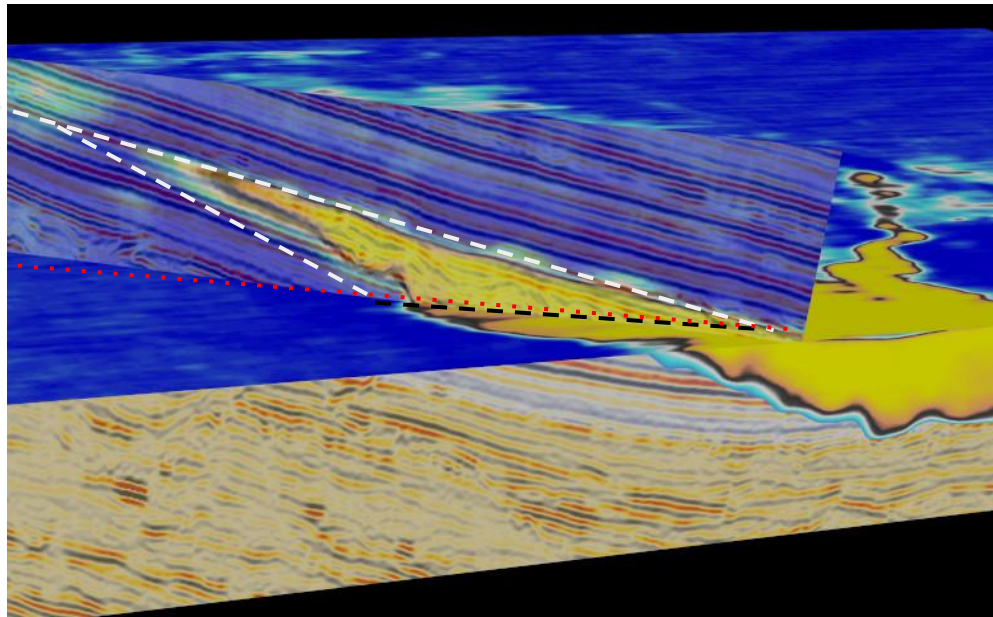


Determining model uncertainty in deep learning

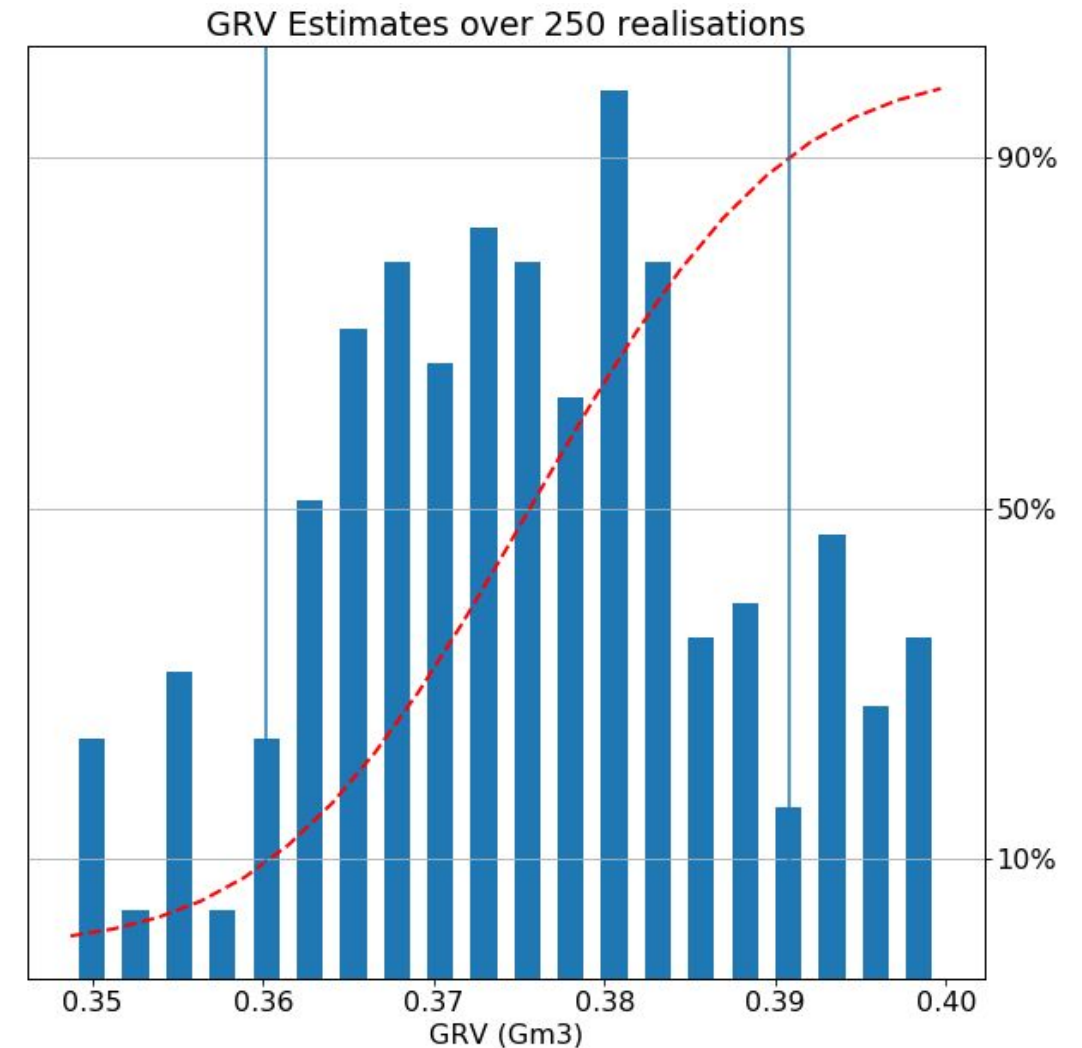


Deep Learning ASI with
Uncertainty

- MC dropout
- Bayesian Networks
- Variational Models
- Deep Probabilistic Models



(yellow) average geobody of potential stratigraphic trap



HCIIP

=

GRV

*

N/G

*

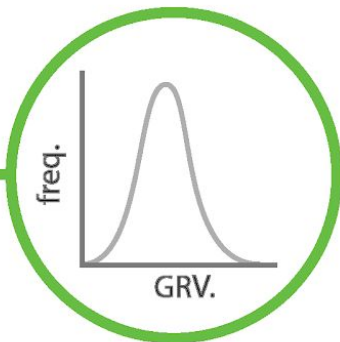
POR

*

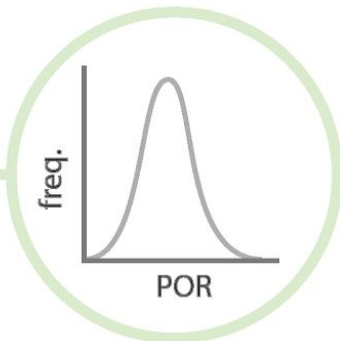
SHC

/

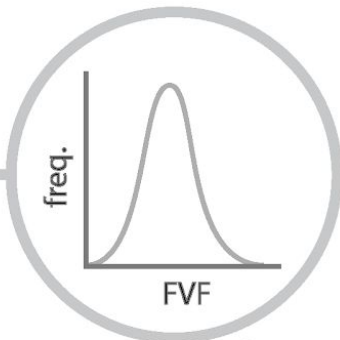
FVF



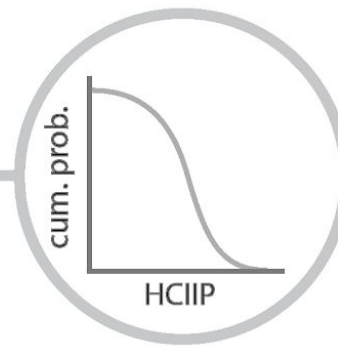
Deep Learning ASI with Uncertainty



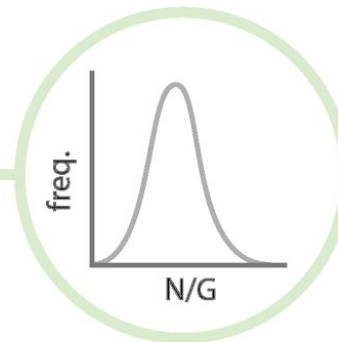
ML inversion and/or contextual queries on ML derived POR logs



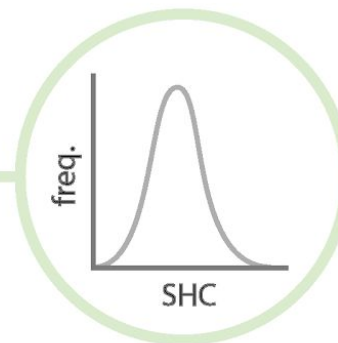
Contextual queries on analogous field data



Monte Carlo simulation based on below distributions

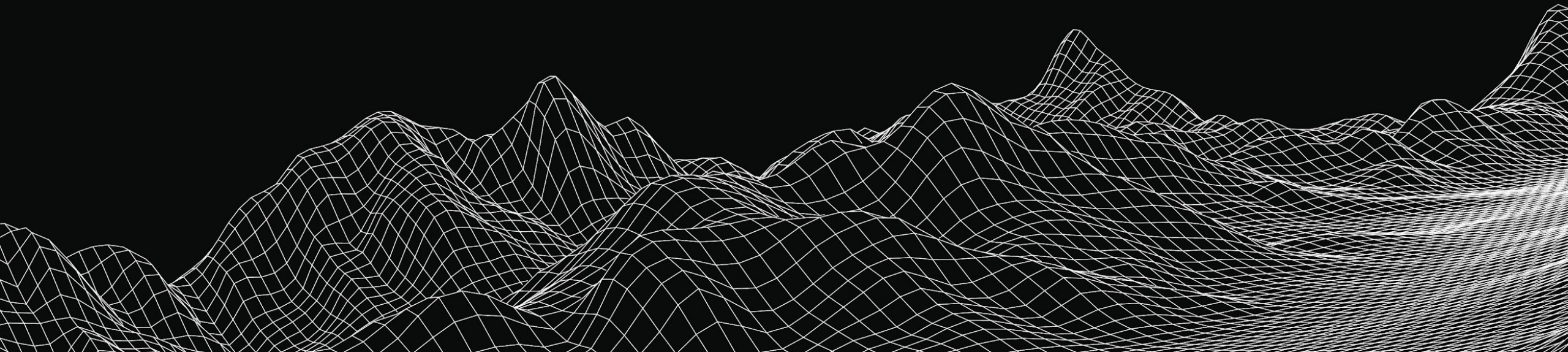


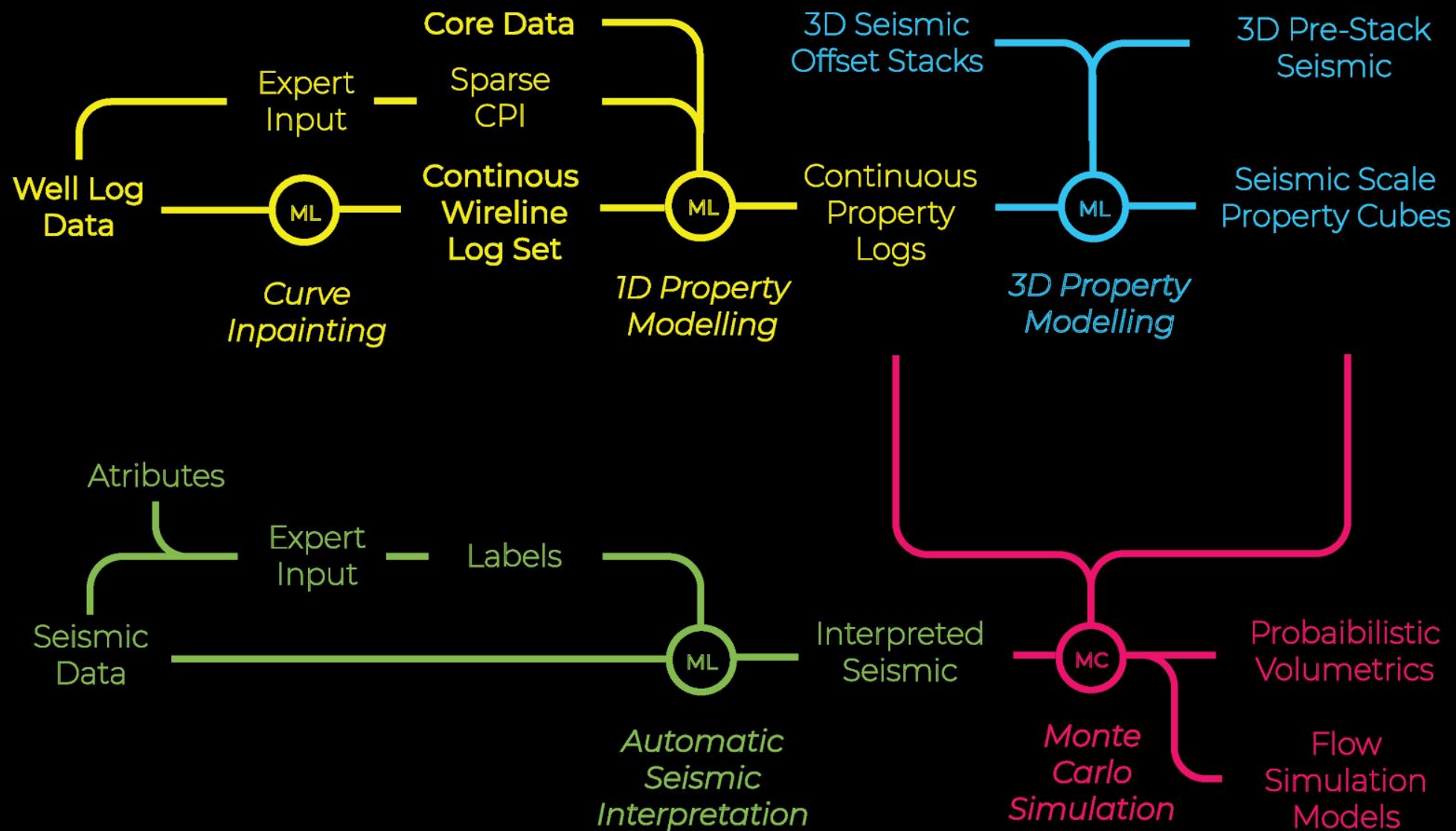
ML inversion and/or contextual queries on ML derived N/G logs



ML inversion and/or contextual queries on ML derived SHC logs

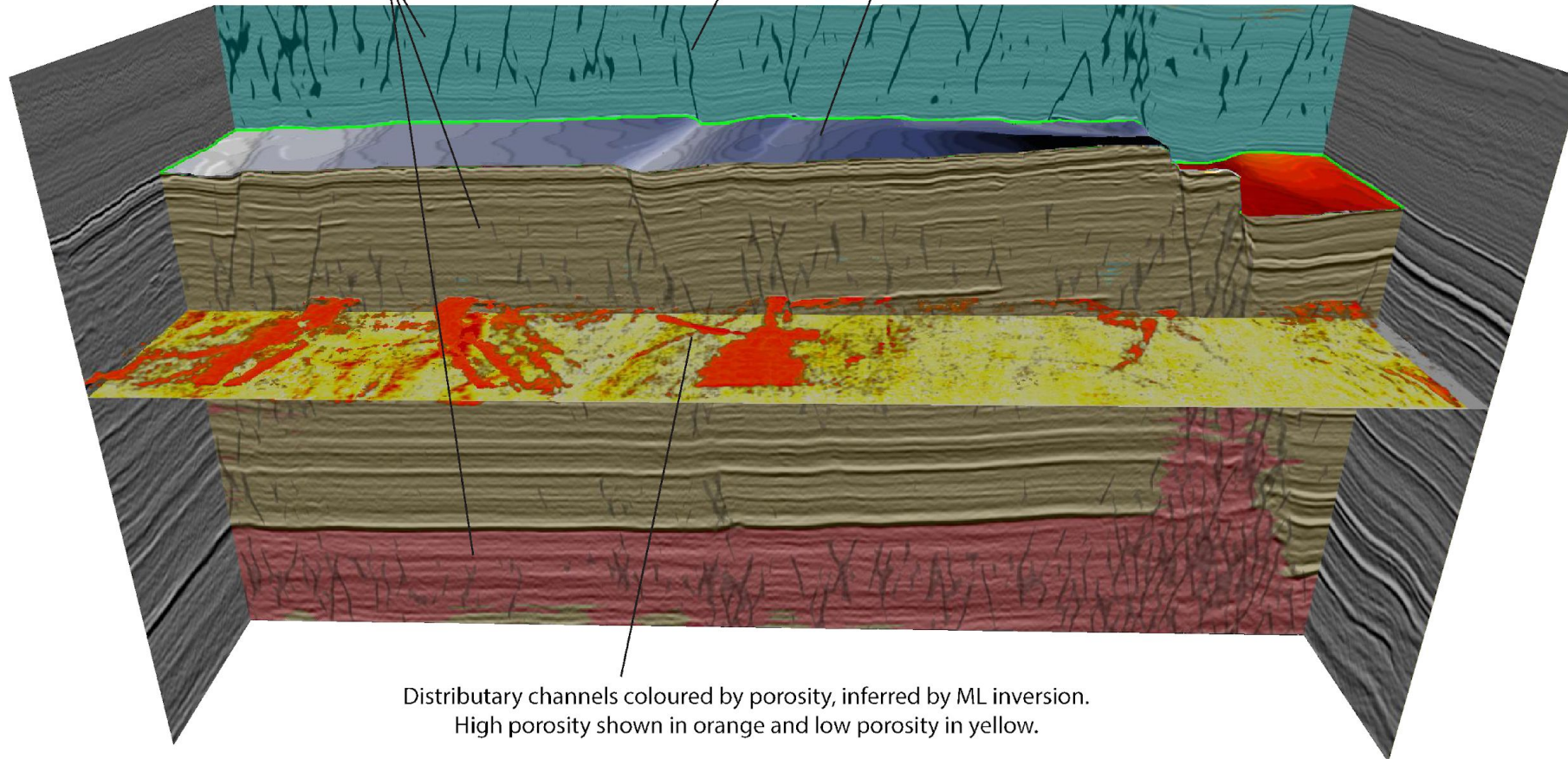
AI is Changing E&P Decisions





Realizing the potential

Stratigraphic units inferred by ML model ML inferred fault Stratigraphic horizon extracted at boundary between units inferred by ML model



3D Geomodels

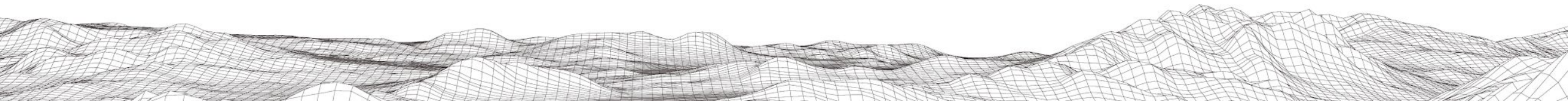
all the components of 3D geomodels can be derived efficiently with ML methods

- Faults
- Stratigraphy
- Rock & fluid properties

Data-Driven Decisions

Data Platform

Data Analytics



https://earthnet.ai/earthnet/ x https://earthnet.ai/earthnet/ x Earth Science Analytics - | x

Secure | https://earthnet.ai/earthnet/models/ Search Star Home Chat Mail Menu

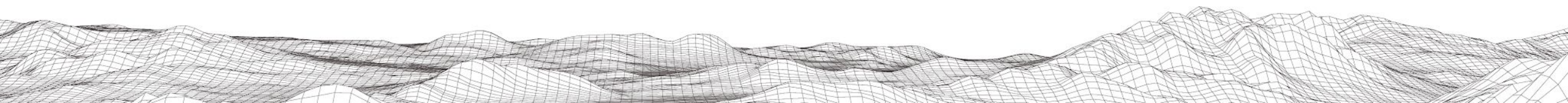
EarthNET Data Management Machine Learning Workers **Models** Select Theme barents Eirik

All Projects All Labels eirik.larsen All Wells Selected Show Hidden

Datetime	Project	Label	Label Type	Model Name	Method	Train Size	State	User	Train Score	Test Score	
9/7/2018, 11:17:52 PM	barents	POR	POR	POR = RFR(DEN,DT,GR,RDEP,RMED,NEU,MD)	RFR	60 %	processing	eirik.larsen			View Logs
9/7/2018, 10:31:50 PM	barents	POR	POR	POR = RFR(DEN,DT,GR,RDEP,RMED,NEU,MD)	RFR	60 %	created	eirik.larsen	97.7 %	91.4 %	Review
9/7/2018, 10:26:22 PM	barents	POR	POR	POR = RFR(DEN,DT,GR,RDEP,RMED,NEU,MD)	RFR	60 %	created	eirik.larsen	97.4 %	91.0 %	Review
9/7/2018, 10:23:32 PM	barents	POR	POR	POR = GB(DEN,DT,GR,RDEP,RMED,NEU,MD)	GB	60 %	processing	eirik.larsen			View Logs
9/7/2018, 9:44:39 PM	barents	LITHesa	LITH	LITHesa = RFC(DEN,DT,GR,RDEP,RMED,NEU,MD)	RFC	60 %	created	eirik.larsen	76.3 %	73.1 %	Review

Data Provenance
Data Lineage

Reproducibility



Ask the Data

Alexa.

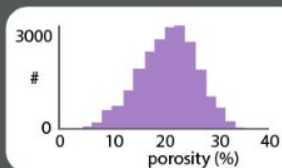
Can you show me the porosity distribution;

- for all the wells in Quad A
- for Formation B
- for the fluvial channels only
- using inferred data

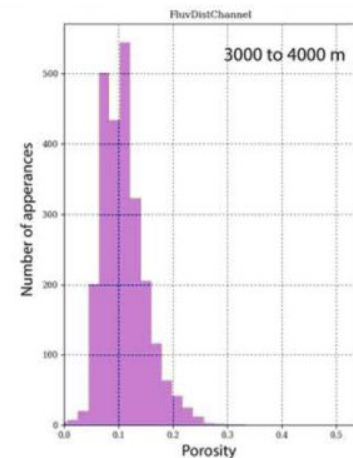
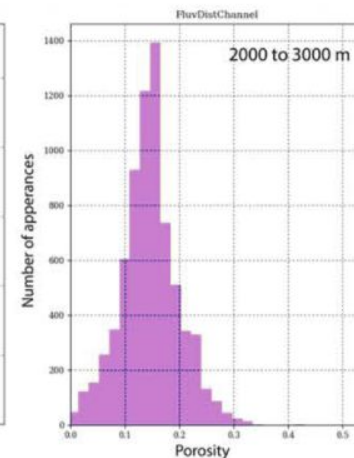
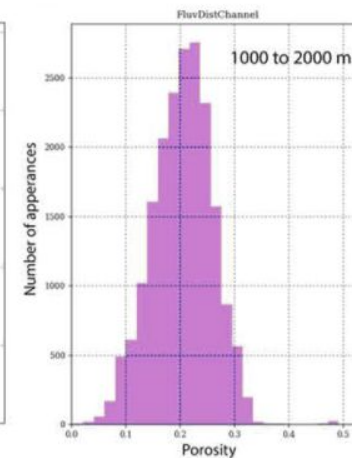
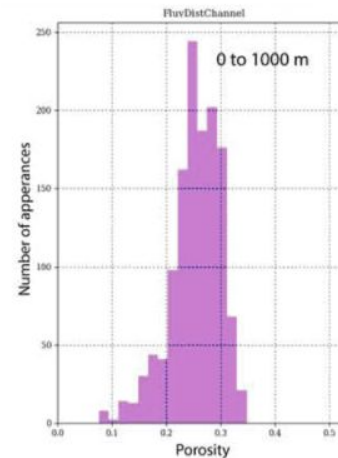
Do you want to specify a depth range?

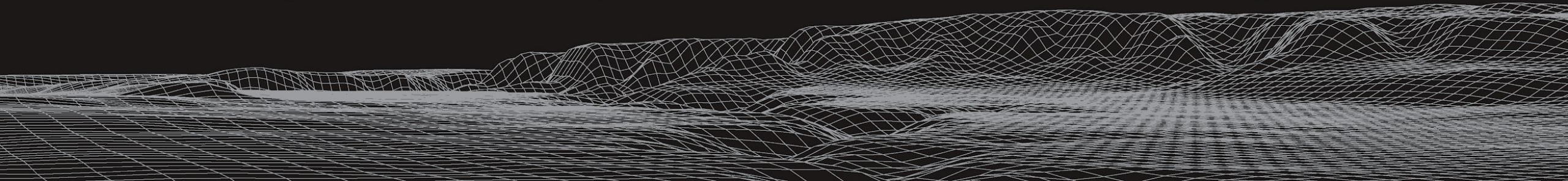
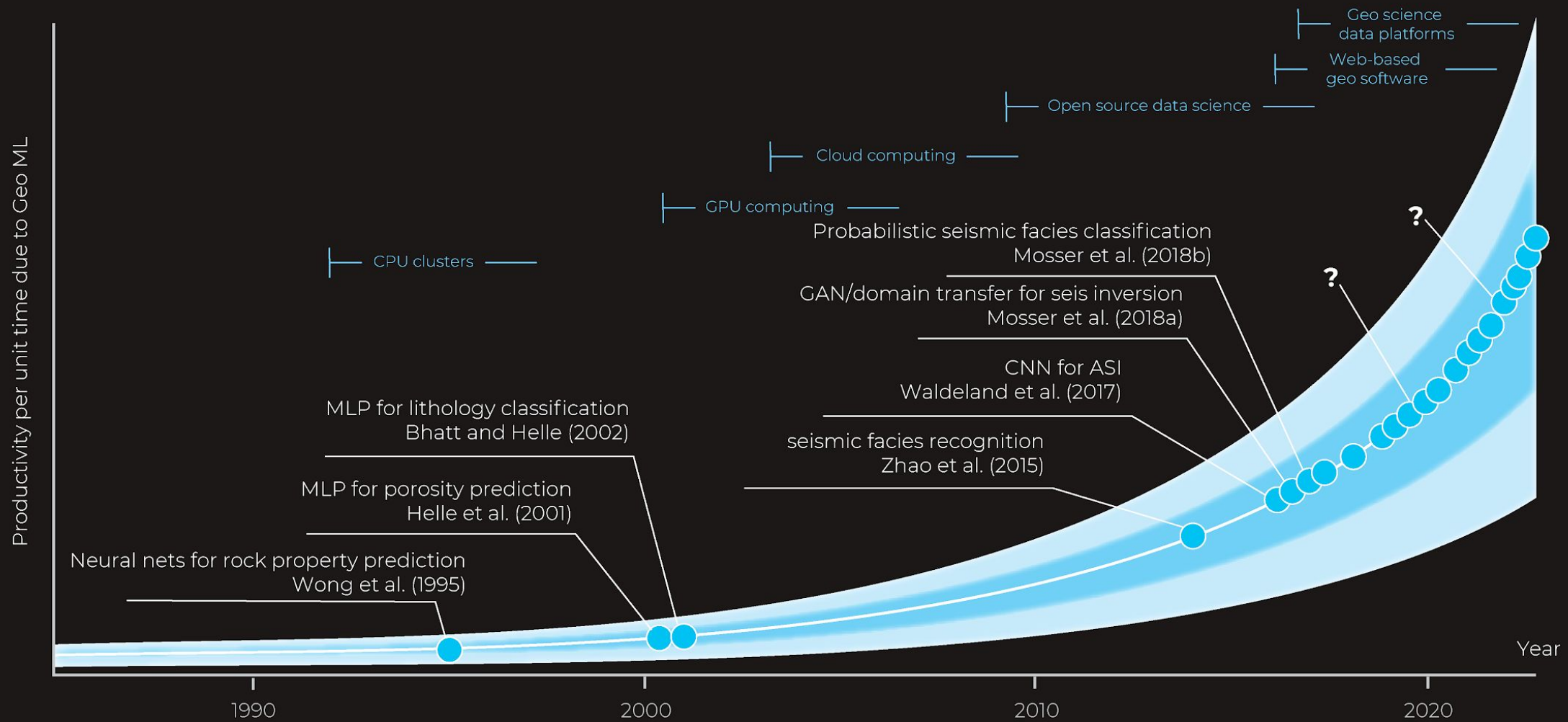
Yes. Between 1000 and 2000 metres below sea level please

Here you go



Thanks! Let's use this for the volumetrics







twitter: @earth_analytics

web: earthanalytics.ai

