HALLIBURTON
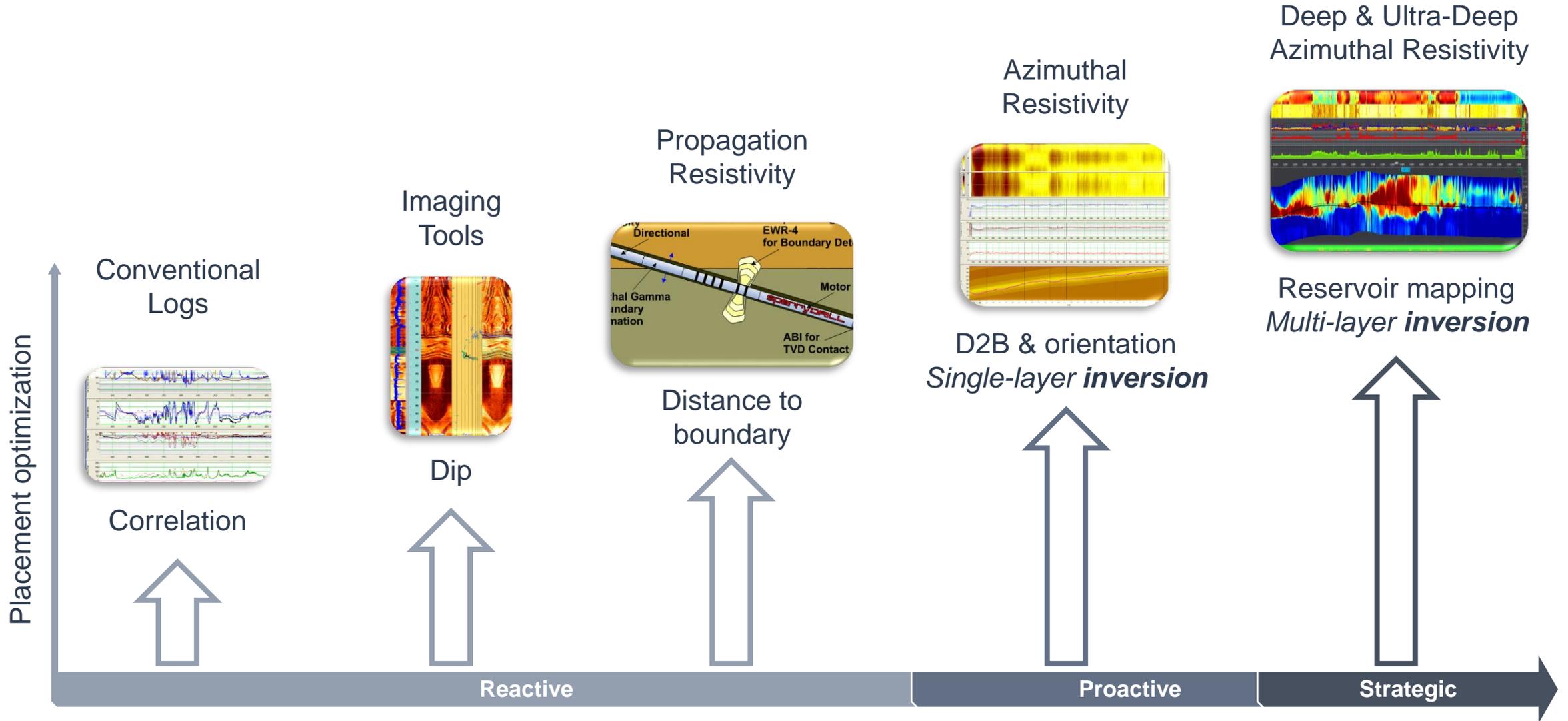
EarthStar® 3DX

The industry's first horizontal lookahead technology

Arthur Walmsley
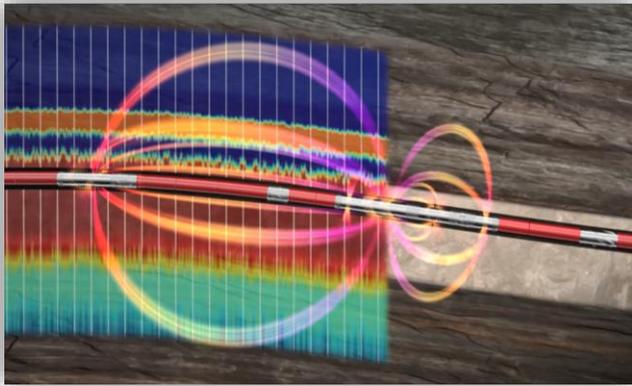
A Brief History Of Geosteering

Deep & Ultra-Deep
Azimuthal Resistivity

Azimuthal
Resistivity

Propagation
Resistivity

Imaging
Tools

Conventional
Logs

Reservoir mapping
Multi-layer **inversion**

D2B & orientation
Single-layer **inversion**

Distance to
boundary

Dip

Correlation

Placement optimization

Reactive   Proactive   Strategic

EM Geosteering Technology

StrataStar®
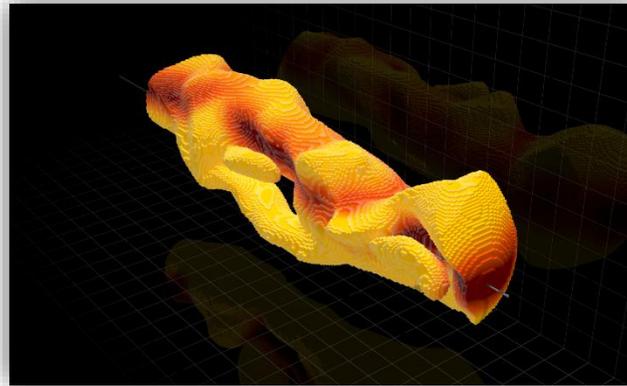Deep Azimuthal Resistivity Service

Precise well placement from detailed layer mapping

- INCREASE NET TO GROSS IN THIN TARGETS
- AVOID WATER ZONE
- ACCURATELY CHARACTERIZE FLUIDS

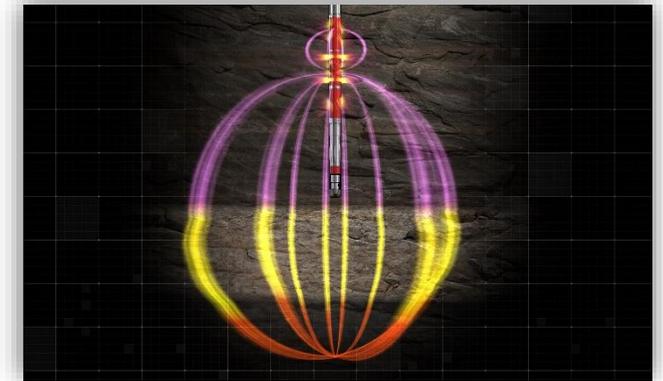## EarthStar® 3D
Ultra-Deep Resistivity Service

Geosteer and map reservoir at unprecedented scale

- INCREASE NET TO GROSS IN LARGE TARGETS
- VIEW RESERVOIR IN ALL DIRECTIONS
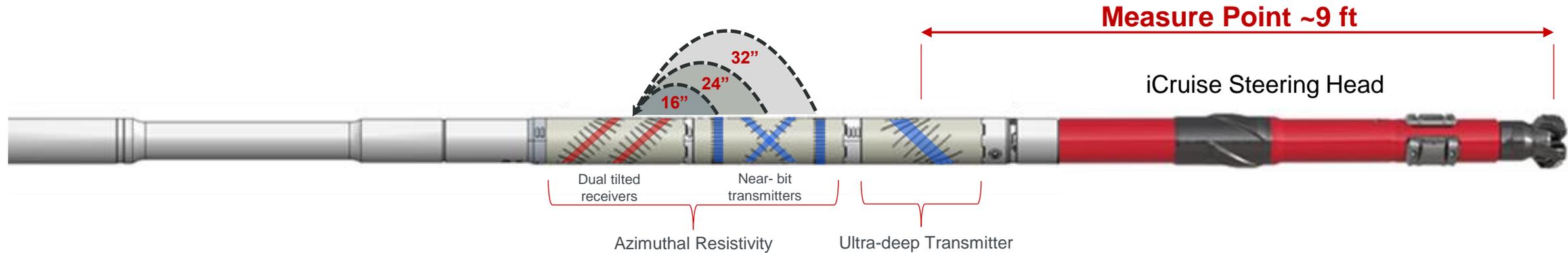- MAPP BYPASS PAY

BrightStar®
Look-ahead Resistivity Service

Detect formation and fluid changes ahead of the bit

- CASING POINT PICK
- CORING POINT PICK
- ANTICIPATE HAZARDOUS FORMATIONS

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BrightStar® 1D Vertical Look-Ahead Resistivity

Measure Point ~9 ft

32"
24"
16"

iCruise Steering Head

Dual tilted receivers

Near- bit transmitters

Azimuthal Resistivity
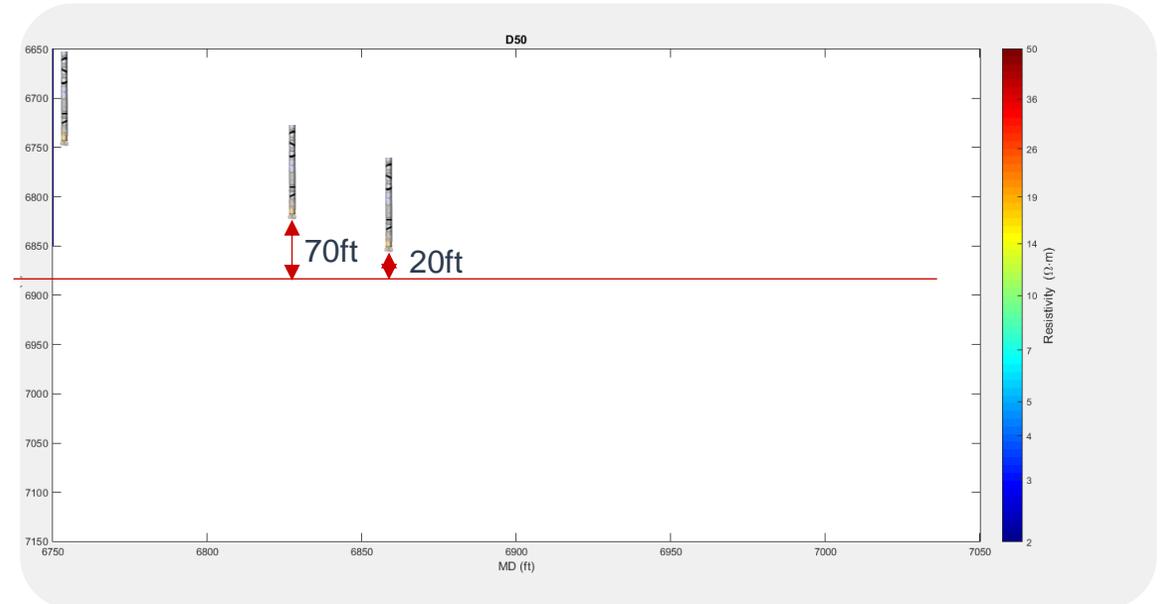
Ultra-deep Transmitter

FEATURES

- Up to 100ft mapping ahead at low angle (<40deg)
- Near-bit compensated resistivity
- Formation anisotropy at any angle

BENEFITS
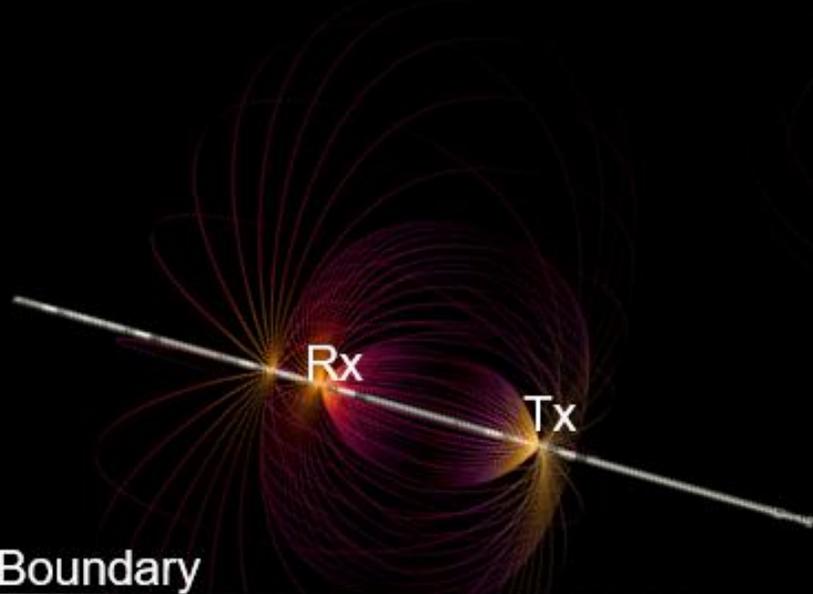
- Simplify BHA
- Industries shortest sensor measure point
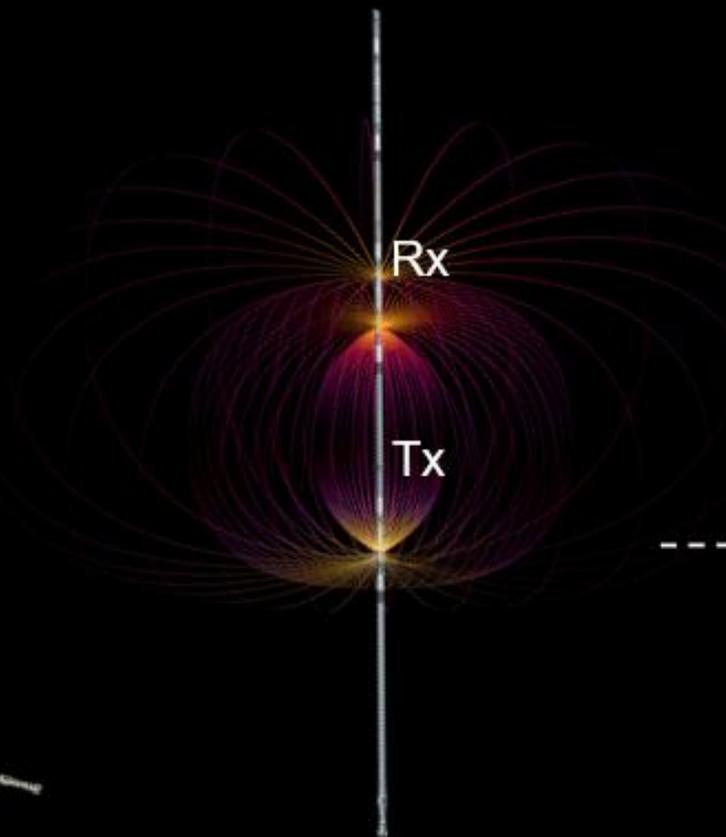- Reduce risk and operating time for casing point and reservoir pick up

70ft   20ft

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The First Look-Ahead Systems

EarthStar Service Look-around

BrightStar Service Lookahead

Known formation EM property

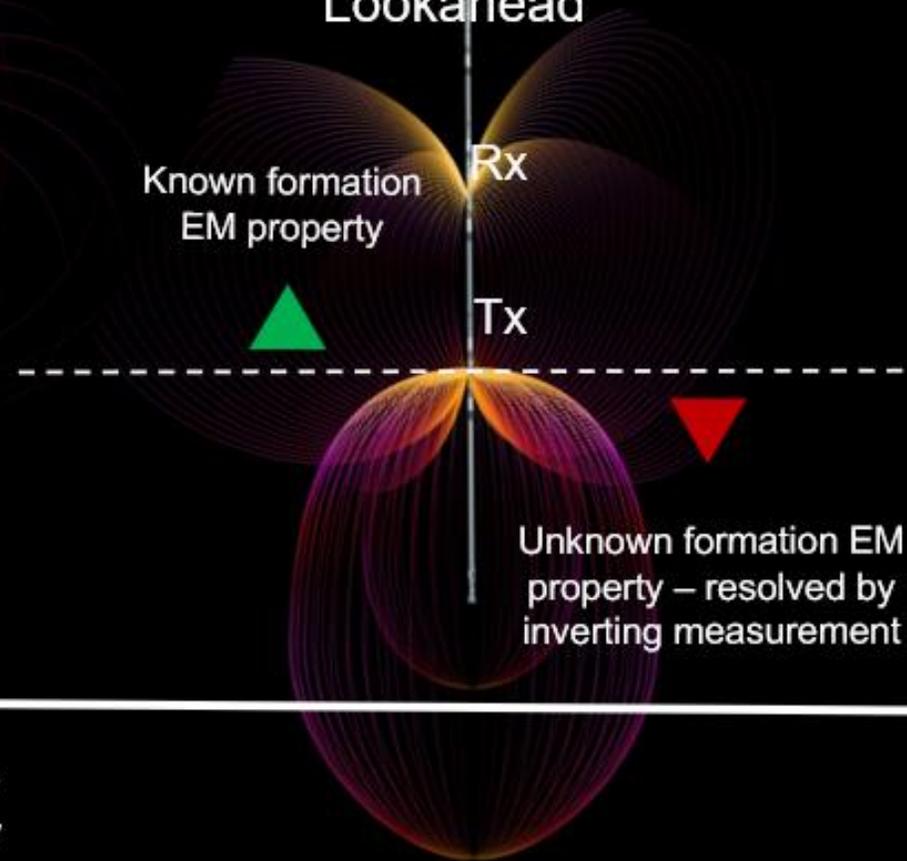Unknown formation EM property – resolved by inverting measurement

Target Boundary

EarthStar Look-around for Geostopping

Look-around unable to detect boundary at low inclinations

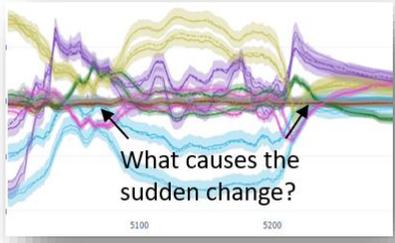**HALLIBURTON**

Near-Vertical Lookahead Inversion Principle

Inversion Parameters		Look-Ahead
Upper Layers	Resistivity	Constrained
	Boundary	Constrained
	Anisotropy	Constrained
	Formation Dip	Constrained
Lower Layers	Resistivity	**Inverted**
	Boundary	**Inverted**
	Anisotropy	**Inverted**

Rh

SquareLog

Local inversion

Measured/fixed

Look-behind

Look-around

Look-ahead

Known

Unknown

Upper layers

Lower layers

1. Measures EM input to overall field
2. Calculate the contribution of behind and around
3. Invert ahead contribution of EM signal

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Oilfield Data Acquisition Scales

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General Inversion Principle From 1D To 3D

Downhole measurements

Complex data

What causes the sudden change?

Geological models

Forward modelling

Observed Data

→ **Measure of DIFFERENCE** ←

Calculated Data

Most likely geology

Statistical distribution of models

1D Drilling ❶❷❸❹...

2D Drilling

3D Drilling

8

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EarthStar® 3D Inversion Method

- 3D Octree grid using forward and inverse mesh decoupling
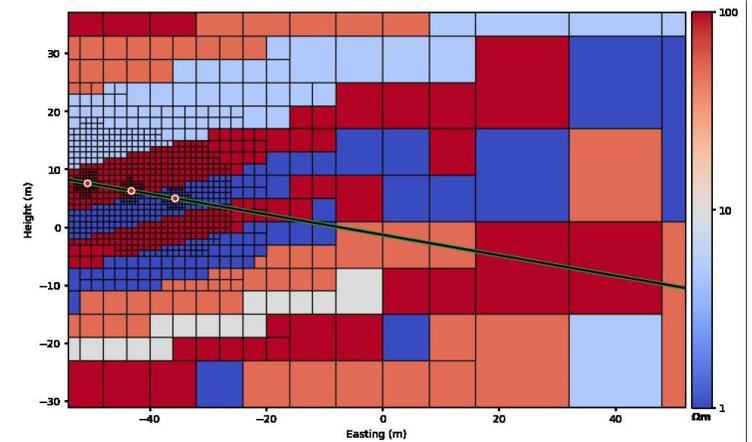
Inverse mesh for a section of the well
871,588 cells required to mesh 1km of well

Forward mesh for a single point
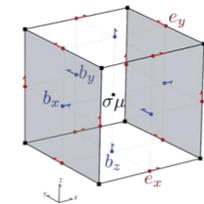Only 24,350 cells required

Multiple points forward mesh video
Overlapping with inverse mesh

Efficient FV forward solver that
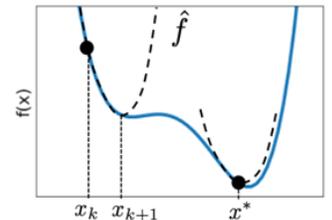solves millions of unknowns within minutes
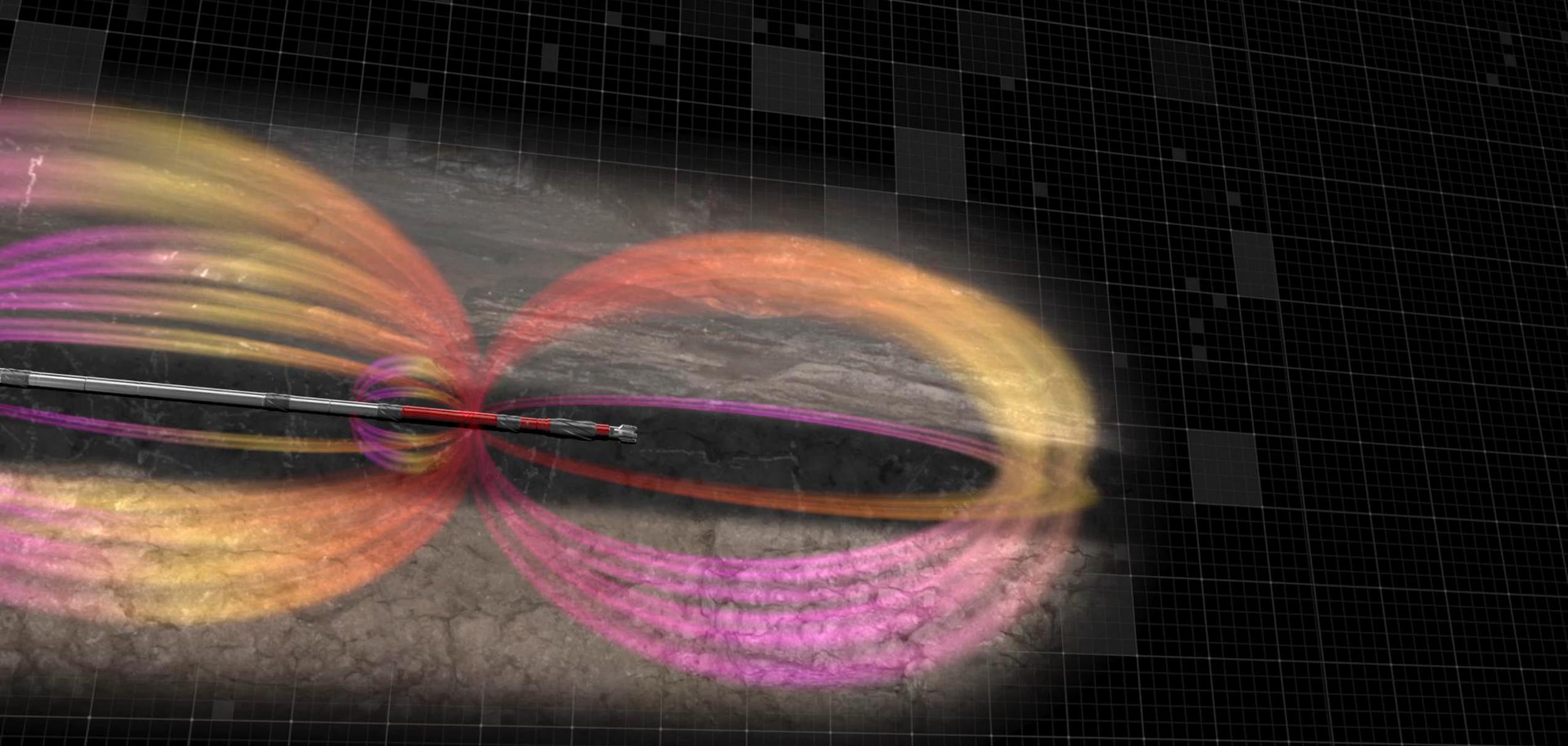
$$\vec{\nabla} \times \vec{E} + i\omega\vec{B} = \vec{0}$$

$$\vec{\nabla} \times \frac{1}{\mu}\vec{B} - \sigma\vec{E} = \vec{J}_s$$

Efficient deterministic GN inversion solver that
matches the speed of wired pipe data rates –
2~5 mins / point

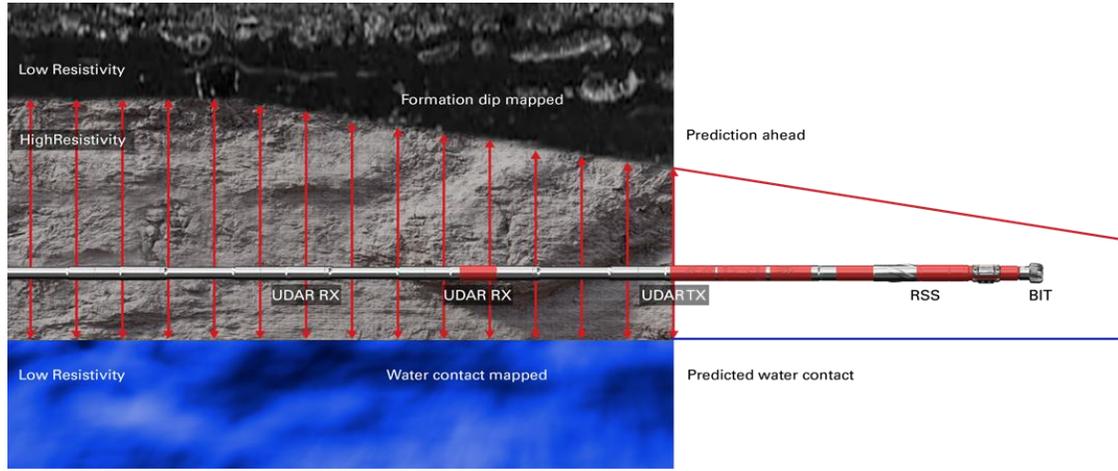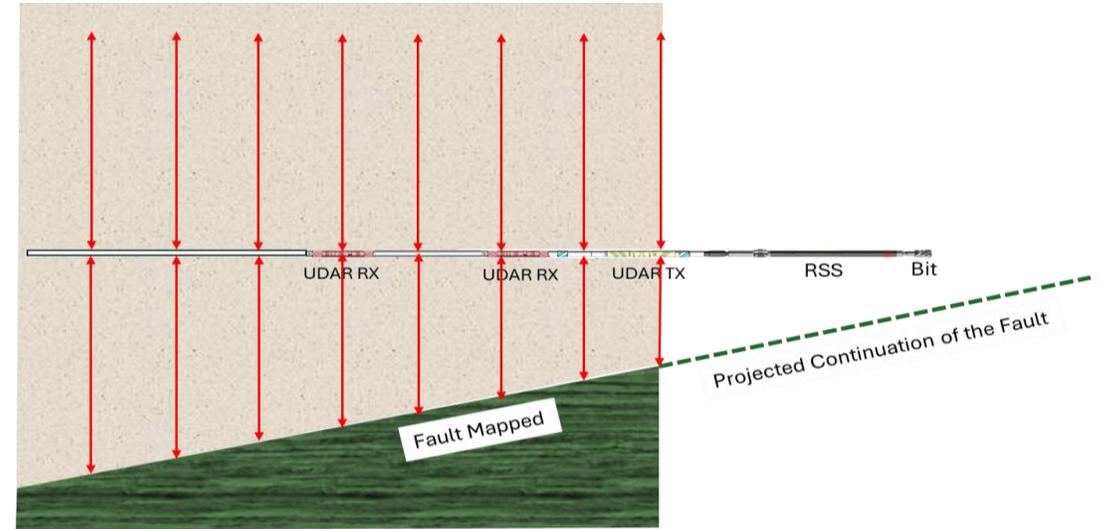$$\phi(m) = \frac{1}{2}\|\mathcal{F}[m] - d^{obs}\|^2 + \frac{\beta}{2}\|m\|^2$$

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Early detection of channel discontinuity enables faster decisions to adjust well path.

Current Status Of UDAR Geosteering – Look Around

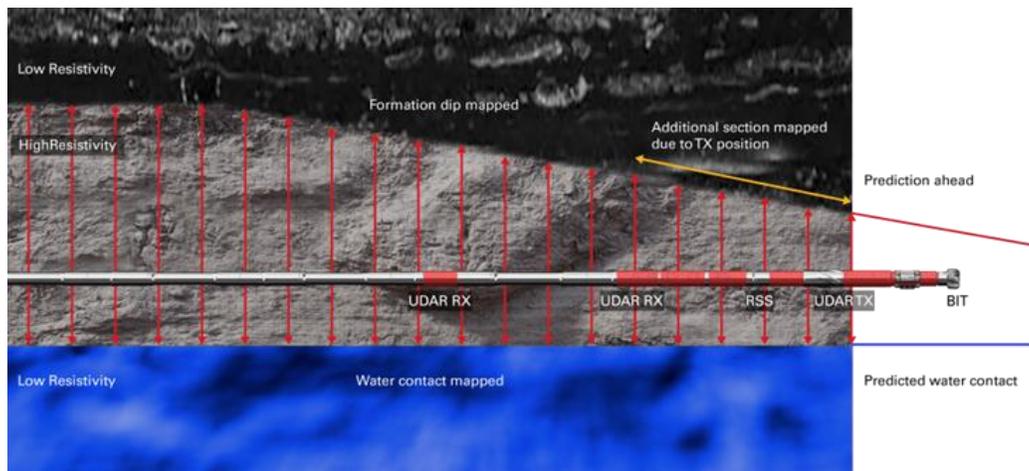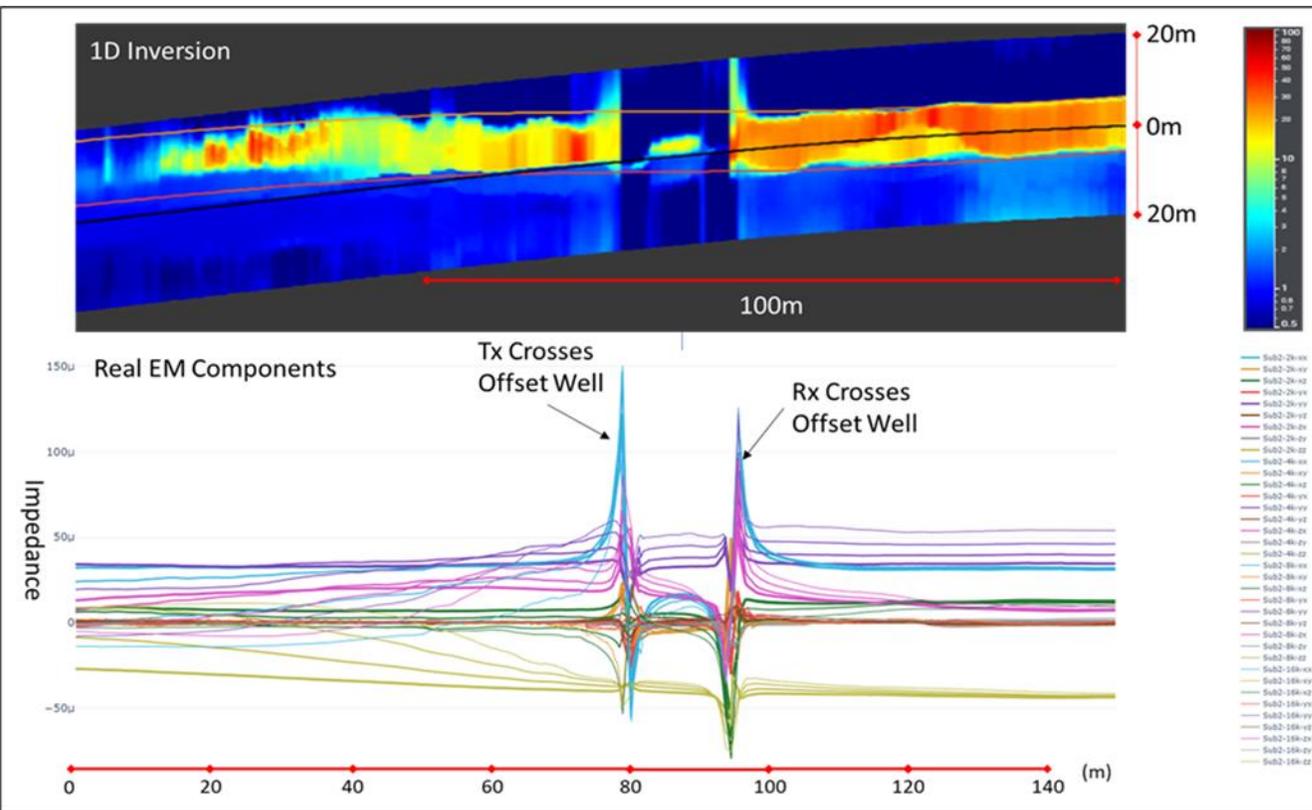## Standard UDAR configuration

EarthStar X Near Bit UDAR configuration

3D Inversion Plan View

Project Ahead Approach

- Measure Point Critical
- Cannot account for Variability ahead
- No Sensitivity Ahead

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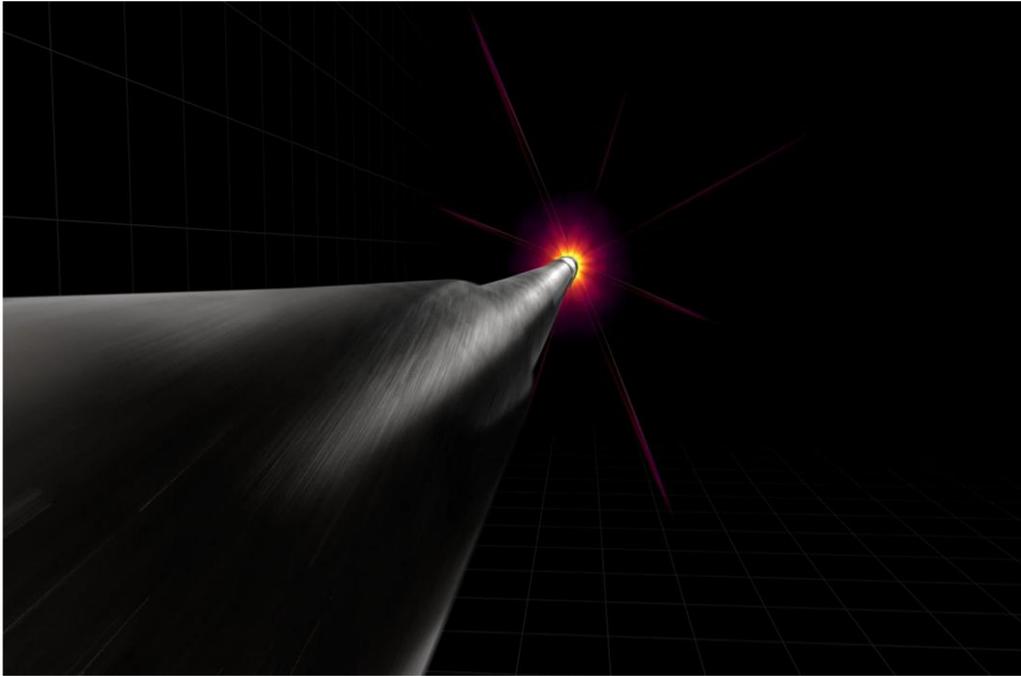
Understanding EM Sensitivity Ahead Of Transmitter

- Scenario: the crossing offset well while drilling lateral

- The metal from an offset well can influences EM components ahead of the transmitter

- This complexity makes it challenging for local 1D or 2D inversion technologies to accurately measure the response
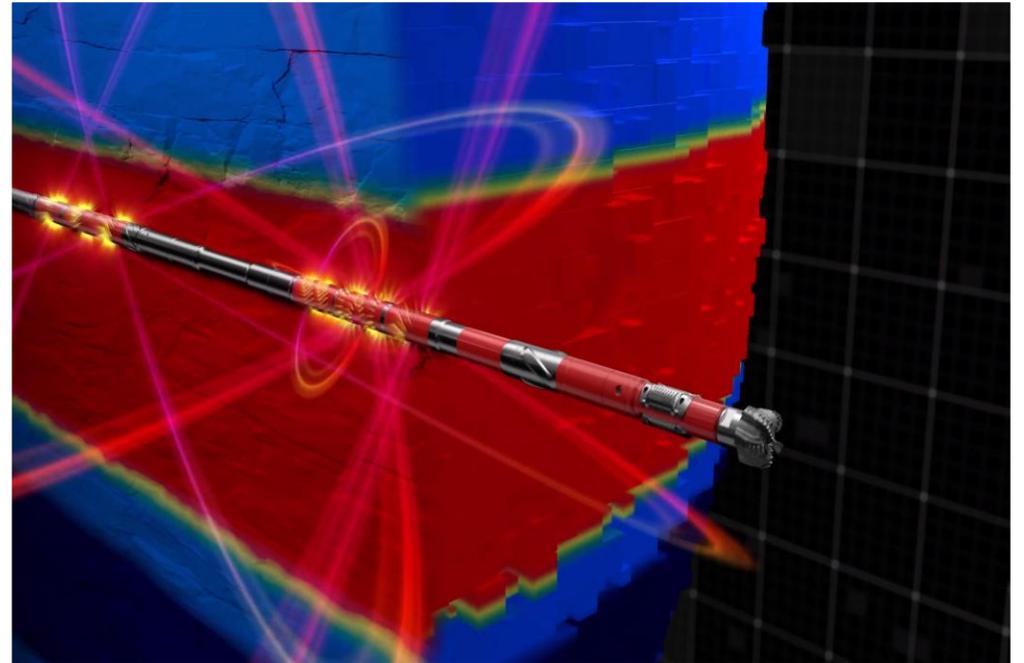
Clegg N.; Duriez A.; Kiselev V.; Sinha S.; Parker T.; Jakobsen F.; Jakobsen E.; Marchant D.; Schwarzbach C.; "Detection of Offset Wells Ahead of and Around an LWD Ultra-Deep Electromagnetic Tool." SPWLA 62nd Annual Logging Symposium, Virtual Event, May 2021.
doi: https://doi.org/10.30632/SPWLA-2021-0039

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EarthStar® 3DX: Combining Technologies

Industry's only continuous 3D
real-time inversion

Closest UDAR sensor to bit distance

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EarthStar® 3DX

Synthetic Studies

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EarthStar® 3DX Demonstration

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3DX Synthetic Modeling: Sand to Water Vs. Sand to Shale
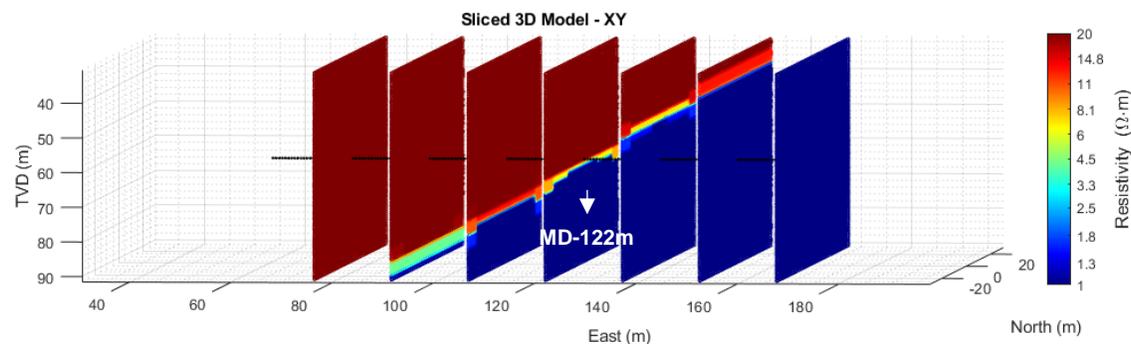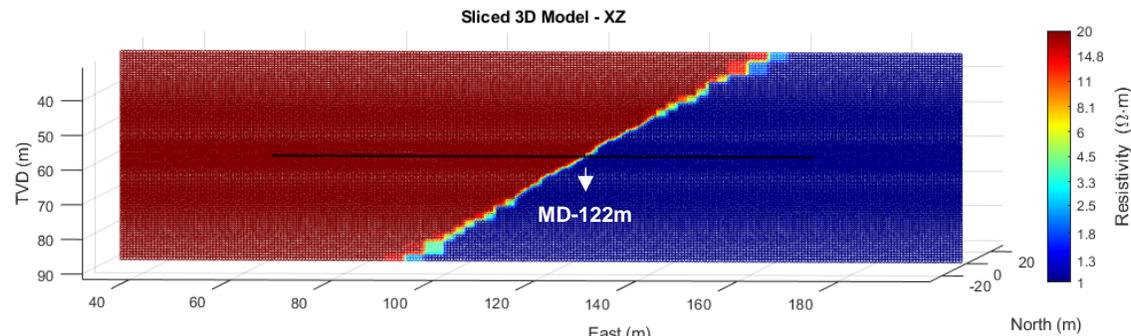
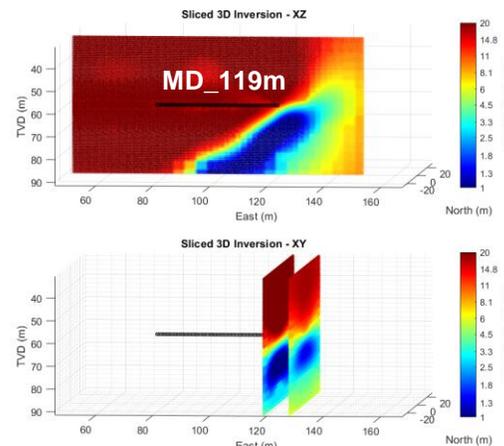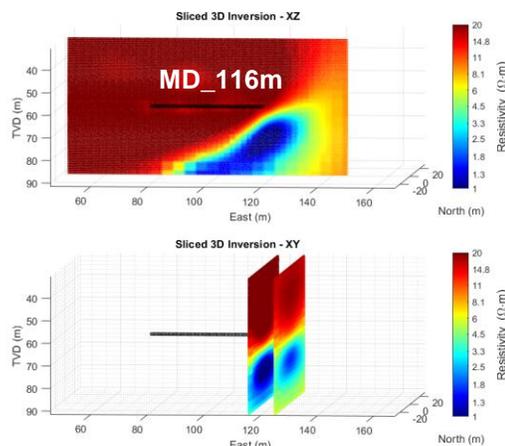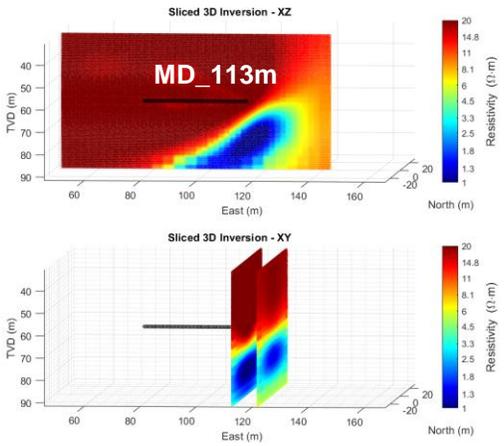**Benchmark model, homogeneous oil-bearing sand**

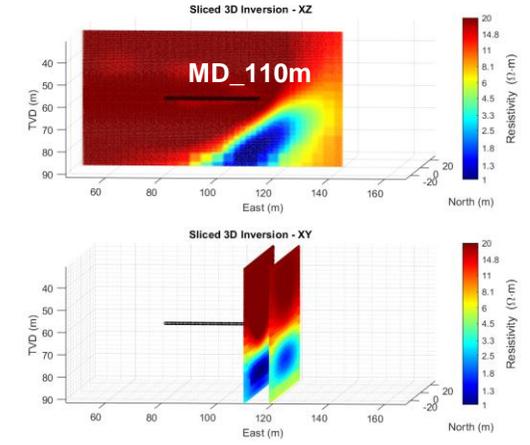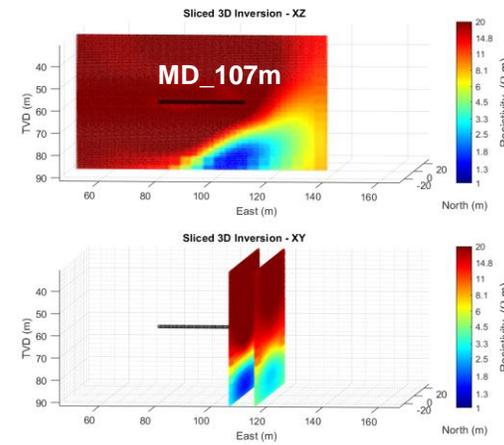Oil-bearing sand: Rh=20, Rv=20

Case 1, Oil sand to water

Oil-bearing sand:
Rh=20, Rv=20

Water:
Rh=1, Rv=1

Rv

Rh

Case 2, Oil sand to shale

Oil-bearing sand:
Rh=20, Rv=20

Shale:
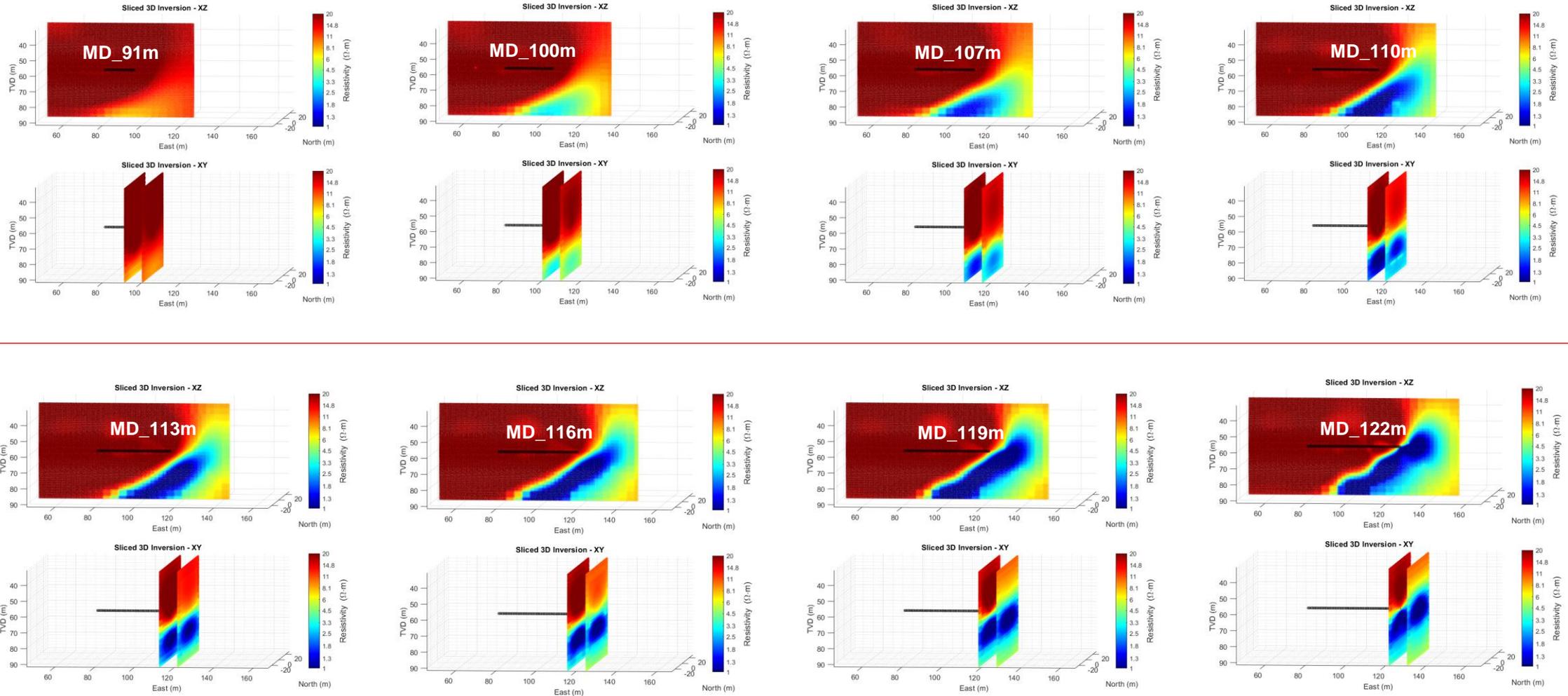Rh=1, Rv=5

MD-122m

Sliced 3D Model - XZ

MD-122m

Sliced 3D Model - XY

MD-122m

EarthStar® 3DX Synthetic Modelling: Sand to Shale

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EarthStar® 3DX Synthetic Modelling: Sand to Water

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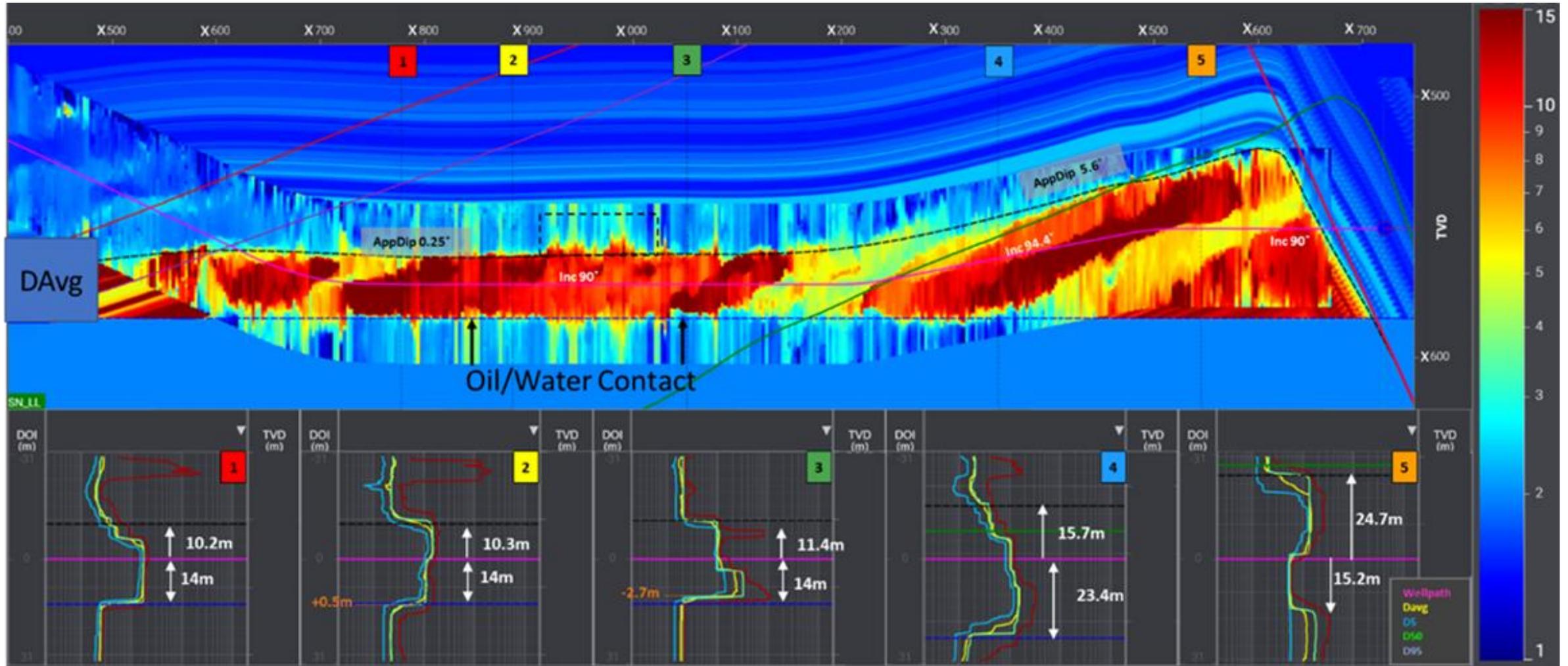# EarthStar® 3DX Historic Well Test

HALLIBURTON
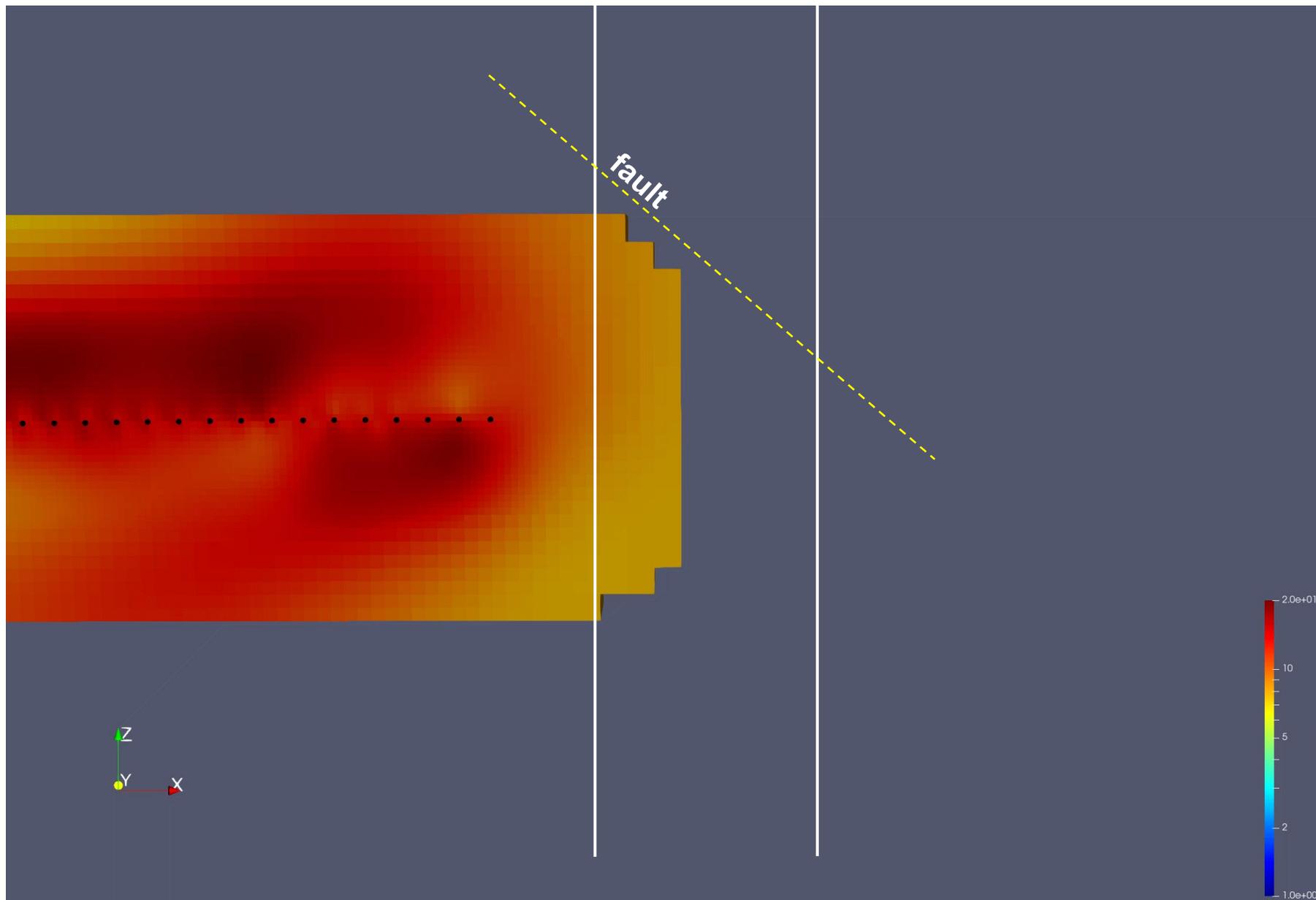
Complex Clastic Environment

Major Seismic Fault

Ma, H., Clegg, N., Walmsley, A., Suarez Arcano, N., Antonsen, F., Røsvik Jensen, K., McGill, A., 2025, UDAR Horizontal Look Ahead Mapping Technology Identifies Fault Ahead of the Bit. Paper presented at the SPWLA 66th Annual Logging Symposium, May 17–21, 2025. Paper Number: SPWLA-2025-0126. https://doi.org/10.30632/SPWLA-2025-0126.
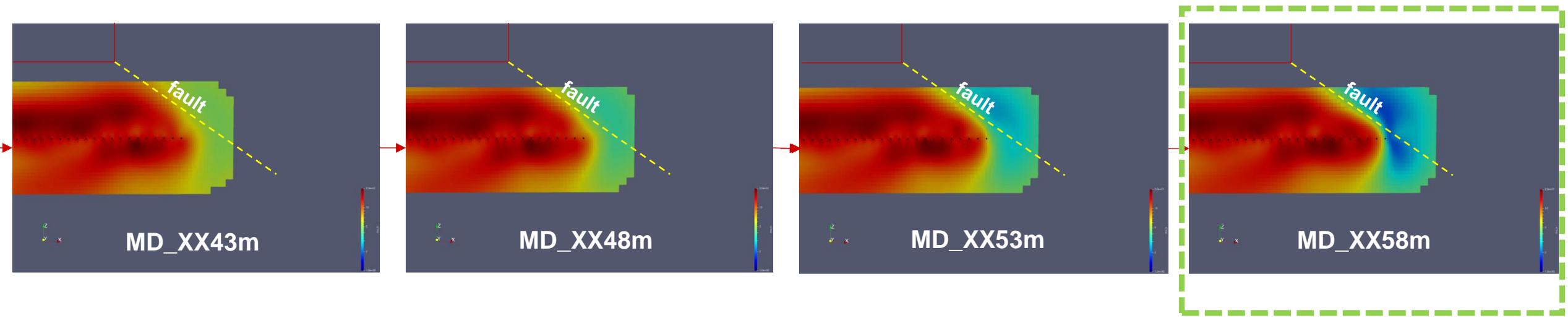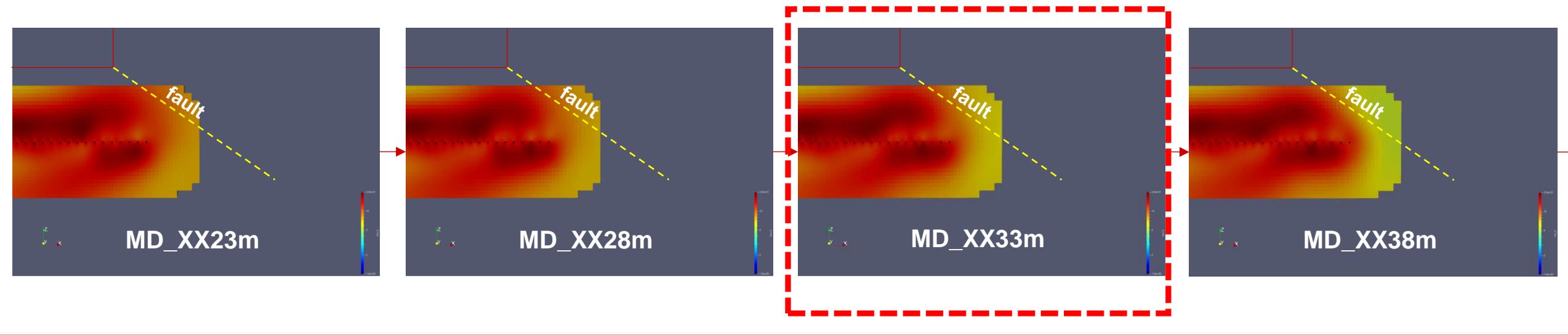
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EarthStar® 3DX Field Study: Geostop Prior to Terminating Fault

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EarthStar® 3DX Real-Time Fault Detection Ahead Of Bit

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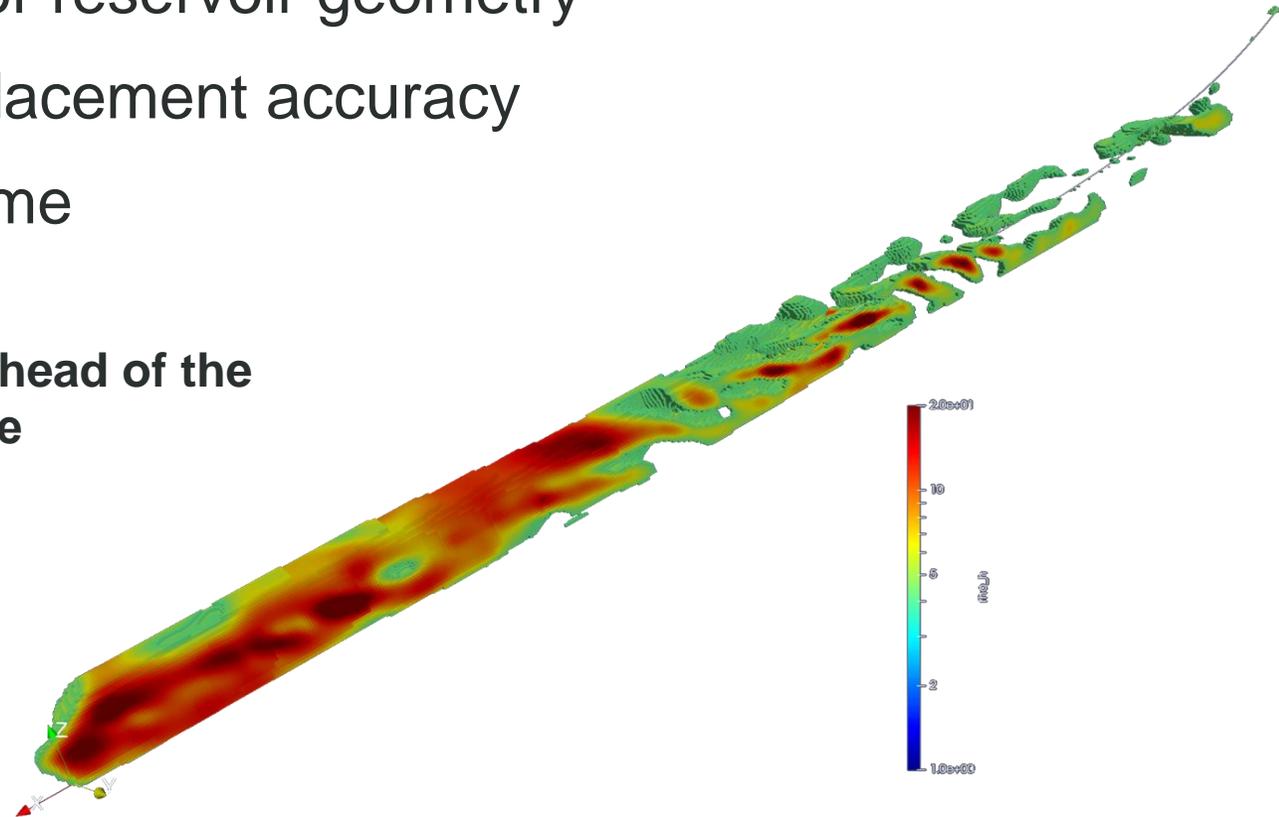# EarthStar® 3DX Real-Time Fault Identification (Rh)

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EarthStar® 3DX Summary

- Near-bit transmitter enables early detection of formation and fluid changes

- EM inversion resolves resistivity contrasts up to 50ft ahead of the bit

- No longer limited by well inclination or reservoir geometry

- Accelerates delivery and improves placement accuracy

- Transform drilling decisions in real-time

Based on the unique continuous 3D inversion ahead of the bit and Industry's shortest sensor to bit distance

- Inform well placement decisions faster
- Detect and avoid geohazards
- Couple with automation for improved steering

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THANK YOU

https://www.halliburton.com/en/products/earthstar-3dx-horizontal-look-ahead-3d-resistivity-service

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