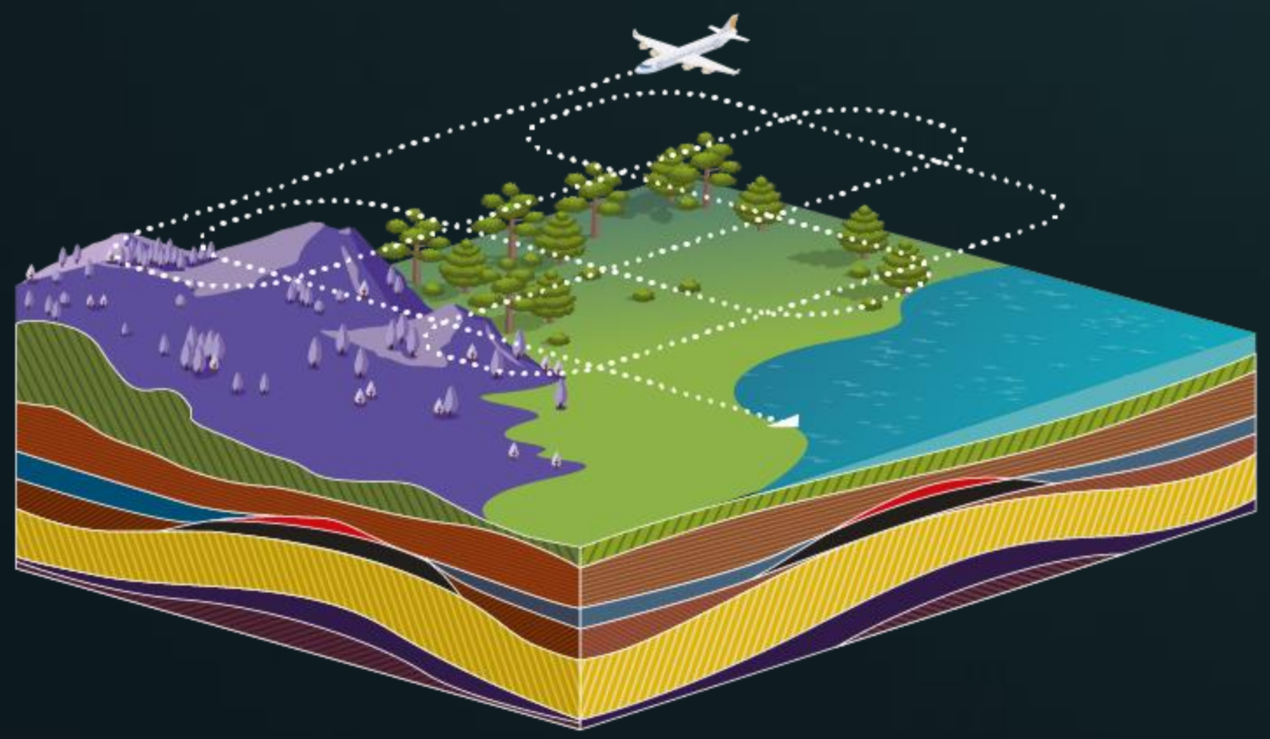
NXT

Energy Solutions

High Resolution Geophysical Survey Tool Applications in Hydrocarbon & Geothermal Exploration 2023

Executive Summary

Stress Field Detection (SFD®) is an airborne geophysical survey technology developed by NXT Energy Solutions Inc., headquartered in Calgary, Canada.



Public Company

- TSX: SFD
- OTC: NSFDF
- HDQTR: Calgary, Canada

Key Business Points

- Patented Technology
- Proven Success
- Repeat Clientele
- 10+ Years R&D
- Applicable to hydrocarbon & geothermal exploration

SFD® Projects Completed

- USA
- Canada
- Colombia
- Mexico
- Bolivia
- Argentina
- Belize
- Guatemala
- Nigeria
- Pakistan

NXT Clients

PEMEX, bp, NNPC, YPFB Corporación, YPFB Chaco S.A., PPL, ecopetrol, PENGROWTH, PCR, NEXSTAR ENERGY LTD., HOCOL, Pacific Exploration & Production, CPA Compañía Petrolera del Atlántico, BLACK GOOSE HOLDINGS INC, RESULT ENERGY INC., BlueParrot Energy Inc, crew energy inc., Encal Energy Ltd, Providence Energy Group, KEROGEN EXPLORATION LLC, BLACK SHALE RESOURCES INC., Renaissance Energy, MONTANA

The Premise

SFD® is a mesoscopic scale transducer that detects fine spatial variations in the gravitational potential energy (GPE)

"field coupling vs force interaction"

P. Silva, "A New Interpretation of the de Broglie Frequency?" *Physics Essays* 10 (1997)
S.C. Burd et al., "Quantum amplification of boson-mediated interactions", *Nat. Phys.* 17, 898–902 (2021)

GPE changes associated with fluid bearing discontinuities are characterized by horizontal stress reorientation, reduction of shear stress and a general minimization of the horizontal density gradient

"subsurface homogeneity"

S. Schmalholz et al., "Relationship between tectonic overpressure, deviatoric stress, driving force, isostasy and gravitational potential energy", *Geophysical J. Int.* 197, 680–696 (2014)

The identification of these discontinuities via the SFD® method has been correlated to the presence of conditions that are conducive for fluid entrapment or conditions such as plastic solids, shear zones, etc.

"Independent lead identification"

M. Belmonte et al., "Advancing YPFB's Hydrocarbon Exploration Programs in the Bolivian Sedimentary Basins using the leading-edge SFD® airborne geophysical survey method", *XII Bolivarian Symposium,* Bogota (2016).

J. A. Escalera, "Application of Stress Field Detection (SFD®) Technology for Identifying Areas of Hydrocarbon Potential in the Gulf of Mexico Region", *Next Generation Oil & Gas Summit LATAM*, Cartagena (2013)

Proven by Clients
Successful Oil & Gas Exploration

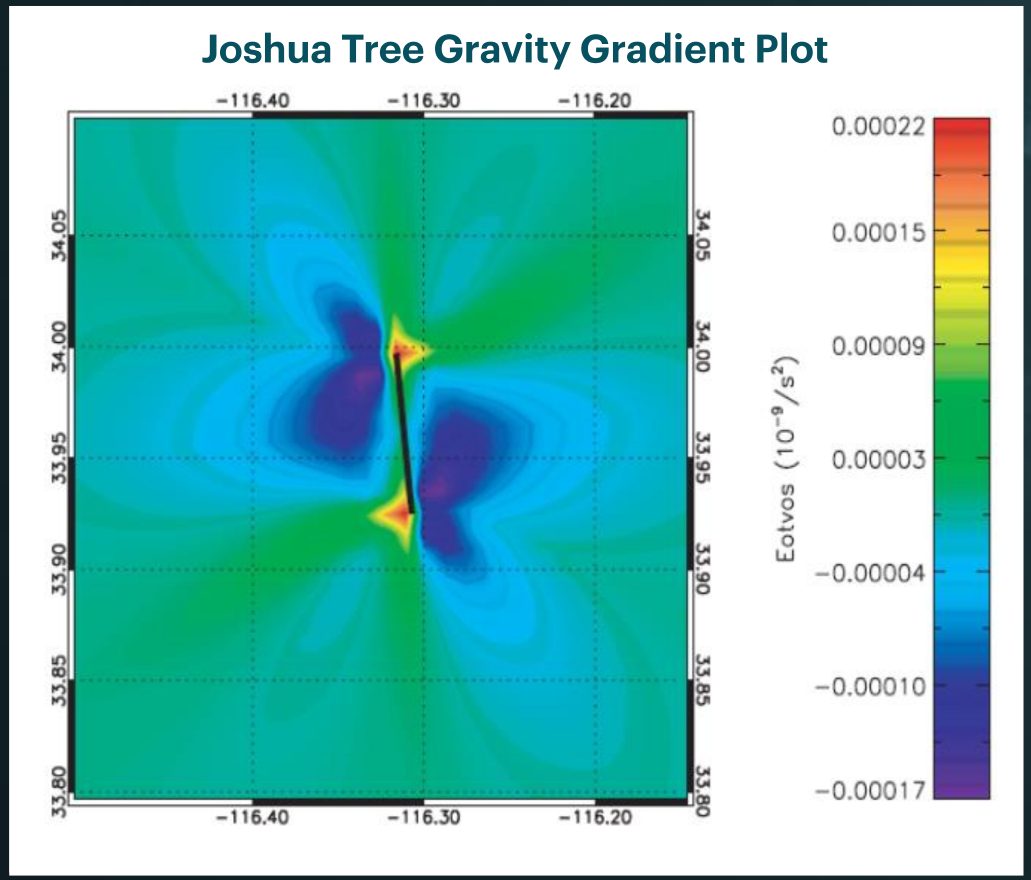
30 SFD® Recommendations Drilled to Date Internationally

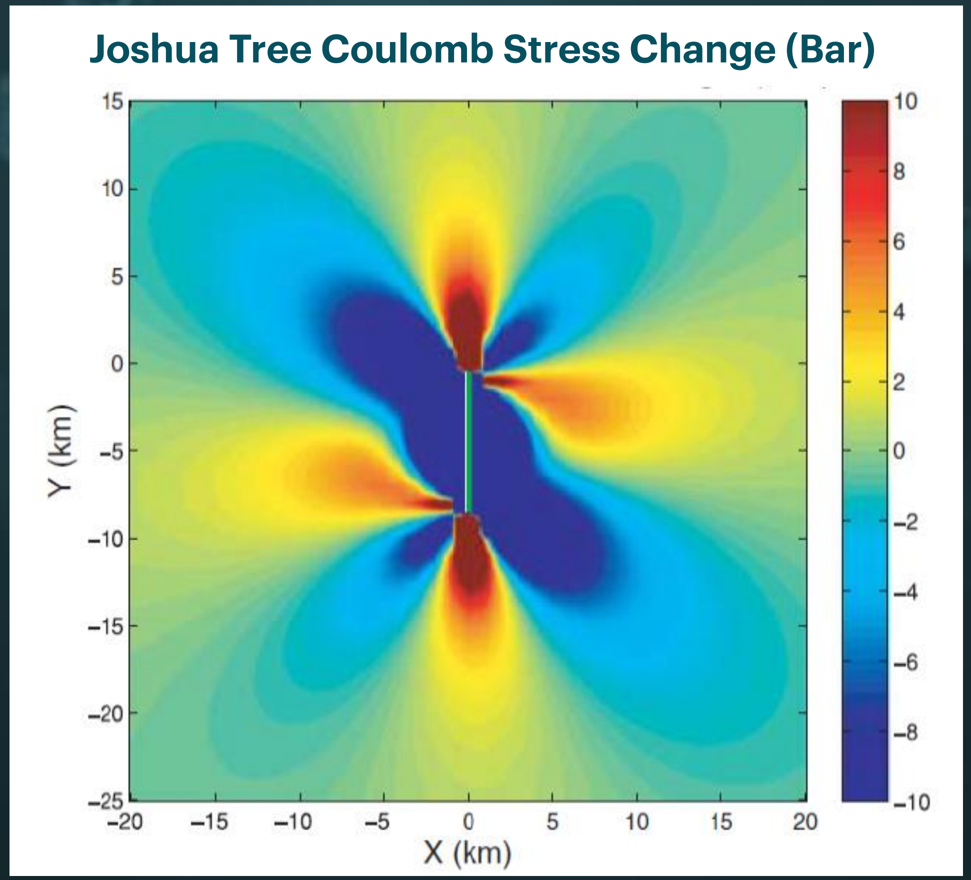
- **21** Commercial Discoveries
- **6** Dry Holes
- **3** Others

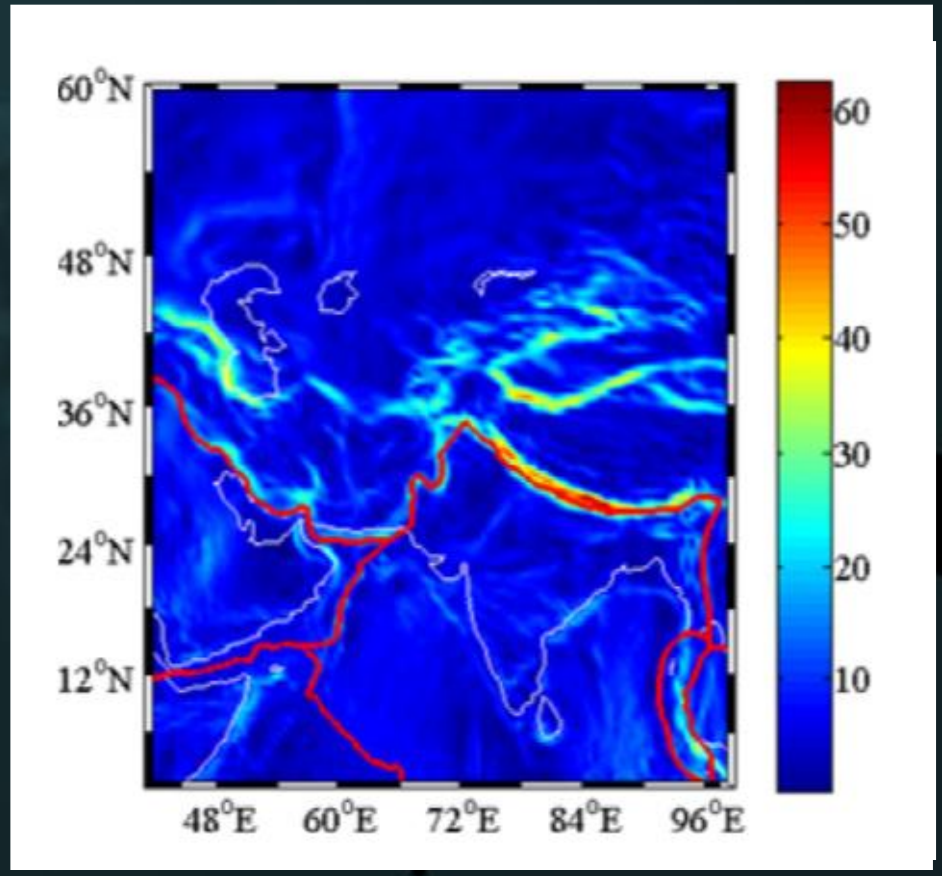
Prediction Strength

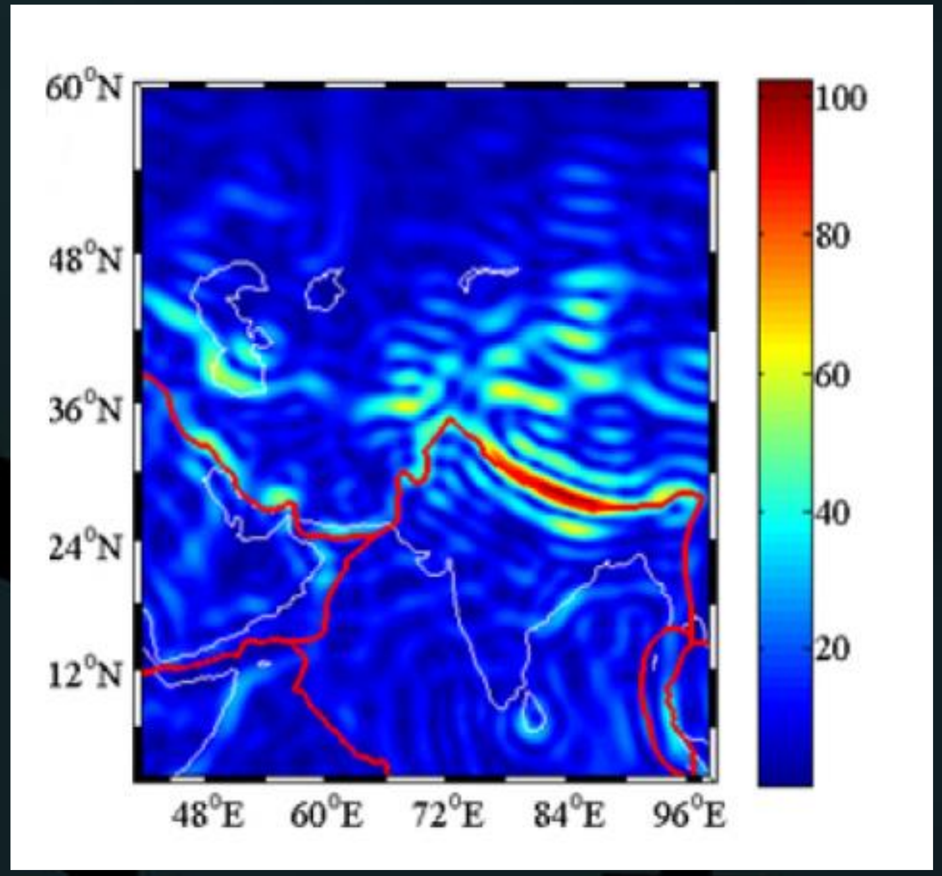
~ 70% (raw)
~ 64% (weighted)
~ 42% (corrected)

Subsurface Stress and Gravity









"Gravity gradient solutions exhibit similar spatial distributions as those calculated for Coulomb stress changes, reflecting their physical relationship to the stress changes".

"…subsurface stress changes can be approximated by the dilatational gravity gradients, and thus measured using gravity as a proxy."

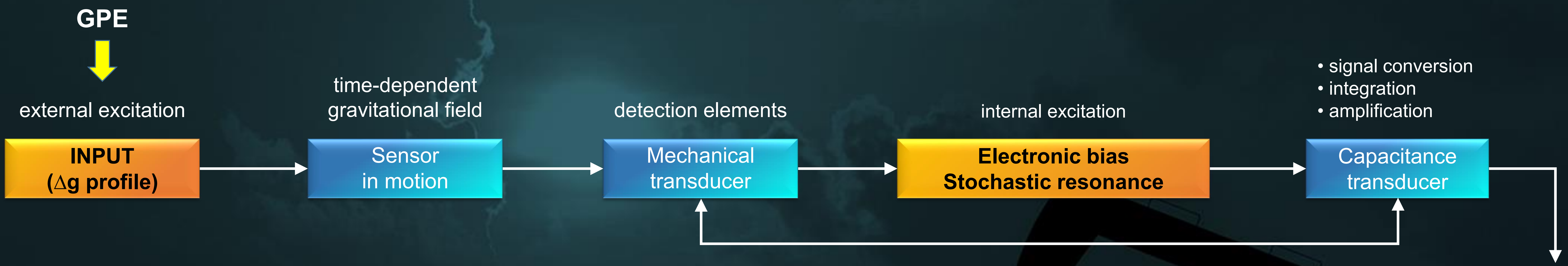
T.J. Hayes *et al.*, *"A gravity gradient method for characterizing the post-seismic deformation field for a finite fault", Geophys. J. Int.* 173, 802–805 (2008)

T.J. Hayes, *Using Gravity as a Proxy for Stress Accumulation in Complex Fault Systems*, Ph.D. thesis, University of Western Ontario (2008).

"...we focus on some gravimetrically-determined quantities like …. vertical-horizontal gravity gradients and the shear sub-lithospheric stress components …We show that how these quantities are related to each other mathematically so that one of them can be written in terms of another."

M. Eshagh *et al*., "Relationship amongst Gravity Gradients, Deflection of Vertical, Moho Deflection and the Stresses Derived by Mantle Convection: A Case Study over Indo-Pak and Surroundings", *Geodynamics R. Int*. **12,** 03–04 (2015)

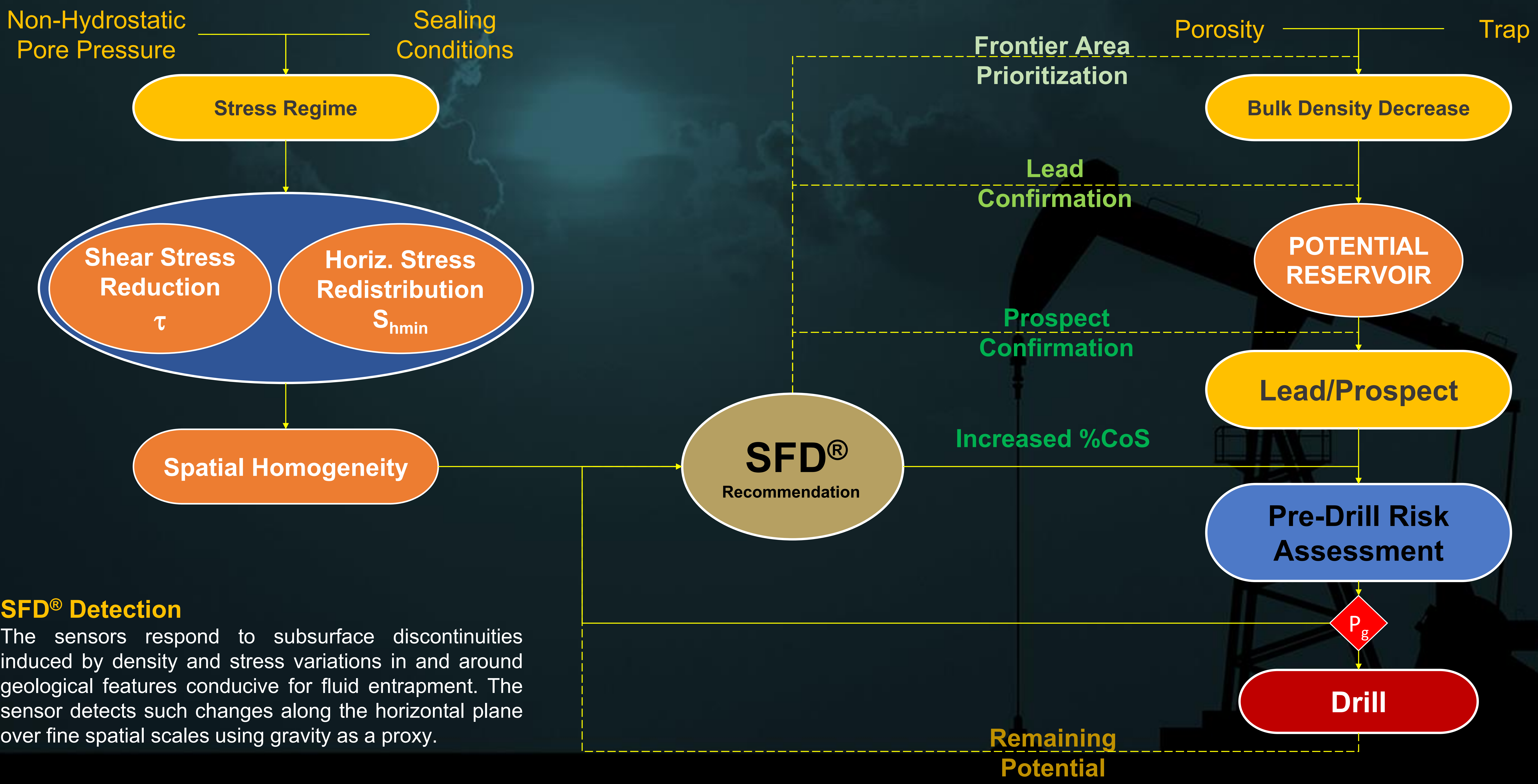
SFD® Detection Flowchart



- External excitation: the gravitational potential energy (GPE)
- Gravity transducer: GPE → Electromechanical conversion
- Internal excitation: electronic oscillation, signal modulation, stochastic resonance
- Motion effect: dynamic interaction, signal integration
- Sensor output: a non-linear time series
- Interpretation: patterns and trends consisting of signal attributes

✓ Dynamic Interaction
✓ Waveform Output
✓ High Sensitivity
✓ Fine Spatial Scale
(sedimentary column)

SFD® in the upstream workflow



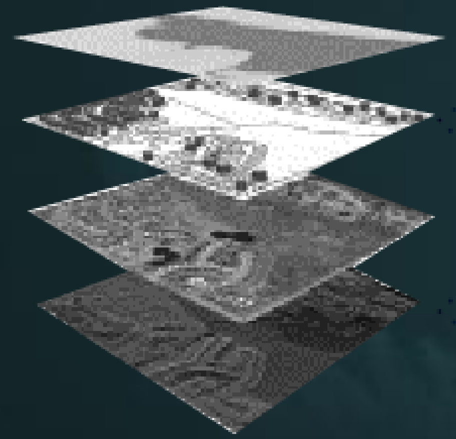
SFD® Detection

The sensors respond to subsurface discontinuities induced by density and stress variations in and around geological features conducive for fluid entrapment. The sensor detects such changes along the horizontal plane over fine spatial scales using gravity as a proxy.

Hydrocarbon Prospect Maturation & Reserves Replacement

Conventional Cycle

5,000 km² AOI



Basin/Block Analysis

Select Optimal Prospects

Prospect #1 Exp Drilling

Total CAPEX 200 MMUSD

- G&G/3D Seismic Data Base
  - √ 1-2 Surveys
- Prospect Portfolio
  - √ 7 Prospects
- Land Base
  - √ 70% Relinquishment
  - √ 1 D&PL

Commercial Discoveries 1

1 out of 7

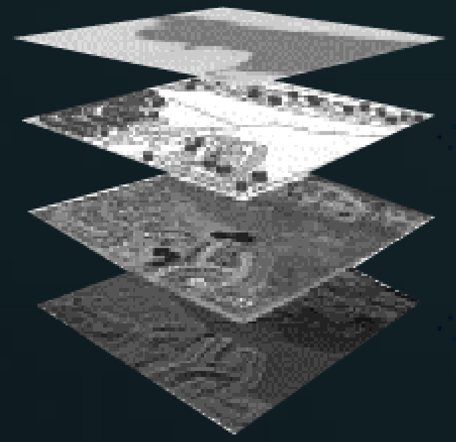
UPSTREAM CYCLE | **4 to 5 Years +**

1st wildcat proposed

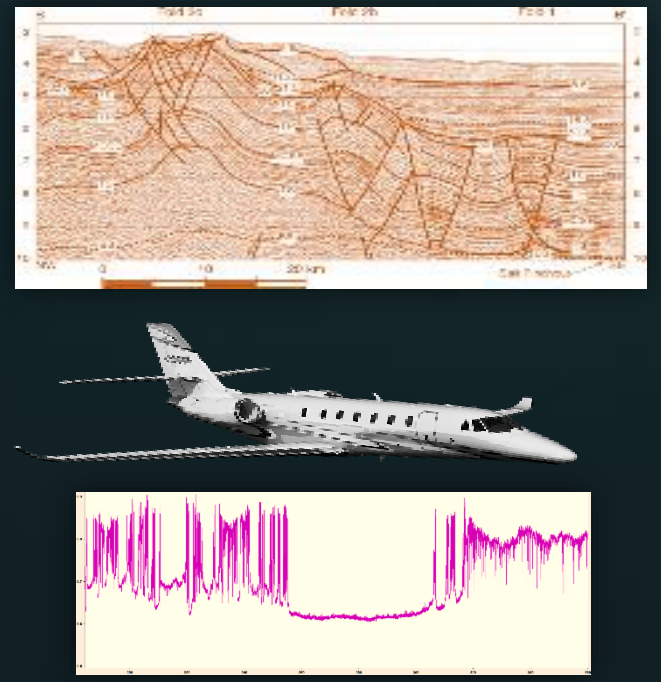
SFD®

Stress Field Detection®

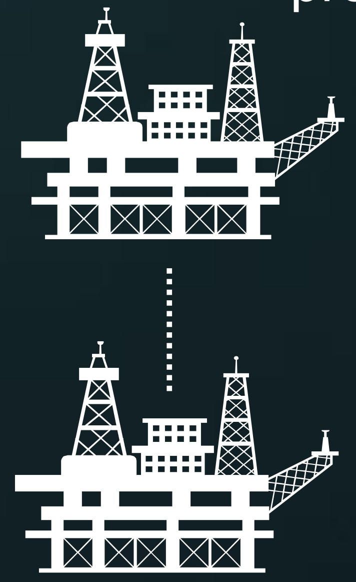
5,000 km² AOI



Basin/Block Analysis



Select Optimal Prospects



Prospect # 1→ 7
Exp. Drilling

Total CAPEX 460 MMUSD

- G&G/3D Seismic Data Base
  - √ 4-5 Focused Surveys
- Prospect Portfolio
  - √ 14 Prospects
- Land Base
  - √ 50% Relinquishment
  - √ 2-3 D&PL

Commercial Discoveries 4

4 out of 7

UPSTREAM CYCLE | **6 to 7 Years +**

Wildcats #1-3 proposed

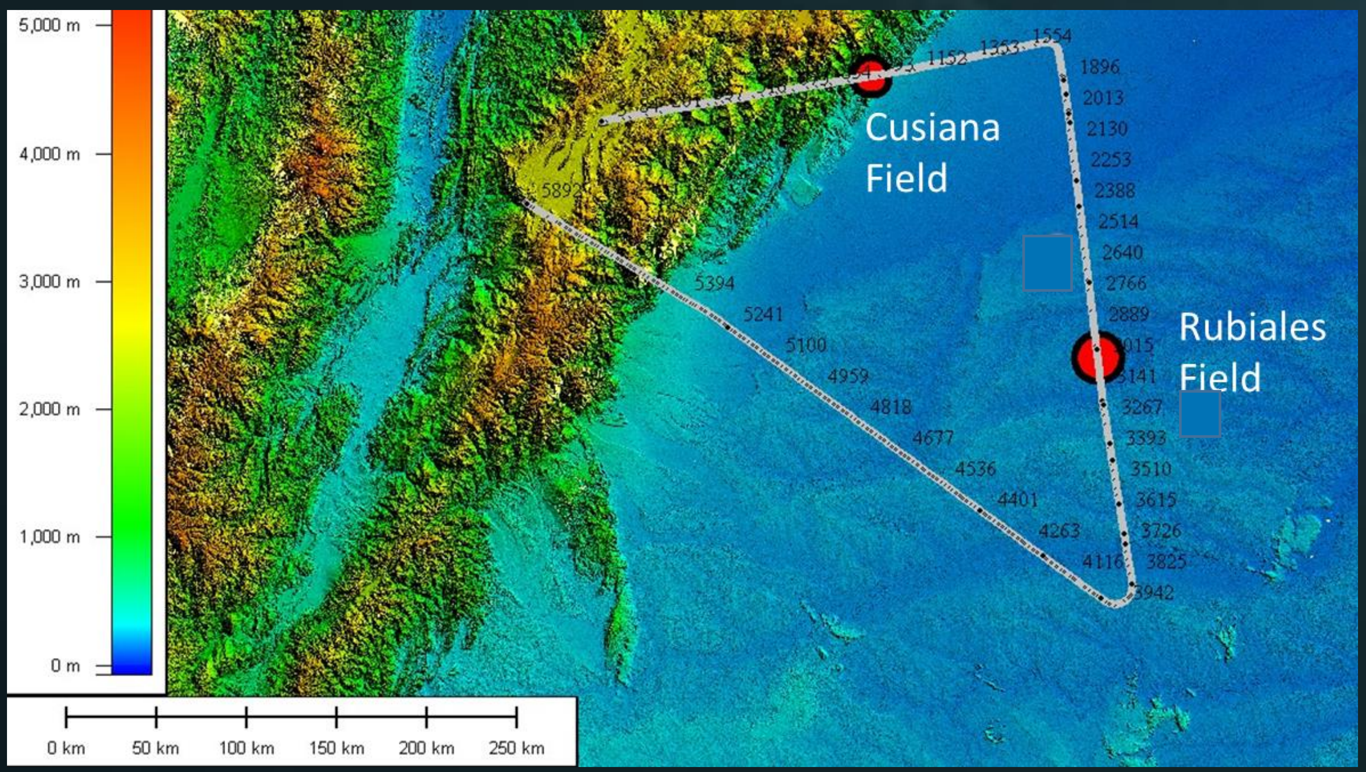
Wildcats #4-7 proposed

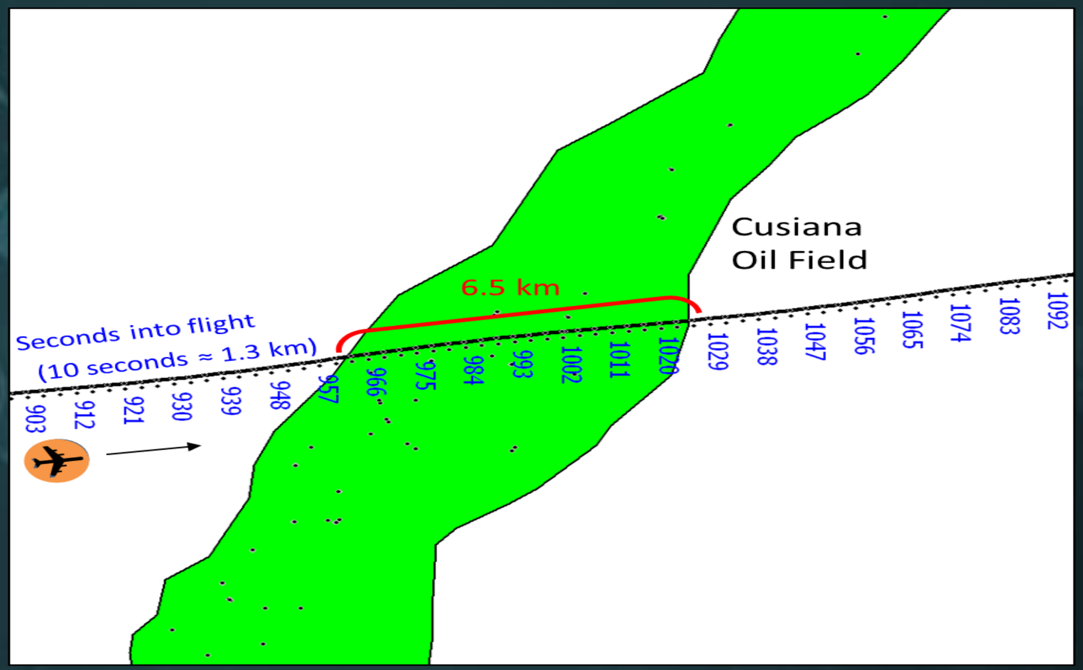
SFD® Survey Operations

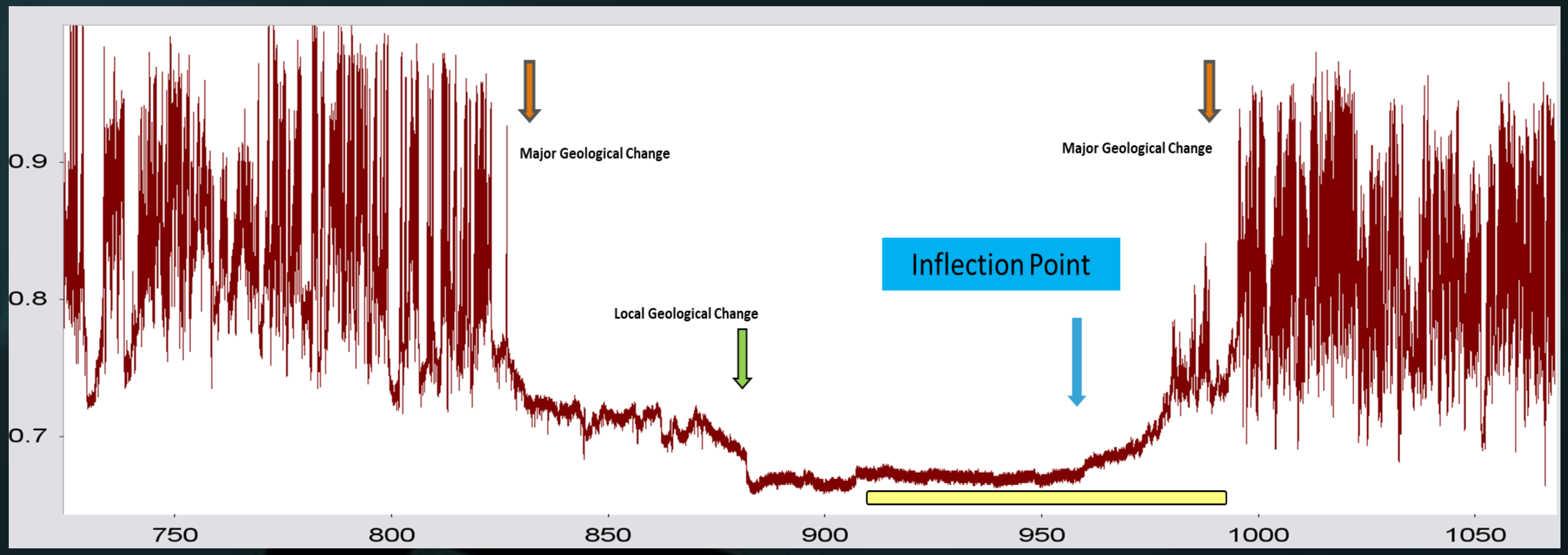
Speed	500 km/h
Altitude	3,000 m
Sample Rate	2 kHz per sensor
Number of Sensors	22 independent sensors

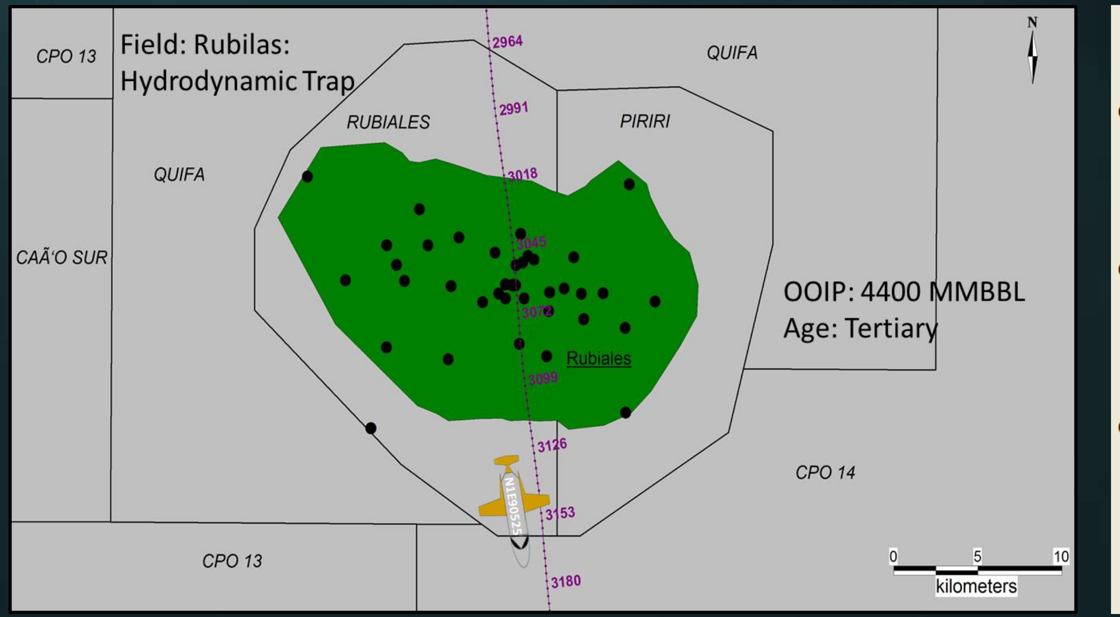
The Next Generation Geophysical Prospecting Tool

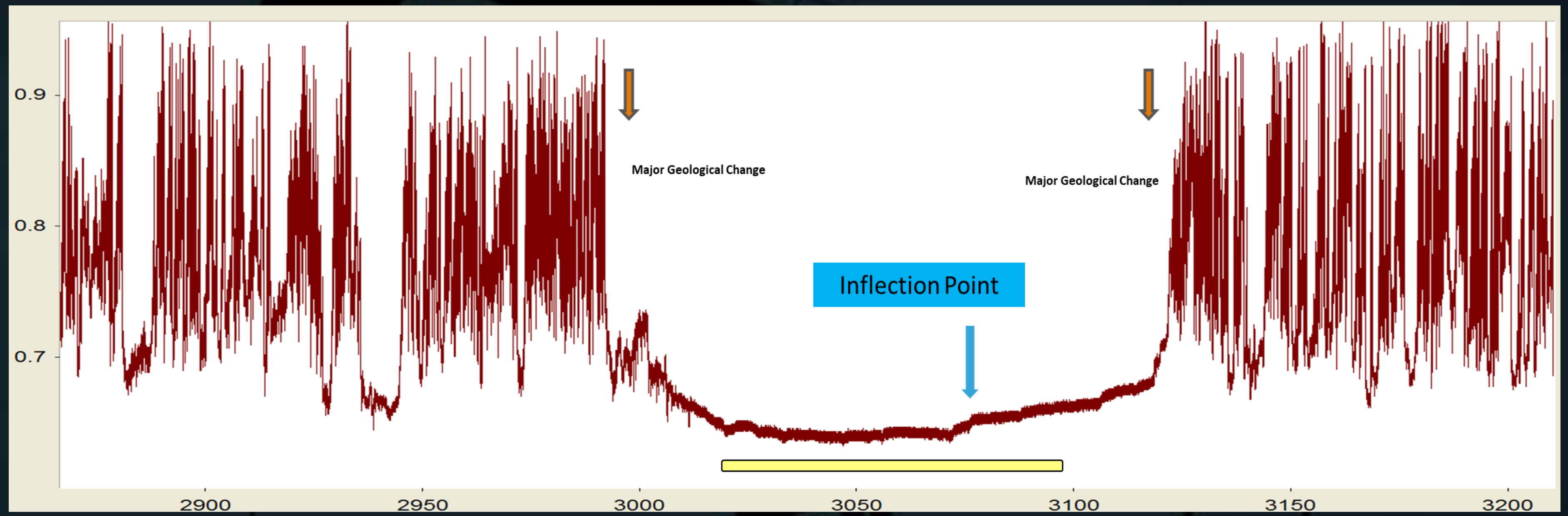
SFD® Signal Examples across major oilfield Colombia







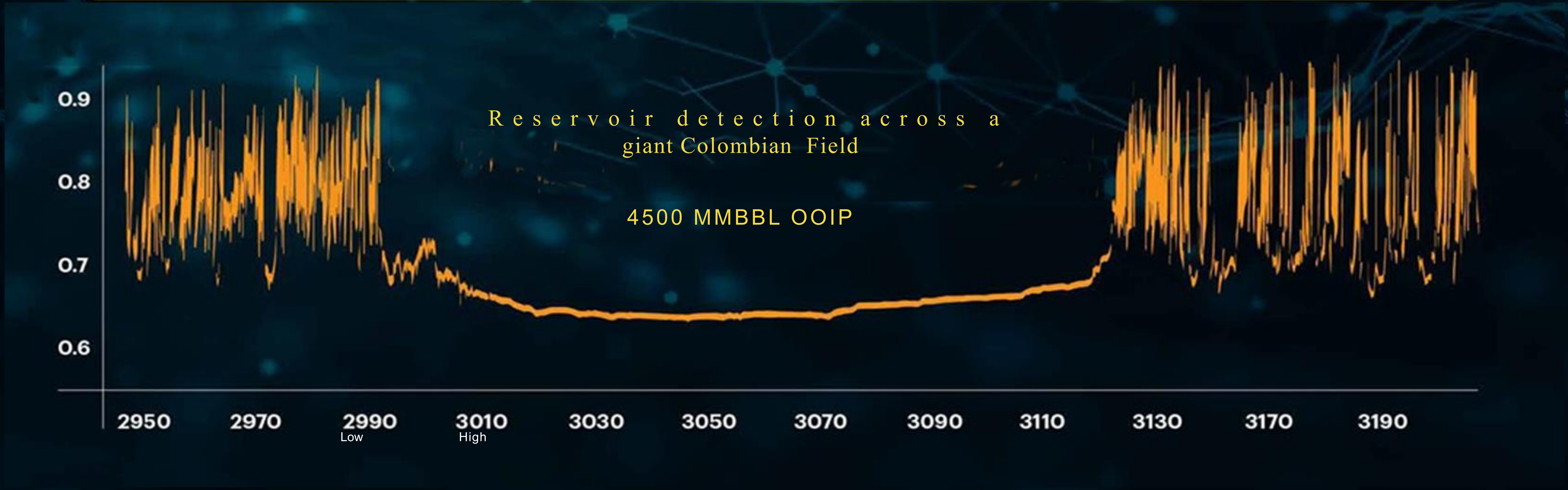




1) *SFD® response is a non-linear time series.*
2) *SFD® responds to 'trap integrity', irrespective of the trap type – structural, stratigraphic or hydrodynamic.*
3) *No a-priori information is required about the geology or structural orientation.*
4) *No a-posteriori modelling is required to arrive at AOI recommendations.*

SFD®Value Proposition

- Provides prospect level investigation
- Onshore / offshore applications
- Effectively opens up under-explored and frontier regions
- Prioritize "drill no-drill" decisions
- Minimize environmental / community impact and security concerns
- Significantly increases the chance of commercial discoveries



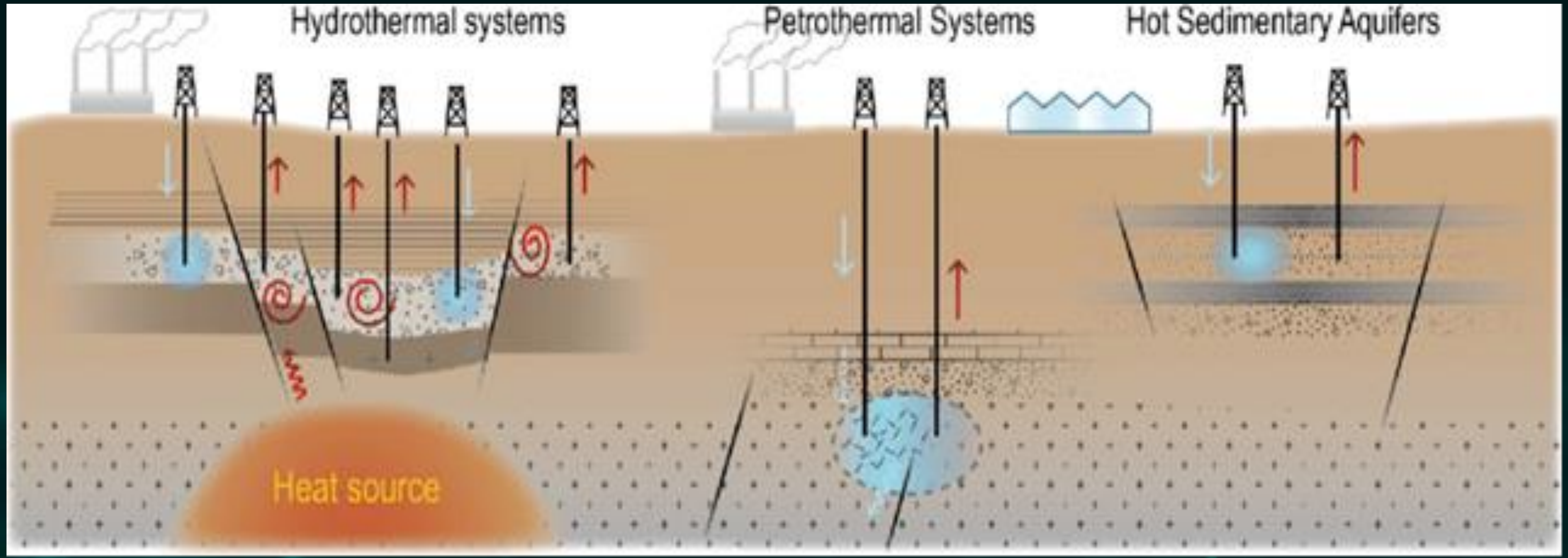
Applications to Geothermal Exploration

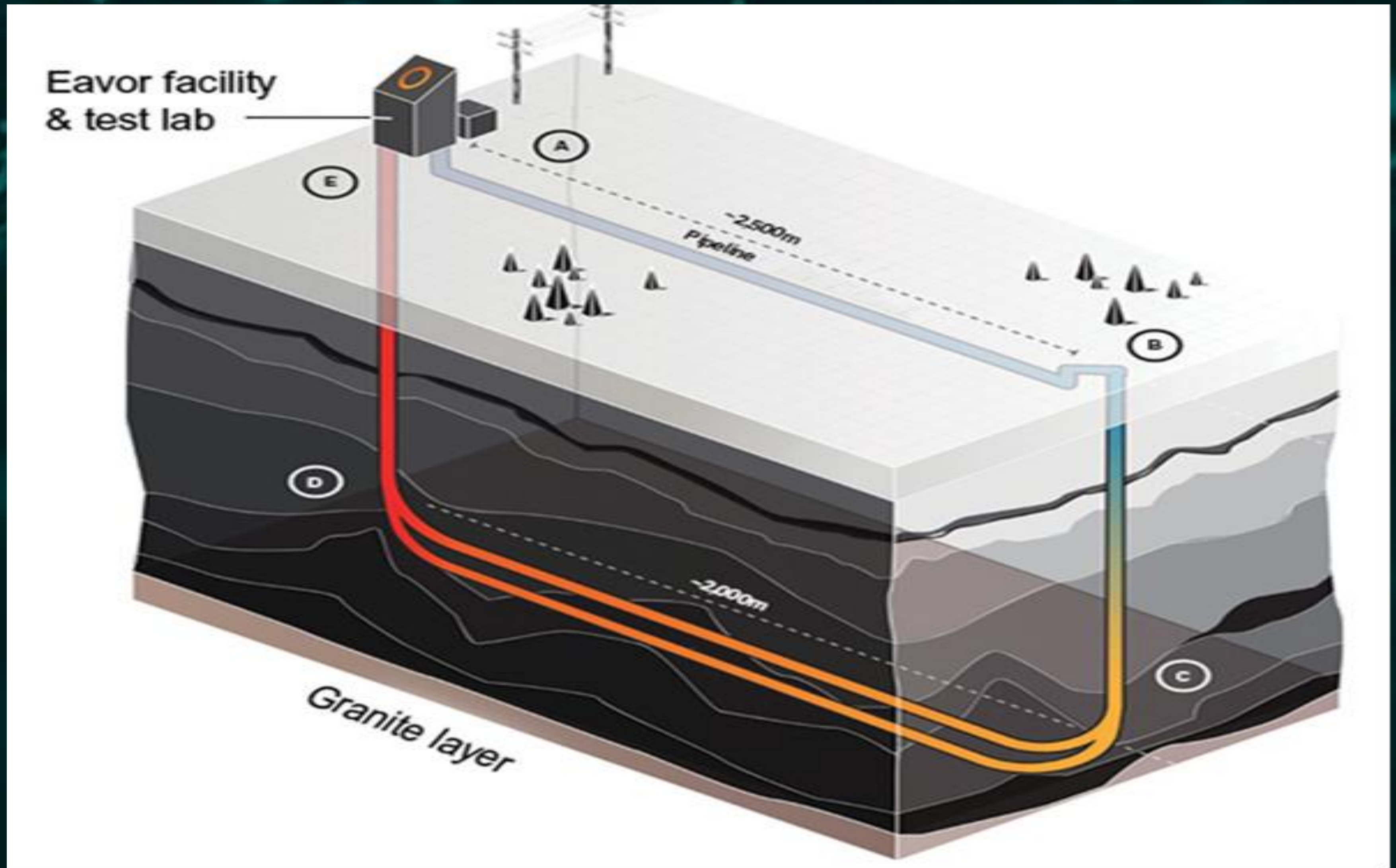
- NXT is developing SFD® sensor configurations which may be applied to the exploration for and evaluation of geothermal resources. The Company is still testing and documenting SFD® effectiveness for geothermal resource identification.

- Sensor response is being calibrated against known geothermal terrains in Canada.

- SFD® allows highly cost-effective evaluation of potential geothermal targets with effectively zero environmental impact.

Applications of SFD® to Geothermal play concepts





The role of pore pressure and its prediction in deep geothermal energy drilling – examples from the North Alpine Foreland Basin, SE Germany

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Abstract: Pore pressure prediction is a well-developed key discipline for well planning in the hydrocarbon industry, suggesting a similar importance for deep geothermal wells, especially, since drilling cost is often the largest investment in deep geothermal energy projects. To address the role of pore pressure prediction in deep geothermal energy, we investigated pore pressure-related drilling problems in the overpressured North Alpine Foreland Basin in SE Germany – one of Europe's most extensively explored deep geothermal energy plays. In the past, pore pressure was mainly predicted via maximum drilling mud weights of offset hydrocarbon wells, but recently more data became available, which led to a re-evaluation of the pore pressure distribution in this area. To compare the impact of pore pressure and its prediction, 70% of all deep geothermal wells drilled have been investigated for pore pressure-related drilling problems and two deep geothermal projects are given as more detailed examples. Thereby, pore pressure-related drilling problems were encountered in one third of all wells drilled, resulting in several side-tracks and an estimated drilling rate decrease of up to 40%, highlighting the importance of accurate pore pressure prediction to significantly reduce the cost of deep geothermal drilling in overpressured environments.

Thematic collection: This article is part of the Geopressure collection available at: https://www.lyellcollection.org/cc/geopressure

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Deep geothermal energy can contribute to reduce the CO_2 footprint (IRENA 2021) and compared to most other renewable energy forms has the advantage of providing base load capacity and the opportunity to offer clean energy for both electricity generation and district heating (IRENA 2017). Thereby, the technical challenges and associated subsurface risks of deep geothermal energy are closely related to those of classical hydrocarbon exploration and production: finding a producing reservoir, drilling deep wells in sometimes challenging environments, and ensuring safe and sustainable production over timespans of several years to decades. In particular, drilling of deep wells is a significant economic factor in each deep geothermal project and can account for 30–70% of the overall project cost (Stefansson 2002; Stober and Bucher 2013). Consequently, the EU-Commission (2018) has formulated in its strategic energy transition (SET) plan that the cost of drilling for deep geothermal energy (referenced to 2015) has to be reduced by 15% immediately, 30% until 2030 and finally 50% until 2050 to remain competitive on the energy market.

In most cases, the rotary drilling technology is used to drill deep geothermal wells. Here, the deep geothermal industry uses, to a large extent, the experience and technical knowledge built by the hydrocarbon industry (c.f. Stober and Bucher 2013). In the hydrocarbon industry, minimum and maximum drilling fluid densities (mud weight) to prevent kicks, instabilities, sticking and drilling fluid losses as well as designing casing strength and landing points are generally driven by accurate analysis and estimation of pore pressure and subsurface stresses (Mouchet and Mitchell 1989). This task is generally known as pore pressure prediction. Pore pressure prediction is a critical tool to minimize economic, environmental and safety-related drilling risks (e.g. Pinkston and Flemings 2019), but depends on a sufficient database of offset wells (Mouchet and Mitchell 1989). Its significance for drilling hydrocarbon wells suggests a similar importance for deep geothermal wells, which we investigate for the North Alpine Foreland Basin in SE Germany.

The North Alpine Foreland Basin is a low enthalpy (reservoir temperature <200°C) deep geothermal play, which has already completed the transition from being a classical hydrocarbon play in the 1950s to late 1980s (Lemcke 1979; Bachmann *et al.* 1981) into one of Europe's most prolific and most extensively explored deep geothermal (hydrothermal) energy plays (Agemar *et al.* 2014*a*). It also contains a heterogeneous pore pressure distribution with hydrostatic pore pressure, significant overpressure, pressure regressions and underpressure (Lemcke 1976; Müller *et al.* 1988; Drews *et al.* 2018, 2020; Drews and Stollhofen 2019), which makes it an ideal candidate to investigate the role and impact of pore pressure in deep geothermal energy drilling. Moreover, the possible impact of pore pressure prediction on improving drilling performance and lowering drilling cost for the deep geothermal energy sector will be addressed.

North Alpine Foreland Basin in SE Germany

Geological setting

The North Alpine Foreland Basin (referred to NAFB hereafter) is the peripheral foredeep of the European Northern Alps (Schmid

Geothermal Applications for SFD-GT

- ✓ Geothermal resource include naturally occurring sub-surface fluid reservoirs or rock conditions from which heat can be extracted and utilized for generating electric power, or for direct utilization in industrial, agricultural or domestic applications.
- ✓ The main subsurface properties such as porosity, permeability and impermeable cap rock that are vital in hydrocarbon prospecting are equally critical for identifying geothermal resources.
- ✓ NXT is leveraging its extensive research and marketing skillset to develop and commercialize the geothermal application of the SFD® technology.
- ✓ Geothermal resource exploration is a natural extension of NXT’s patented SFD® technology.

Geothermal Opportunity

- ✓ Geothermal energy has gained greater prominence for its environmental benefits as a non-intermittent renewable baseload energy source, unlike solar or wind.
- ✓ Industry is expected to be valued at US$6.8 billion by 2026[1].
- ✓ Global trend to go green is expanding exponentially.
- ✓ Competitive advantages:
  - ECO Friendly
  - Applicable to all potential geothermal geologic settings.
  - Airborne deployment enables industry leading time and cost benefits, even in vast and frontier areas.
  - Significant ESG benefits associated with minimal land, community and wildlife disturbances.
  - Proven and effective exploration method with demonstrated success rates[2].

[1] https://www.alliedmarketresearch.com/geothermal-power-market
[2] NXT Corporate Presentation 2021

Path to Commercialization for NXT's Geothermal Segment

- ✓ Expanding existing portfolio to include green energy sector.
- ✓ Approved government R&D grants for sensor modification and field testing.
- ✓ Engaging Geothermal experts.
- ✓ Anticipated geothermal projects in North America and internationally.
- ✓ Sales model will be initially based on fee-for-service.
- ✓ SFD-GT is the practical solution to locate and prioritize geothermal resources.

ESG Benefits of Using NXT's
Stress Field Detection Technology (SFD®)

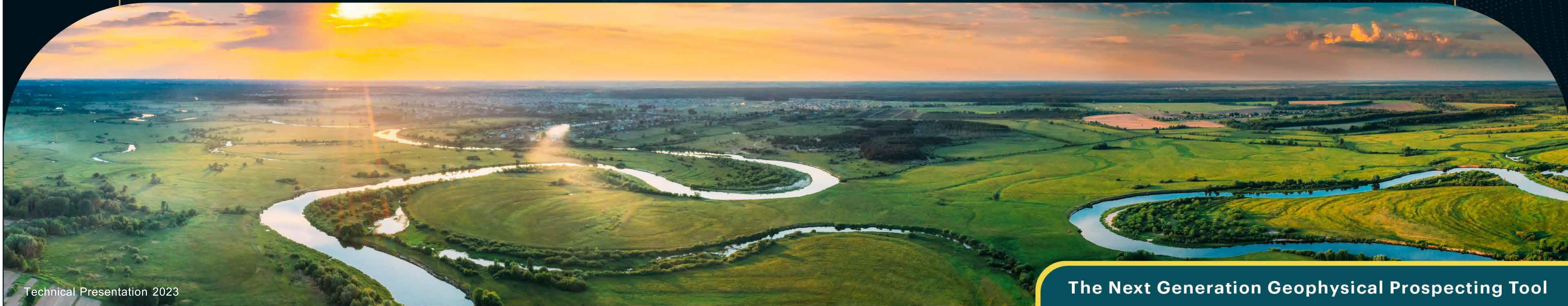
0

- ✓ Zero direct environmental footprint
- ✓ Zero disruption of surface and community use
- ✓ Zero disturbance to wildlife habitats

The non-intrusive SFD® airborne survey drastically reduces the negative environmental impact of large-scale ground surveys.

SFD® surveys minimize disruptions to community life and surface use.

Using SFD® as the lead technology will enhance Corporate and Social responsibilities for the E&P sector via focusing upstream activities on the highest value prospects.



NXT Energy Solutions

The next generation of airborne geophysical survey technology

Thank You!