

From an Art to a Science: Factory Drilling Plug and Abandonment Wells at Twice the Speed for Half the Cost

Presented by: Clinton Moss and Anas Sikal

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SPE Wellbore Positioning Technical Section

The Hague, NL



Agenda

Slide 2

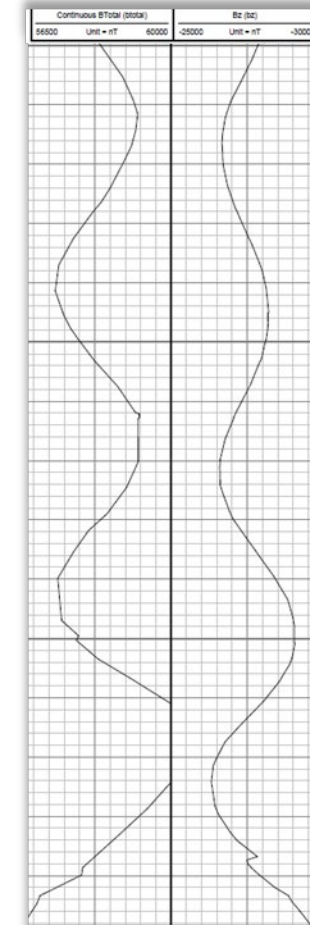
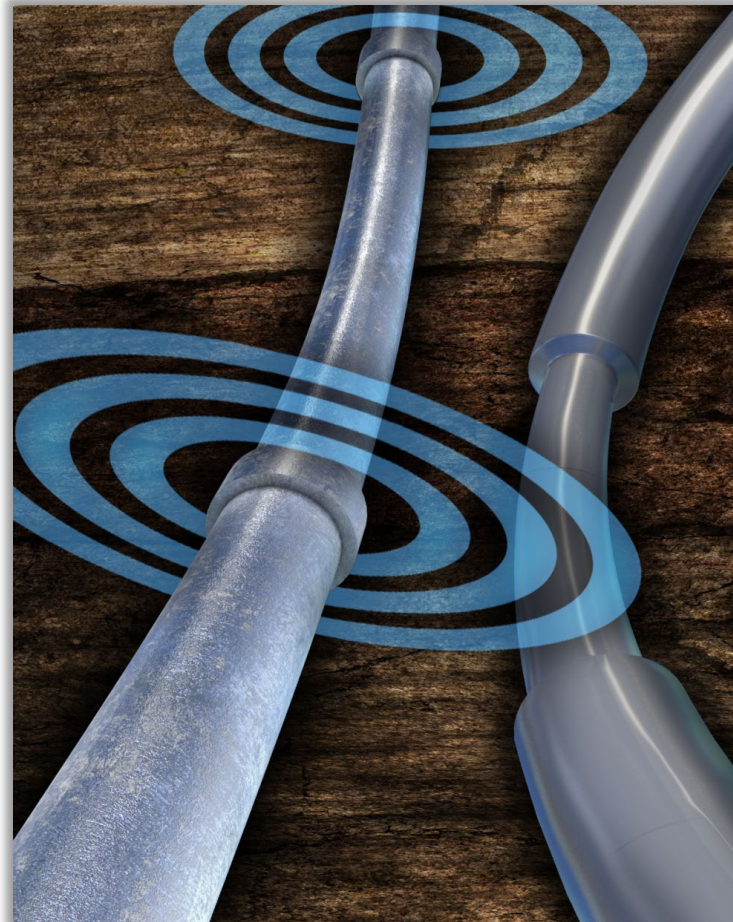
- A brief review of ranging techniques
- Project details
- Technical challenges
- The engineered approach - methodology
- Ranging tool response
- A selection of ranging data
- Milling and re-entering the target
- Results



Passive Magnetic Ranging

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- MWD detects interference from the adjacent well
- While Drilling logging allows one to identify precise interval over which to acquire ranging data
- Can be transmitted in both sliding and rotary drilling modes
- Useful especially in presence of pipe breaks



While Drilling BTotal & Bz log

Active Ranging While Drilling

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Surface Injection - Patent # 9938773, Moss et al.

- Current injected on surface travels down the pipe
- The current has associated with it a magnetic field
- The MWD sensor can detect the magnetic field while drilling
- A distance and direction can be computed
- Motor highside to target is known at an instant in time
 - Referenced to gravity HS, Magnetic TF and **GYRO TF**



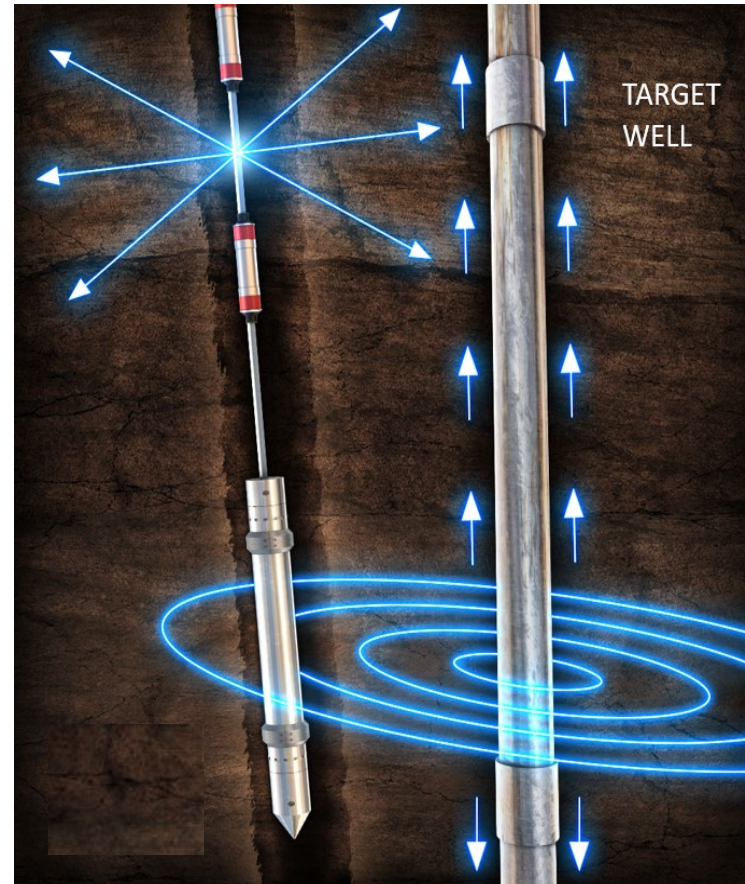
Wireline Active Ranging

What is it?

- Wireline deployed in the drilling well
- Current injection and detection in one assembly
- Array of onboard sensors to detect:
 - Magnetic Field
 - **Gravity field**
 - Earth spin rate
- Distance and direction from the open hole to the target well

Specifications

- Detection up to 200' away
- Direction to target +/- 3°
- Distance to target +/- 10% when in gradient range



Project Details - Field History

- Developed field with high congestion – 1000s of wells
- Fluid injection over many decades has caused shifts in formations causing casing damage
- Historically, additional casing and tubing strings used to get more production. Workover tools and cementing also used to abandon wells
- Preference is to re-enter the target to abandon
- Intercept and abandonment work highly specialized and historically completed by dedicated/experienced/small group of experts



Project Challenges

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- Casing damage
 - Breaks lead to electrical discontinuity
- Parasite wells
 - Active ranging signal possible from multiple wells
- Low angle target means corrupt magnetic azimuth to target and no HSTFtTG
 - Gyro corrections required
- Shallow intercept depths (800-1000' MD/TVD)
- Poor/no surveys, high target well uncertainty
- High precision required for re-entry
- Shallow intersect depth means fast trips and challenging pace. Little room to make corrections



Methodology

- Complex abandonments are an engineering problem that can be SOLVED
- First and foremost, follow industry best practices (ISCWSA)
- Use a combination of methods to address the problem, some new, some old:

Industry Standard Methods

- GWD
- EMMWD
- Active and Passive WL Ranging

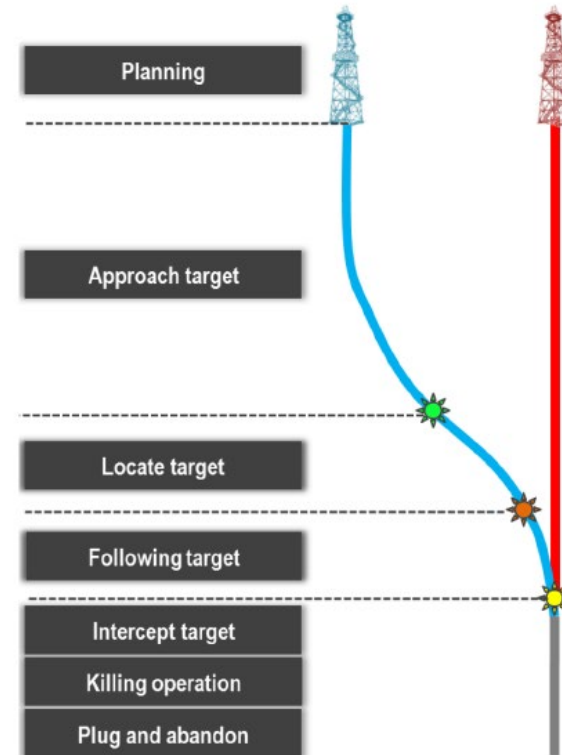
New Methods

- Active ranging while drilling oriented with a gyro
- Active WL ranging oriented with a gyro
- Active ranging logging



P&A Well Phases

- Workgroups on location include
 - Directional and MWD
 - Ranging Engineers
 - Well Intercept Specialists
- Remote Operations
 - Project Management
 - Well Intercept Specialists
 - Well-Planning
 - Engineering Team



Activities

- 1** Planning
- 2** Approach
- 3** Locate
- 4** Following
- 5** Intercepting
- 6** Killing operations
- 7** Plug and abandon

SPE 186901



Ranging Process Flow

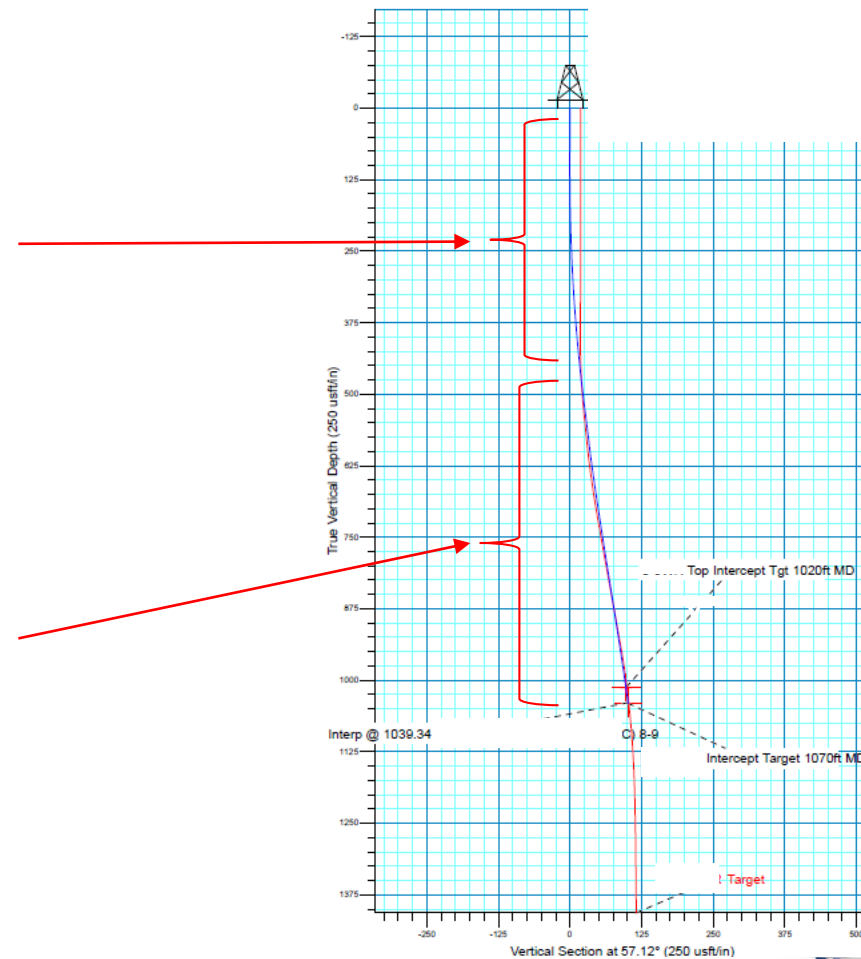
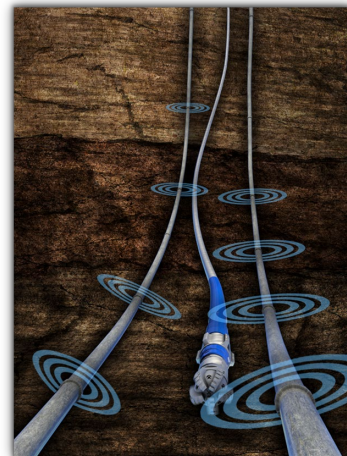
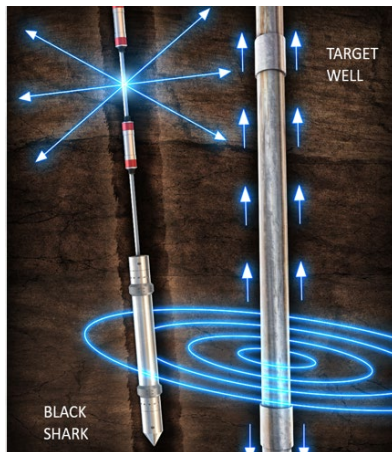
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1. Run in wireline ranging tools
2. Perform log on target well
3. As data is gathered, it is sent to cloud for analysis and report generated by Real-Time Operations Center
 - Advanced ranging analysis completed as the raw data is collected
4. New wellplan generated and next drilling interval prescribed before ranging tools are laid down
 - No NPT while waiting on a new wellplan
 - Often 3 drilling/ranging intervals completed per day



A Combination of Techniques

Ranging While Drilling to identify and monitor relative position during top hole section

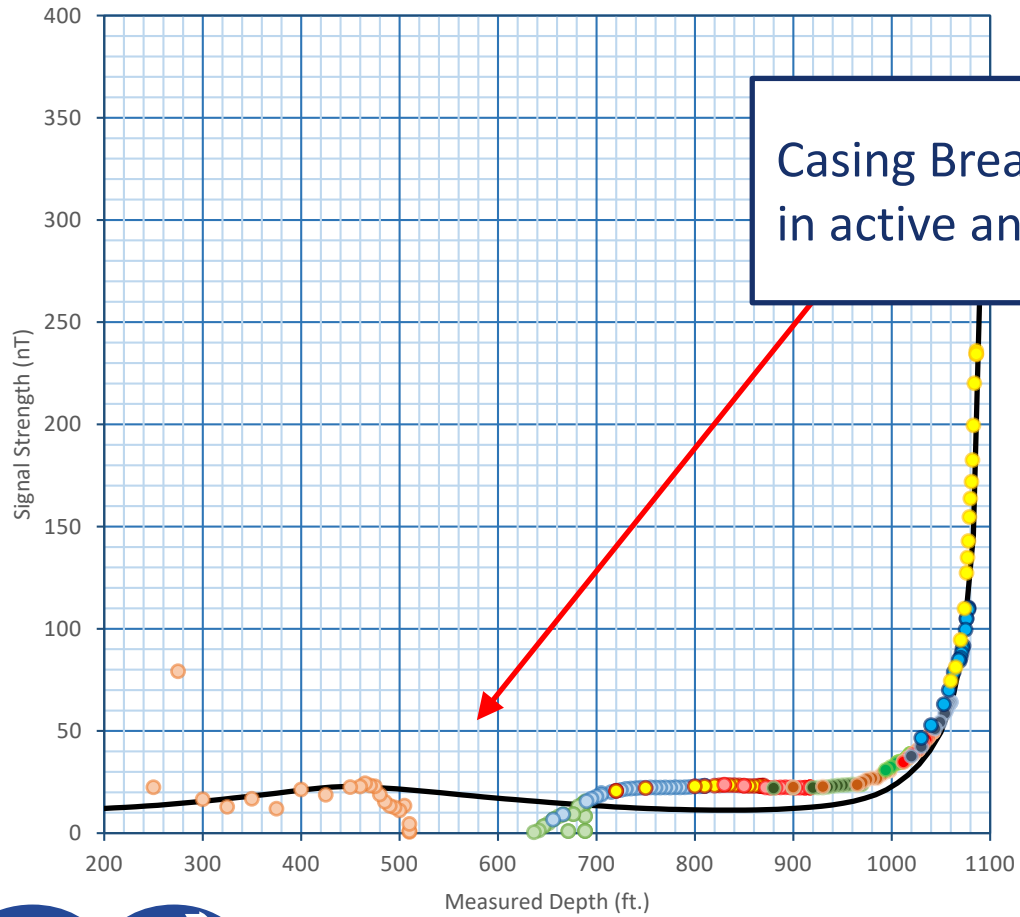


Active Wireline and Passive to follow, intersect and mill the target

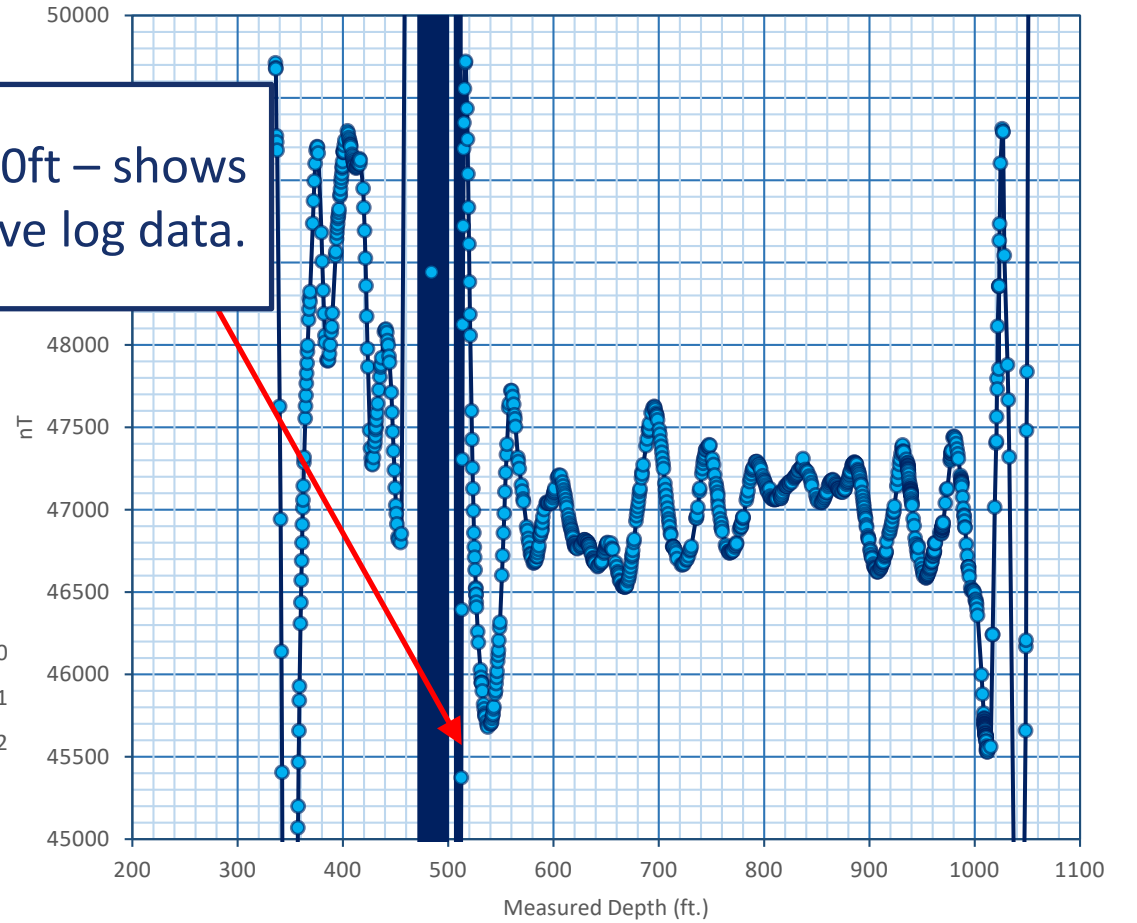


Technical Challenges – Casing Breaks

Active Signal Strength



Passive Continuous BTotal Log



Casing Break at 510ft – shows in active and passive log data.

- Run 3
- Run 4
- Run 5
- Run 6
- Run 7
- Run 8
- Run 9
- Run 10
- Run 11
- Run 12

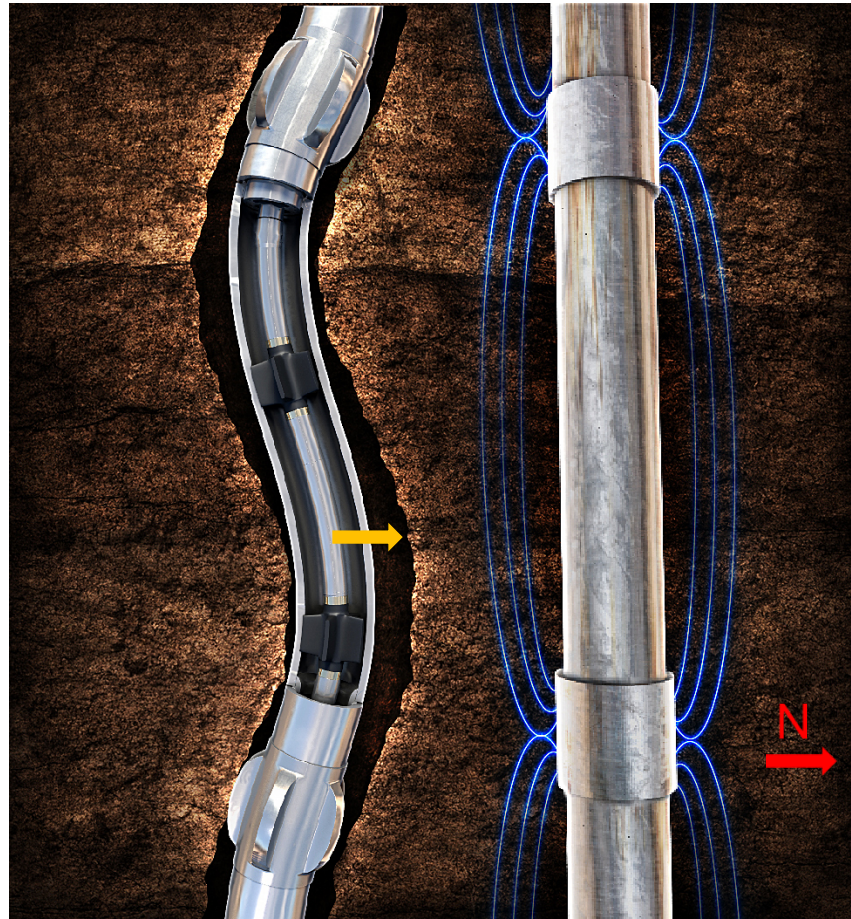


Challenges of Referencing the Target in Vertical Hole

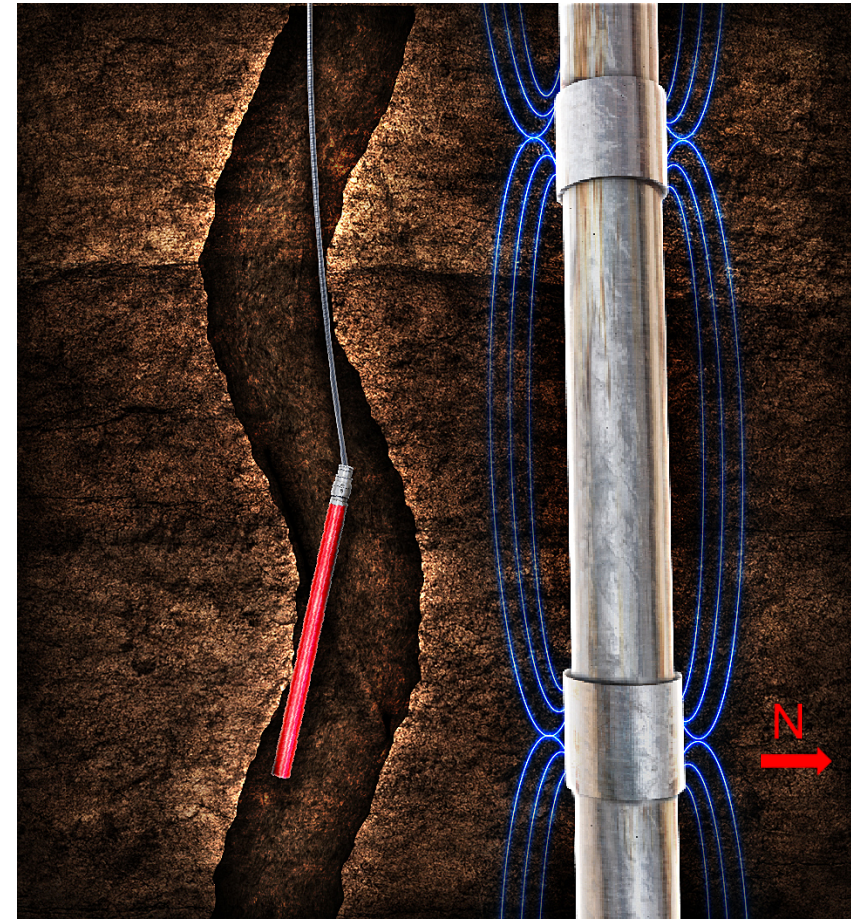
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Challenges of Referencing the Target in Vertical Hole



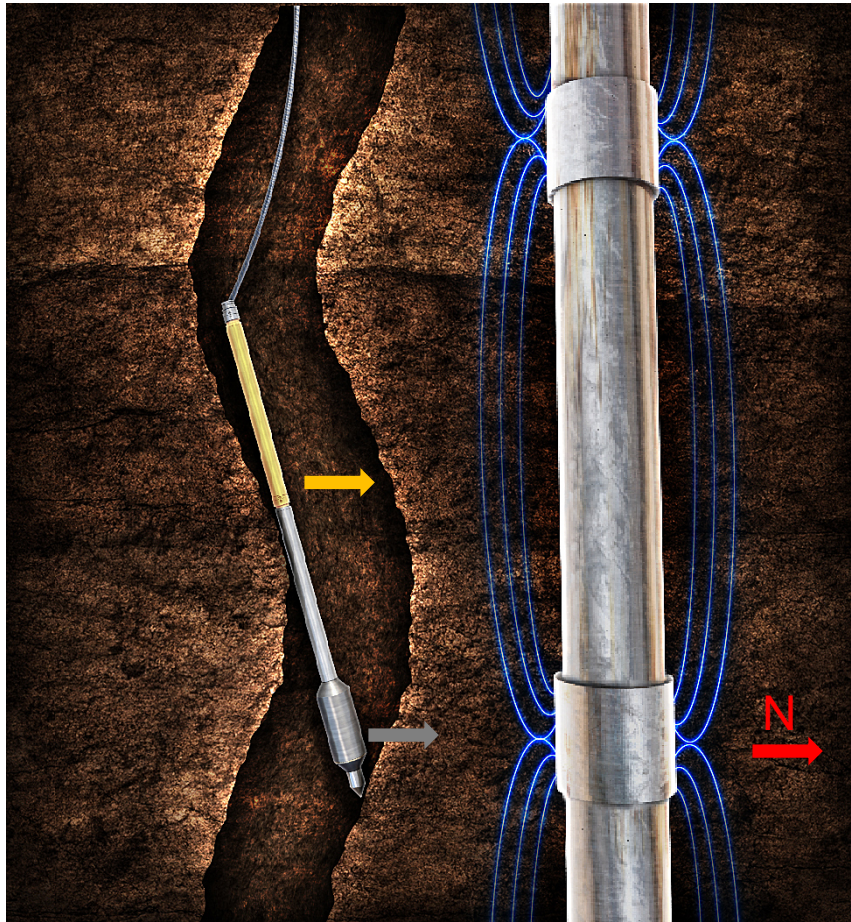
Gyro Az = North 😞



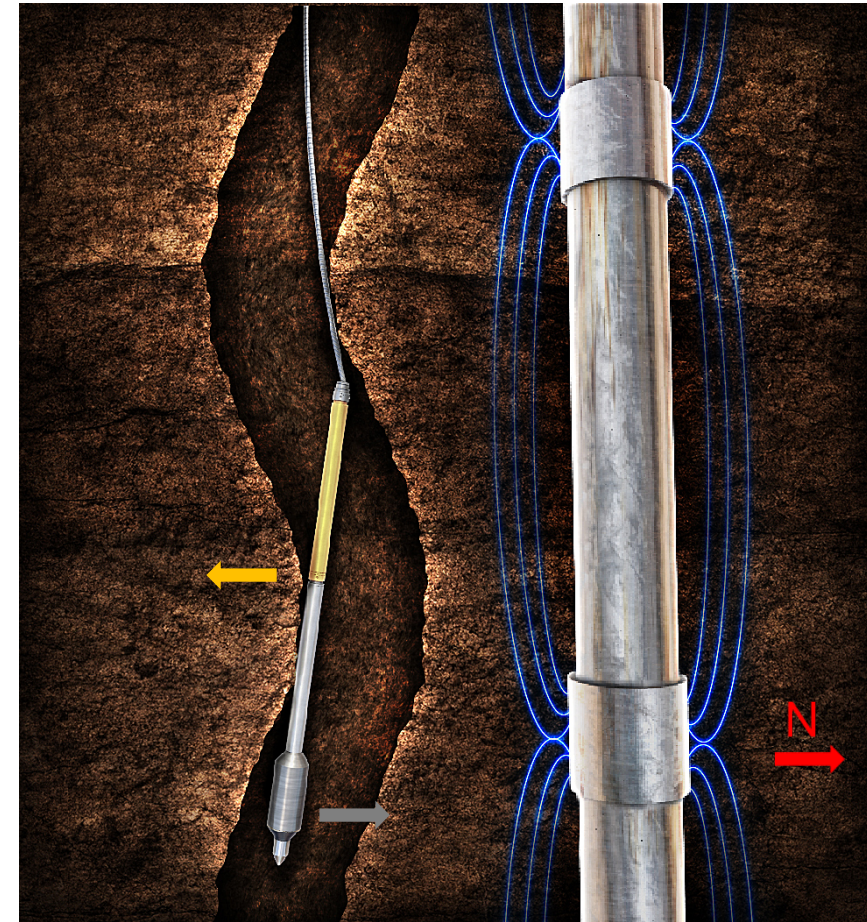
Assume Ranging tool Az= North (Wrong)
Direction to target = 180° from HS (HS is also noisy)
Ranging tool AzTF = Hot
Direction to target = South 😱

Challenges of Referencing the Target in Vertical Hole

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GyroTF=N, Direction to target = 0° from Gyro key = North 🕶️

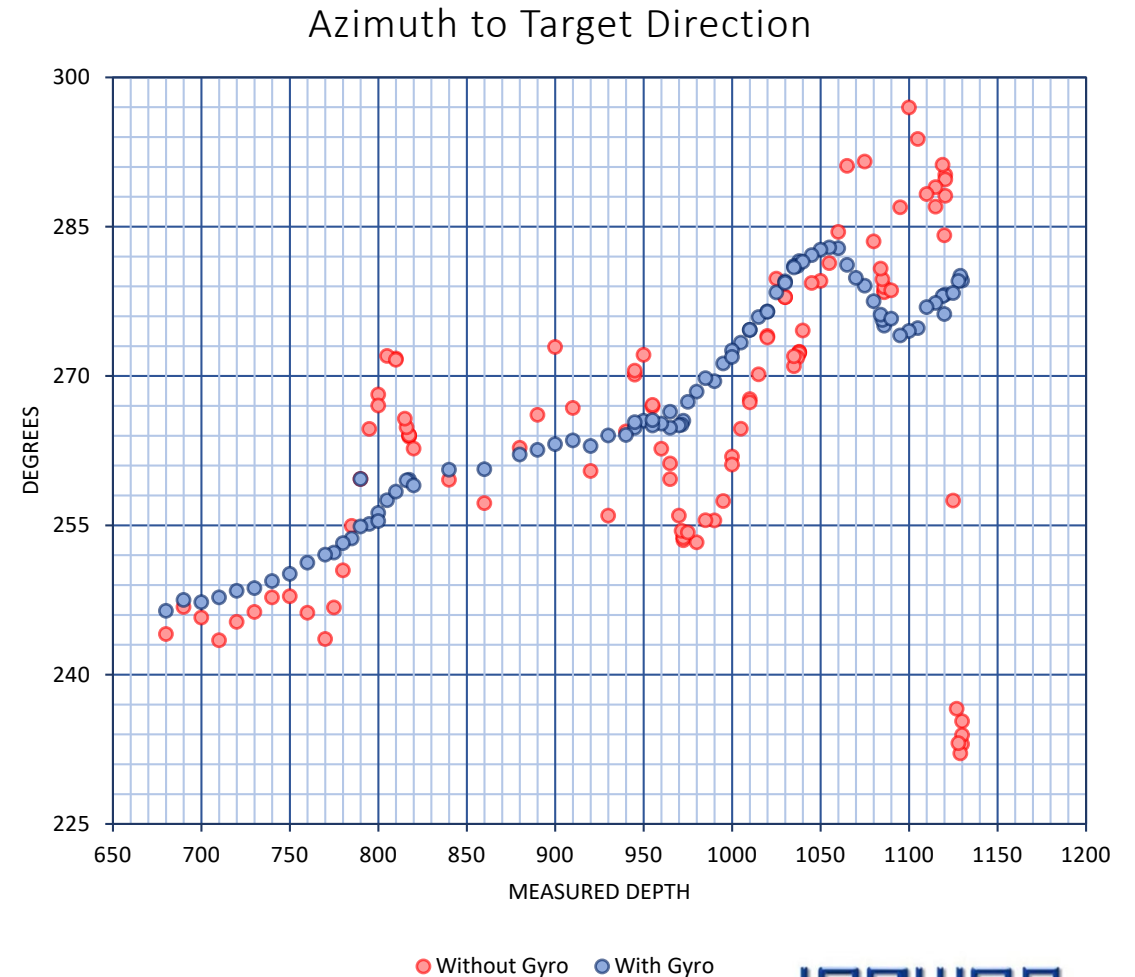


GyroTF=S, Direction to target = 180° from Gyro key = North 🕶️

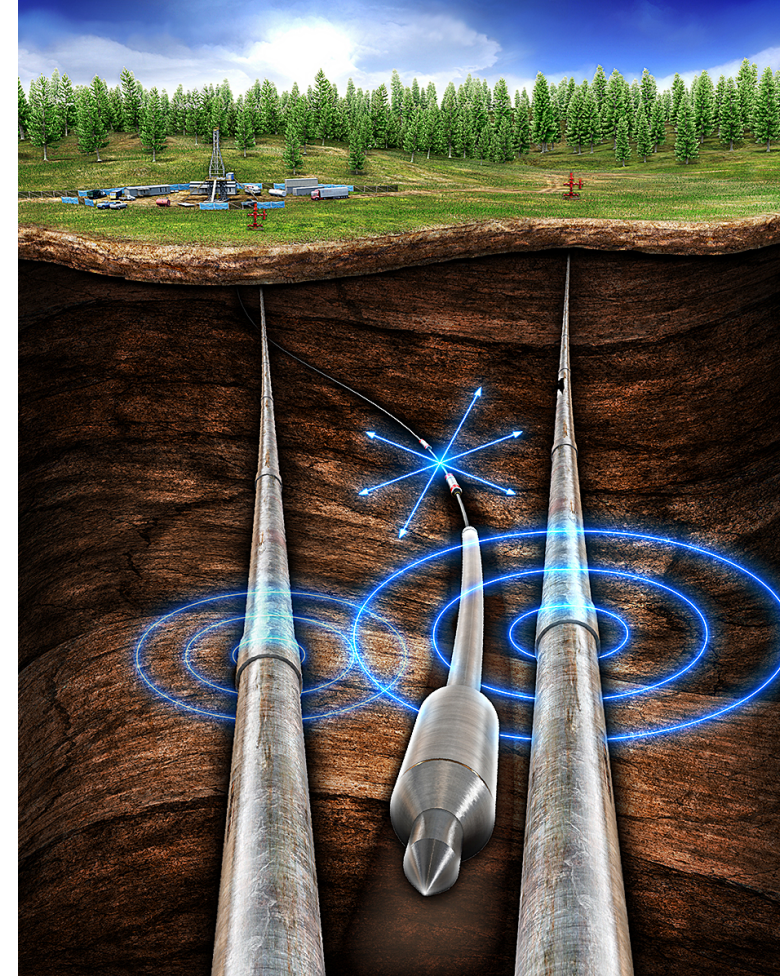
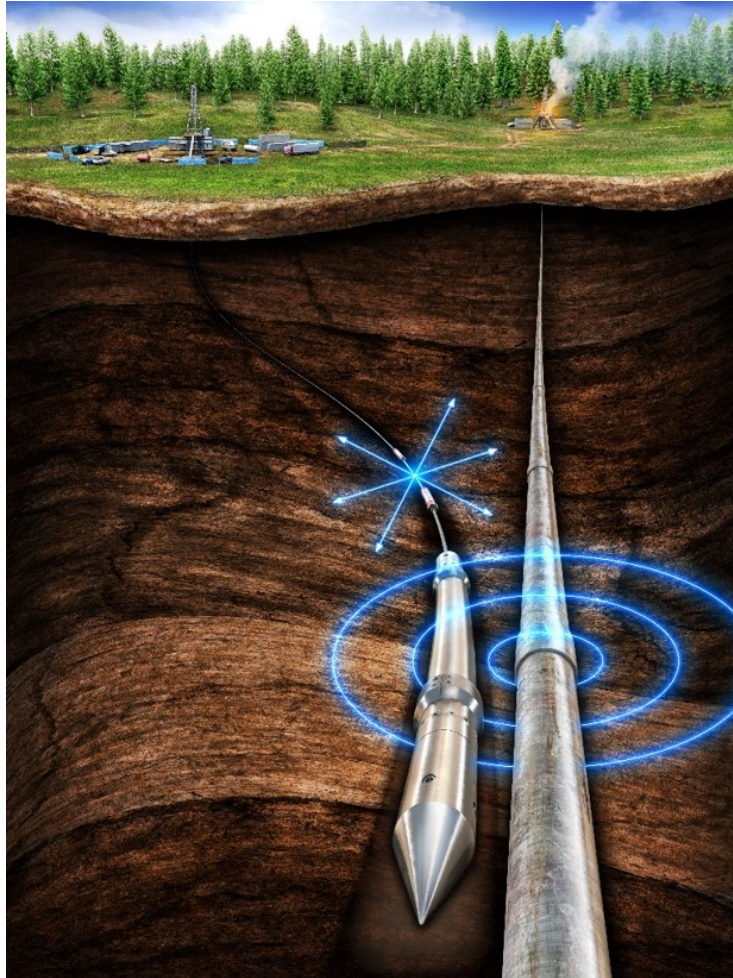


Challenges of Referencing the Target in Vertical Hole

- North-Seeking Gyro integrated into wireline ranging assembly
- Simultaneous Gyro Referencing – Accurately measure relative position referenced to True North
- Fully functioning survey tool – can record continuous gyro log surveys using the one wireline assembly
- Data quality increased particularly at low inclination due to known toolface direction when acquiring active data
- Ranging while vertical 1° inclination has been proven

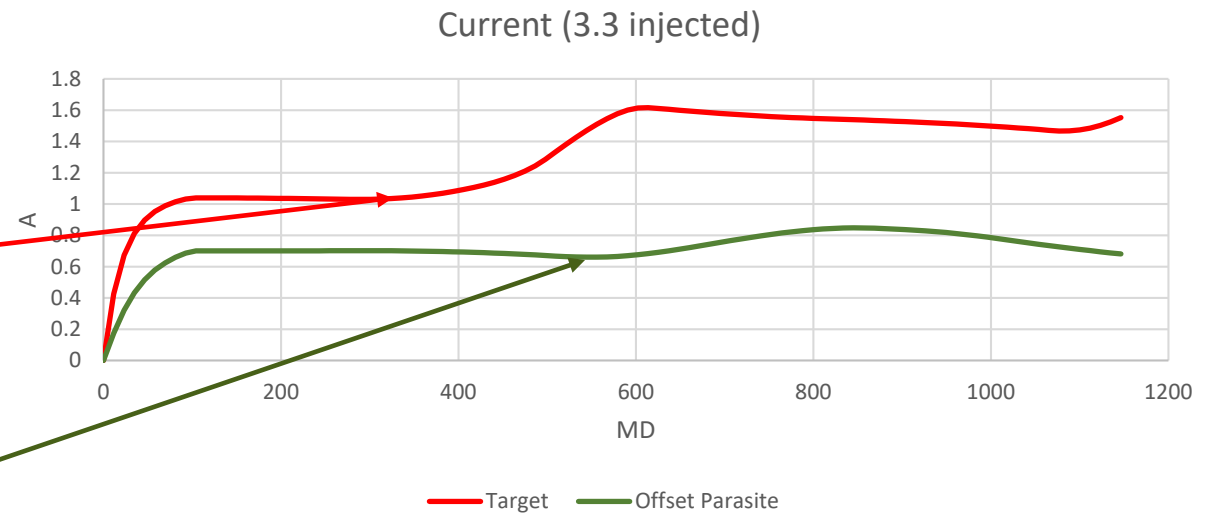
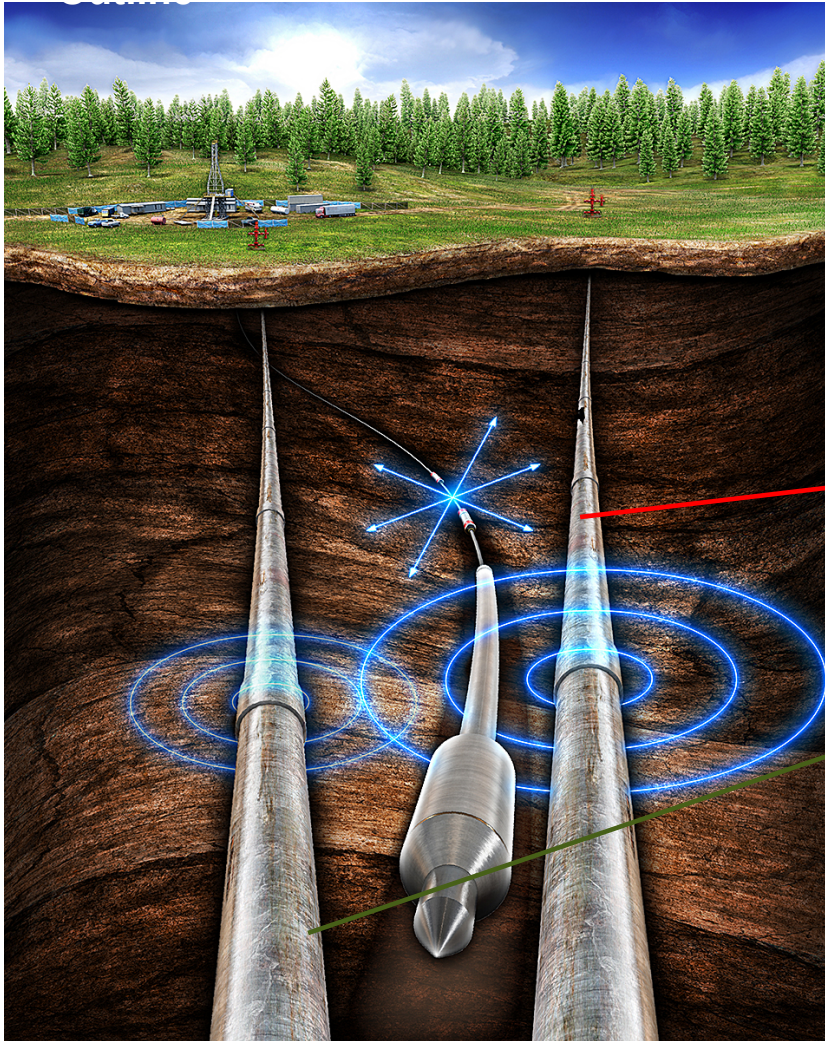


“Parasite” Wells and Associated Technical Considerations

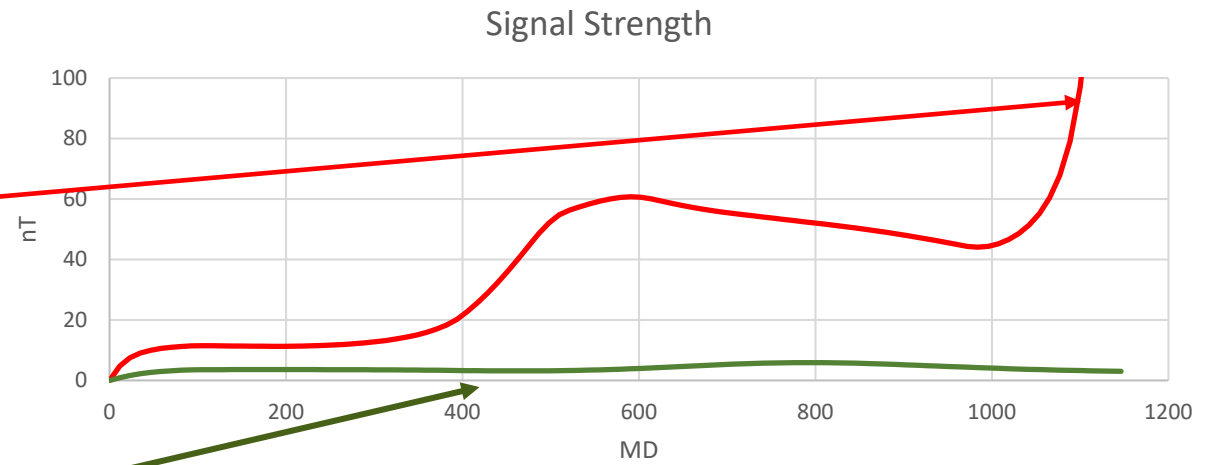
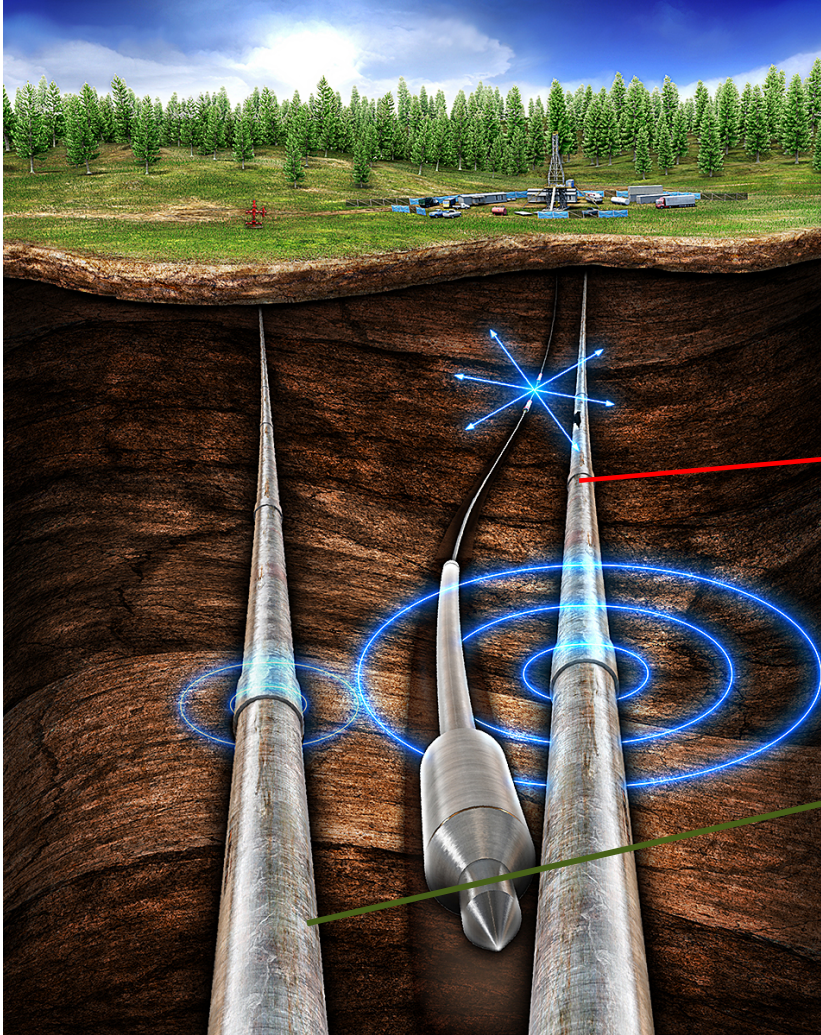


“Parasite” Wells – The Problem

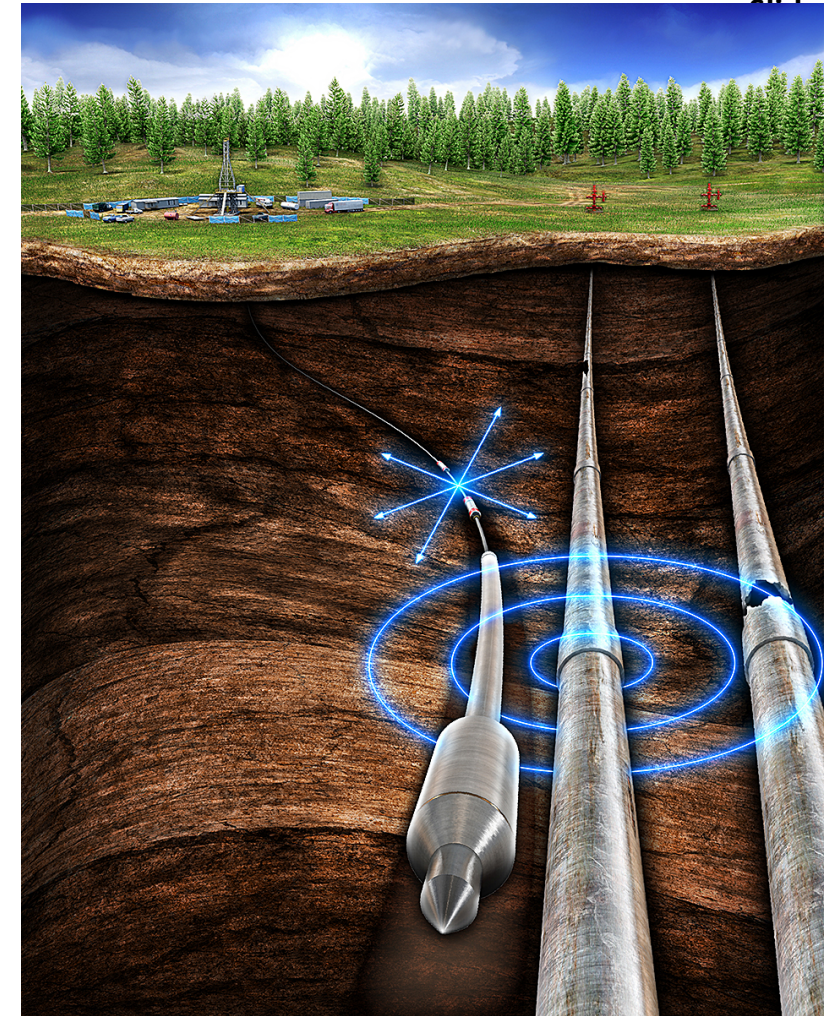
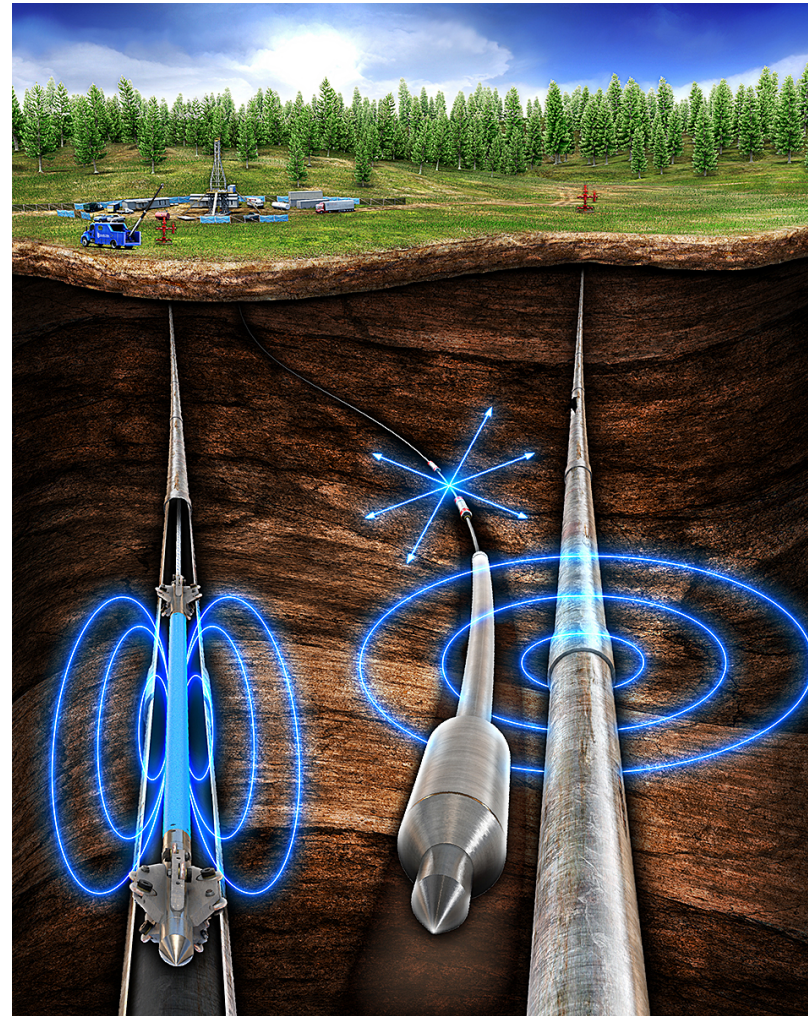
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“Parasite” Wells – A Cure

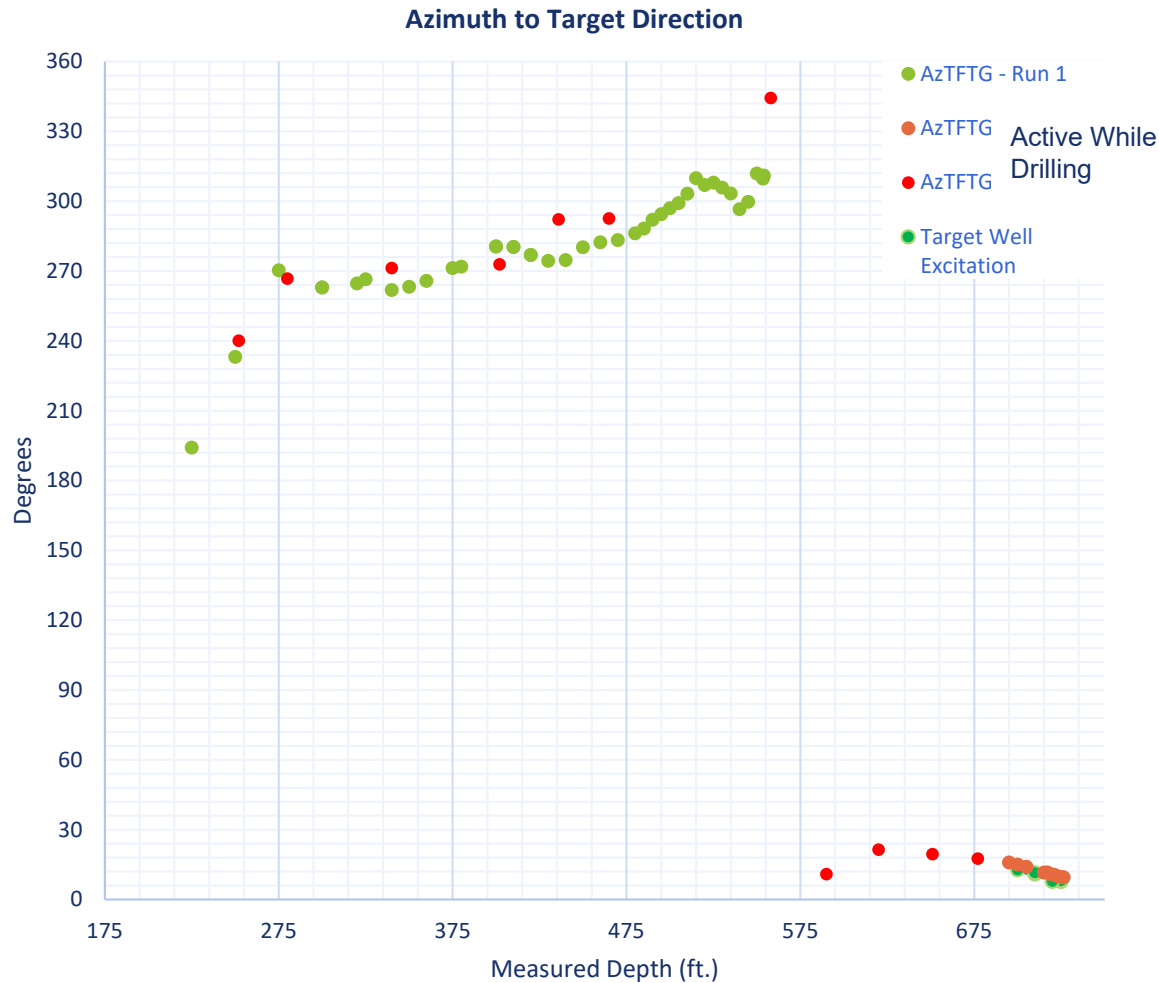


Other Ways Treat a Parasite



Sensor Response - Active Ranging with Drilling BHA

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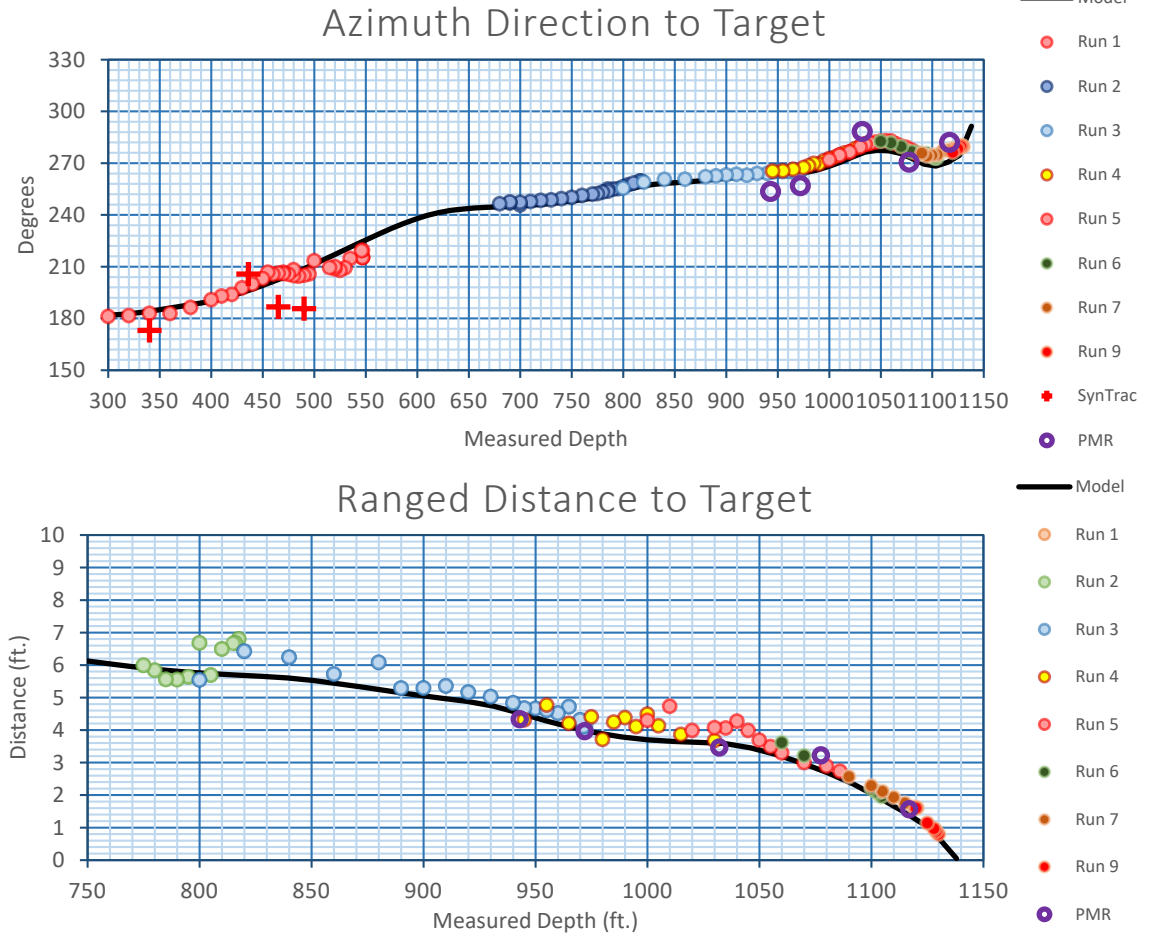


- + Injection on target well while drilling supplies real time Azimuth to Target when taking surveys
- + Consistency with models and actual data from active wireline tool
- + Application would be well location during surface hole
- + Potentially limits wireline ranging runs in shallow hole (down to 675 ft. in this example).



Ranging Data – Well 5

- Successfully milled into target well at 1132ft MD
- Low inclinations of ± 1 deg during follow phase – integrated gyro sensor used to derive tool orientation while taking active ranging data
- Successfully followed target well in close proximity while attempting to drill longer intervals
- Drop in signal and magnetic perturbation at 510-522ft MD indicates possible damage to casing
- Target well shift -0.24ft N, 0.2ft E



Milling Operations

- Intercept milling is eccentric – from open hole into the body of the casing for re-entry
- At shallow depths the “soft touch” can be physically identified
 - Hand, EDR, noise. Precise contact exact to a fraction of a foot routine
- Typically set a casing string in relief well prior to milling
- On 2 of the 2 attempts, successfully milled from open hole! – \$\$ from casing savings

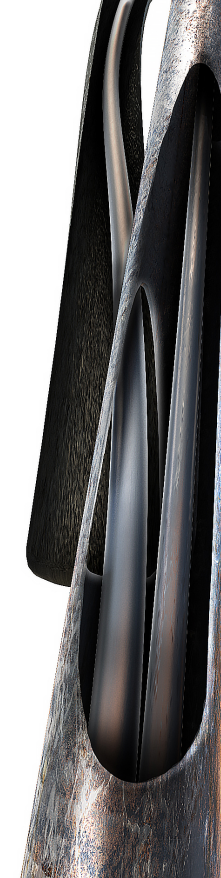
“They said it couldn’t be done, but sometimes it doesn’t work out that way” - Stacey Stengel



1. Soft Touch with BHA



2. Mill from Open Hole



3. Reenter with Tubing



4. Set Cement

Re-Entering the Target

1 Hr. Milling



Milling cuttings from ditch magnet

6 Hrs. Milling



Milling cuttings from ditch magnet

Before



Concave Mill

After



Mill face showing 2-3/8" tubing wear pattern



1"/12min (1/4"/3min) to start the ledge, 1 foot per hour once ledge established

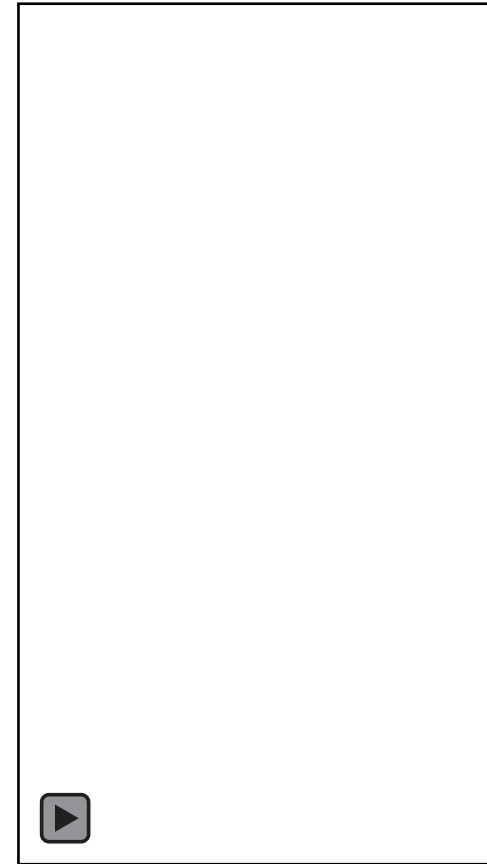
Aim for cuttings of 1/32" to 1/16" thick and 1" to 2" long



Re-Entering the Target



Bending first joint of tubing, can be oriented for re-entry through the window



Routinely run 1000' of tubing past the window into the target

The Results/Conclusion

- Rig Schedule planned wells to take **70 days** to abandon 5 wells
- Actual time taken +/- **36 days**
- **NO SIDETRACKS**
- Significant savings in time and cost realized
- Other efficiencies gained through elimination of hole opening and running intermediate casing
- Industry best practices work! ISCWSA intercept best practices can be used as foundational document to train other personnel involved in similar operations

Well No.	Intercept Depth (ft.)	Ranging Runs	Days Planned	Days Actual
1	1094	12	14	10
2	942	10	14	8
3	975	9	14	6
4	906	8	14	6
5	1132	7	14	6
		Total	70	36

