



Smart Exploration - Prototypes

SkyTEM – Improvement of depth of investigation of the airborne EM system

Per Gisselø (SkyTEM)

- Smart Exploration
 - Prototypes
- SkyTEM
 - 312HP standard system
 - Case study
 - Technical details
 - Technical developments for 6.25 Hz operation
 - Validation surveys
 - Blötberget mine site

- Seismic Mechatronics: E-vibe source
- Bit Sim: Slimhole hydrophone
- Mic Nordic: GPS time synchronization
- SGU: UAV-borne EM-system
- SkyTEM: Depth enhanced helicopterborne EM system

Linear Synchronous Motors



Contact free

No friction/Low distortion

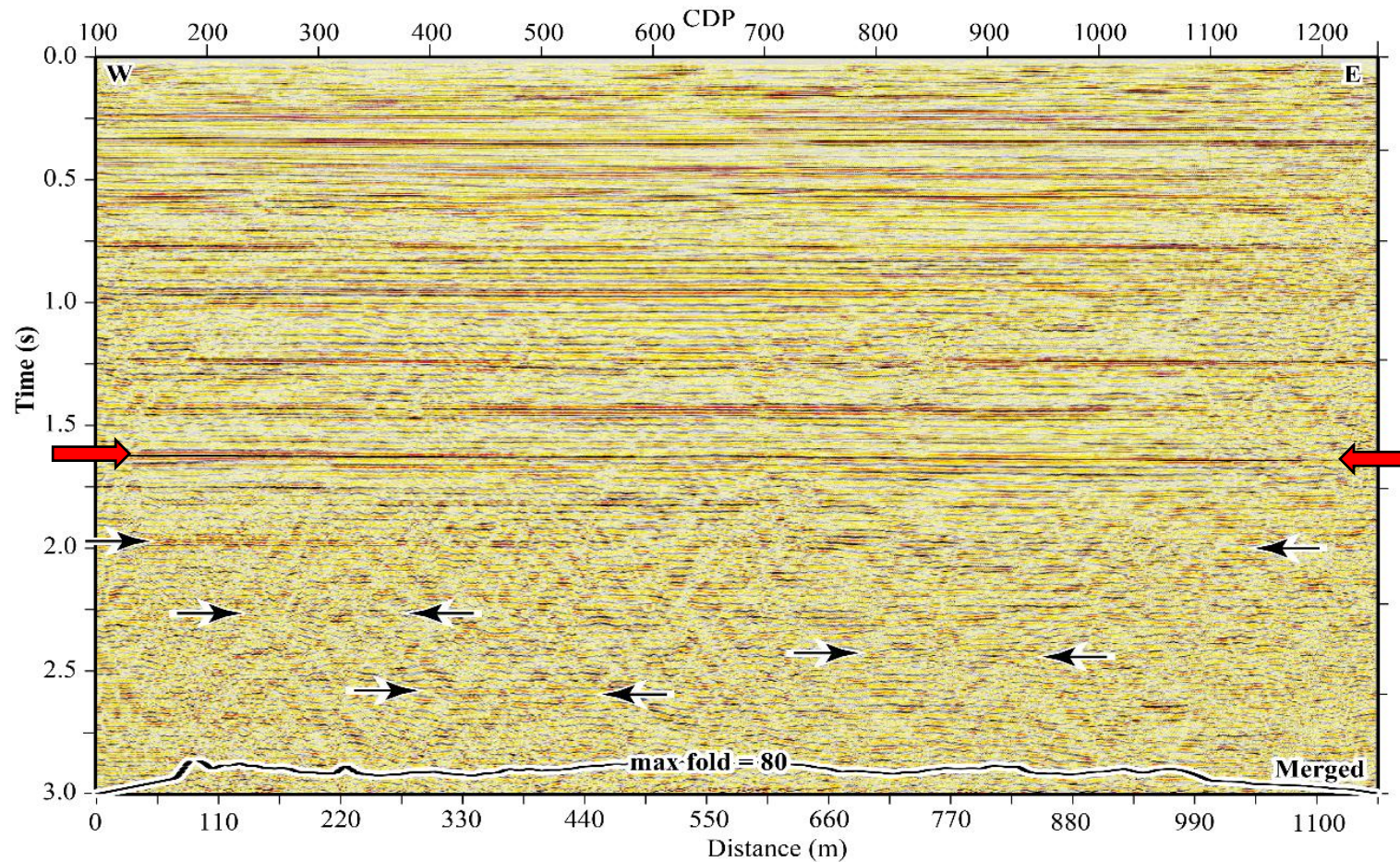
High controllability/Repeatability

Broad bandwidth/low frequencies

7kN (1500lbs) electric seismic source – 2-200Hz Full Force



The merged datasets (wireless + streamer) resolve better both upper portions and structures below 1.6 s.



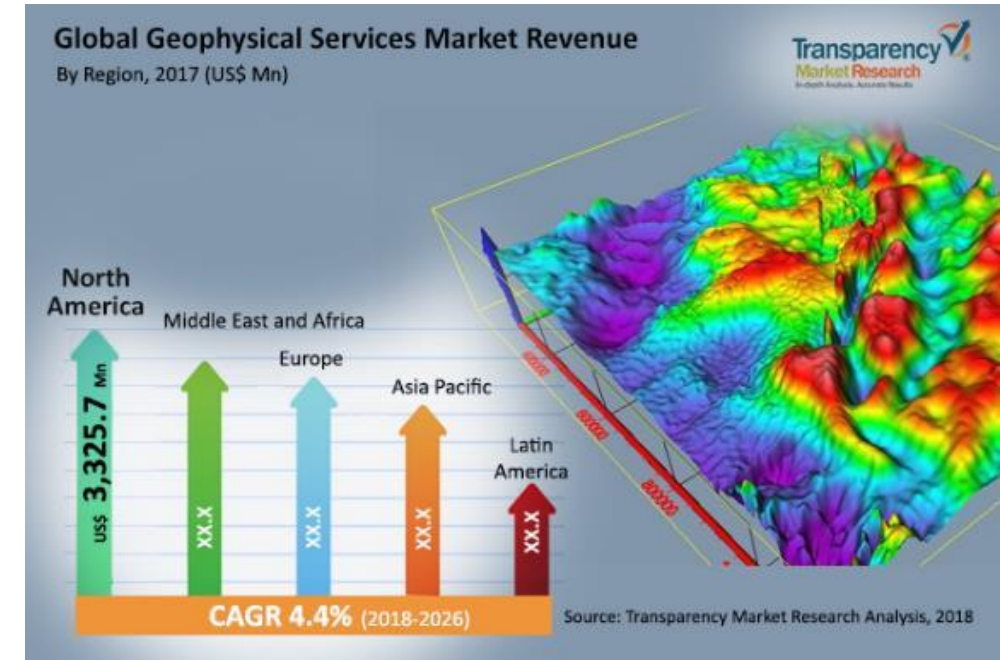
Down to 1.6s easily with
7kN source! (3km)

Deeper events seen (~2.6
s)

Slimhole hydrophone

Pressing needs:

- **Growing world-wide demand** for geophysical services
- **Need to for deeper exploration >1000m**
- **Slimholes NQ size (48 mm): Very thin** and slender sensor equipment
- **Using digital design new components to improve Signal Quality and lower power consumption**
- **Modular and Expandable – not always a fixed number of sensors**

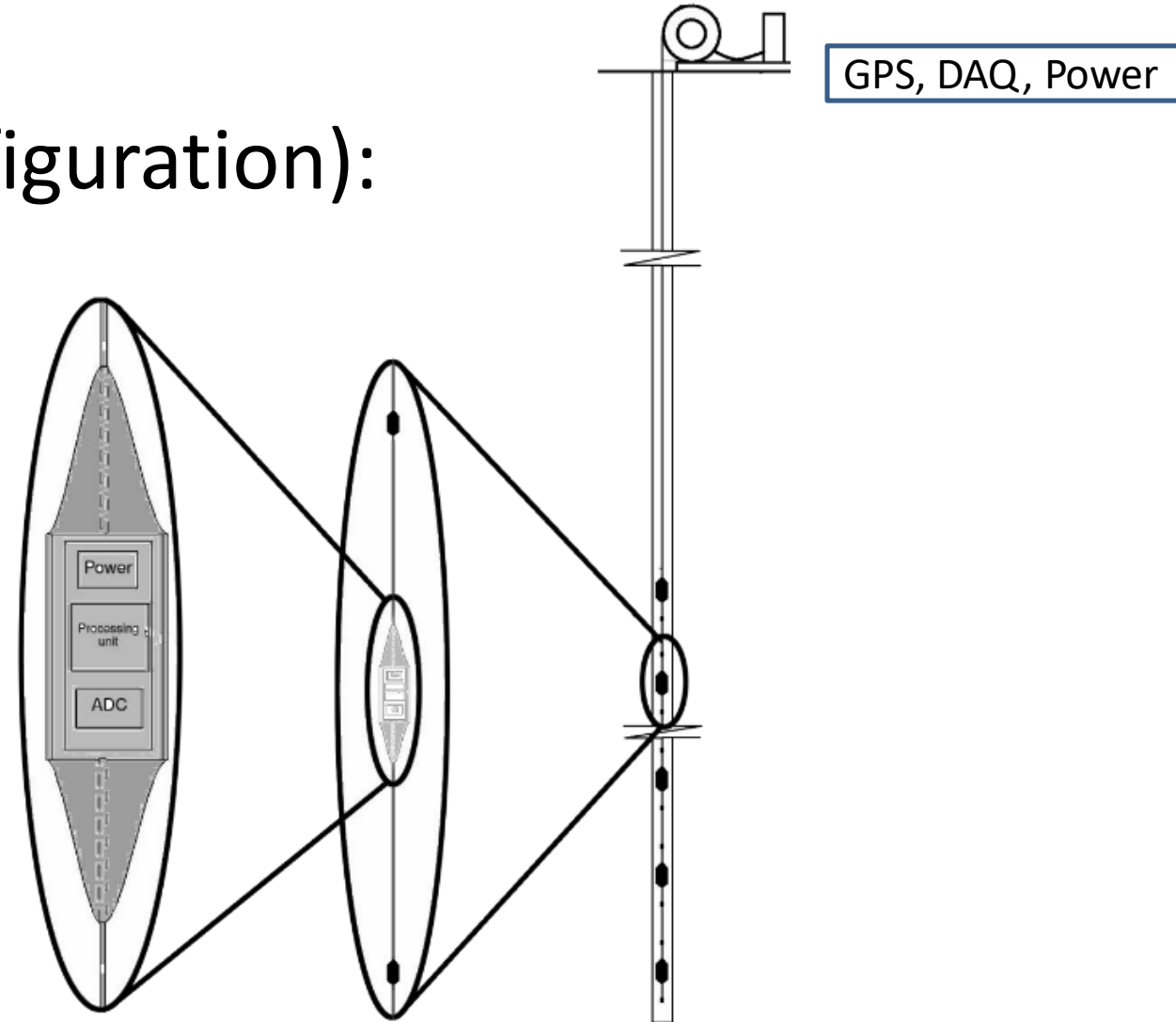


High demand for geophysical data acquisition services and increase in investments in the mining sector for geophysics are anticipated to propel the geophysical services market during the next 5 years.

Slimhole hydrophone

The system consist of (max configuration):

- Array of 100 hydrophones
- 50 bottles
- 1500m downhole cable
- 50x20m (1000m) string

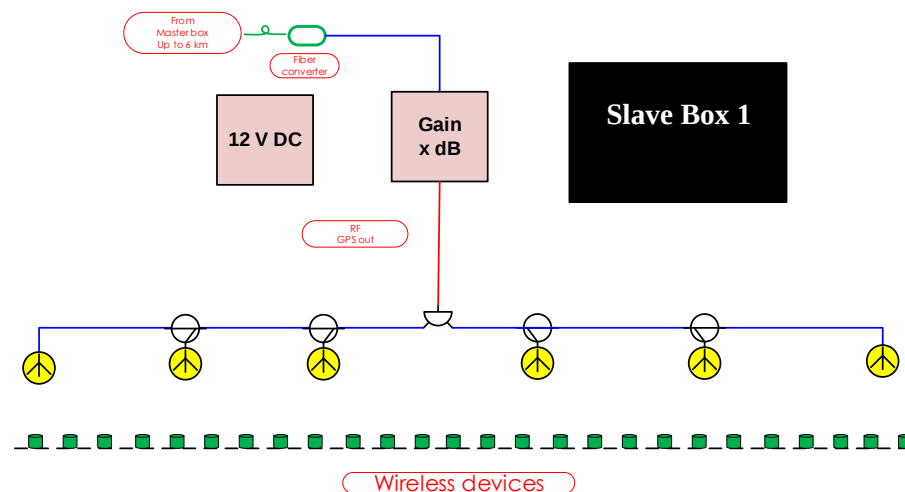
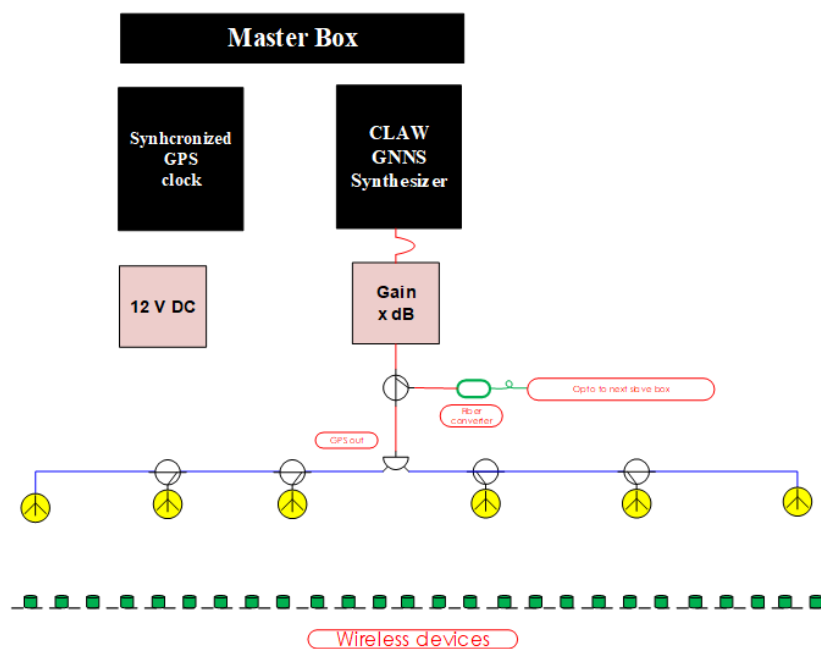


GPS time synchronization

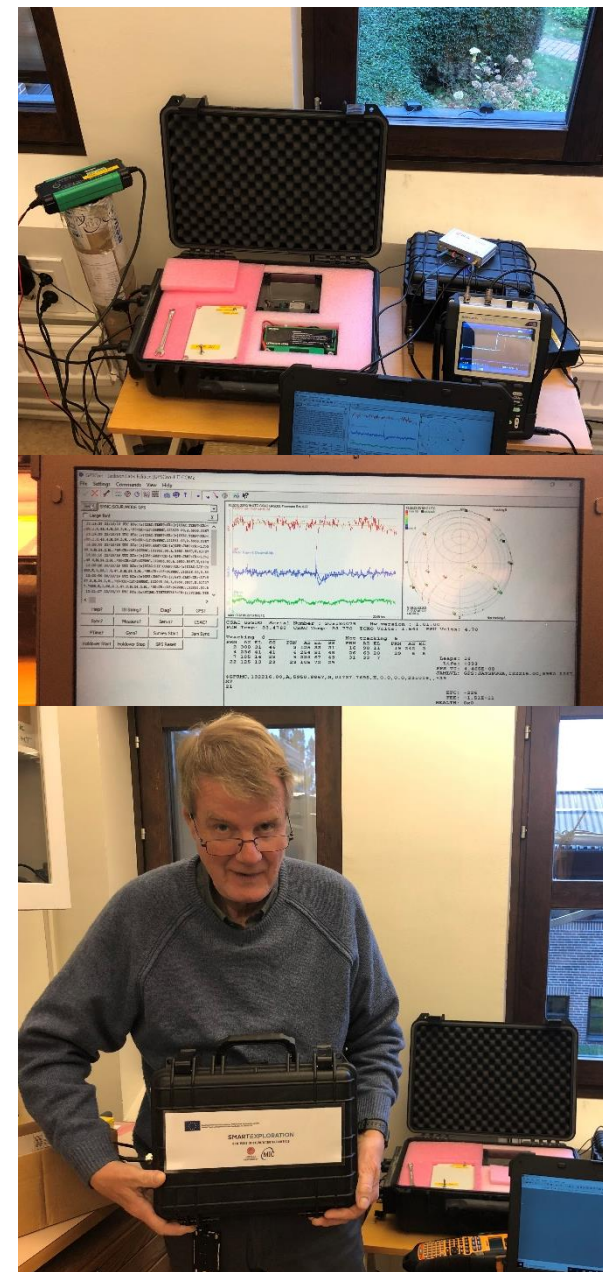
A prototype has been developed to accurately (micro-second accuracy) provide time (relative or real) to an array of various sensors (seismic, electromagnetic etc.) placed in different tunnels and in different depth levels

Strengths

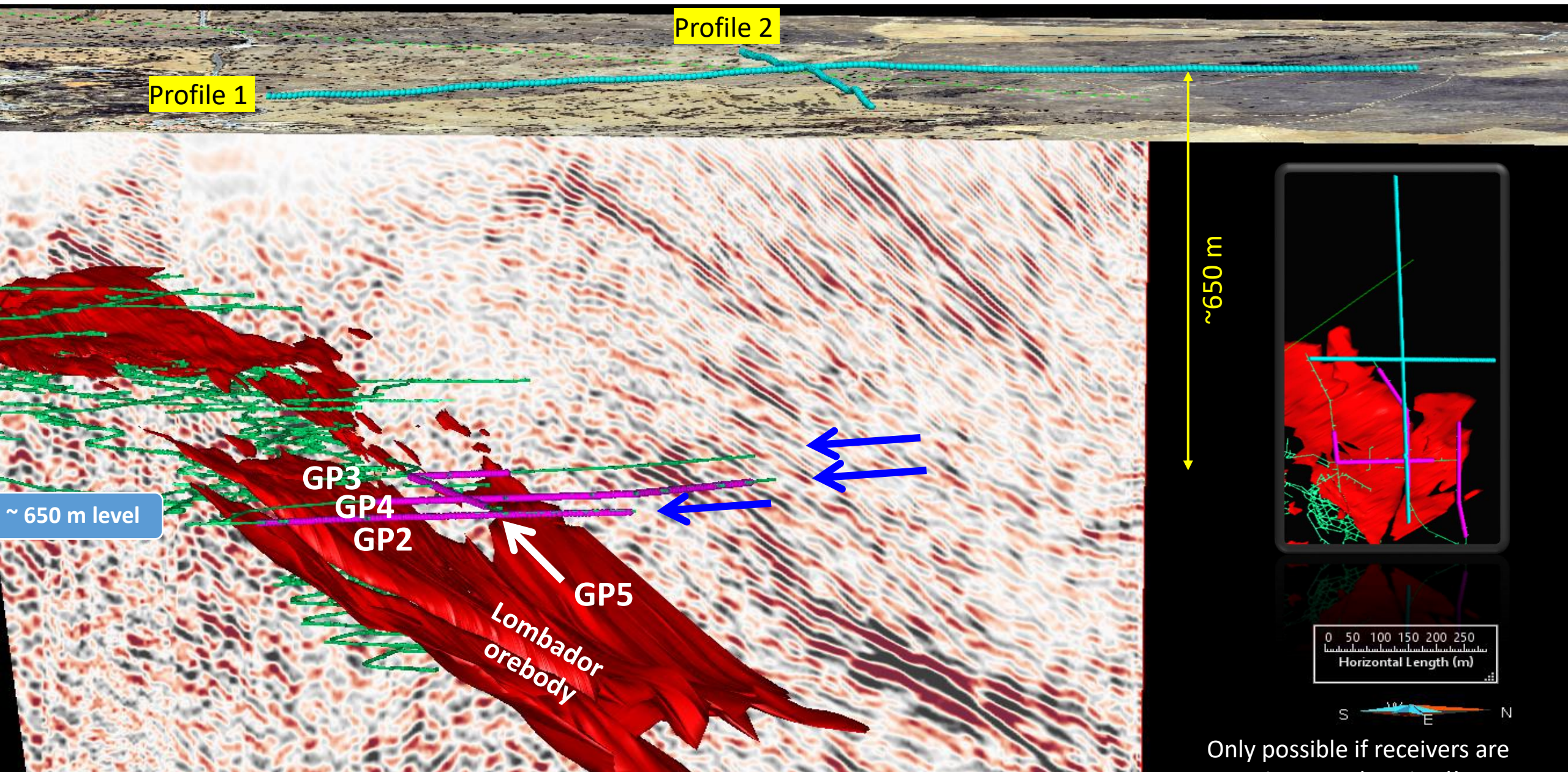
- ① Transportable
- ② Easy to set-up
- ③ Modularity
- ④ No need to revise existing recorders



Fiber-optic equipment, Master and Slave units where the slave unit is connected to the Master via fiber-cable



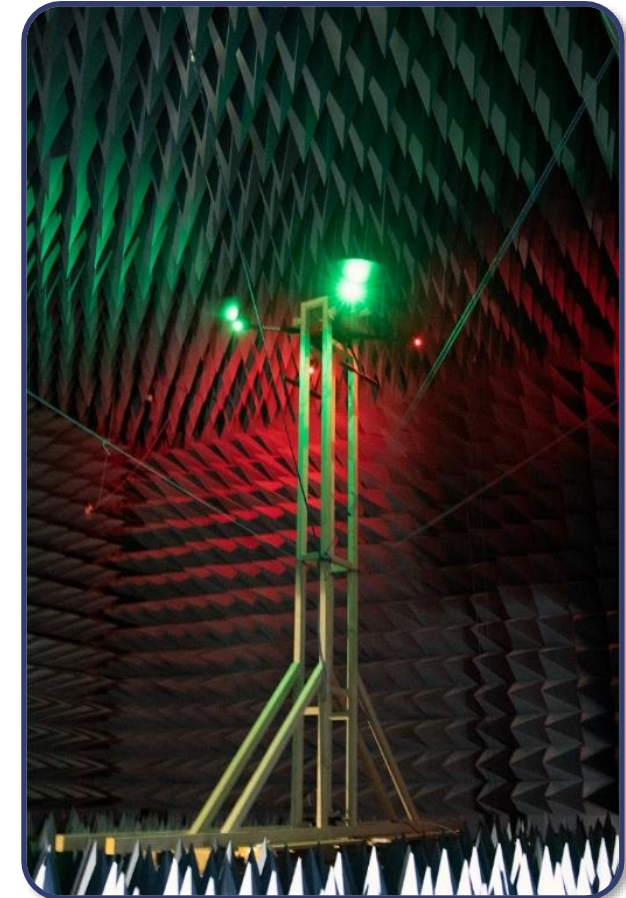
GPS time synchronization



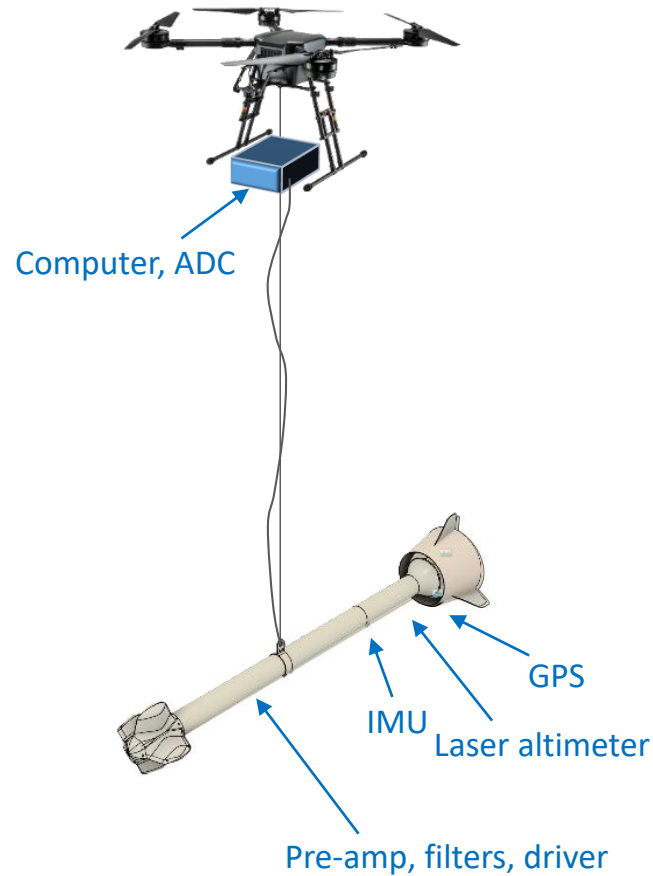
UAV-borne EM System

Custom Built Quadcopter

- Assembled by AMKVO
- Designed for at least 20 min flight time with 5 kg payload



UAV-borne EM System

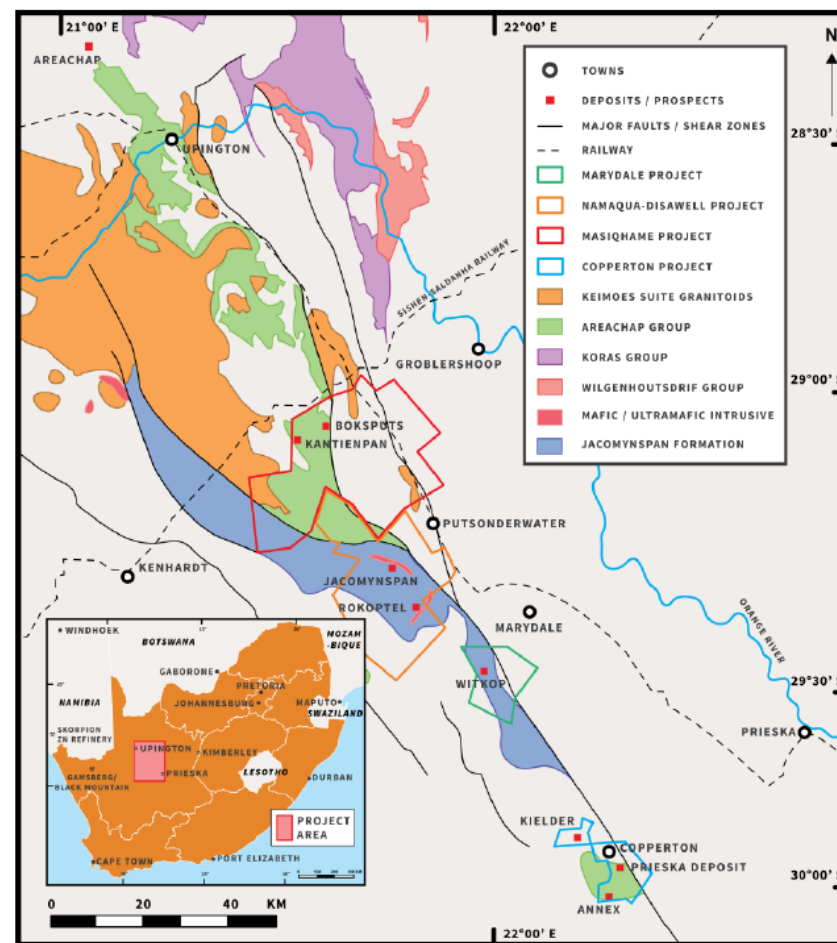


Specifications

- 3 components (X, Y, Z)
- Bandwidth 1 – 350 kHz
- Response 25 mV/nT
- Continuous sampling
- GPS synchronized sampling

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- Areachap Belt, Northern Cape, South Africa
- Orion Minerals has tenements and projects in the area
- Exploration programme started in 2017 and comprised geophysics and drillings

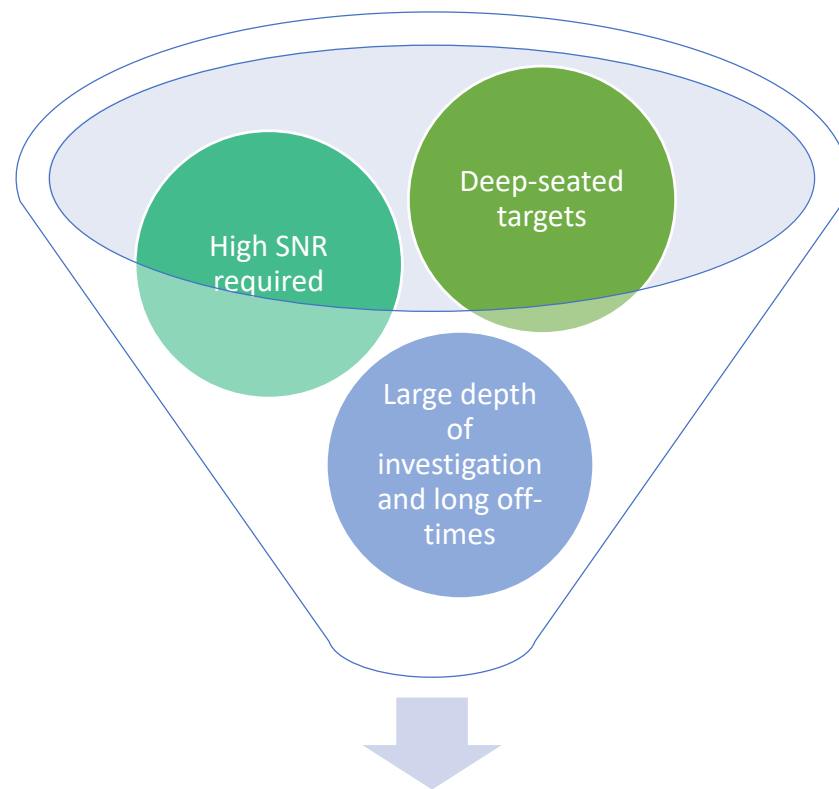


Overall geology Areachap Belt

- **Zn- and Cu-rich VMS occurrences** are present throughout the Areachap Belt and occur in a host of gneisses, amphibolites, and schists
- **Ni-Cu magmatic deposits** present. Several of these are well-known, for example **Jacomynspan**, which is a Ni-Cu-PGE intrusion.



Selection of HTEM system



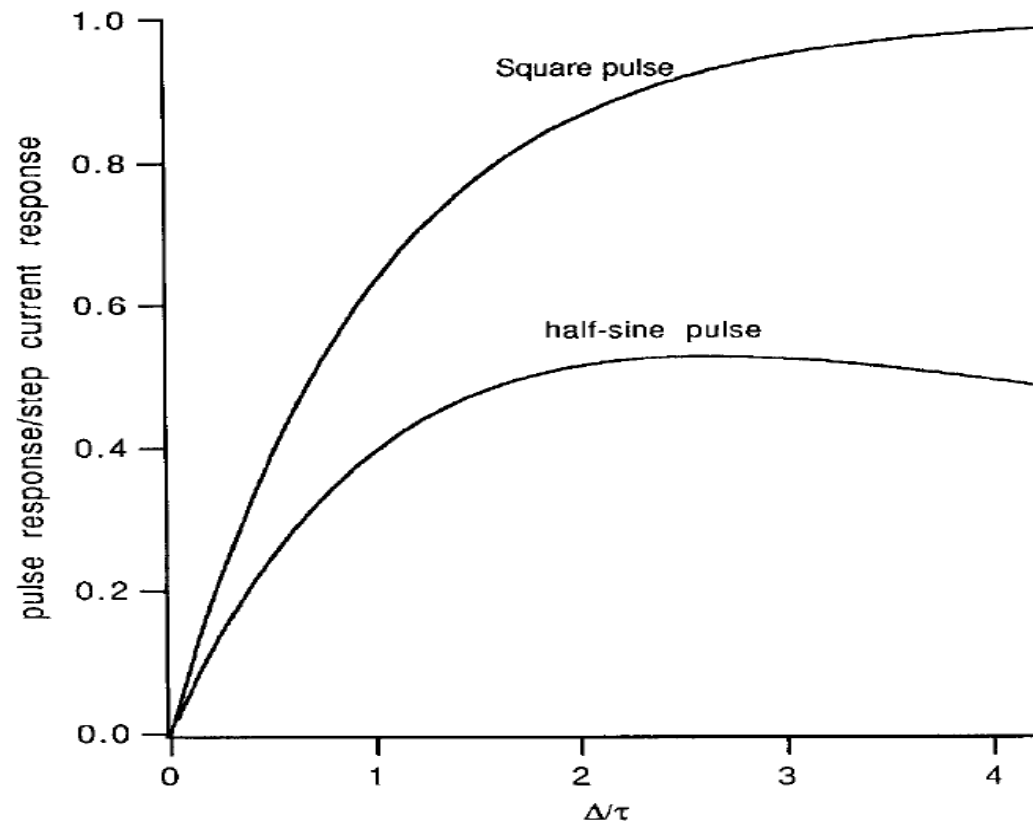
SkyTEM312HP

SkyTEM312HP at a glance

- Used routinely since late 2017:
 - 15 projects
 - Flown more than 70,000 line-kms
- Large depth of investigation (DOI):
 - High dipole-moment (up to 1,000,000 Am²)
 - Low noise level
 - Square current waveform
- Outstanding characterization of conductors:
 - Low base frequency of 12.5 Hz
 - B-field measurements (new feature)

Late time response¹

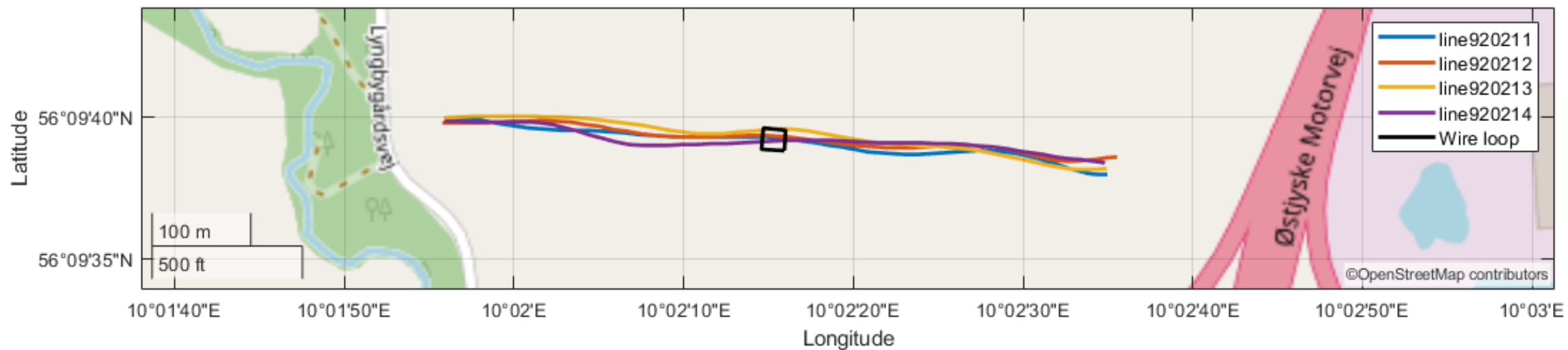
- $V_{square} = \frac{a}{\tau} \left(1 - e^{-\frac{\Delta}{\tau}}\right) e^{-t/\tau}$
- a: Tx amplitude
- Δ : Pulse width (8 ms SkyTEM312 HP)
- τ : Time constant



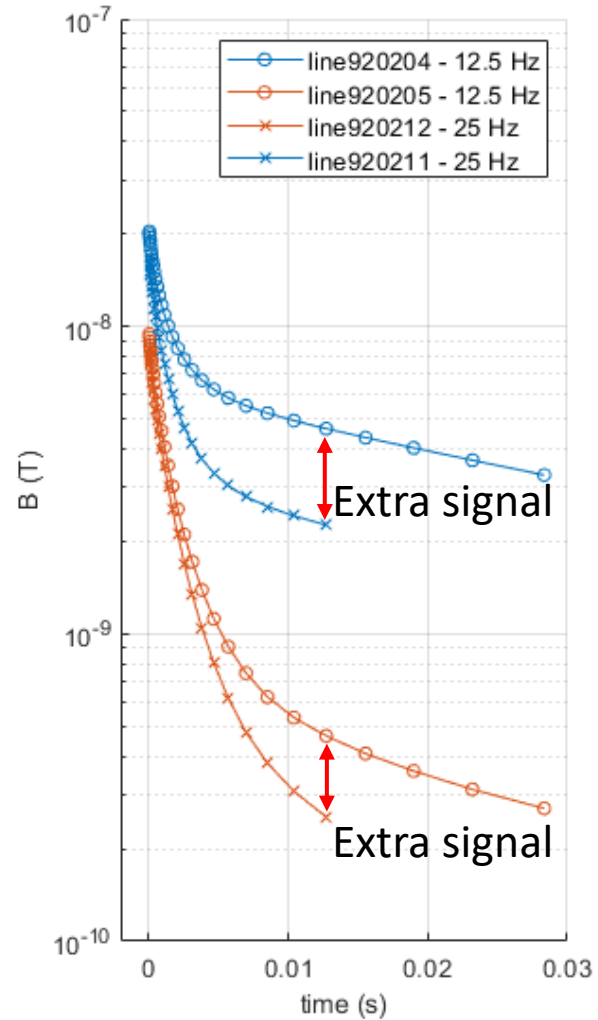
- Square loop with an area of 521 m²
- Time-constant 47 ms of wire loop target



Profiles over wire loop target



Square current waveform



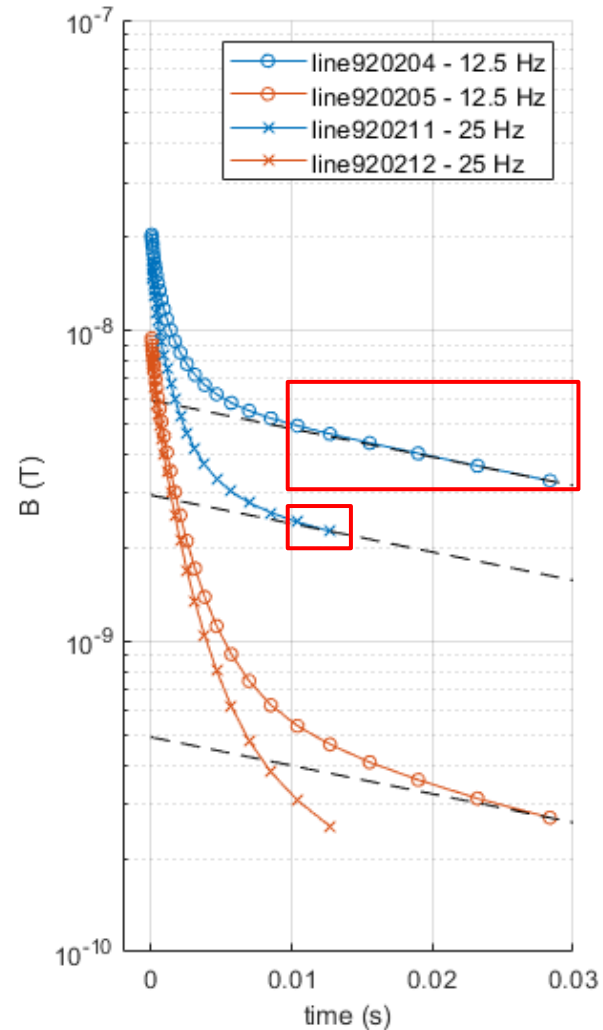
Wire loop target: $\tau = 47$ ms

Blue lines: 30 m height

Red lines: 50 m height

25 Hz (cross): pulse duration 5 ms

12.5 Hz (circles): pulse duration 8 ms



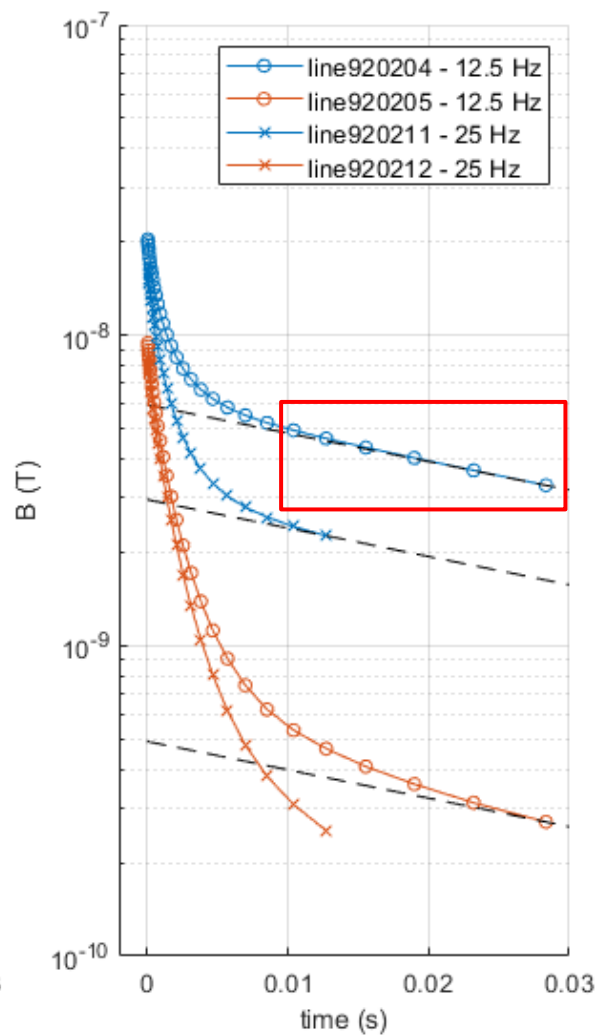
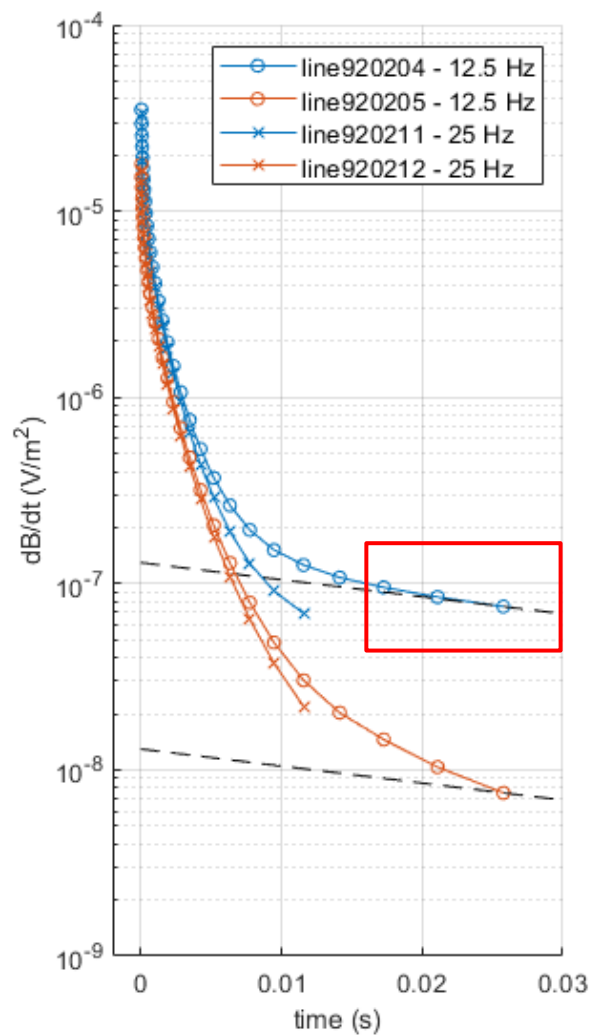
Wire loop target (dashed lines): $\tau = 47$ ms

Blue lines: 30 m height

Red lines: 50 m height

25 Hz (cross): off-times 15 ms

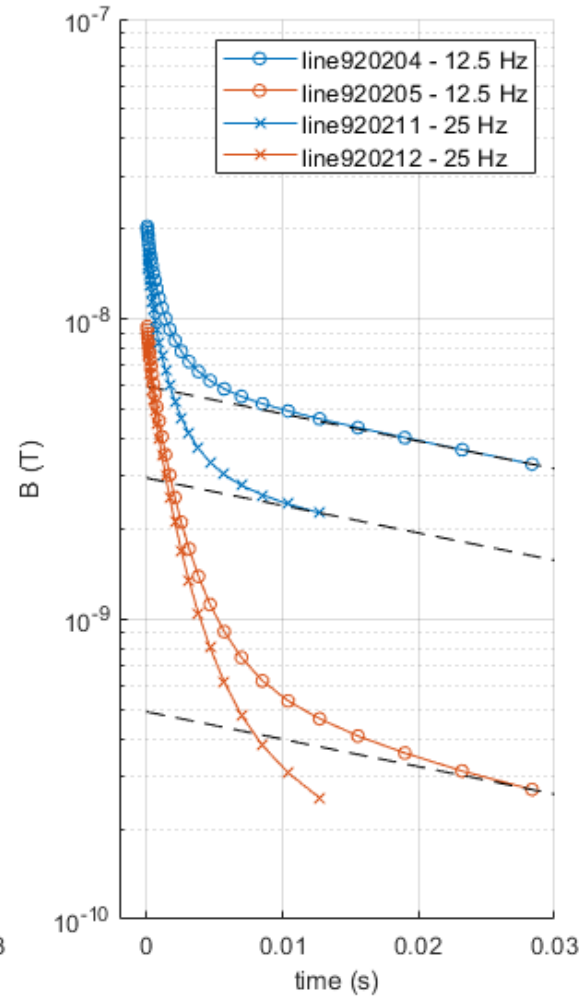
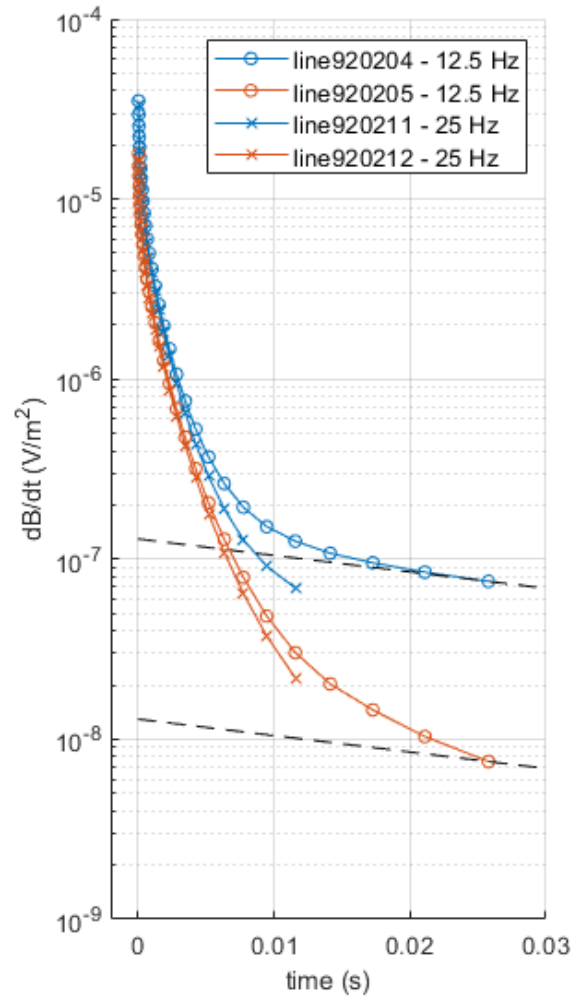
12.5 Hz (circles): off-times 32 ms



Wire loop target (dashed lines): τ
= 47 ms

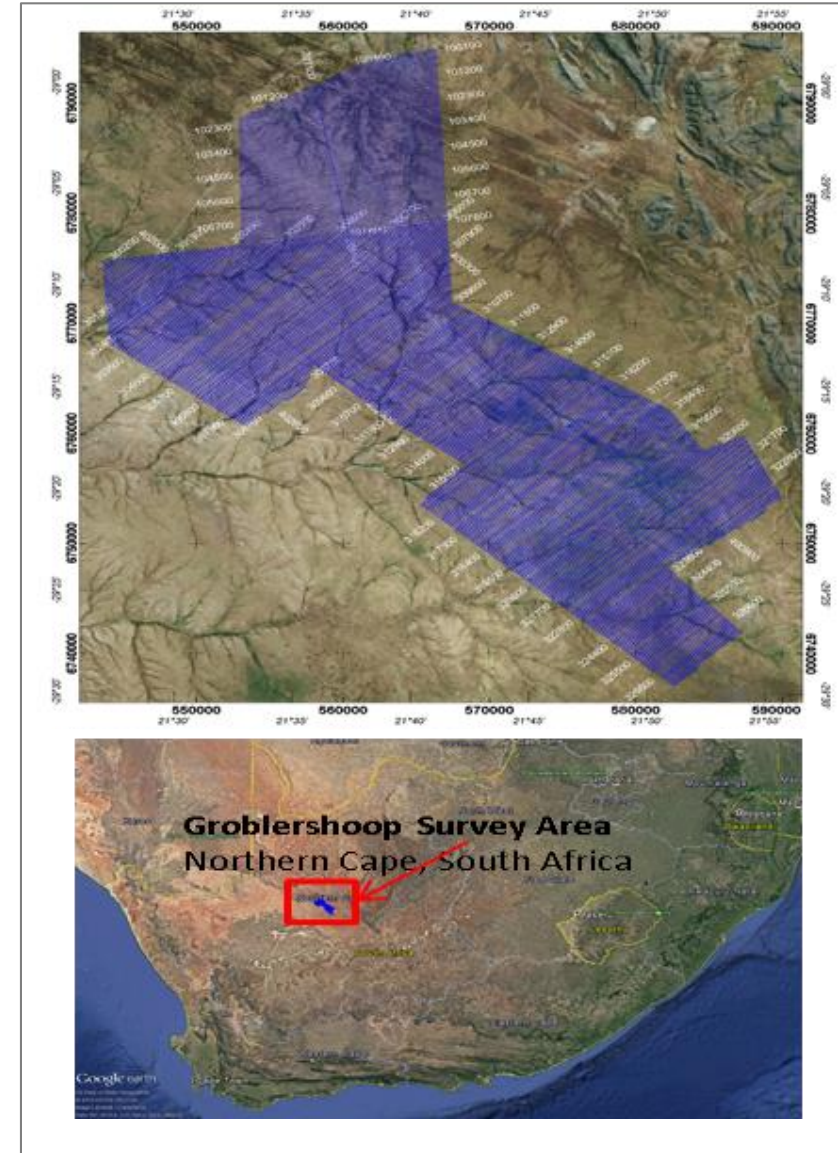
Blue lines: 30 m height
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Summary low base frequency and B-field

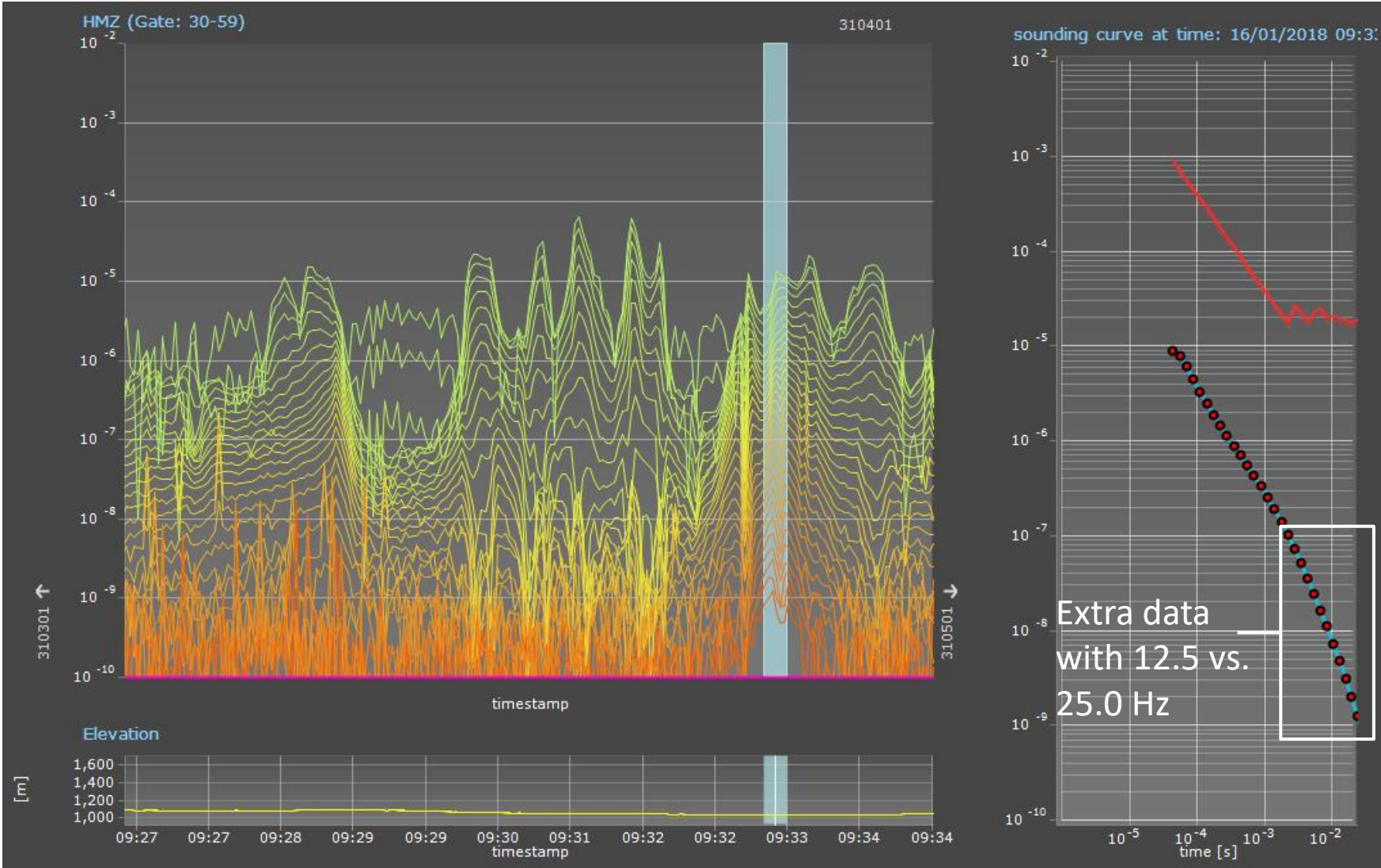


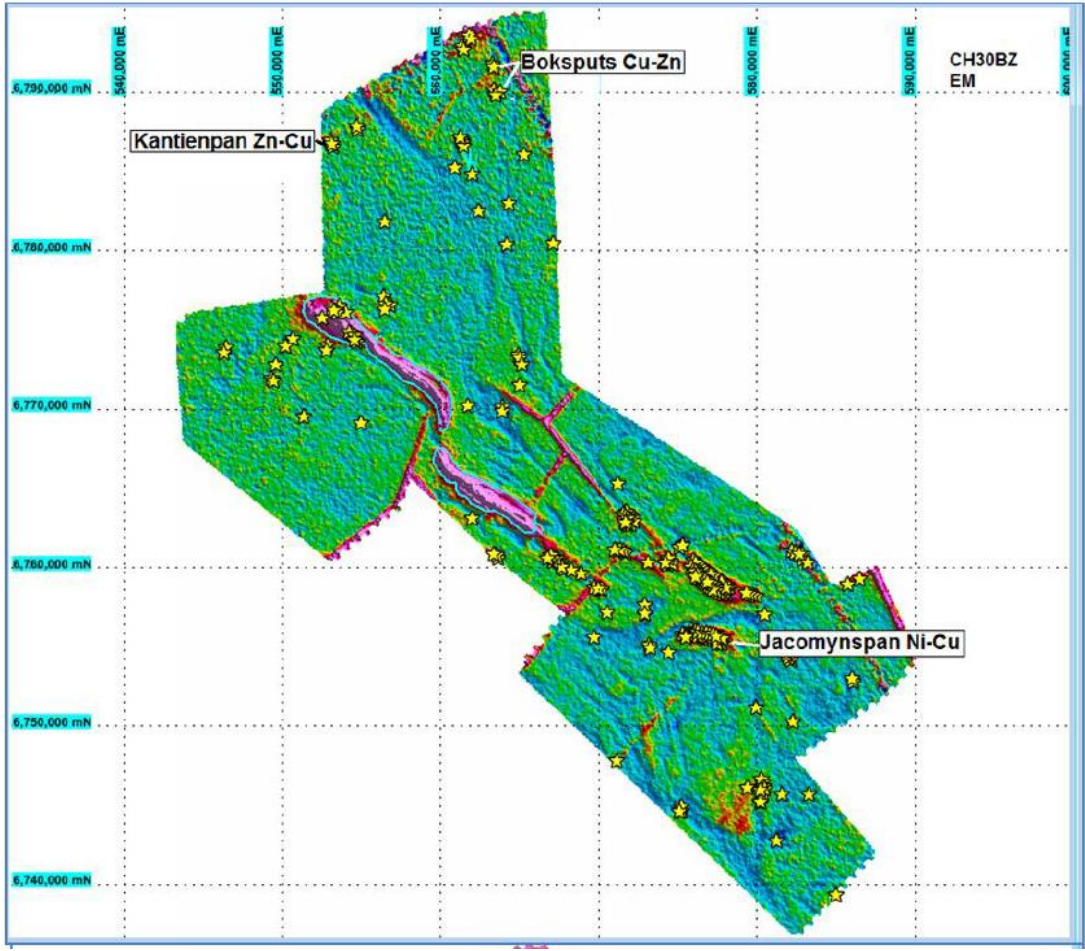
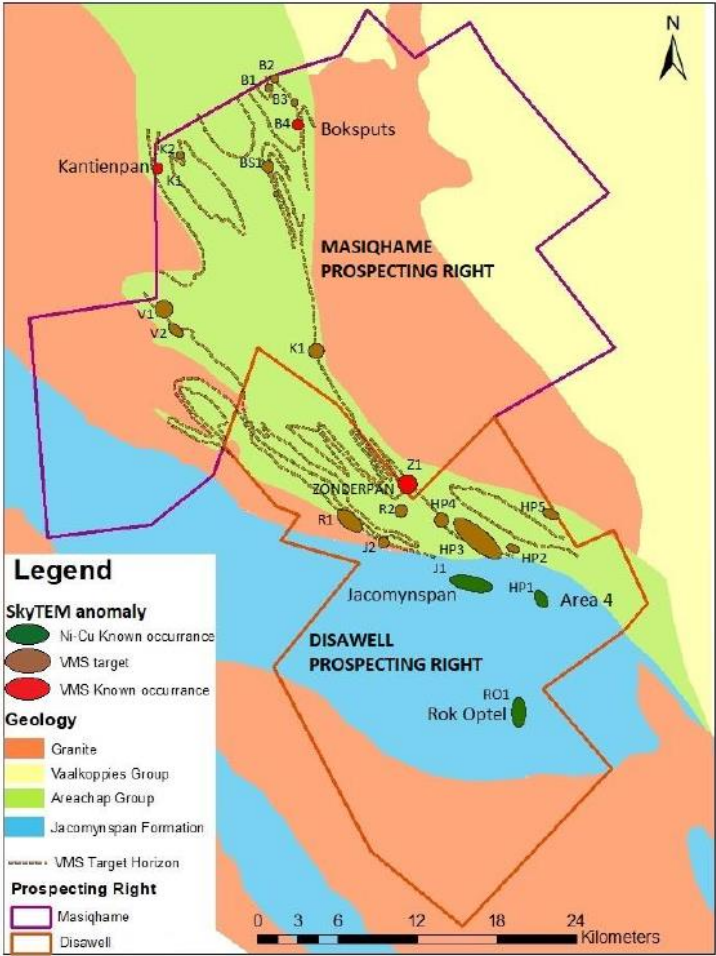
- Improved characterization of conductors:
 - Long off-times
 - Long pulse duration
 - B-field measurements

- Survey area: 962 km²
- 200 m line spacing
- 80 kph acquisition speed
- 6,000 line kilometers



Low base frequency (long off-times)





Known and new anomalies

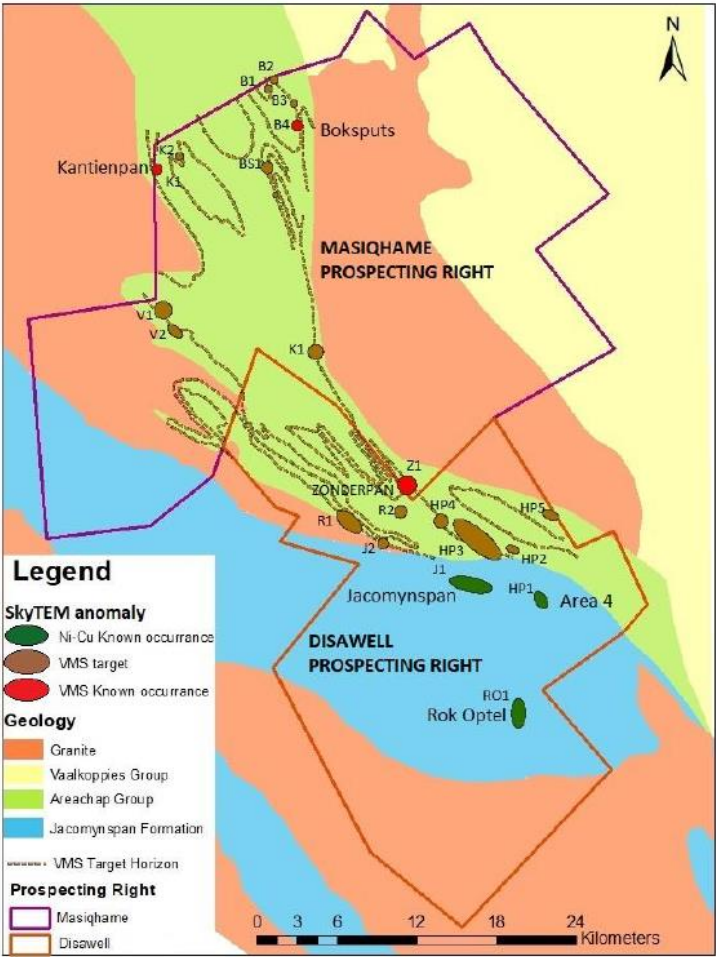
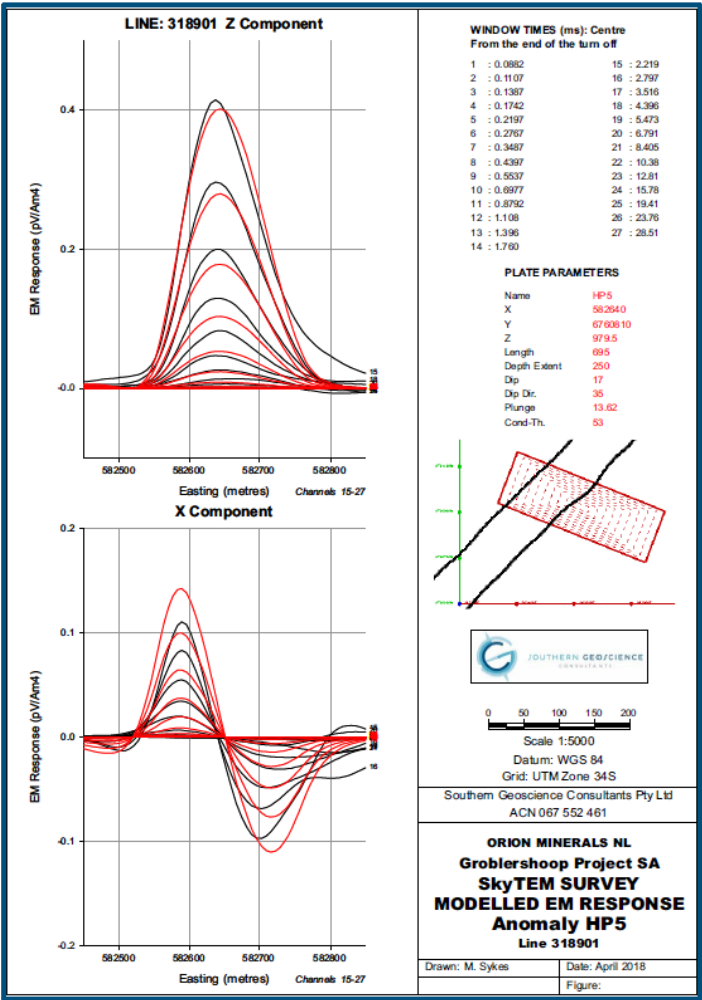
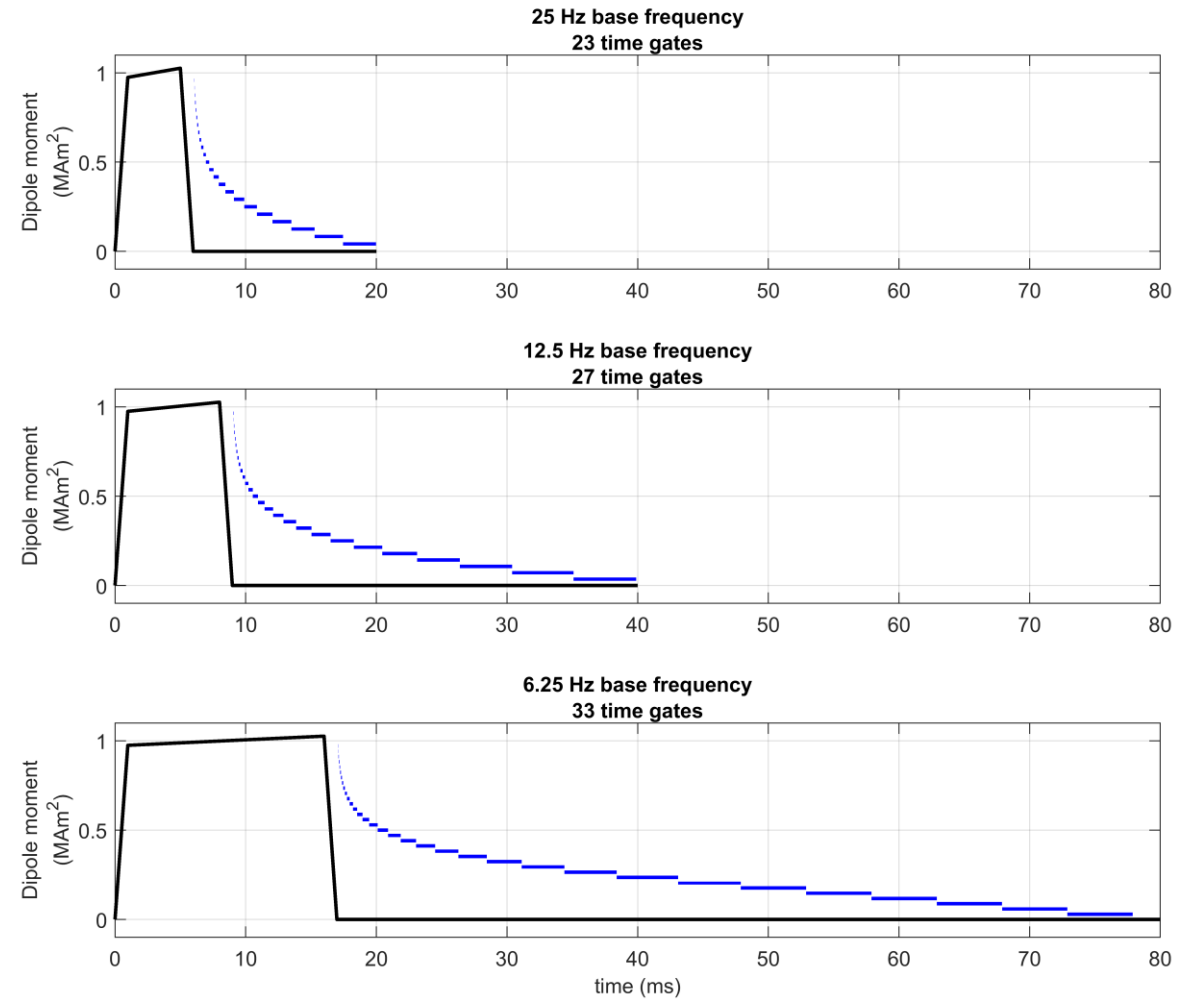


Plate modelling of SkyTEM anomalies

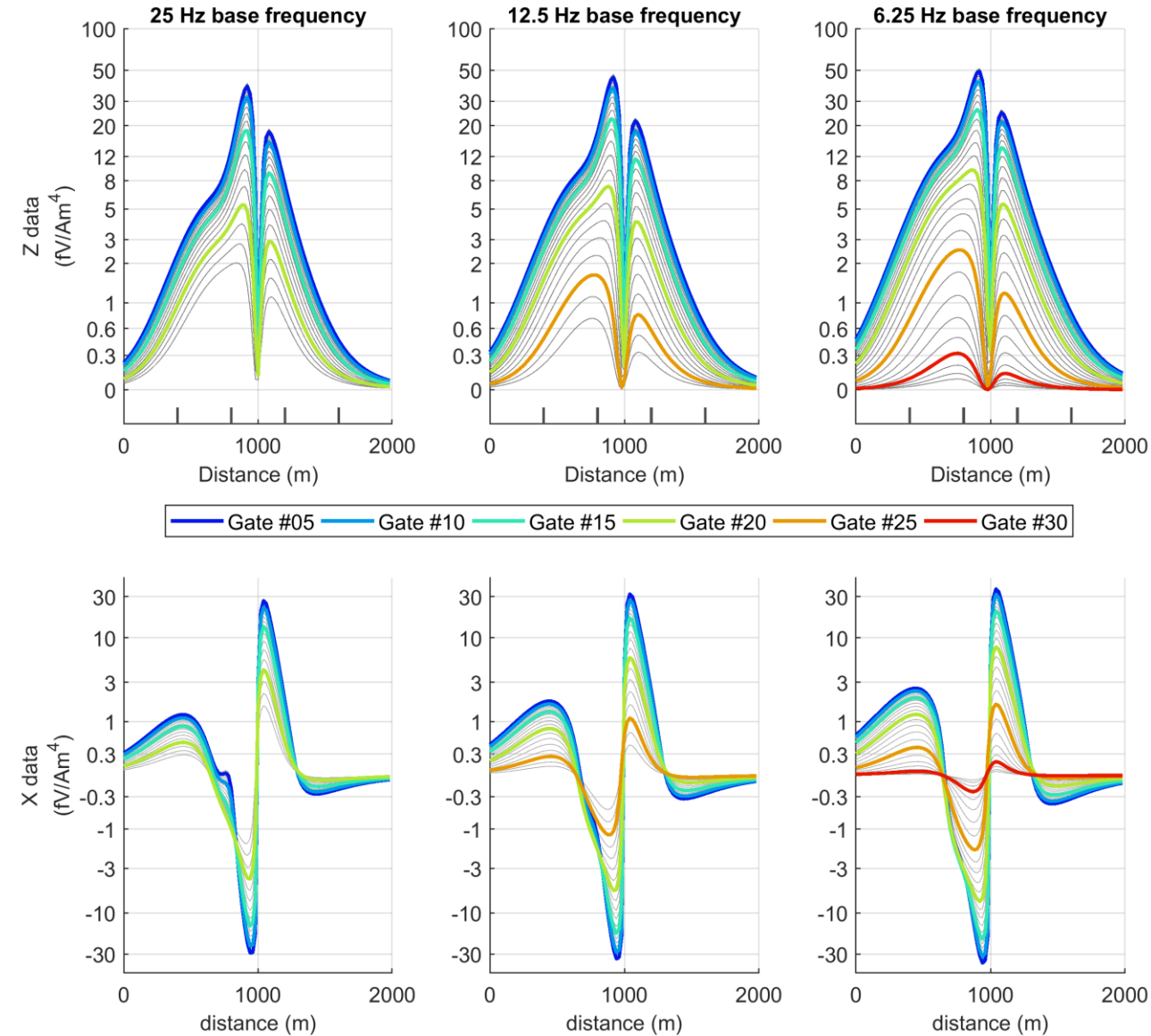
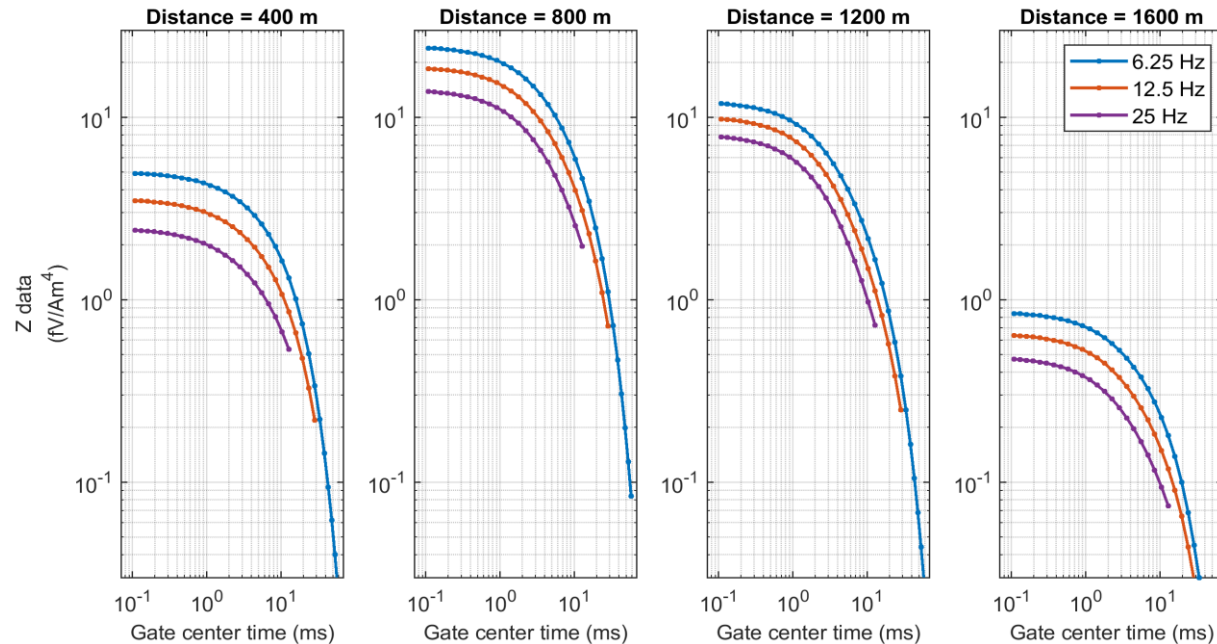


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- Technical developments for 6.25 Hz operation
 - Transmitter signal
 - Reduced noise level
- Validation survey
 - Blötberget mine site

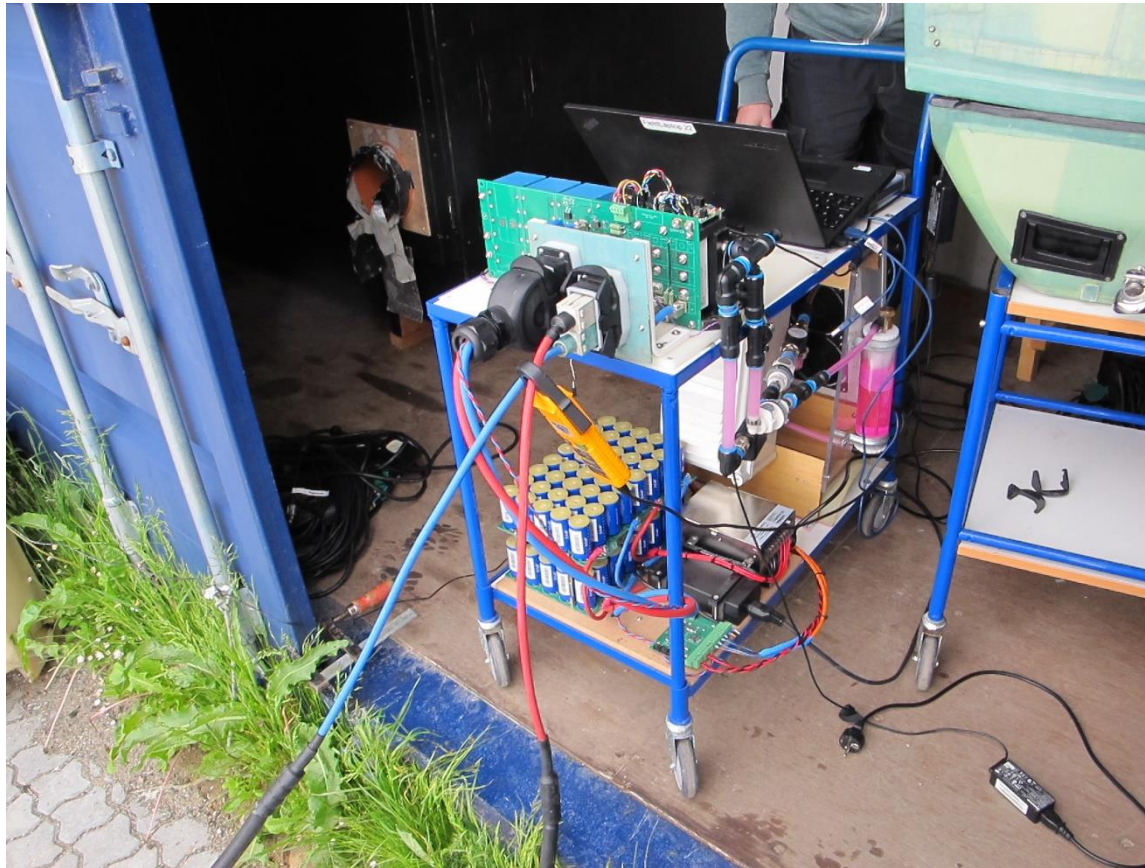
- 6.25 Hz Operation
 - Waveform
 - Increased ontime
 - Longer offtime



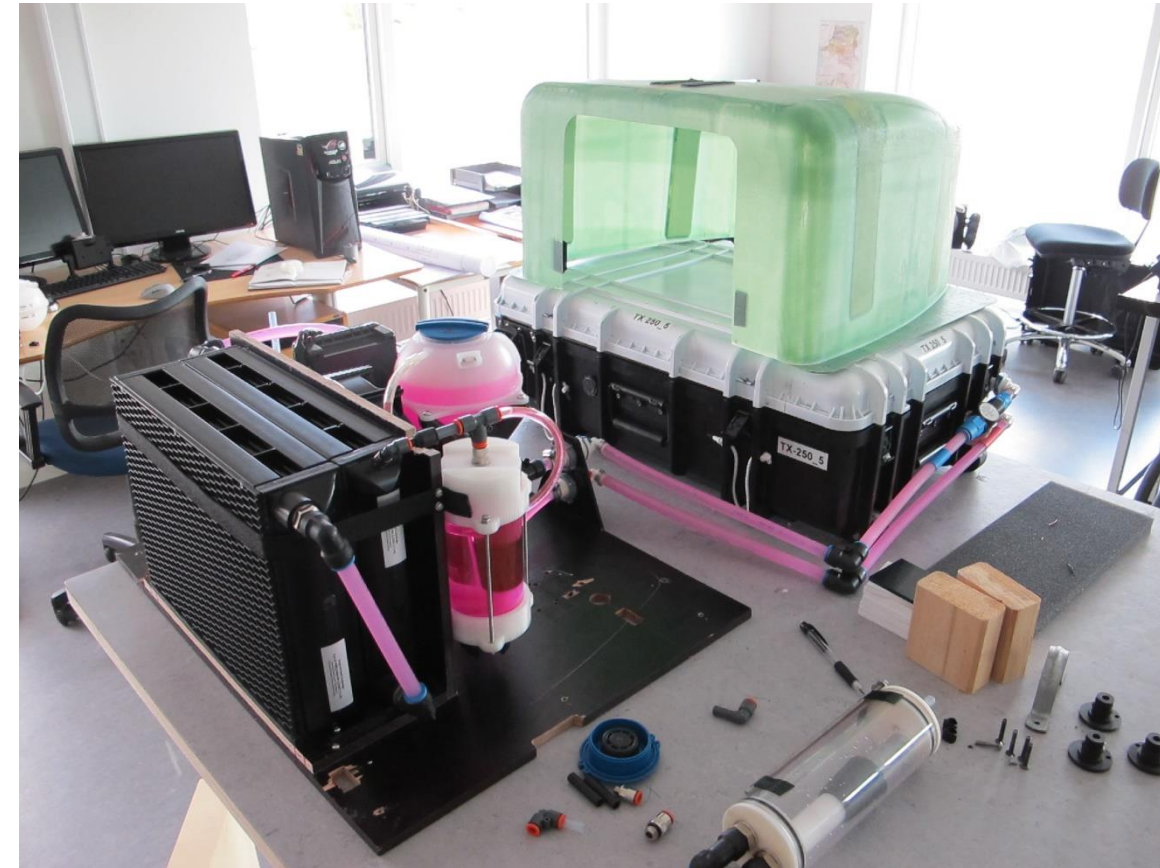
- 6.25 Hz Operation
 - Thin sheet model response
 - MaxwellII
 - Plate extending to 1000 m below surface



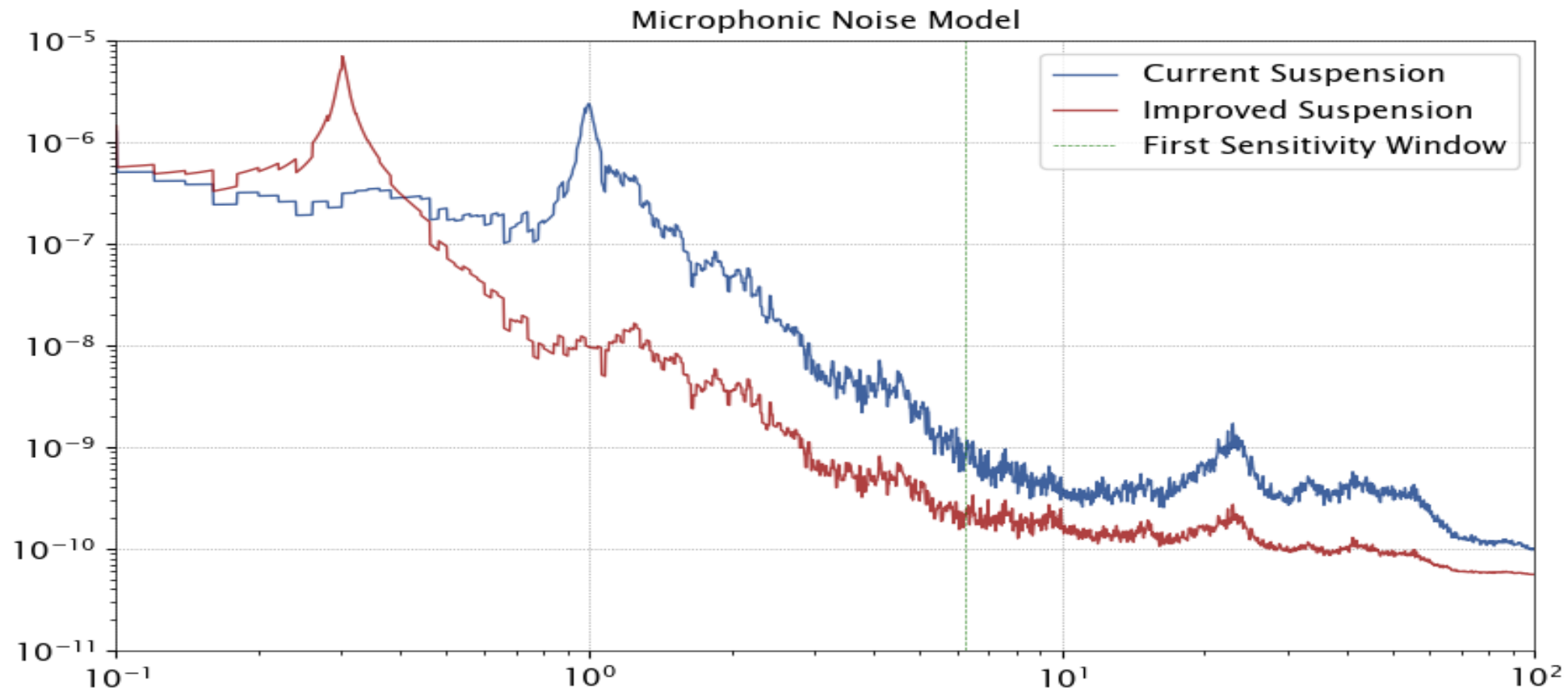
- 6.25 Hz Operation
 - Transmitter Bench Test
 - Firmware upgrades
 - Hardware endurance



- 6.25 Hz Operation
 - Cooling unit
 - Increased efficiency
 - Reduced weight



- Receiver platform
 - Operated at very low frequencies



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- Partners: NiO, SGU, UU
- Flown Kilometers: 577 km
 - Three configurations
 - 25Hz, 12.5 Hz, 6.25 Hz
 - Increased DOI with signal to latest



SMARTEXPLORATION
new ways to explore the subsurface

Öppet hus för helikopterburen TEM

Nordic Iron Ore (NIO) tillsammans med SkyTEM, båda partners i EU projektet Smart Exploration, kommer att utföra helikopterburen djuppenetrerande transient elektromagnetisk (TEM) mätning i Ludvikaområdet. Vi vill bjuda in allmänheten för att titta på utrustningen, ställa frågor och dricka en kopp kaffe. Varmt välkomna!

Var: Ludvika Flygfält

När: 19 juni 2019 11:00 - 16:00

Kontakt: Emma Bäckström, geolog, Nordic Iron Ore AB

Mer information
Projektet fokuserar huvudsakligen på utveckling av kostnadseffektiva, miljövänliga verktyg och metoder för geofysisk prospektering i svårtillgängliga och djupliggande områden. Mer information om projektet finns på www.smartexploration.eu, YouTube och LinkedIn.



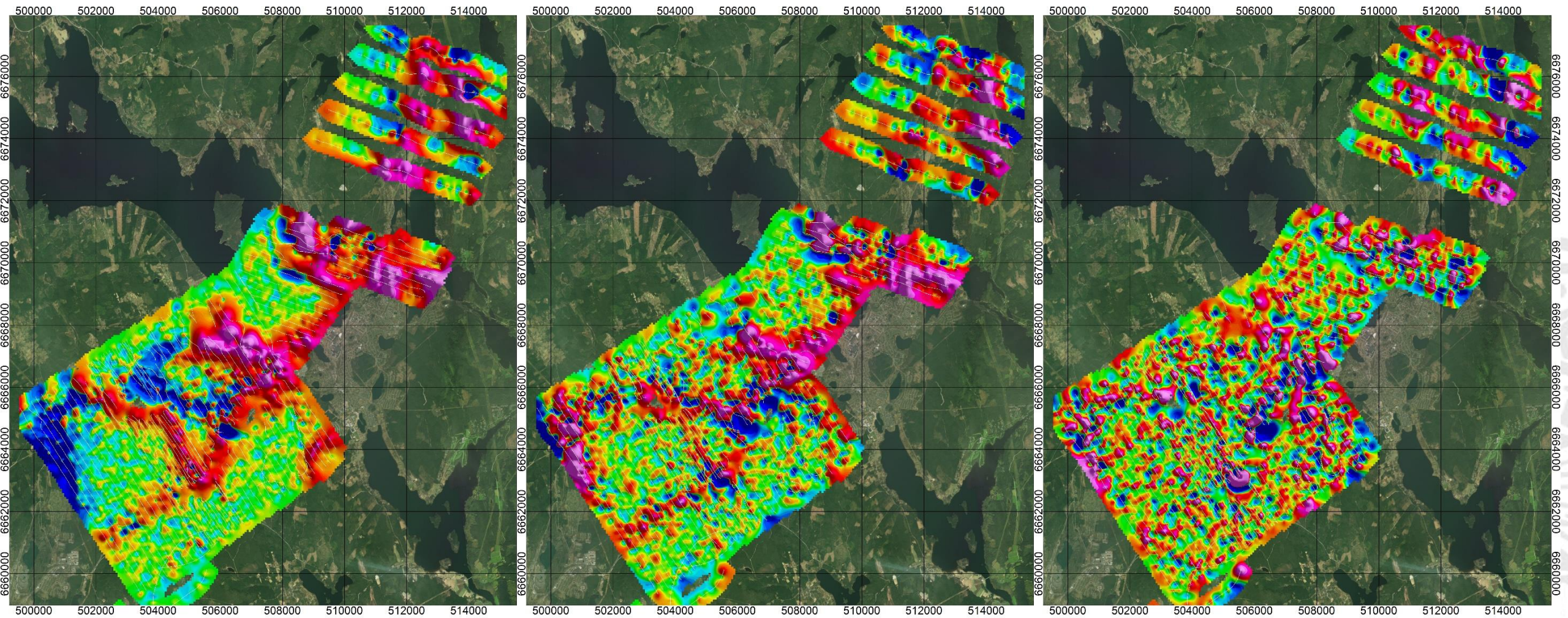
WWW.SMARTEXPLORATION.EU

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SMART EXPLORATION HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO. 775971



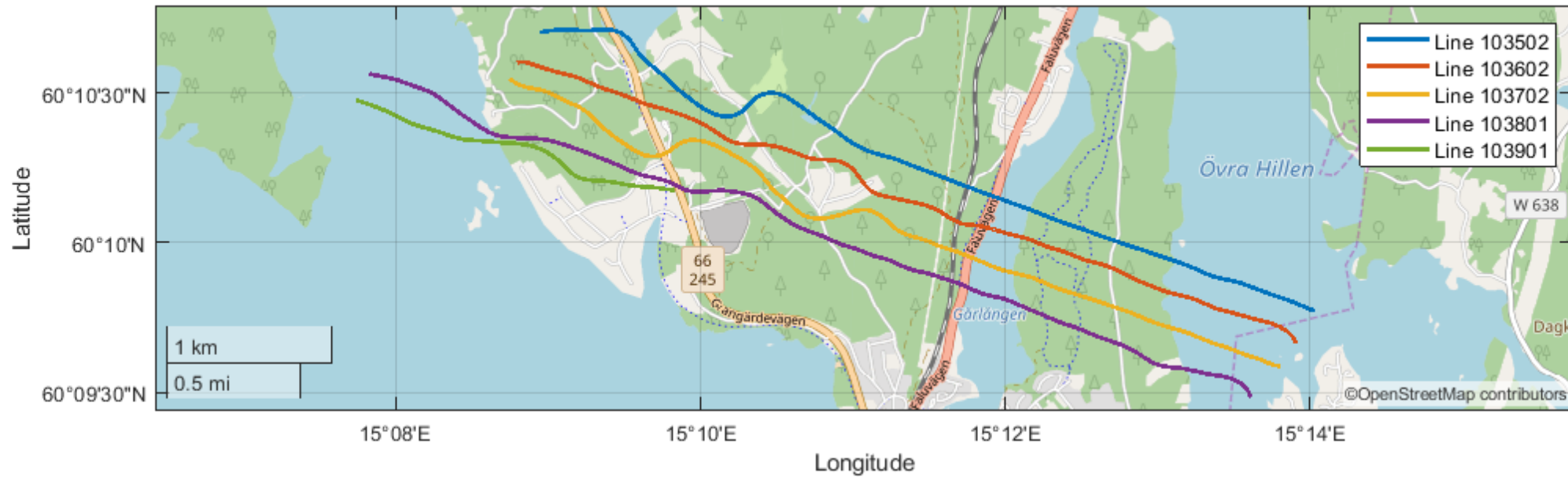


Early gate

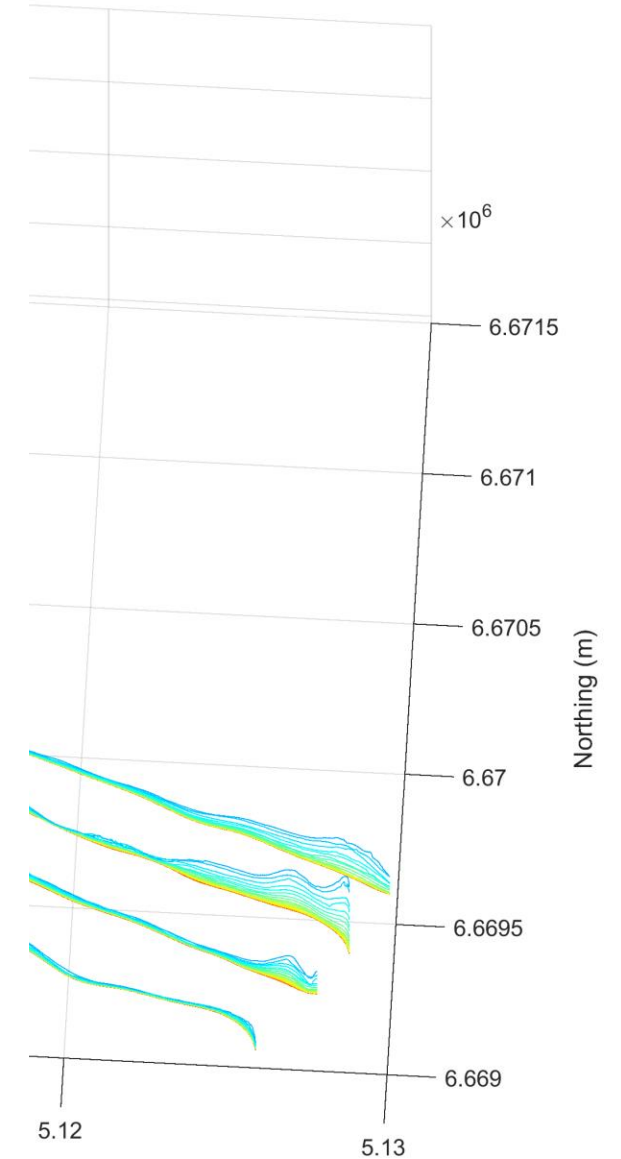
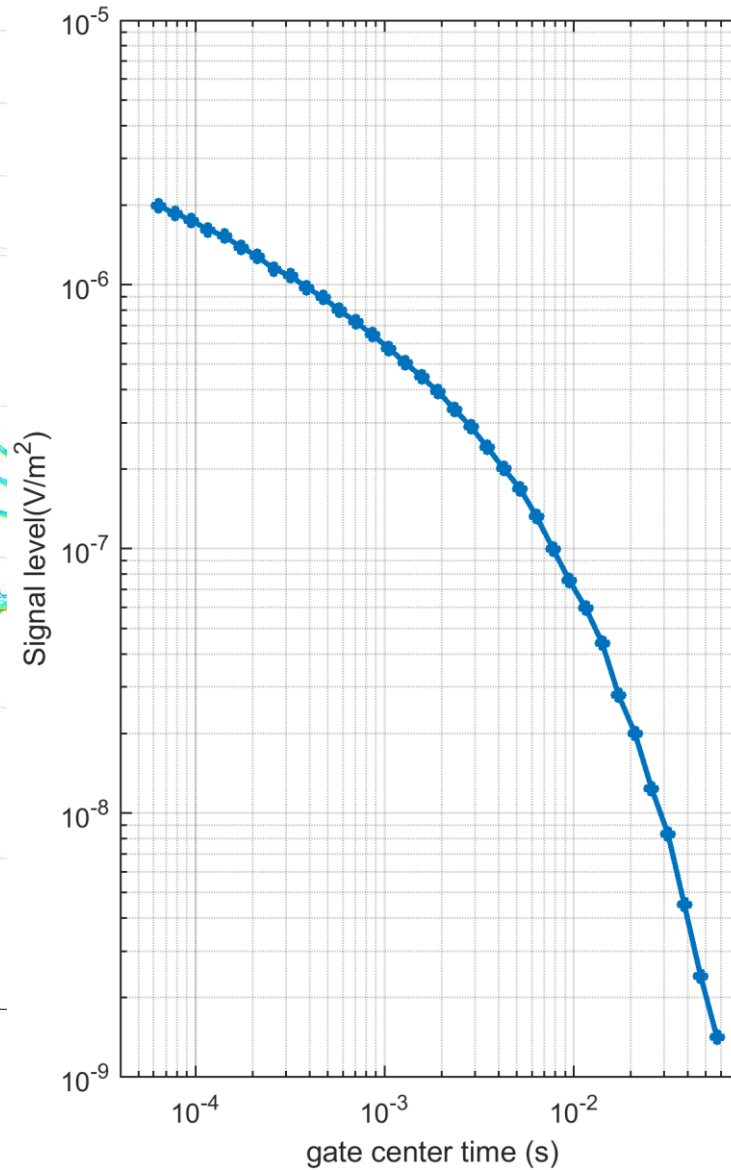
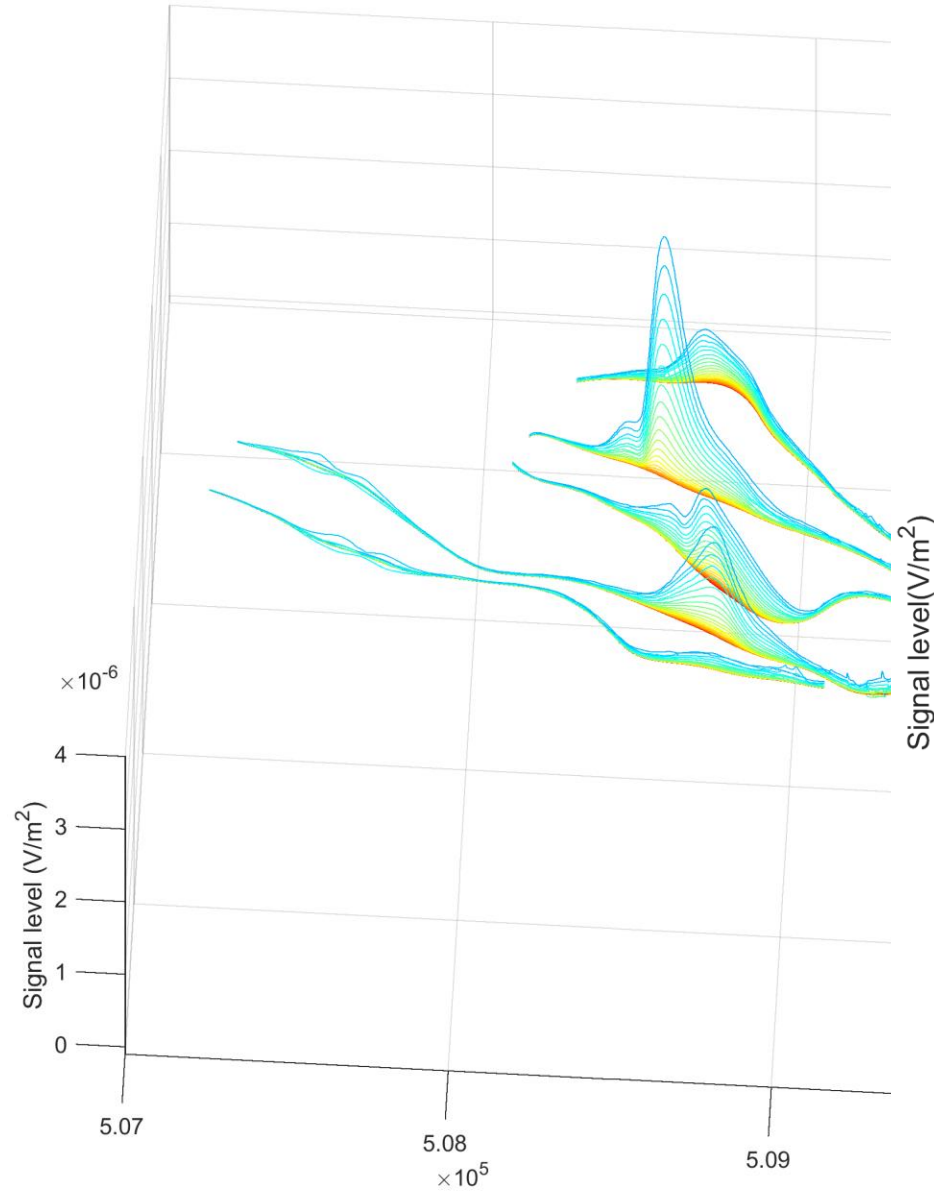
Intermediate gate

Late gate

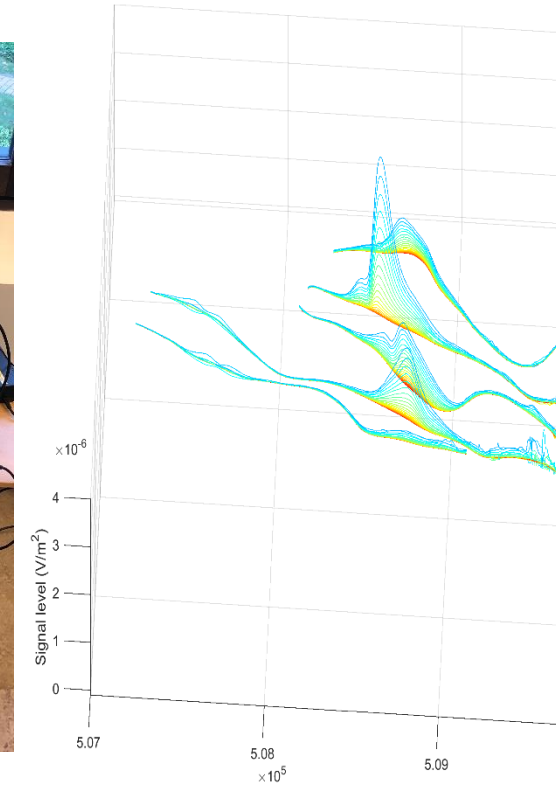
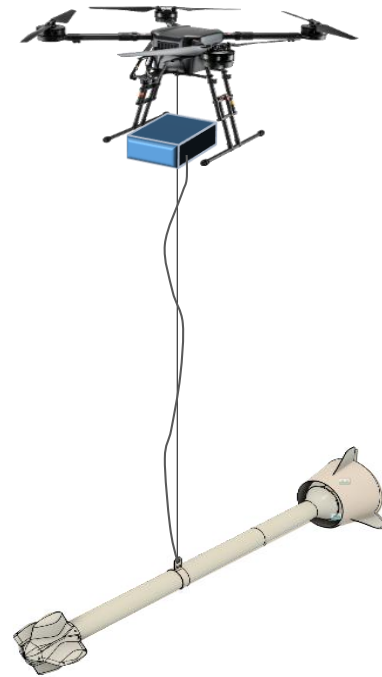
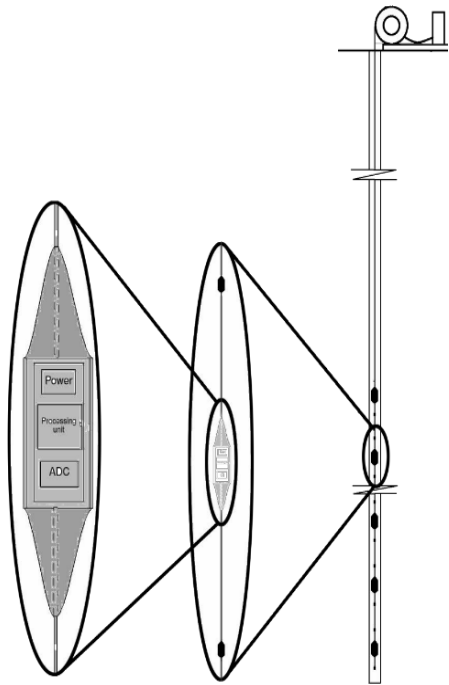
Blötberget Mine Site, Sweden



Blötberget Mine Site, Sweden



- Presentation of five prototypes developed within the Smart Exploration project that all will benefit the exploration community in their own way



- SkyTEM312HP
 - Square Waveform
 - B-field
- 6.25 Hz operation
 - Longer ontime and later offtime
 - Deeper penetration and higher tau values

SMART=EXPLORATION

new ways to explore the subsurface

THANK YOU



Smart Exploration has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.775971.