Geophysics at mine sites:
Mapping near mine geology with advanced geophysical technology.
Applications for delineation, mine planning and exploration.

Presented by Rob Gordon MBA P. Eng.

CIM 2017, Montreal

QUANTEC
Geoscience

World Leaders in Ground Geophysics

Since 1986

Presentation Objectives

- Demonstrate new role of effective imaging at mines
- Overview issues and solutions regarding effective use of geophysical imaging near mine and on mine site environments
- Present examples of deep imaging mine site surveys and results

Geophysics at mine sites ?

Committed to Safety

Safety

- HSE management system
- Full-time HSE specialist
- Member of ISNetworld & GGSSA
- Insured with Chartis
- Pre-field risk assessment
- Training (First Aid, WHMIS, TDG, driving, ATV, chainsaw, etc.)

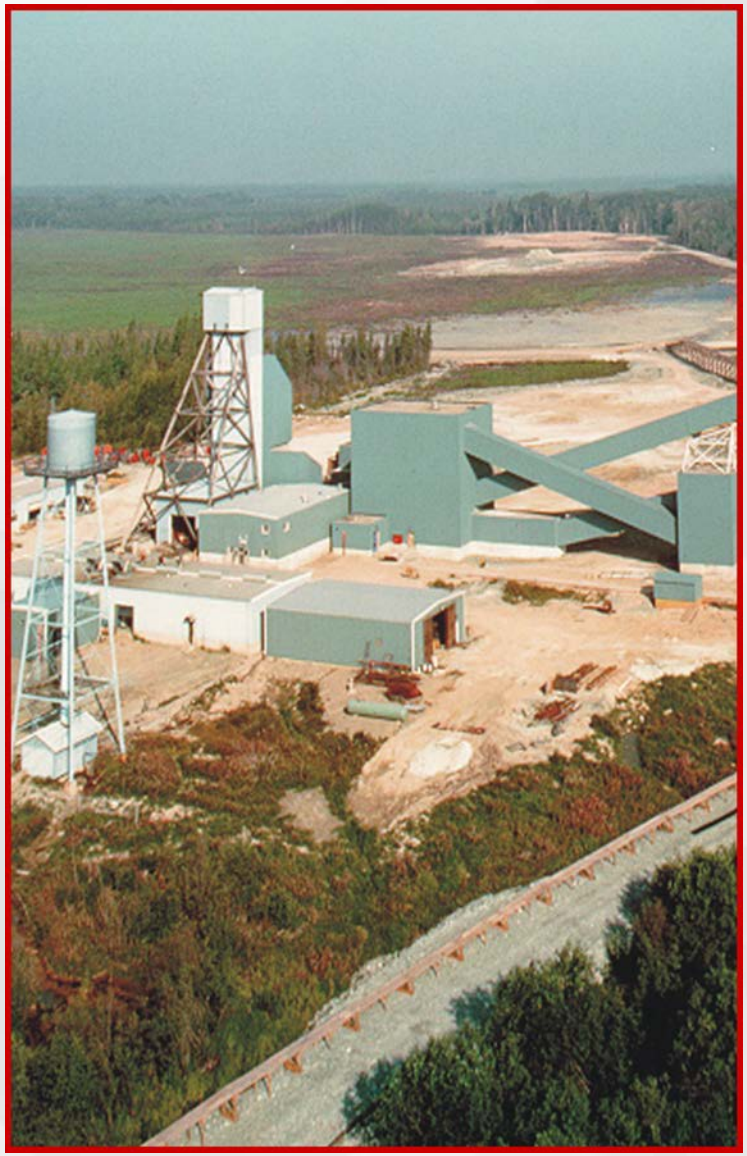
Experience

Our safe operations keep our most demanding clients happy. We operate safely for Junior Explorers and are approved operators for Major Mining companies like RTZ, BHP and AREVA.

Mine site surveying has been challenging

- **Cultural noise**
  - Static metal
  - Buildings
  - Fences
- **Scheduling**
  - Haul roads
  - Active Mine working
  - Crew shifts
- **Electrical noise**
  - Power lines
  - Transformers
  - Shaft

Mine site and near mine imaging



- **Exploration**
  - Rapid Imaging
  - Little disruption
  - Effective deep near mine search
- **Delineation**
  - Effective drill planning
  - Orebody geometry
  - Depth Extent
- **Mine Planning**
  - Condemnation, Tailings Plan

Technology typically for exploration

World Leading Deep Exploration Technology

TITAN 24

2D Deep earth imaging – distributed data acquisition of multi-parameter geophysics: Resistivity, IP and broad band magnetotellurics (MT resistivity)

ORION 3D

3D Imaging – complete 3D data acquisition for complex environments providing accurate surface to depth imaging of Resistivity, IP and MT

SPARTAN MT

Flexible 2D and 3D deep resistivity imaging utilizing high resolution 24-bit MT

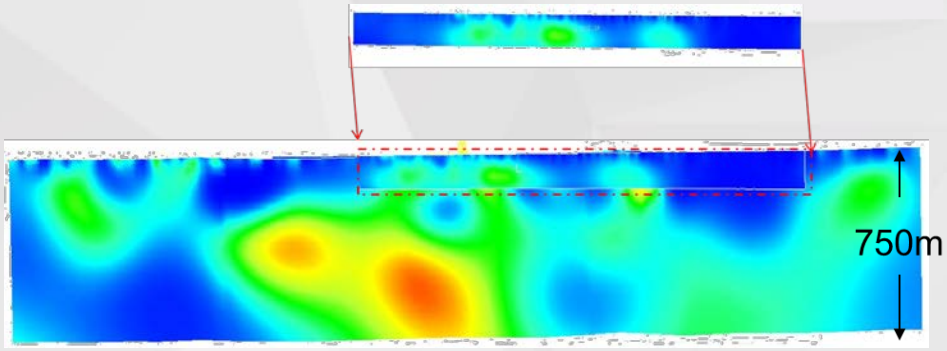
Broad Range of Expertise and Services

- Survey design, planning, acquisition, QA/QC, interpretation, data integration and consulting services
- Complete suite of conventional ground geophysical surveys including; gravity, magnetic, radiometric, IP (surface and borehole), TEM (surface and borehole), Max-Min, CSAMT and VLF

TITAN 24 system

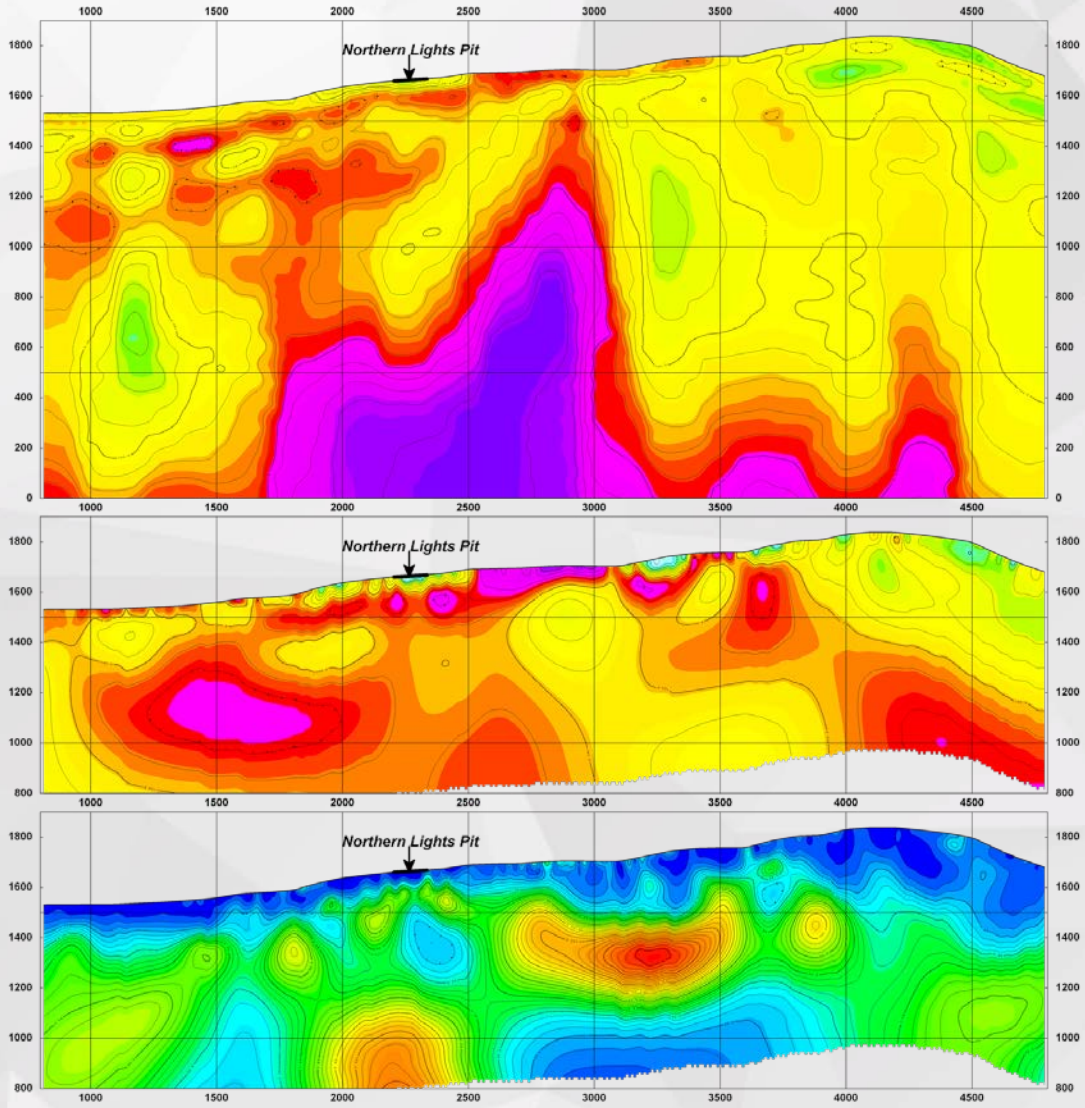
Distributed multi-parameter data acquisition

- Penetrates deeper than conventional geophysics
- DC Resistivity, IP, MT
- Depth of investigation to 700 - 1,500 m
- Well-established in the industry
  - 15 Years
  - Over 400 surveys
- Effective for exploration in mine site environments
  - 60 surveys



TITAN 24

Deep multi-parameter information



Top panel: MT Resistivity

PW 2D inversion;

Typically 1500 metres

Middle panel: DC Resistivity

UBC smooth inversion;

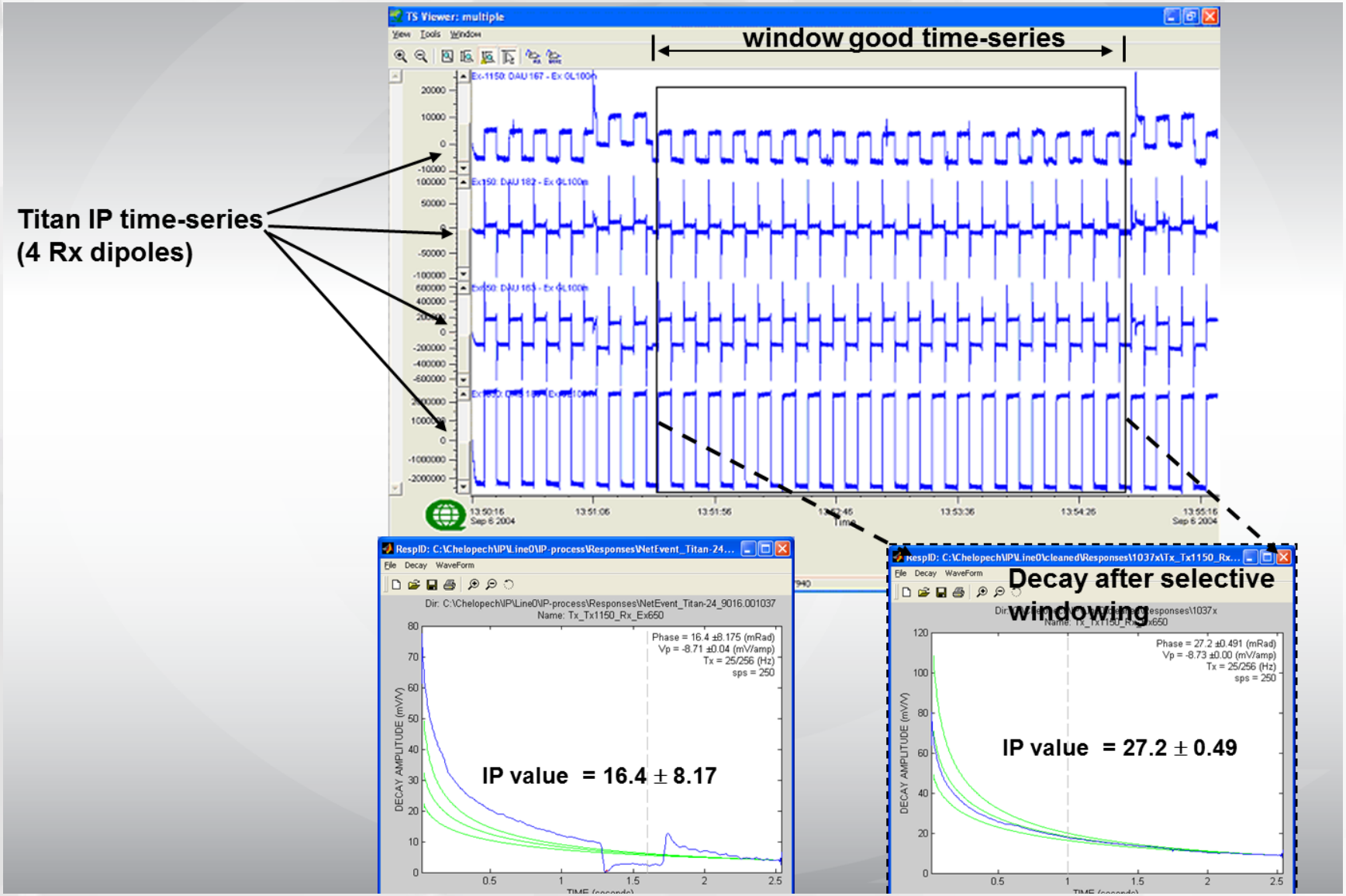
Typically 500-750 metres

Bottom panel: Chargeability

UBC smooth inversion.

TITAN 24

Minimize cultural noise by windowing



Station receivers measuring simultaneously with 24 additional receivers

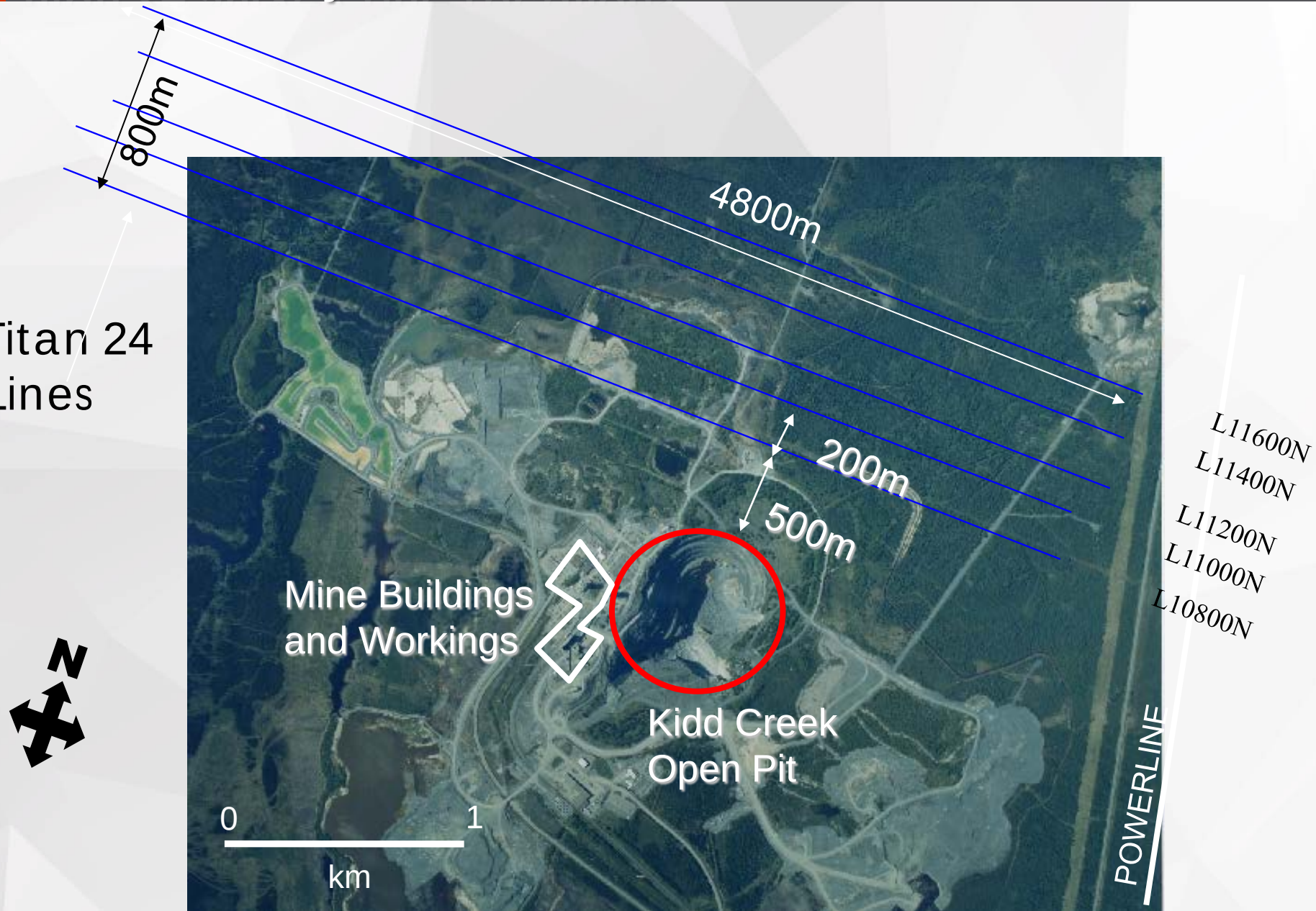
Over 60 mine site surveys

Some of our mine site clients…

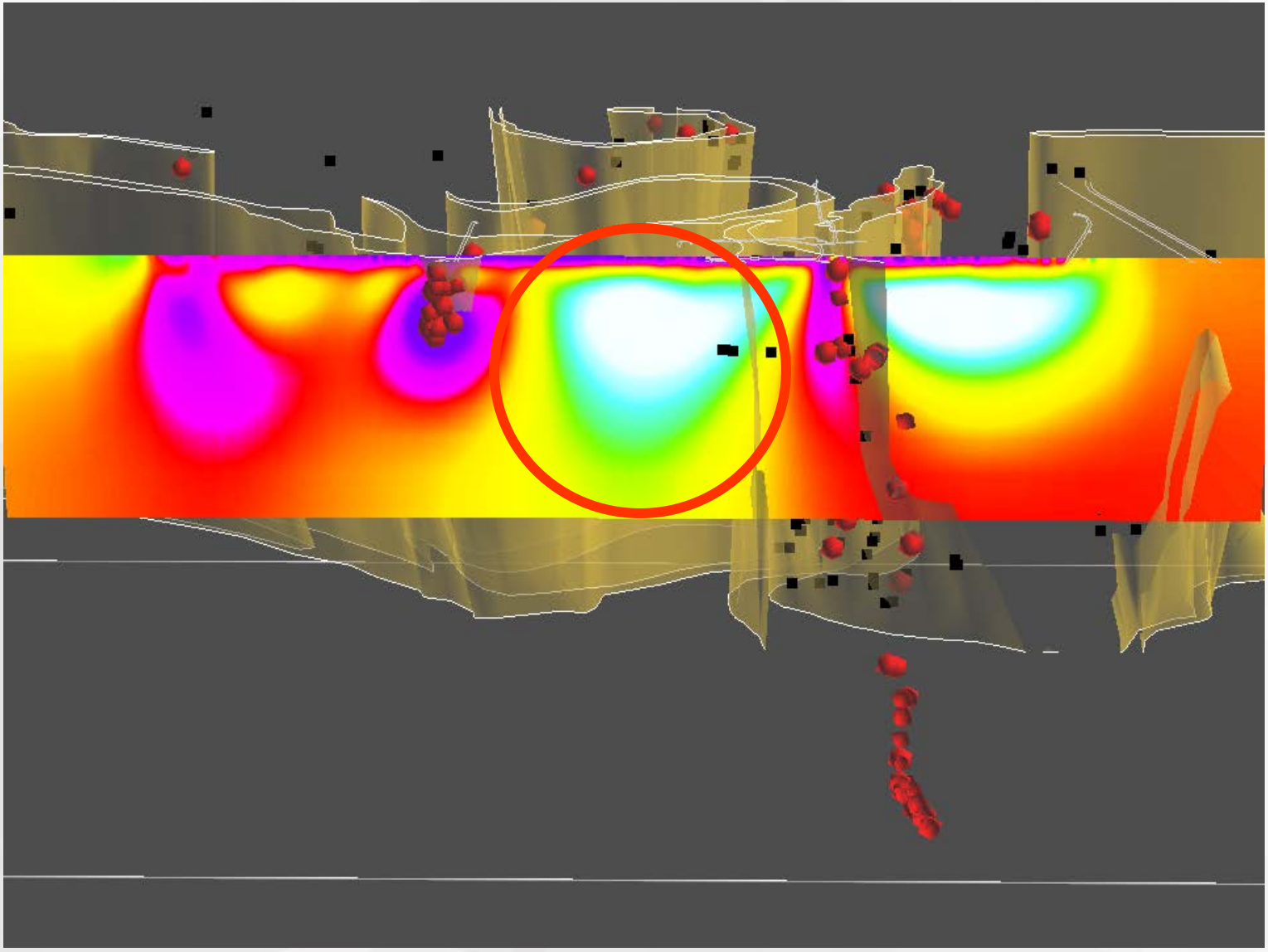
- Copper Mountain
- Tenke Fungurume
- Kidd Creek
- Tati Nickel
- Raglan
- Ren
- Red Lake Gold Mine
- Geikle
- Voisey's Bay
- Levack
- San Nicolas
- Black Fox Gold Mine
- Fortitude
- Chelopech
- Borroo
- Red Chris

TITAN 24

Kidd Creek
Titan 24 Survey Line Locations



Kidd Creek- Ontario



Drillhole Intersection Points

- Massive Sulphide Intersection
- Graphitic Argillite

Unconstrained Inversion

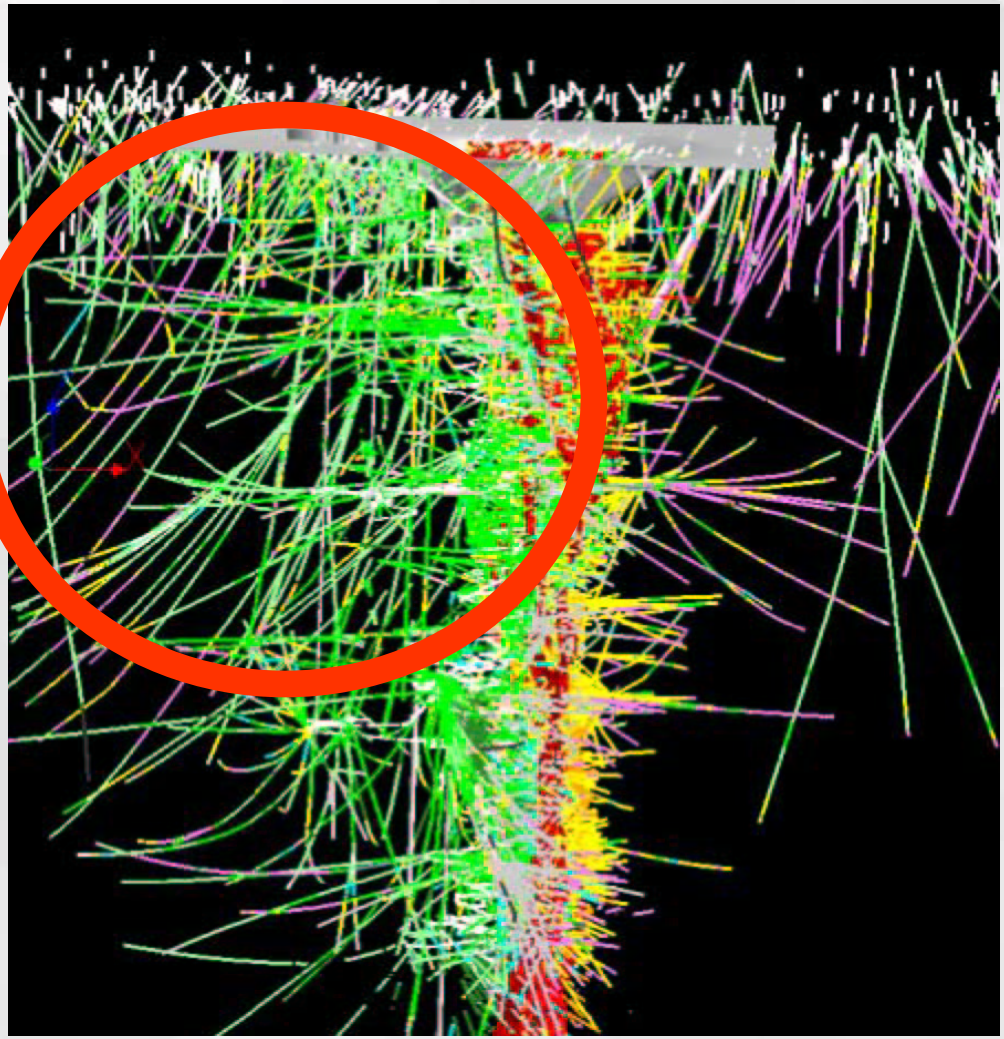
- Surface
- 400m Below Surface
- 800m Below Surface

DC IP Resistivity ohm.m

10,000
5,000
1,000
500
100
50

Kidd Creek- Ontario

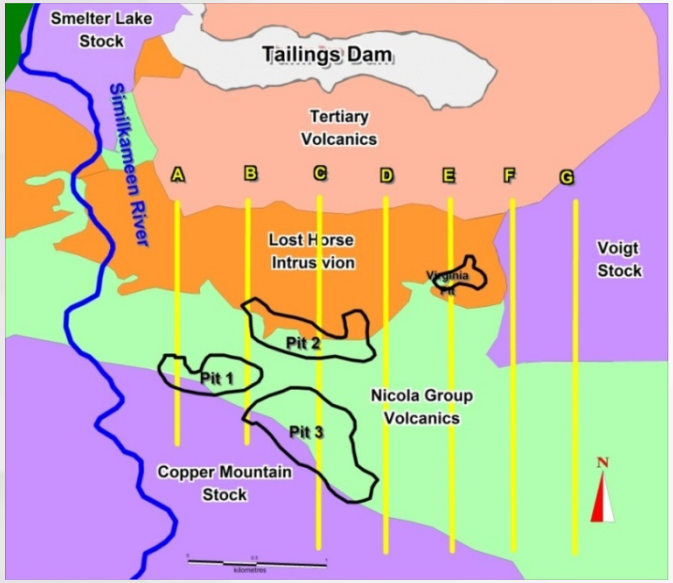
Where to Drill?



- Millions of dollars spent on drilling diamond drill holes ending in the barren rhyolite (circled area).
- TITAN 24 survey indicated that the rhyolite was barren

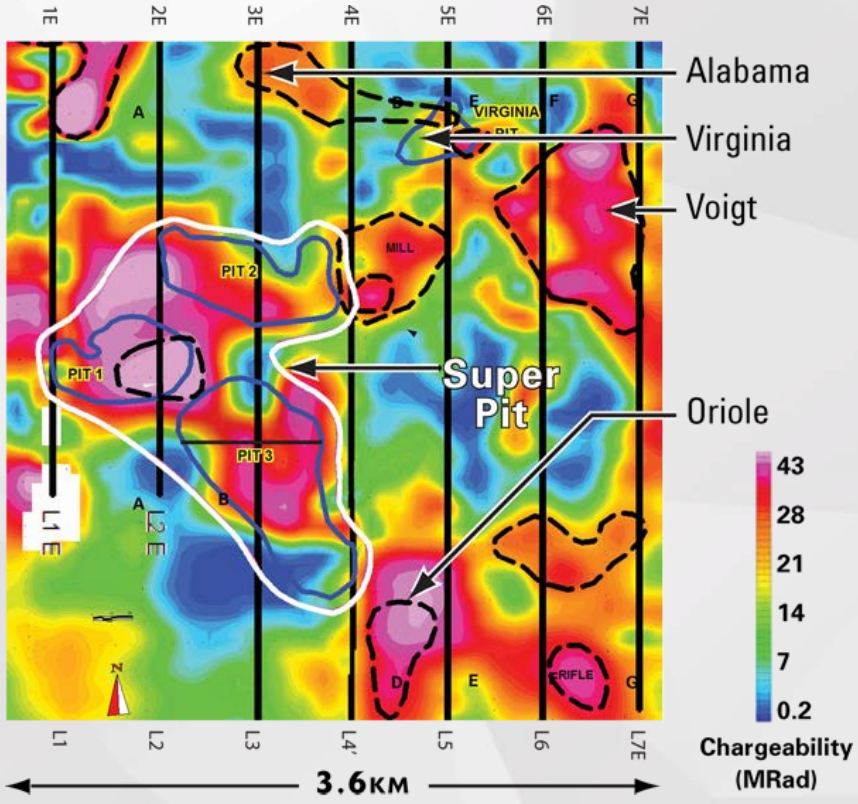
Copper Mountain BC - Exploration Objectives

- To confirm continuity of mineralization between the pits.
- To test and possibly expand reported resources between existing pits in order to identify a new merged pit- known as the “Super Pit.”
- To identify the potential for large, deep-seated porphyry deposits through a **comprehensive mine site exploration** program.



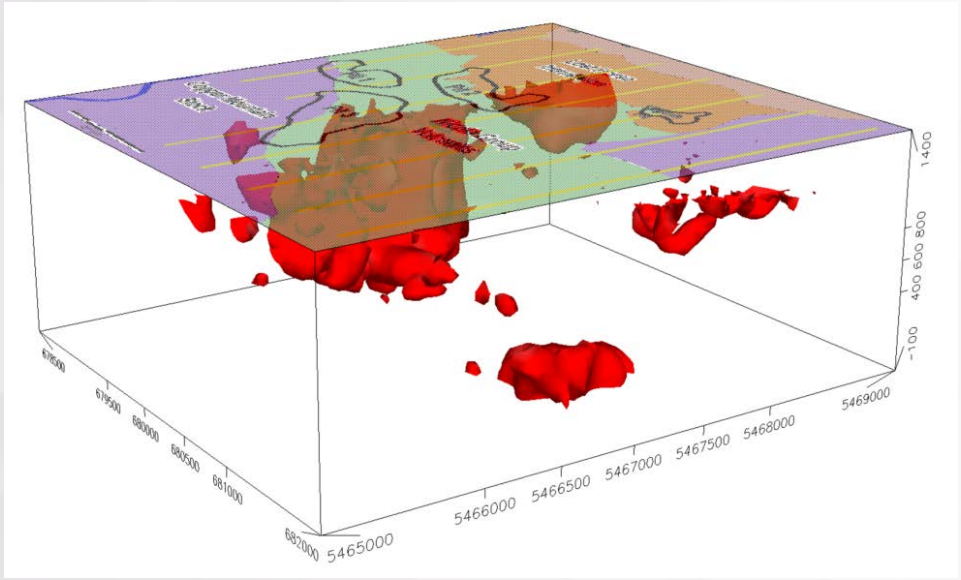
Images of Active Pits and Geology with Titan 24 Line Locations

IP Plan (200 m) and 3D Map



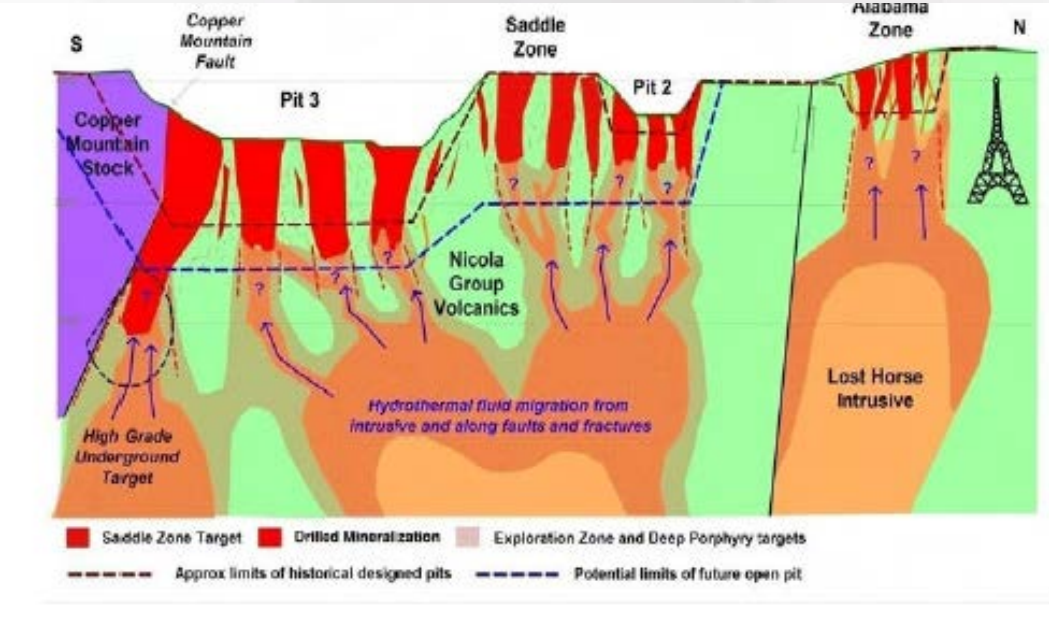
Copper Mountain – 3D View

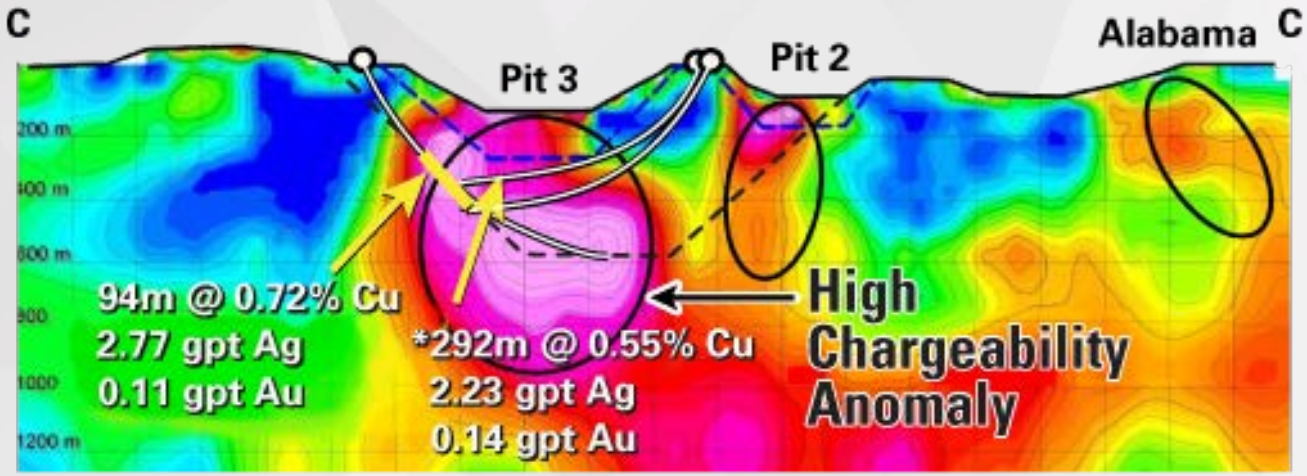
- IP anomalies centred over current pits
- 3D image shows continuity of chargeability and potential depth extent



40 mrad chargeability surface

Geology model and resultant IP

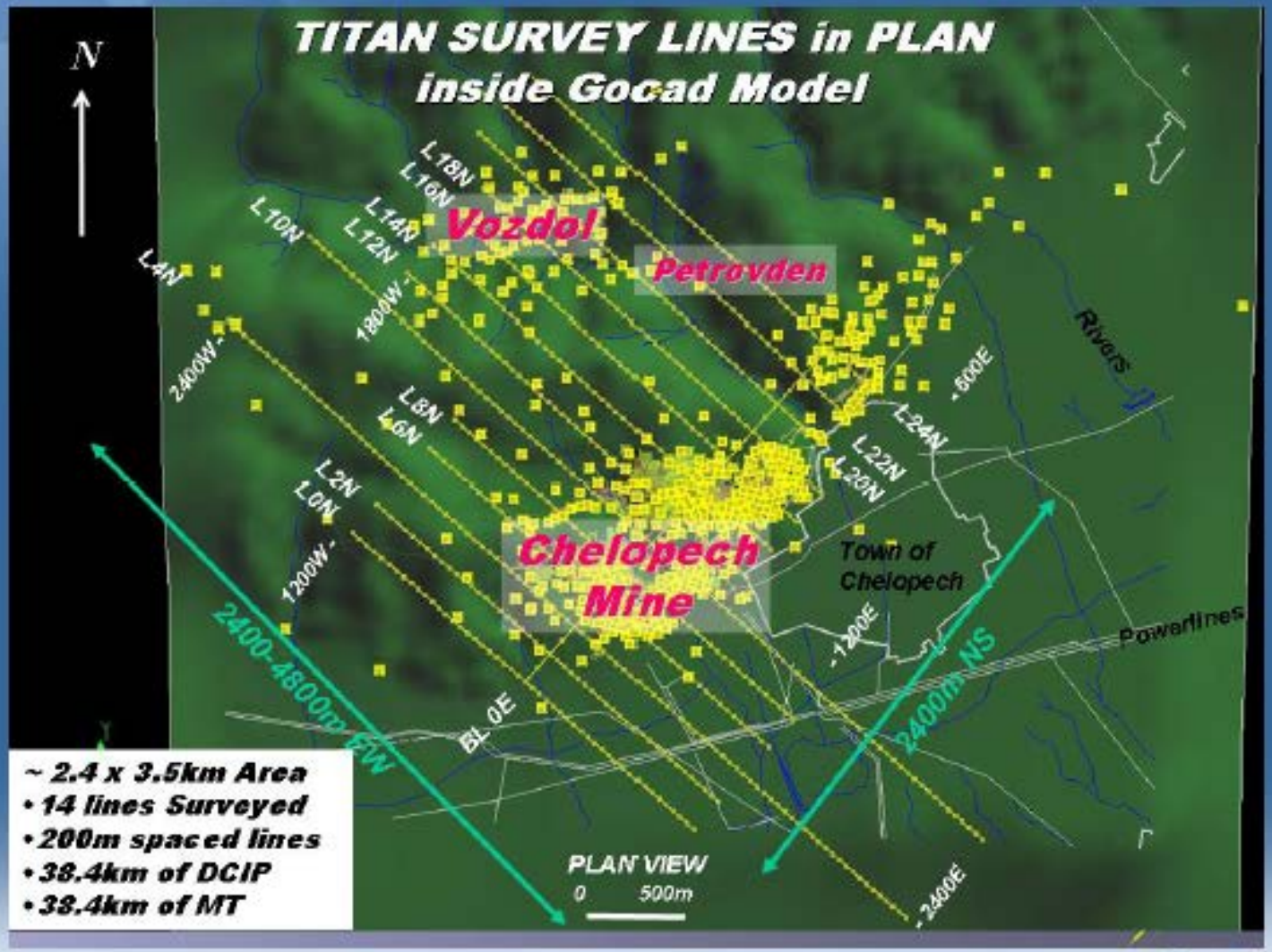




Chelopech, Bulgaria Case Study

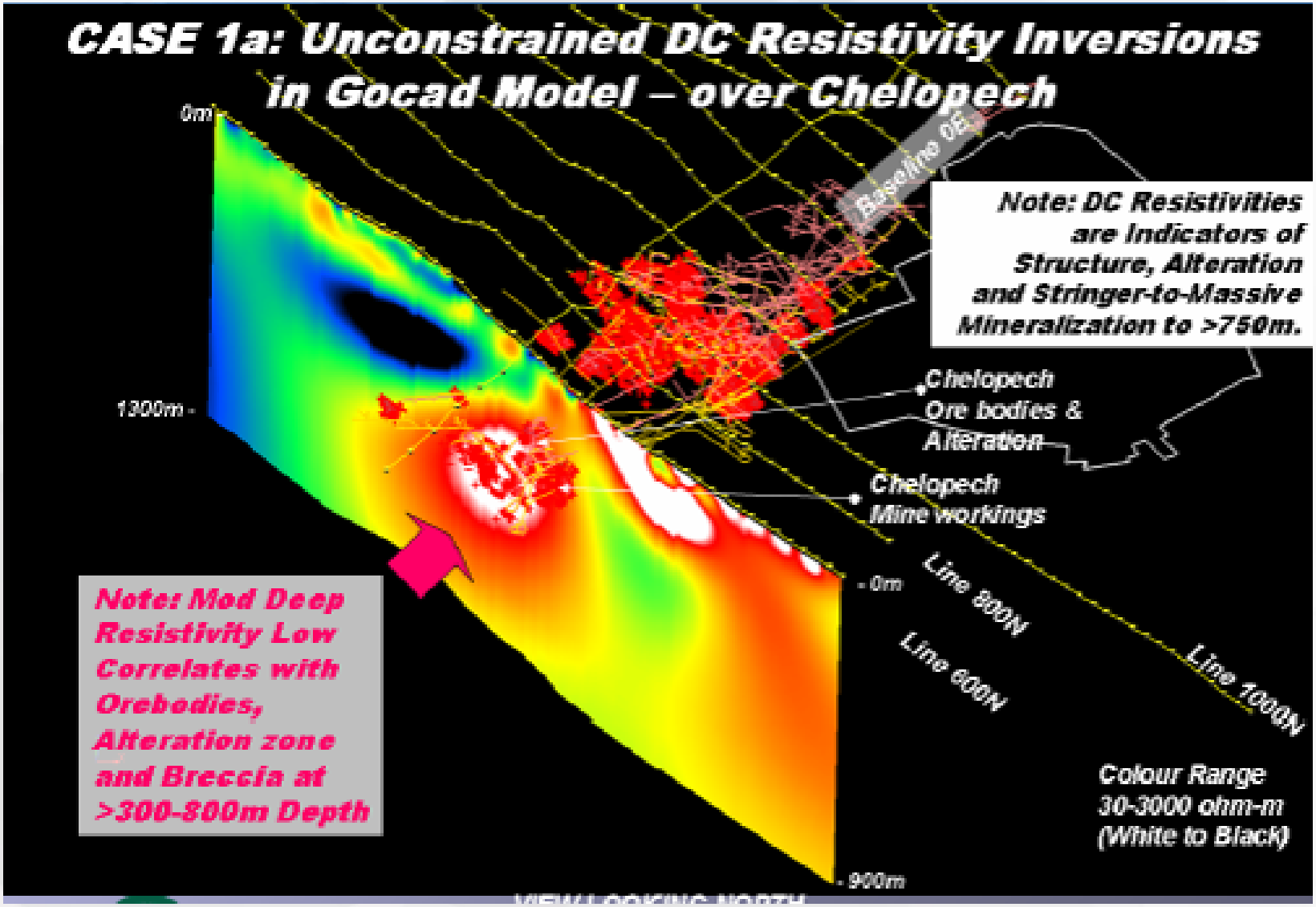
- Digital Signal Processing
- Simultaneity
- Remote Referenced Data

Titan 24 Survey Layout

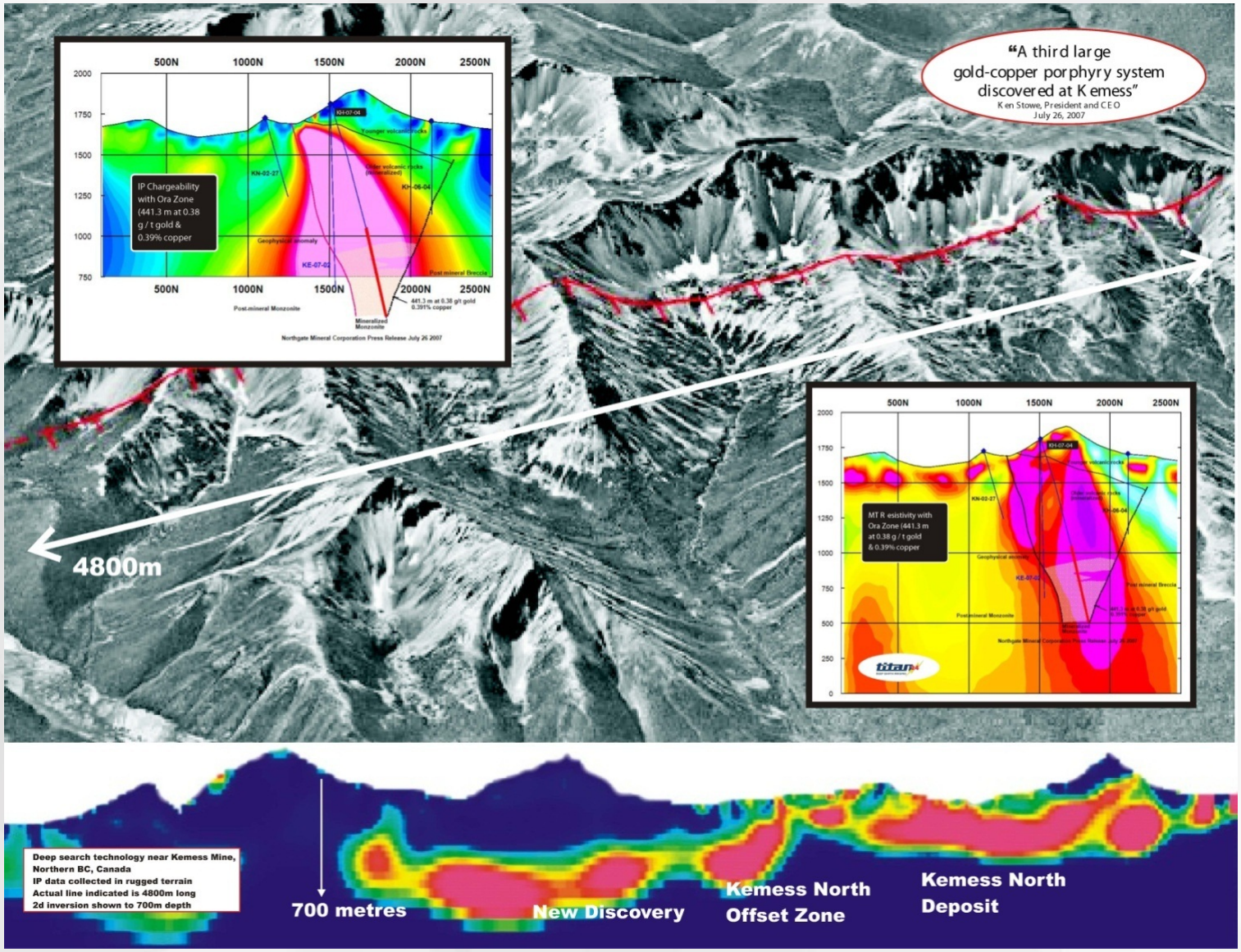


DUNDEE PRECIOUS METALS INC.

Resistivity model matches deposit

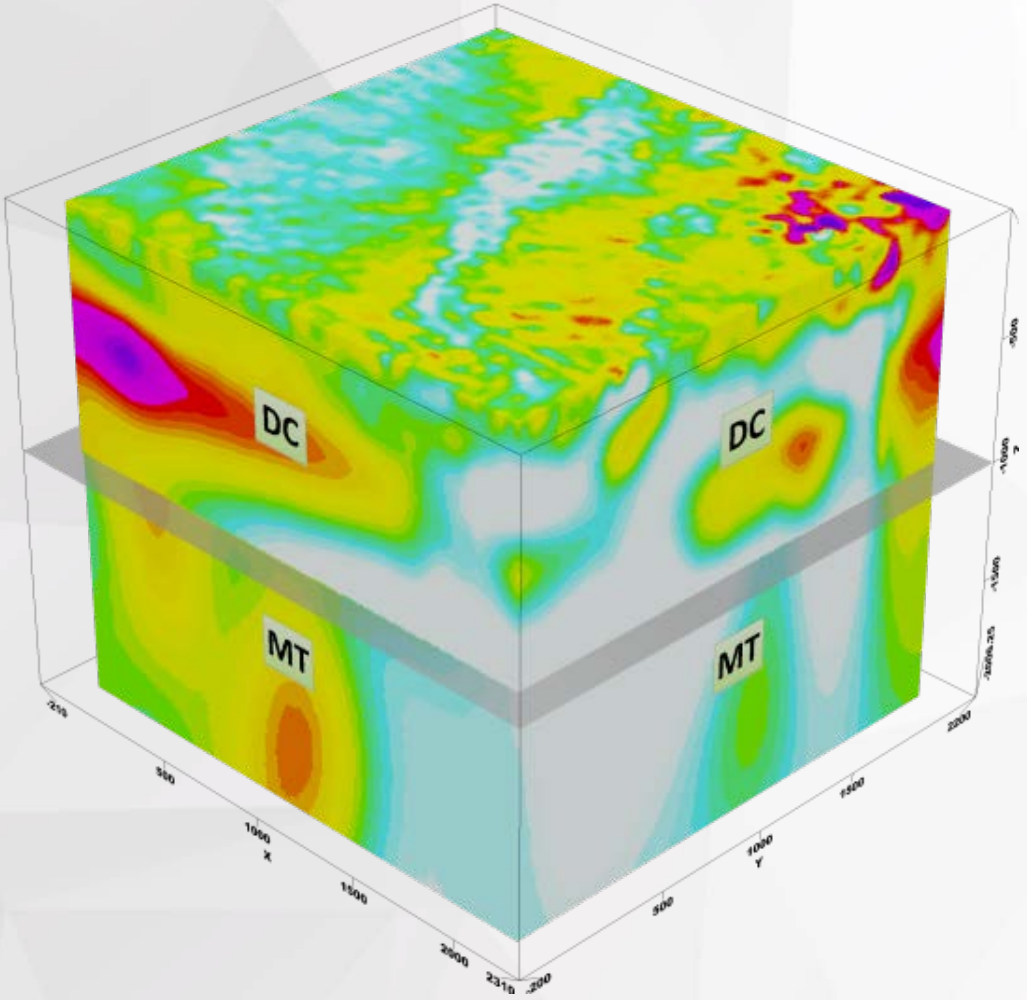


Kemess North – Orebody Extension



ORION 3D surveys

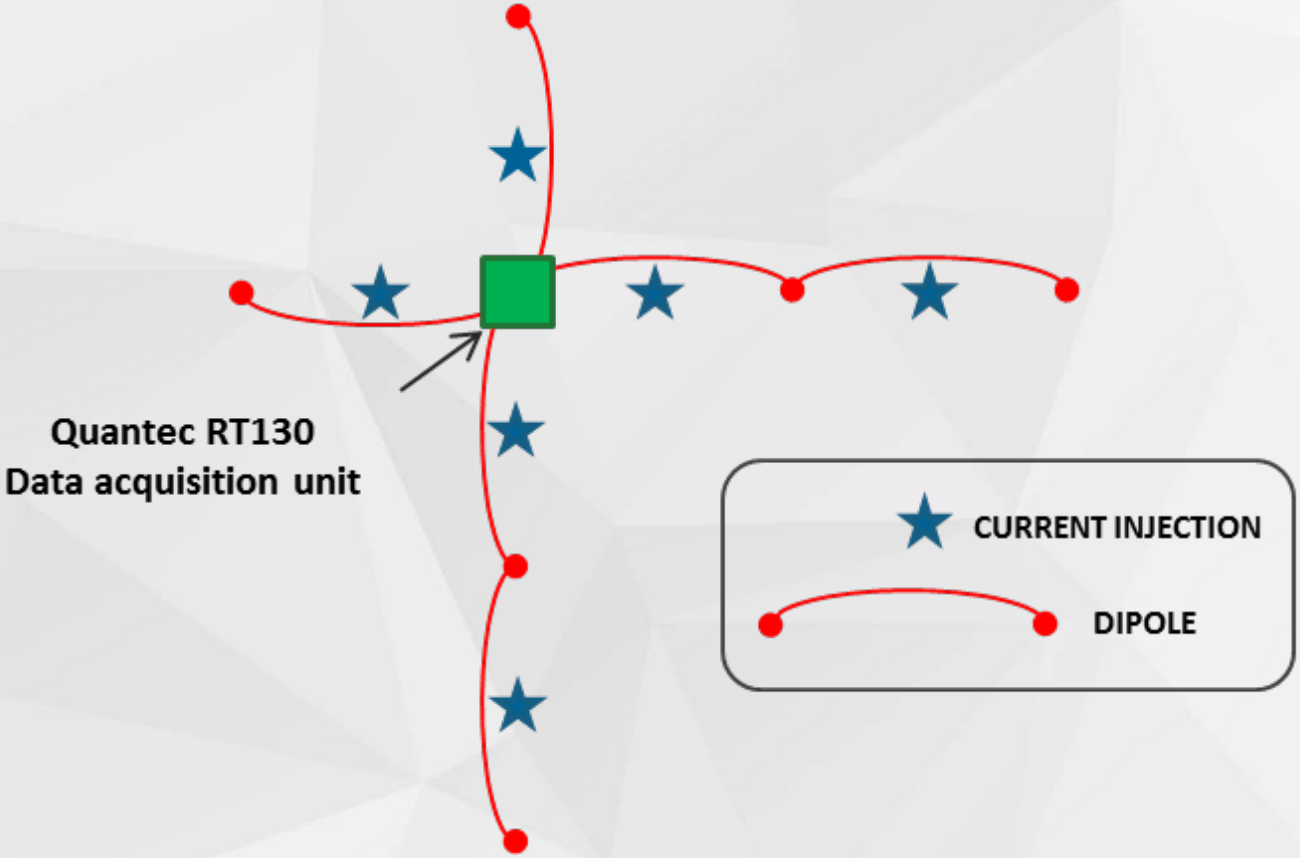
- **Accurate imaging for complex environments**
  - Depth of investigation to 1,500 m for Resistivity, 750m for IP
  - Confidence in interpretation
- **True 3D acquisition**
  - Omni-directional super-sampling
- **Multi-parameter**
  - DC Resistivity, IP, MT



ORION 3D

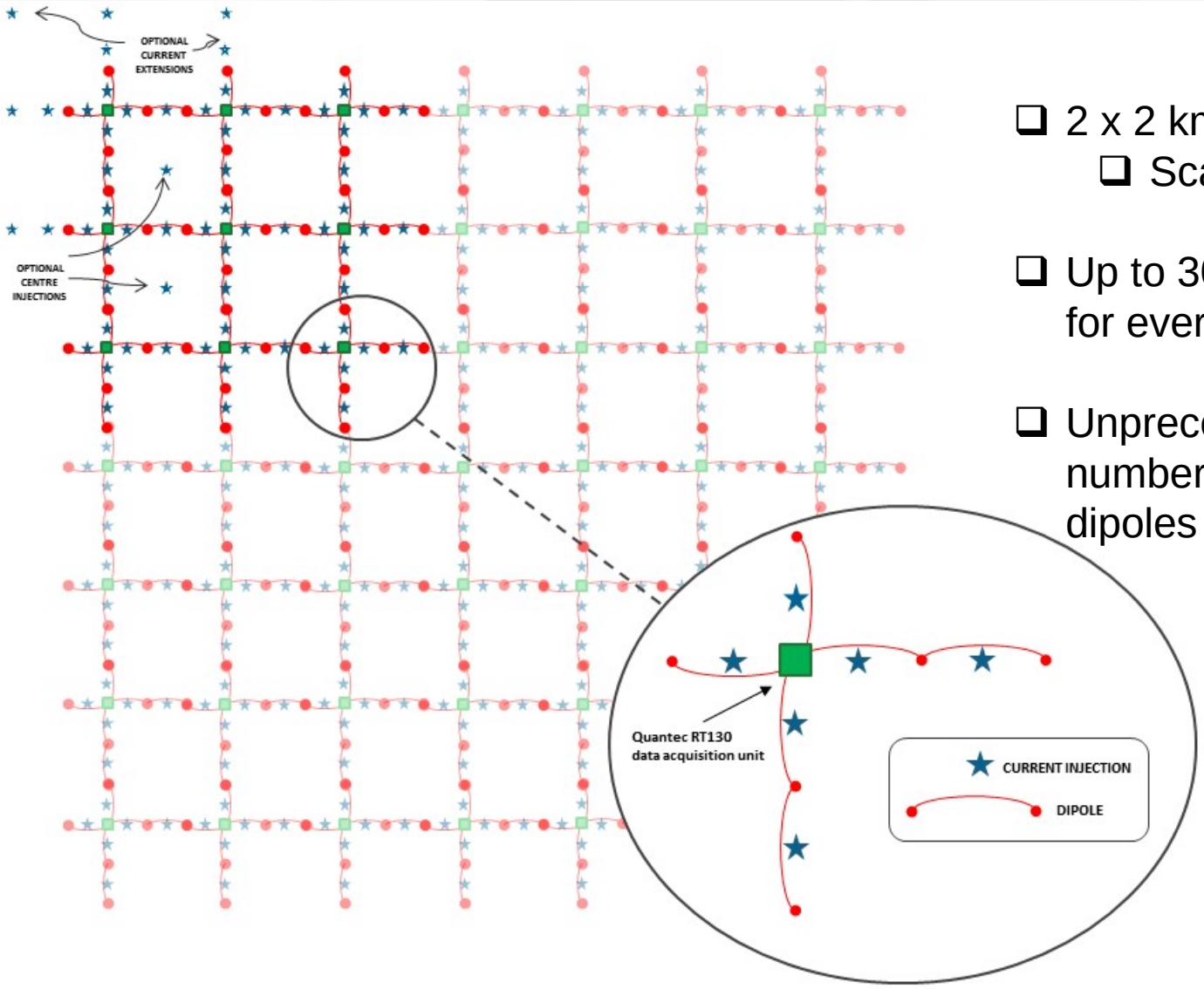
Designed for complex environments

- Built on the strengths of:
  - **TITAN 24** Technology & Processing (over 15 years of technical **Success** and **Discovery**)
  - **SPARTAN MT** Flexibility



ORION 3D

REAL 3D data acquisition



- 2 x 2 km area
  - Scaleable
- Up to 300 receiver channels for every transmit
- Unprecedented: equal number of orthogonal dipoles

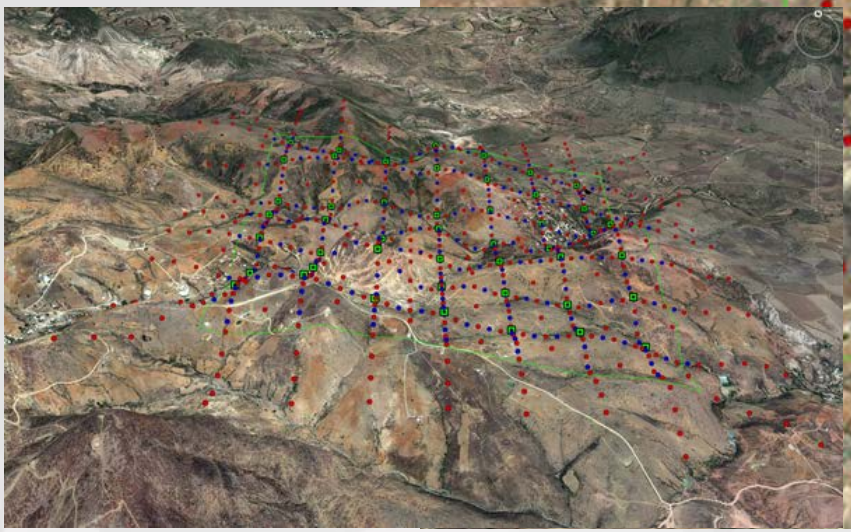
Survey footprint

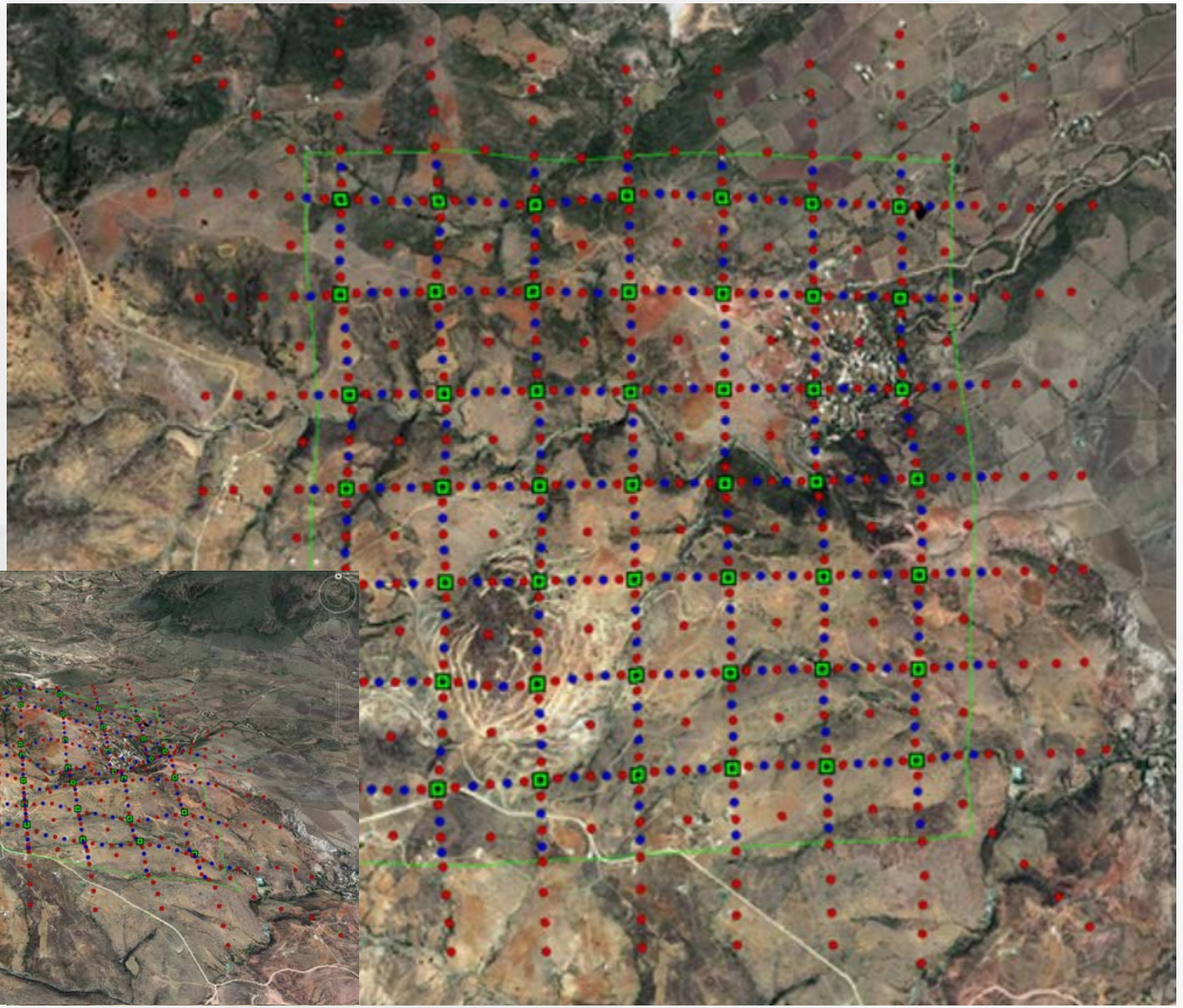
ORION 3D

Tx

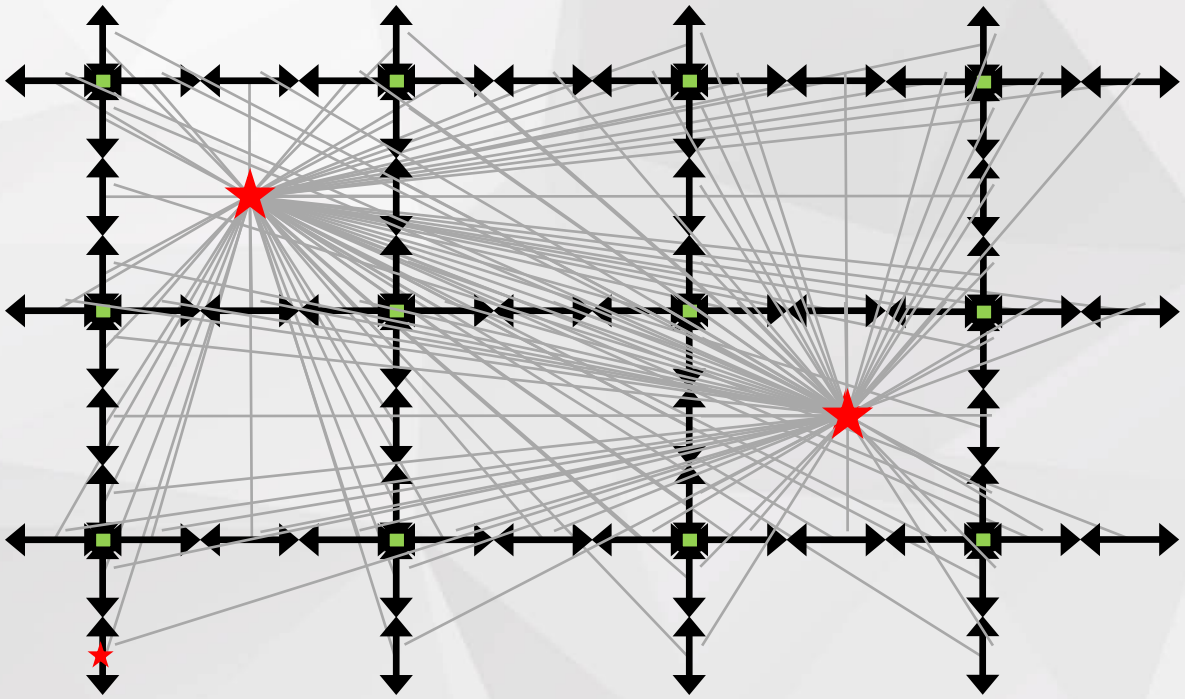
Rx

Logger





ORION 3D layout



Receiver dipole

Data recorder

Current injection

"Conceptual" current path

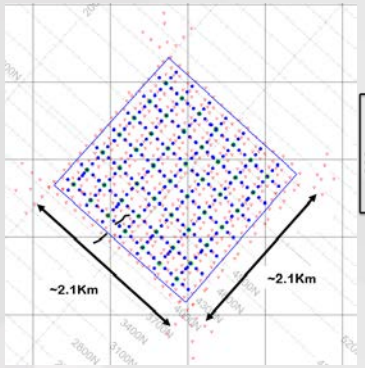
- **True 3D DCIP measurement**
- **Simultaneous receiver sampling**
- **Omnidirectional data free from receiver geometry bias**

ORION 3D

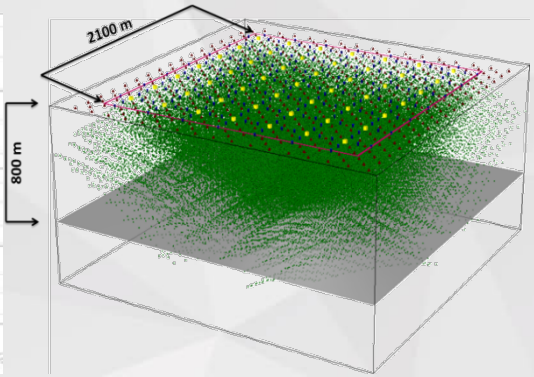
The ORION 3D advantage

- **Survey flexibility**
  - Distributed acquisition allows for customization of the survey layout
- **3D geometry**
  - The survey samples local geology from all directions simultaneously
- **High signal-to-noise ratio**
  - Low-noise electronics ensure high quality data
- **Depth penetration**
  - Large-offset data acquisition ensures maximum depth penetration
- **High resolution**
  - High data volume boosts the resolution of the survey and supports confident and accurate interpretations

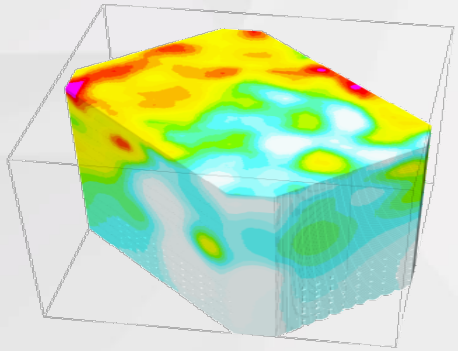
Yields best representation of the subsurface for drill planning

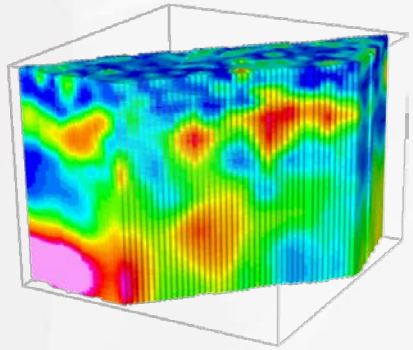


Layout

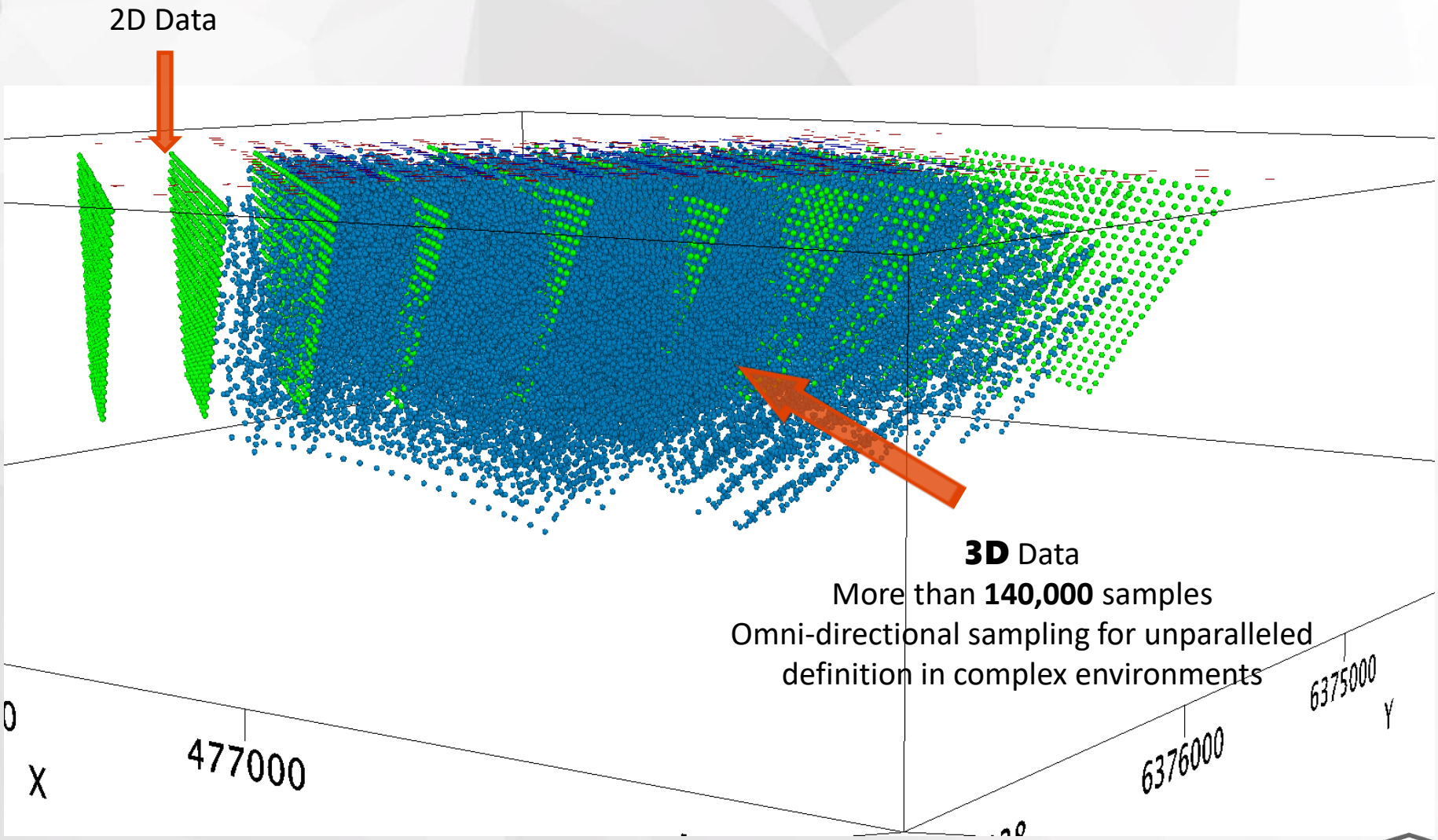


Planned Coverage


Results


Targets

Sampling everything (from all directions)



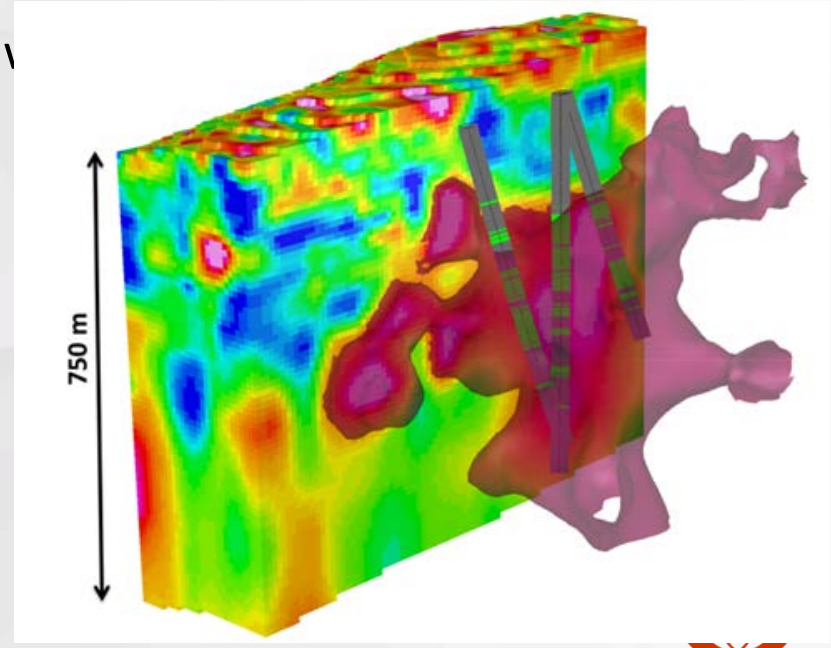
ORION 3D

Technology impact on planning and risk?

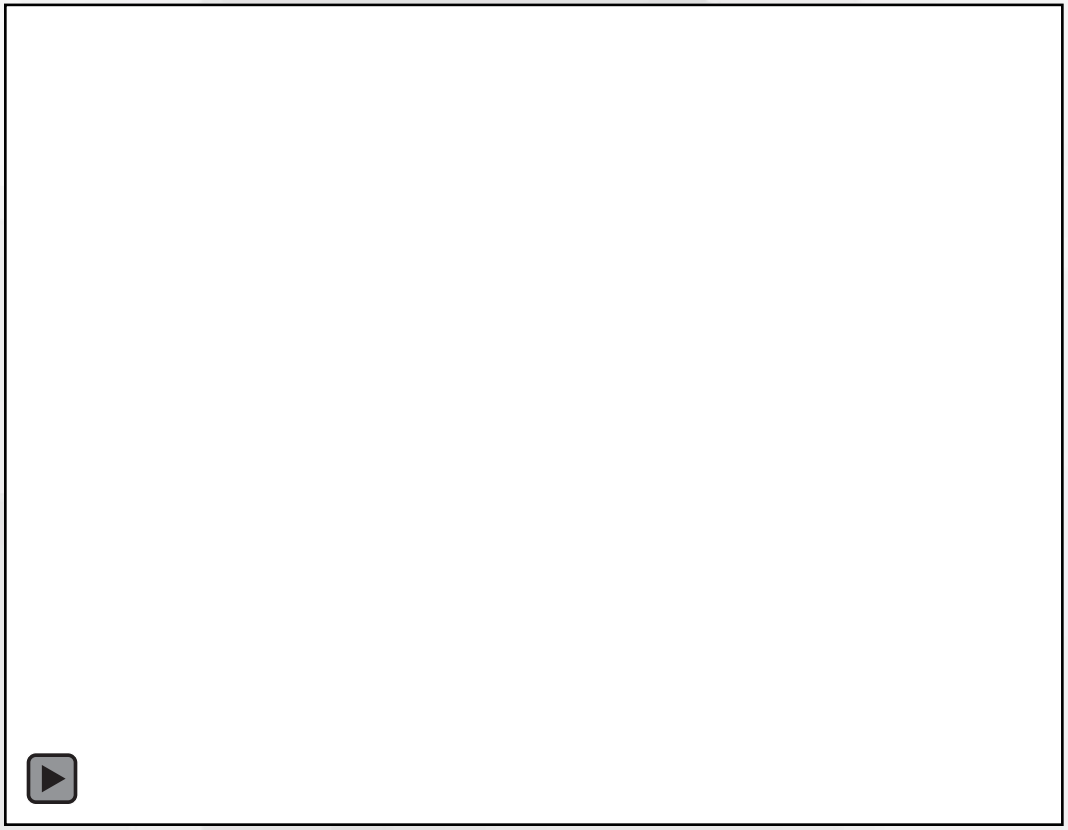
Thorough, accurate imaging for improved drill planning

- Detection of deeper, more subtle geophysical responses
- Imaging through deep overburden conditions
- Surveying in high noise environments (active mining operations)
- Decreases the chance that the “big one” v be missed
- Decreases overall exploration cost by providing better targeting information

- **Applications:**
  - VMS, porphyry, gold, silver, copper
  - Nickel, PGE’s, IOCG, uranium, diamonds

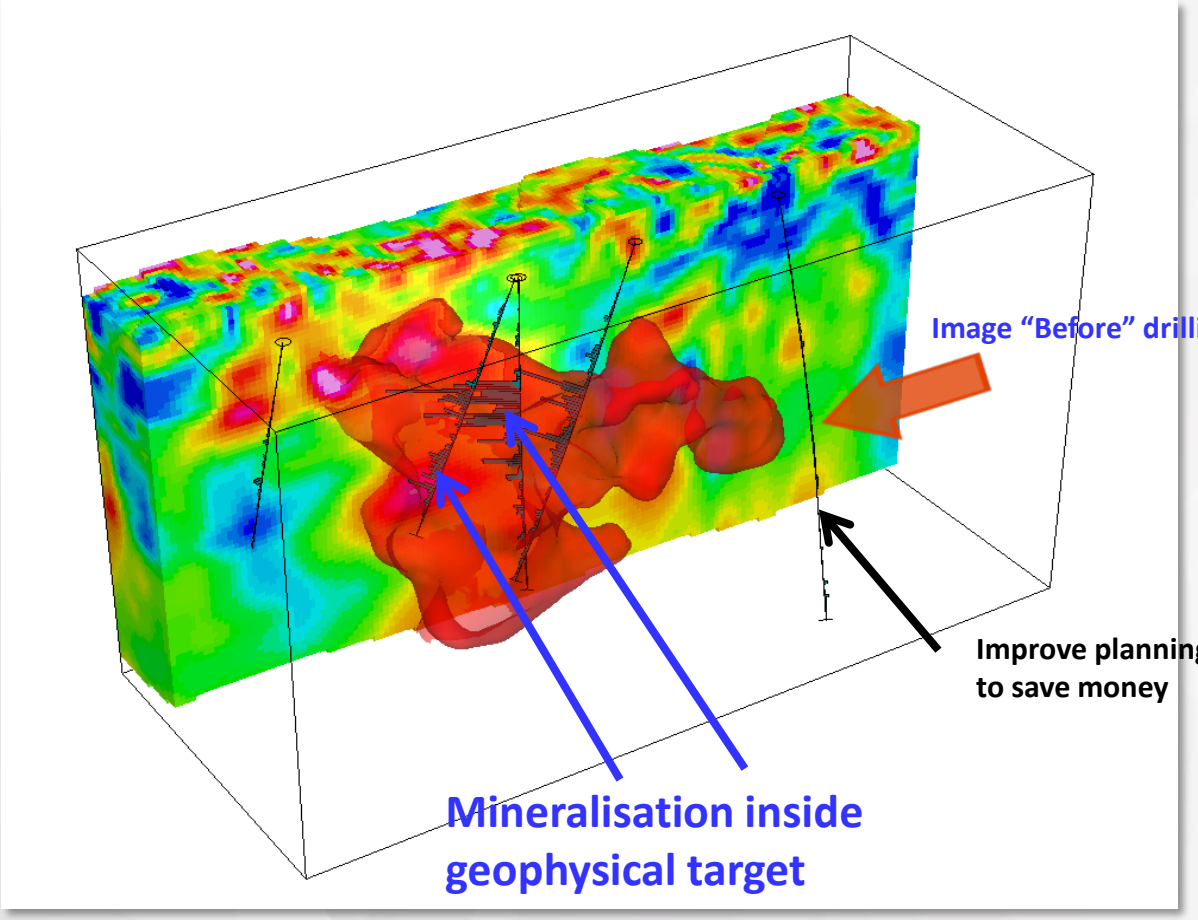


Kitumba, Africa ORION 3D IP Model



1 km x 750m

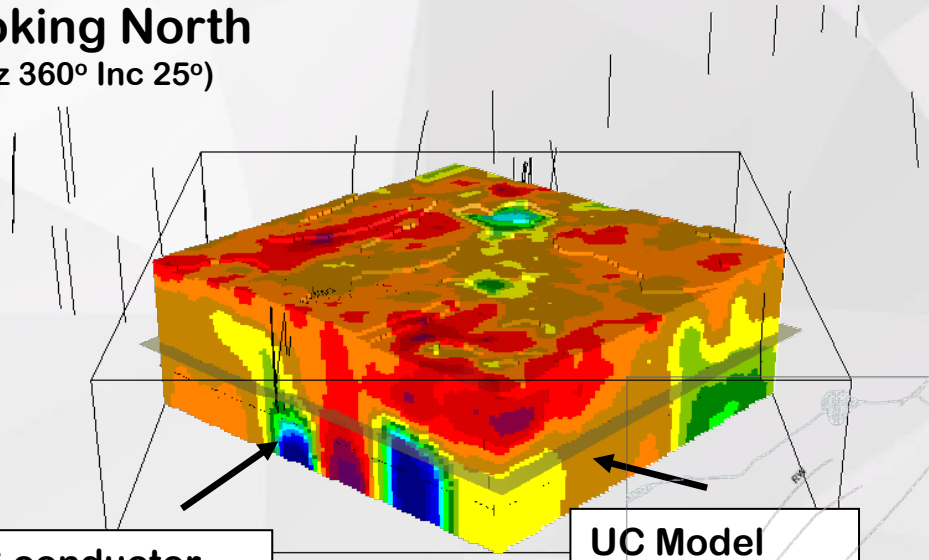
ORION 3D delineation results



ORION 3D

BIG DATA is an asset for the project

Looking North
(Az 360° Inc 25°)

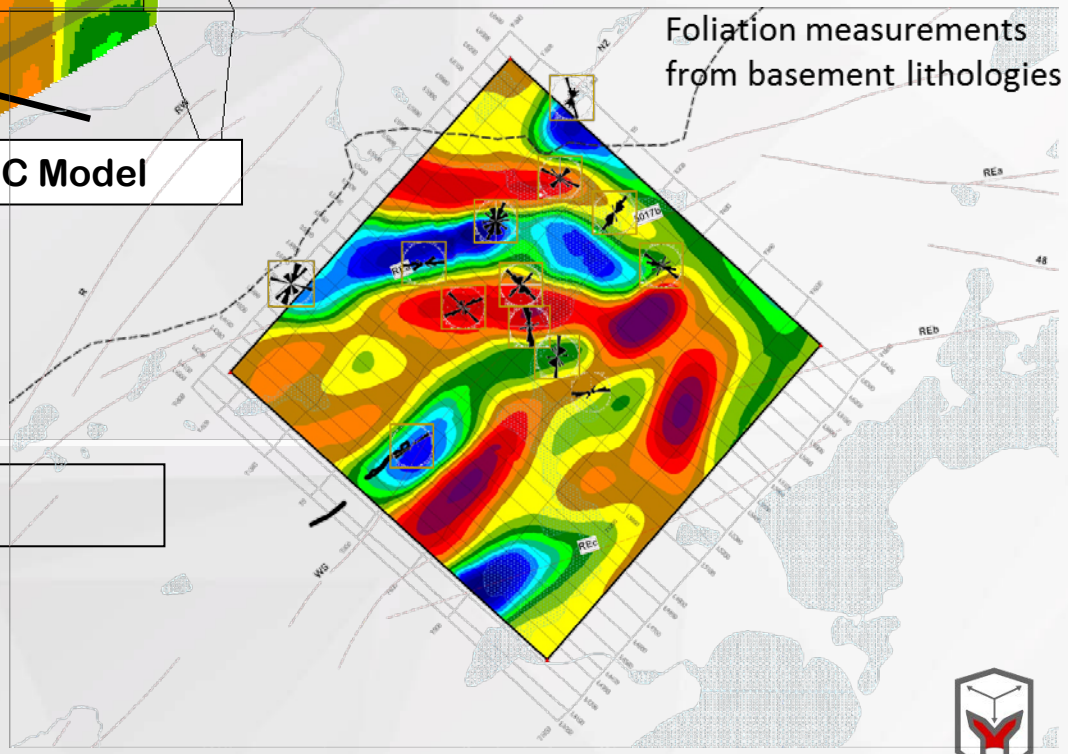


WS conductor with Phoenix drilling

UC Model

Plan at UC-100 m

Foliation measurements from basement lithologies

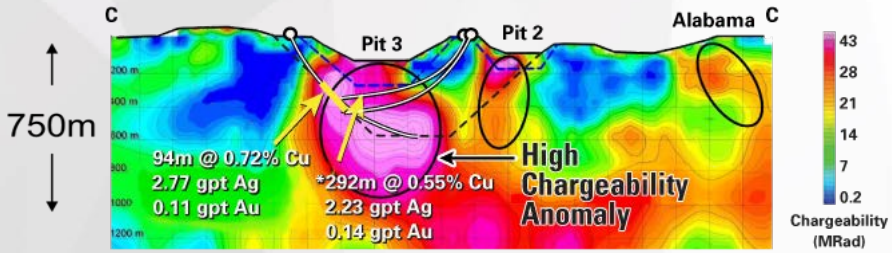


ORION 3D

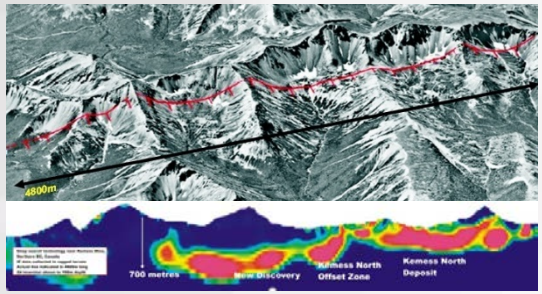
Mine site imaging surveys

TITAN 24

- **Copper Mtn**
  - Mine planning
    - Condemnation
    - Tailings

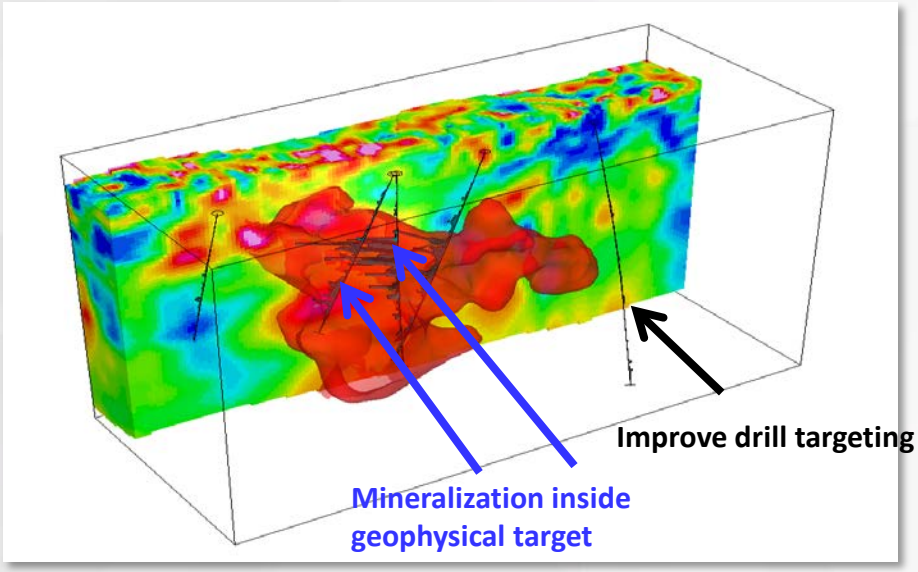


- **Kemess**
  - Discovery



ORION 3D

- **Kitumba**
  - Resource Targeting
    - Drill plans
    - Data asset



Thank YOU!

www.quantecgeoscience.com