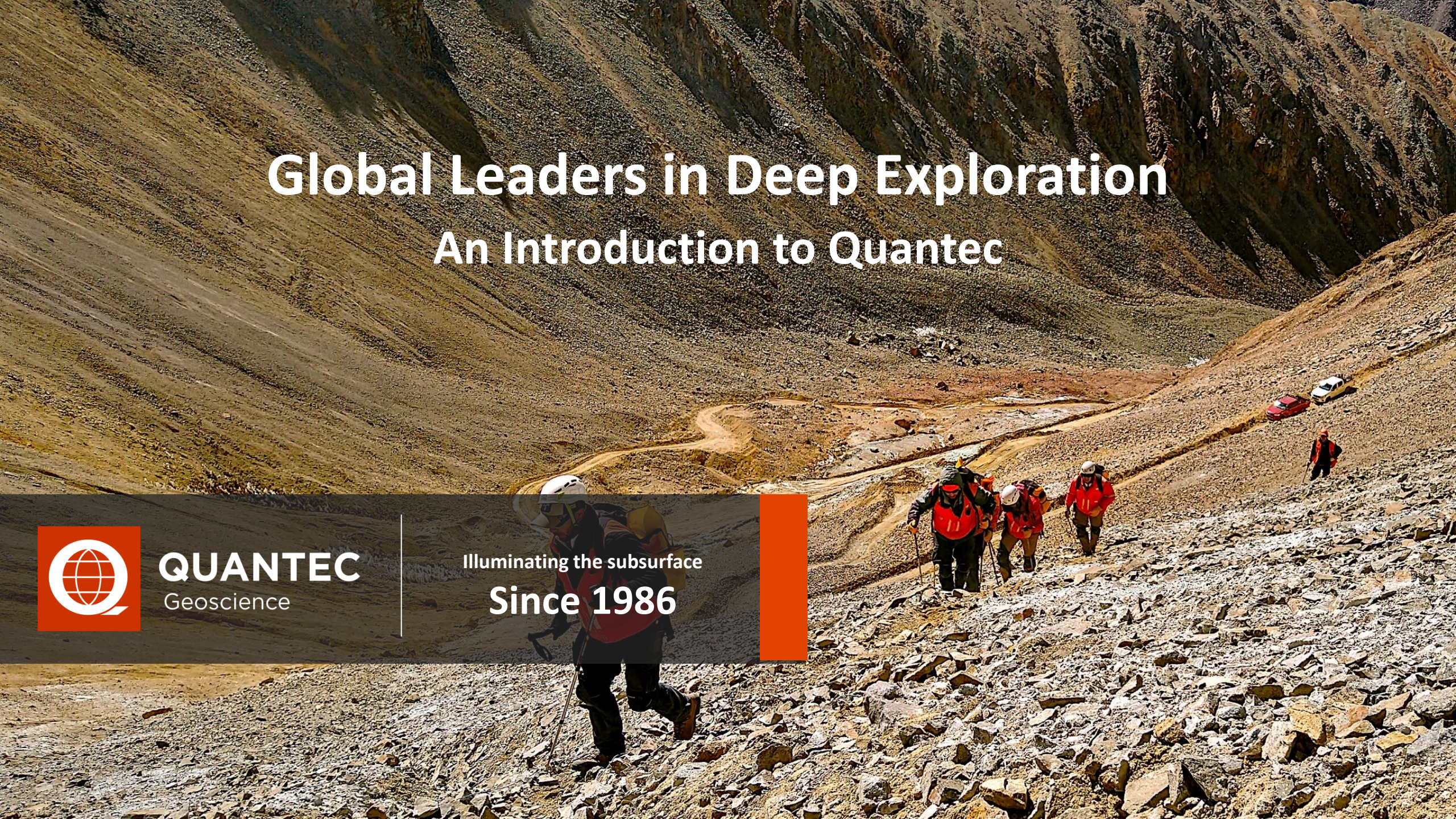


# Global Leaders in Deep Exploration

## An Introduction to Quantec

QUANTEC
Geoscience

Illuminating the subsurface

Since 1986

QUANTEC
Geoscience

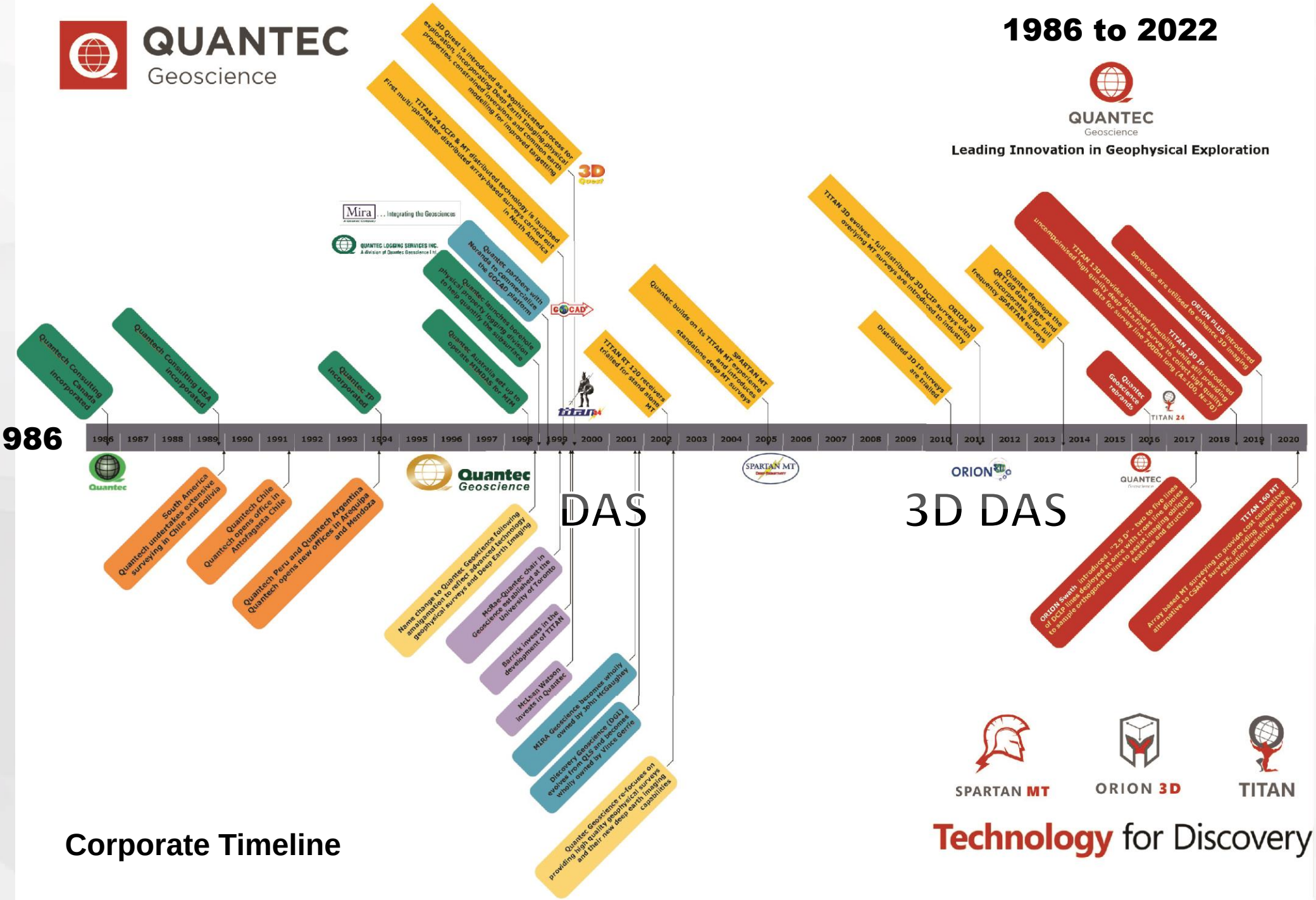

**MAIN OFFICE : 146 SPARKS AVE, NORTH YORK, ON M2H 2S4**
www.quantecgeo.com | @quantecgeo | (416)-306-1941

QUANTEC
Geoscience

# 1986 to 2022

QUANTEC
Geoscience

**Leading Innovation in Geophysical Exploration**




SPARTAN MT ORION 3D TITAN

**Technology for Discovery**

## Corporate Timeline

# Three Key Markets

## Mineral exploration

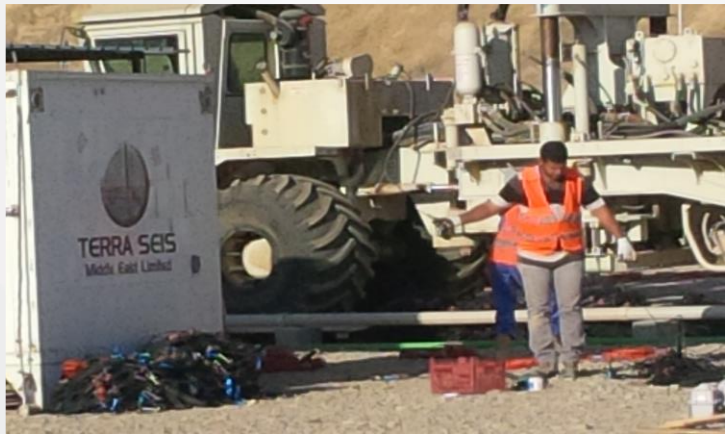
- Grassroots & brownfield environments

## Geothermal exploration

- Evaluate potential geothermal resources

## Oil & Gas exploration

- Image through permafrost, heavy oil & volcanic cover
- Augment seismic  in challenging environments with 3D resistivity

# Values and actions


1. **Safe**
   - ❑ High standards and safe record
   - ❑ Training
2. **Reliable**
   - ❑ Proven record of client successes
   - ❑ Excellent references
3. **Accurate**
   - ❑ Proven record of innovation and development
   - ❑ Track record of drill success and discovery

# Committed to safe operations

## Safety

- Dedicated Health & Safety Specialist
- Safety HSE management system
- Member of GGSSA
- Pre-field risk assessment
- Training (First Aid, WHMIS, driving, ATV, worker HSE awareness training, etc.)

Health and Safety Excellence program Member wsib ONTARIO 2024

## 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 Rio Tinto, BHP and NEXA.

# Proven World Leading Technology and Services

## Technology for Discovery

TITAN

- 2D Deep earth imaging – distributed array based data acquisition : Flexible deployments of: IP and AMT and MT

ORION 3D

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

SPARTAN MT

- Flexible 1D, 2D and 3D deep resistivity imaging utilizing high resolution 24-bit AMT & MT

## Broad Range of Geophysical Expertise and Services

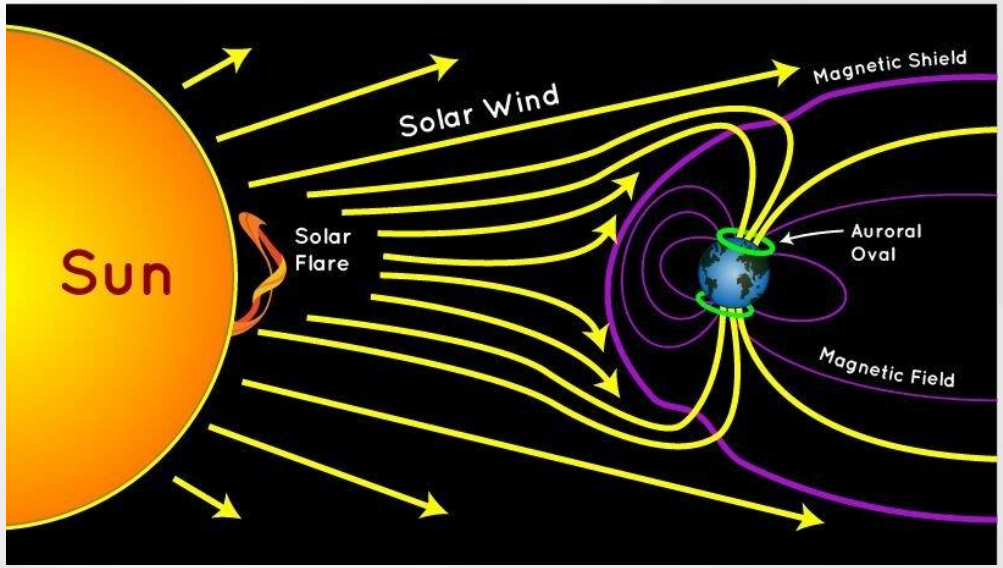
- Survey design, logistics planning, acquisition, QA/QC, interpretation, inversion modelling 2D and 3D, data integration and consulting services
- Complete suite of conventional ground geophysical surveys including; Gravity, Magnetic, Radiometric, DCIP TEM (surface and borehole) & CSAMT

SPARTAN MT

# SPARTAN MT  full tensor magnetotellurics

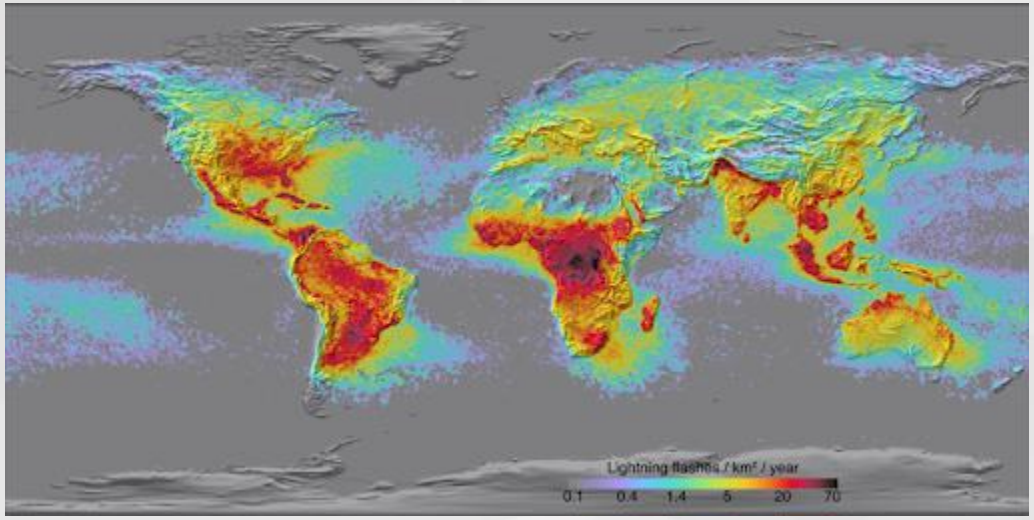
# MT natural source fields






## Solar Wind

- Lower frequencies:
  - f < 1 Hz
  - Interaction of the solar wind with the earth's magnetic field



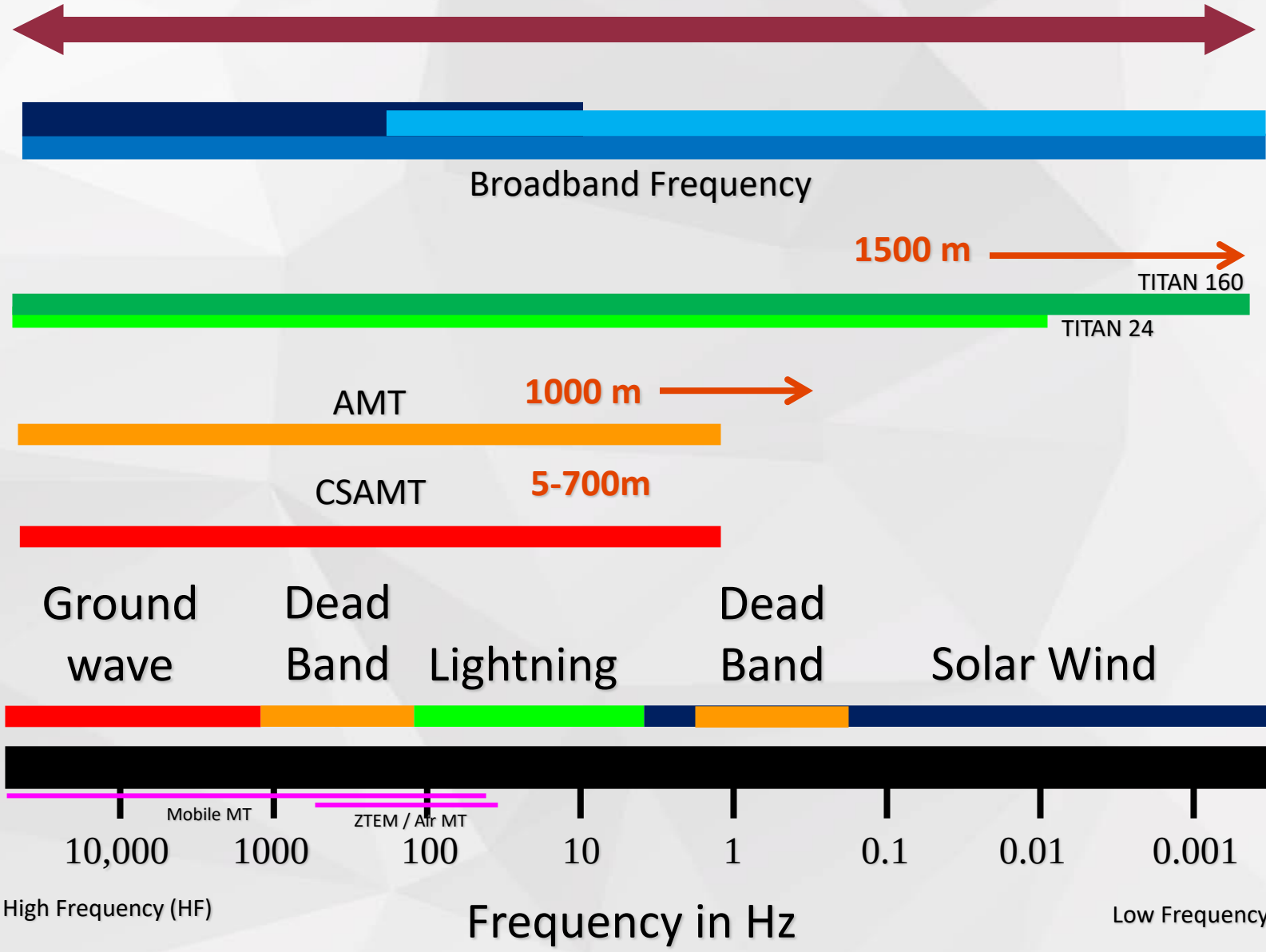

## Global Thunderstorms

- Higher frequencies:
  - f > 1 Hz
  - Lightning activity

SPARTAN MT

# MT – frequency bandwidth & survey types






**MT**

SPARTAN MT
(Broadband or LF & HF)

TITAN MT
(distributed array /close spacing)

# MT/AMT/CSAMT



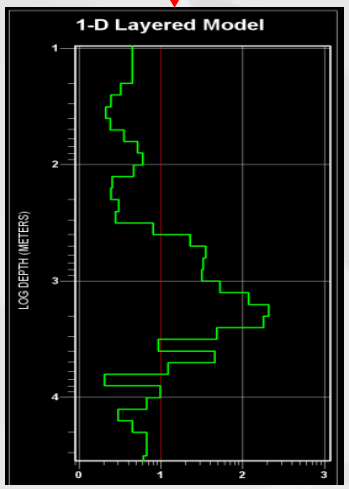
- **MT**
  - Generally refers to Broad Band recording from >10,000 Hz to .001Hz (also referred to as 1000 seconds) or as low as 10K S (.0001Hz) from surface to great depths – (up to **100km** and more)
- **AMT**
  - Refers to “Audio” frequencies
  - Generally recording > 10,000 Hz to 1Hz
  - The bandwidth works well where high resolution inversion modeled resistivity results are needed to depths of **1 km**, (more or less).
- **CSAMT**
  - Refers to “Controlled Source” AMT (depth range of up to 1000m but typically useful for **500m** more or less due to source effects)
  - Advantageous for measurements with smaller dipoles less than 50m

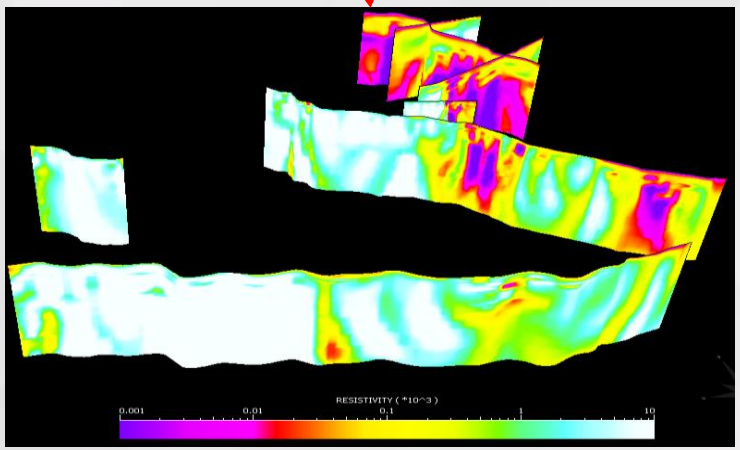
# MT deployments and processing

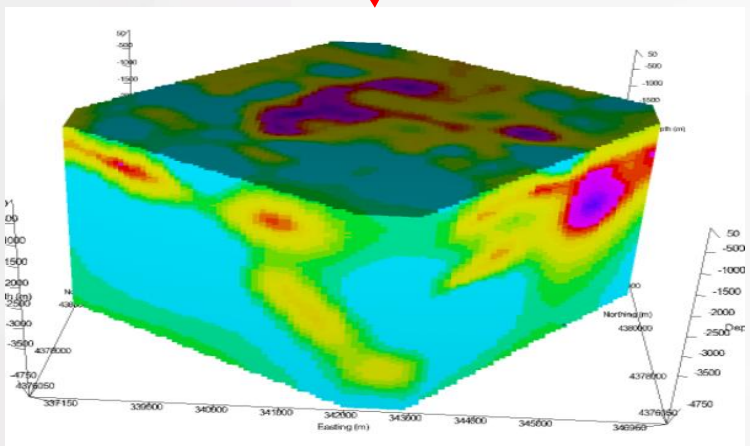


- DATA
- INVERSION
- RESISTIVITY MODEL

| Single Site | Profile | Grid |
|---|---|---|
| $\begin{pmatrix} 0 & Z \\ -Z & 0 \end{pmatrix}$ | $\begin{pmatrix} 0 & Z_{xy} \\ Z_{yx} & 0 \end{pmatrix}$ | $\begin{pmatrix} Z_{xx} & Z_{xy} \\ Z_{yx} & Z_{yy} \end{pmatrix}$ |
| $\rho$ | $\rho_{xy}, \rho_{yx}$ | |
| 1-D | 2-D | 3-D |



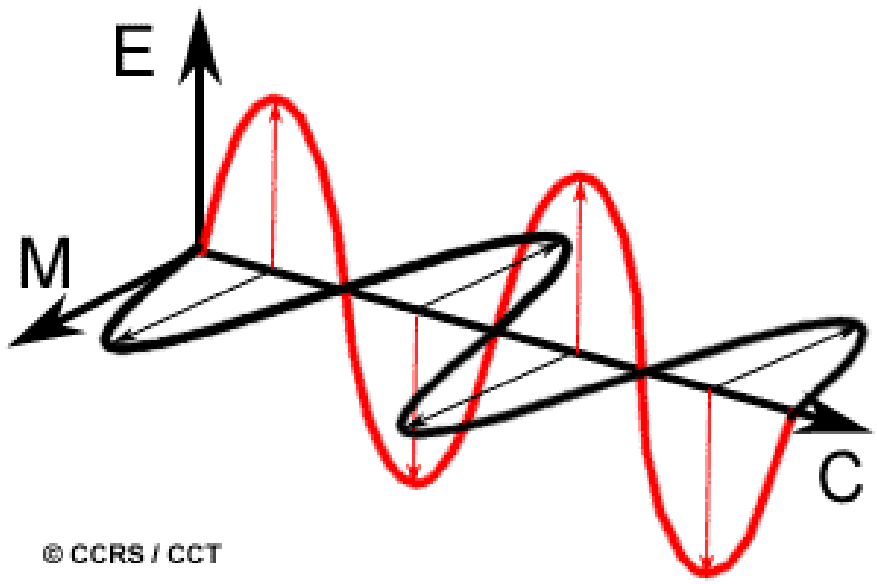



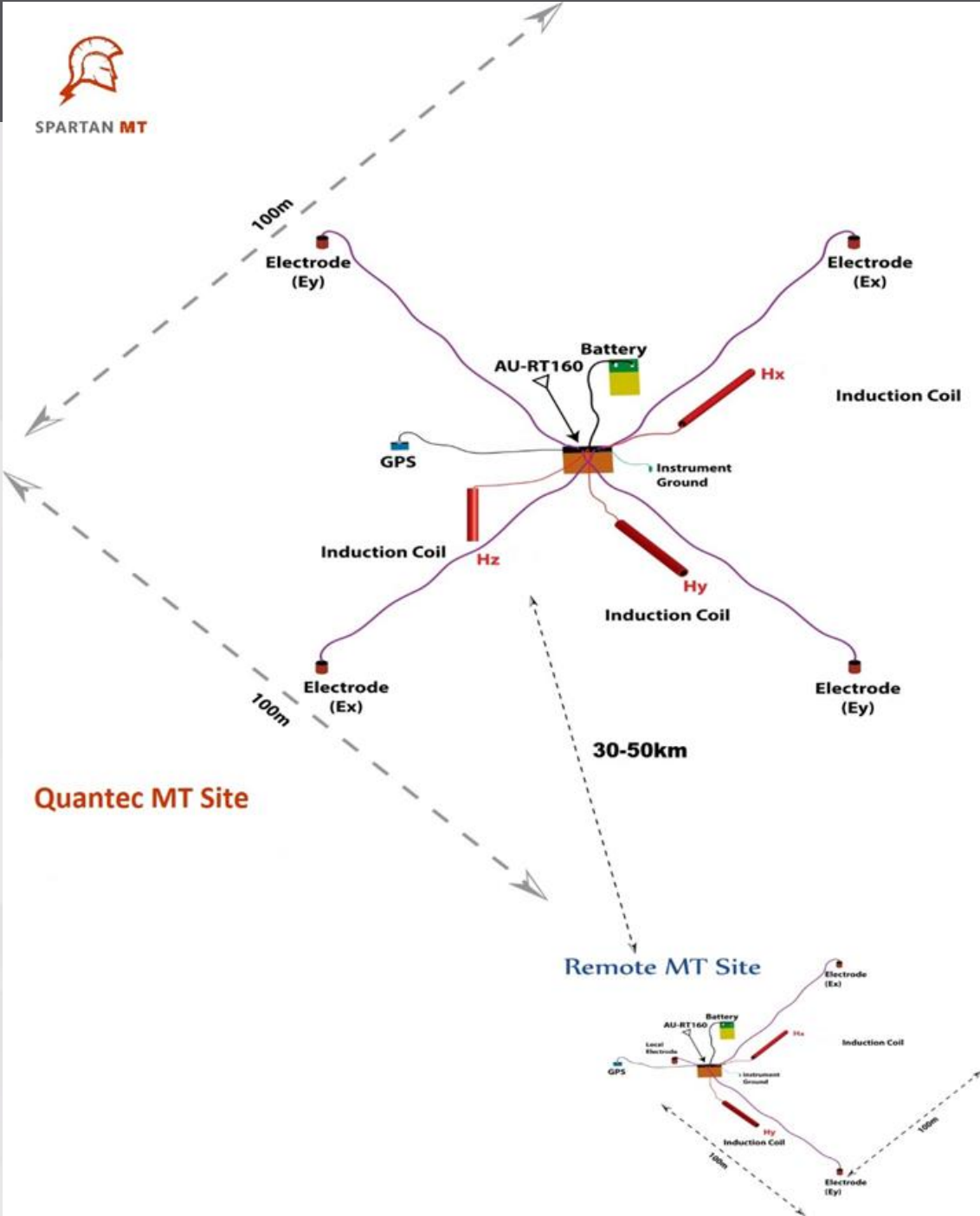



SPARTAN MT

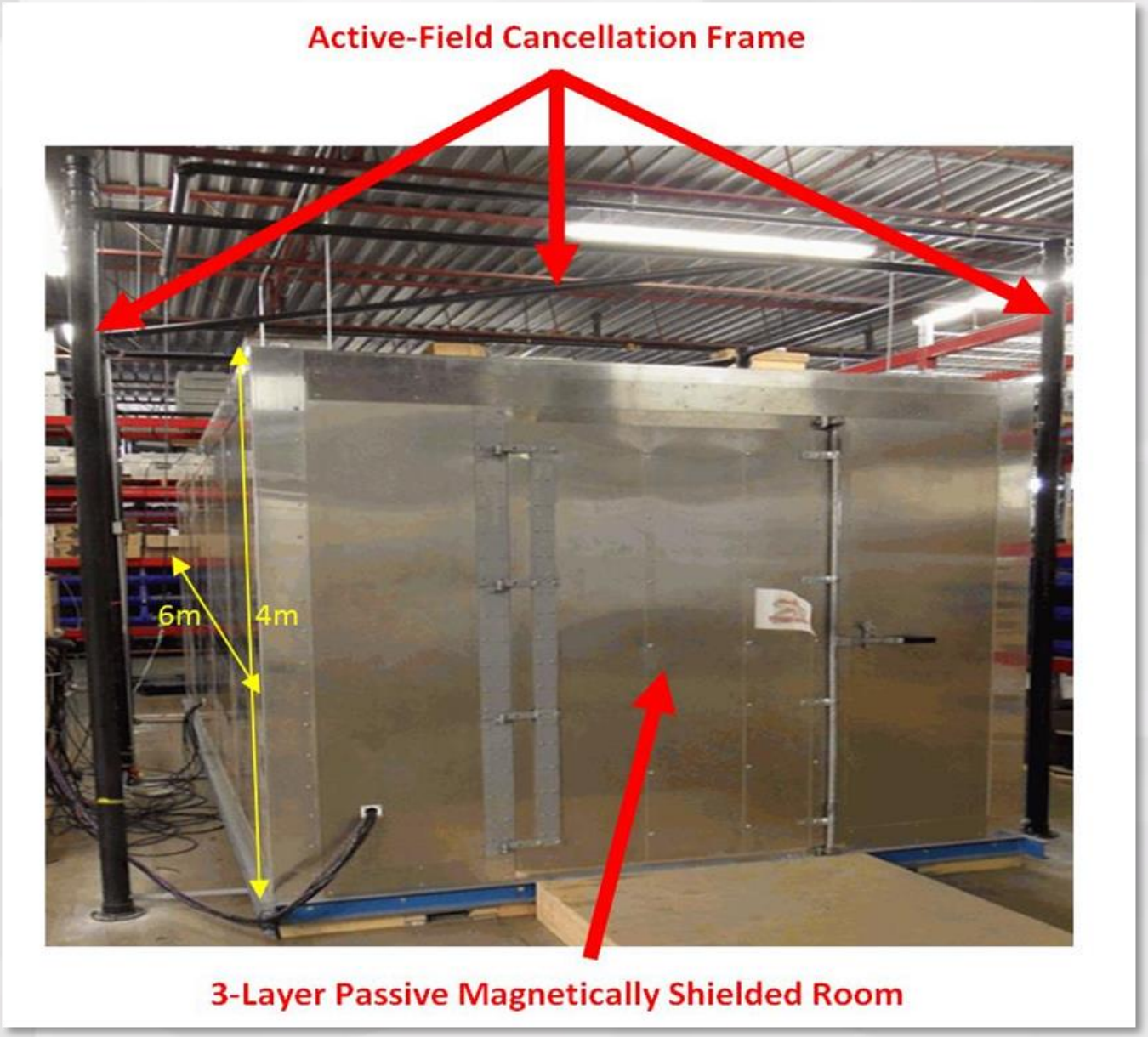
# MT data acquisition

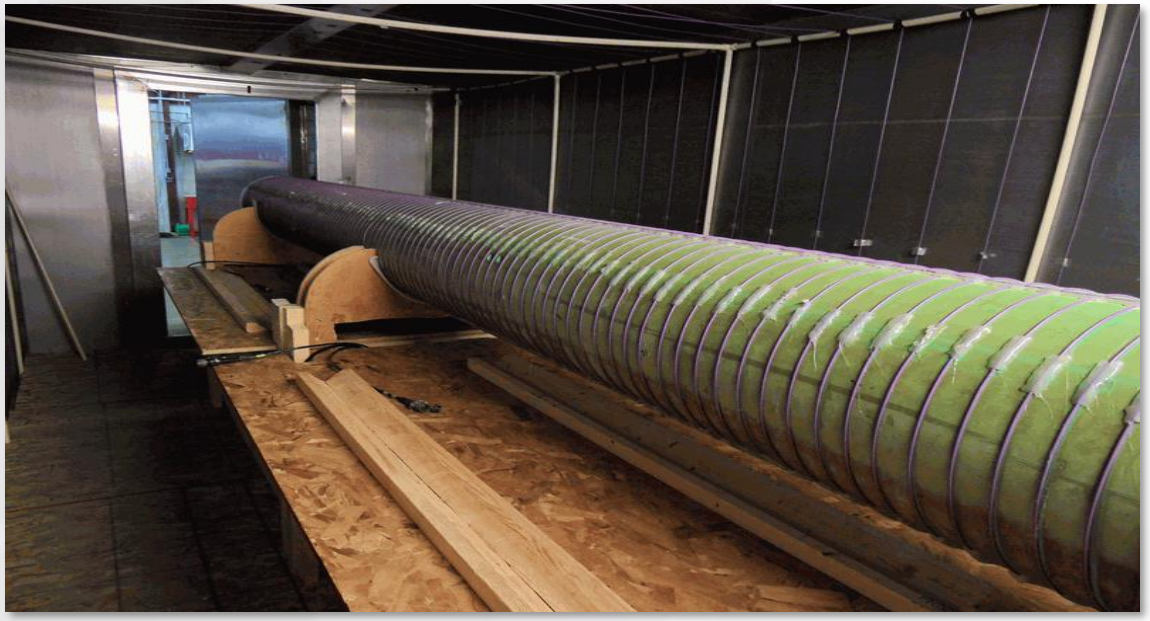
Measure the natural **electric field** and the natural **magnetic field** over a range of frequencies

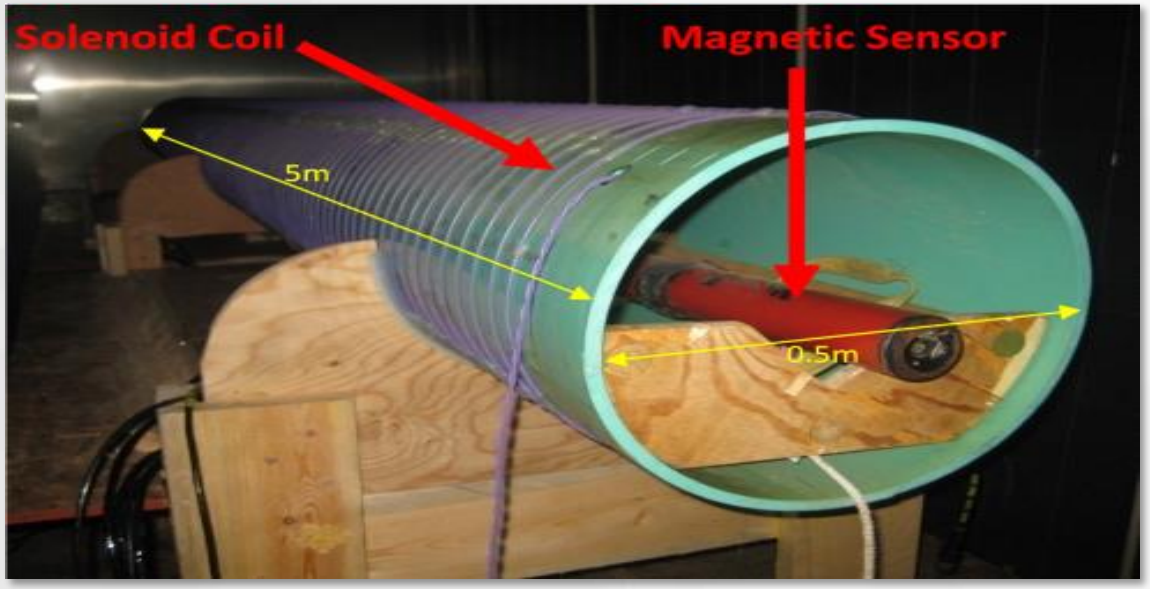


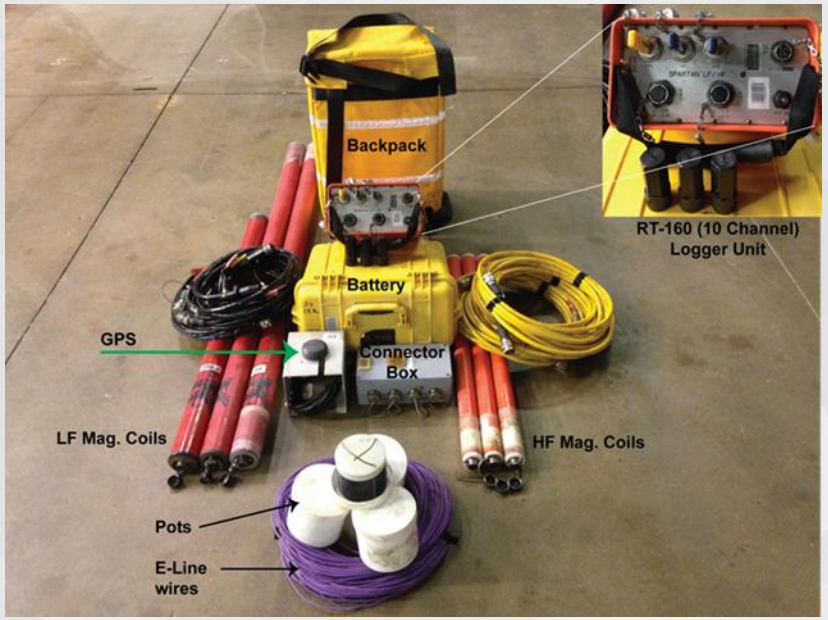
# Quantec's Calibration chamber for MT coils





# Typical equipment required for one site


# Portable - can go almost anywhere

# Testing the coils prior to starting a survey

# FIELD SETUP



Various images above showing layout of field equipment including recording systems, cables, electrode and buried magnetometer sites.

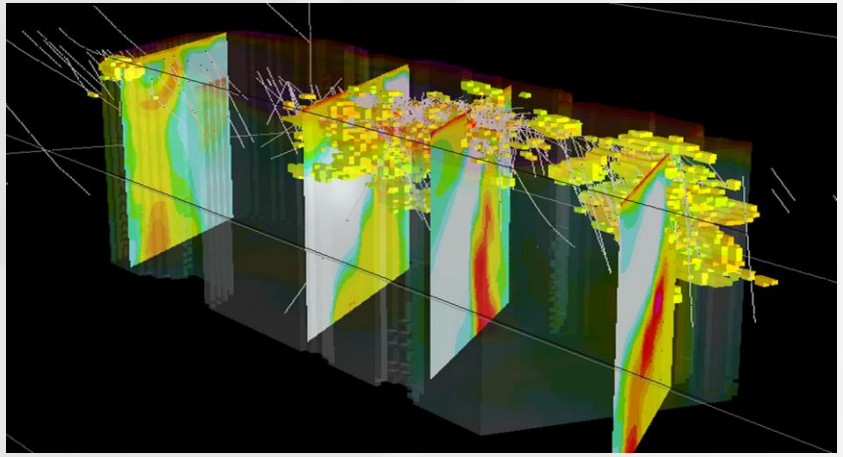
SPARTAN MT

# MT applications - flexible resistivity mapping

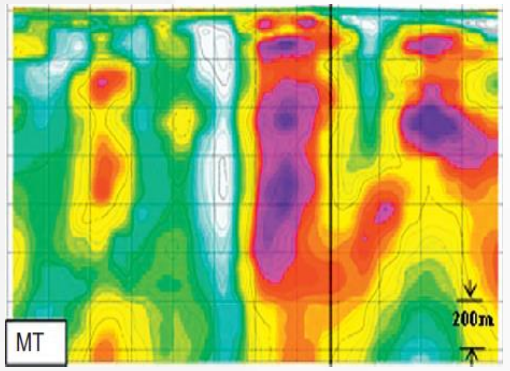
## Mining & Exploration

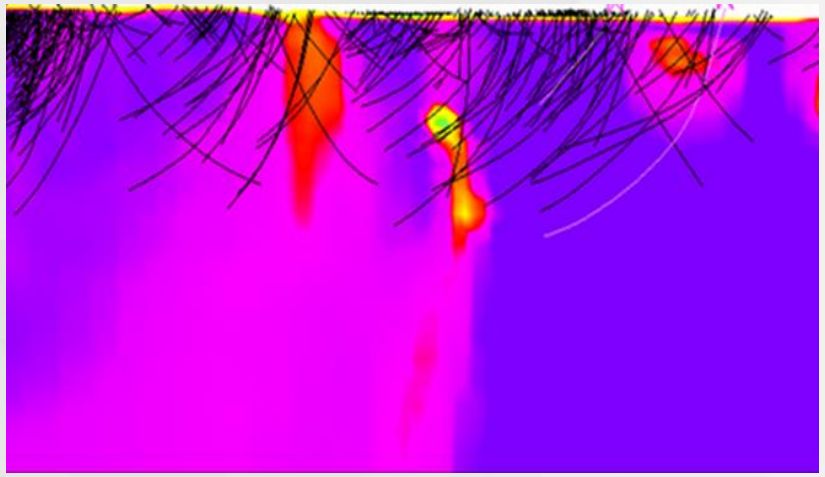
- Porphyry exploration
- Gold exploration
- Brine mapping
- Structural mapping - Faults/ shears
- Near-mine exploration
- Pre-Mine Risk evaluation
- Regional potential target evaluation
- Basin mapping (depth of cover)
- Crustal studies

- Geothermal
- Oil & Gas

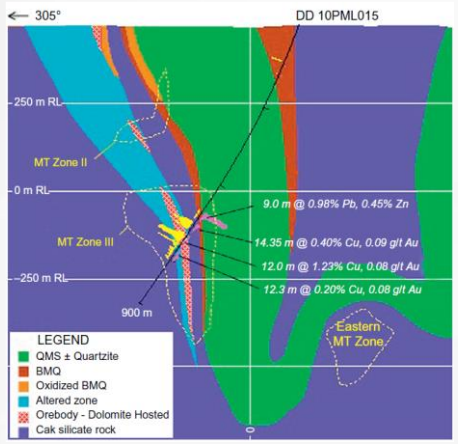


Timmins Camp, Dester Porcupine fault mapping



Louvicourt (constrained MT inversion) deposit delineation



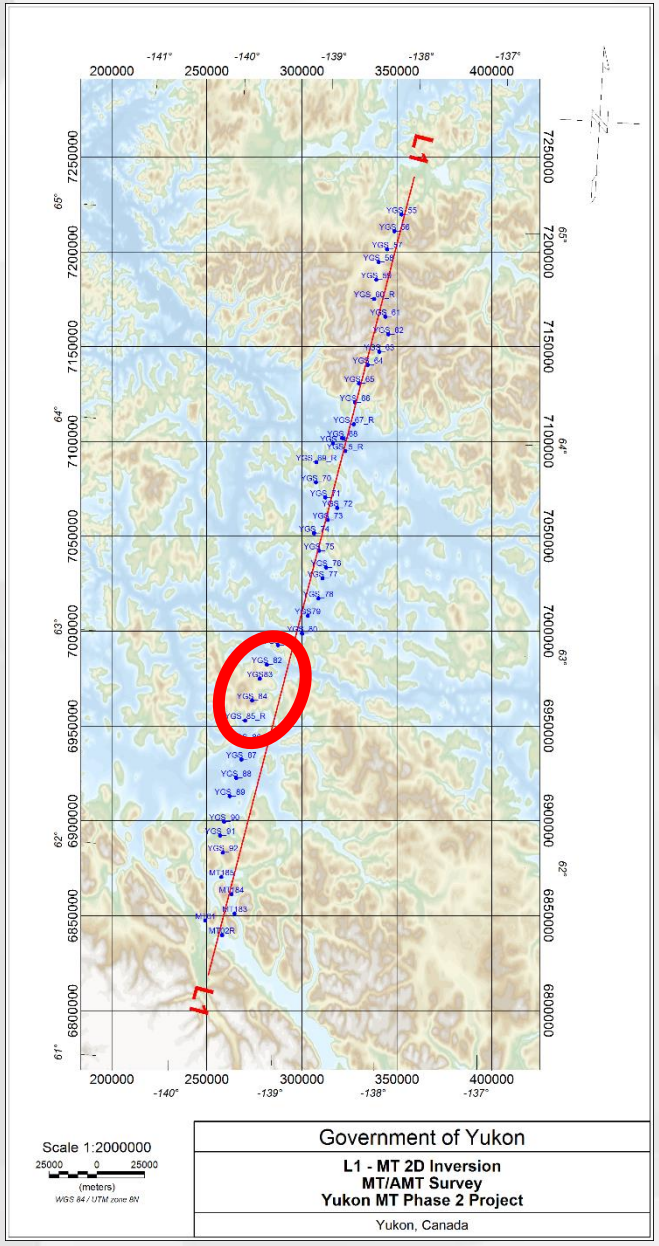

Pur-Banera Prospect, Rajasthan, India Kavdia et al., 2015).

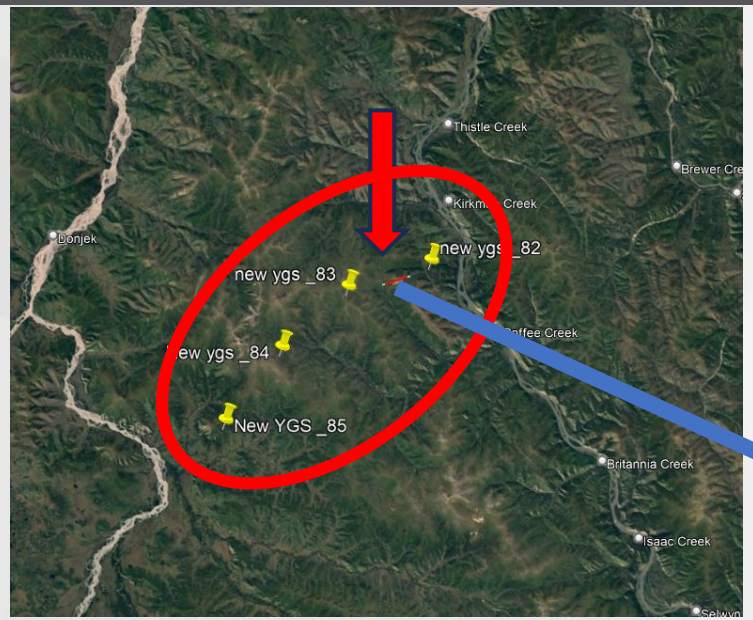
SPARTAN MT

SPARTAN MT

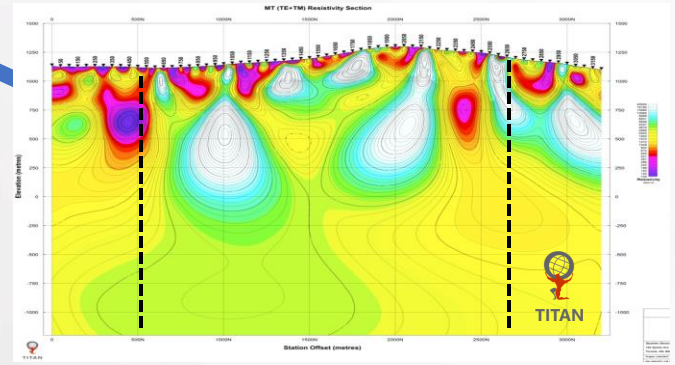
# GEOTHERMAL Experience & CASE STUDIES

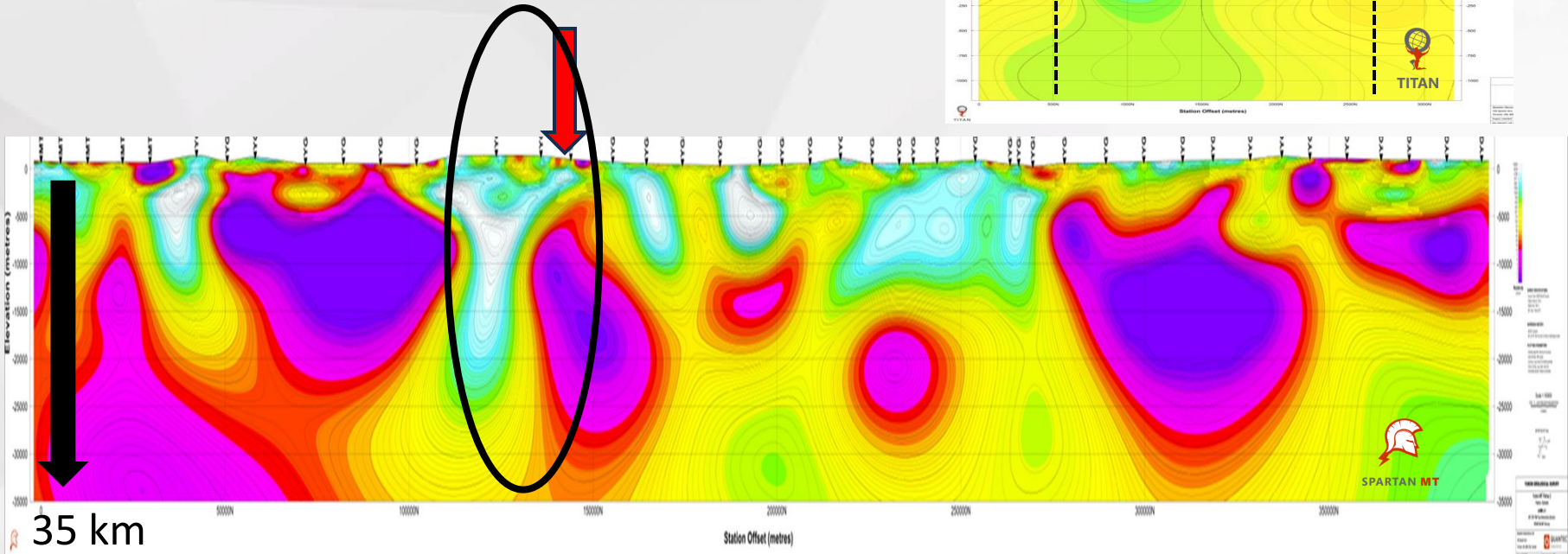
# Deep Regional transects
# GSC-Yukon Government Geothermal MT initiative 2023




- Coffee Deposit location
- Detailed MT @ 100m spacing
- Resistivity section shown to 2250 m




35 km

# Gov't Reference

Whitehorse, Yukon
February 27, 2023

To whom it may concern:

Quantec Geoscience completed two MT surveys under contract for the Yukon Geological Survey (YGS) in 2021 and 2022. These surveys were designed in collaboration with geophysicists from the Geological Survey of Canada (GSC) in support of the YGS geothermal exploration program in southern Yukon. The surveys were combination of detailed AMT/MT grids focused on specific target areas and regional MT transects with stations spaced every 10 km along highway corridors. Quantec has a contract with the YGS for completion of the regional MT transects in summer 2023.

Our experience working with Quantec was professional and positive. Throughout the survey, the Quantec crew maintained daily communication with YGS and GSC which allowed for adjustments in survey acquisition to ensure optimal data quality. We look forward to work with Quantec again in 2023 for completion of our regional MT survey.

Feel free to contact me should you require additional information on the surveys that Quantec conducted for YGS.

Sincerely,

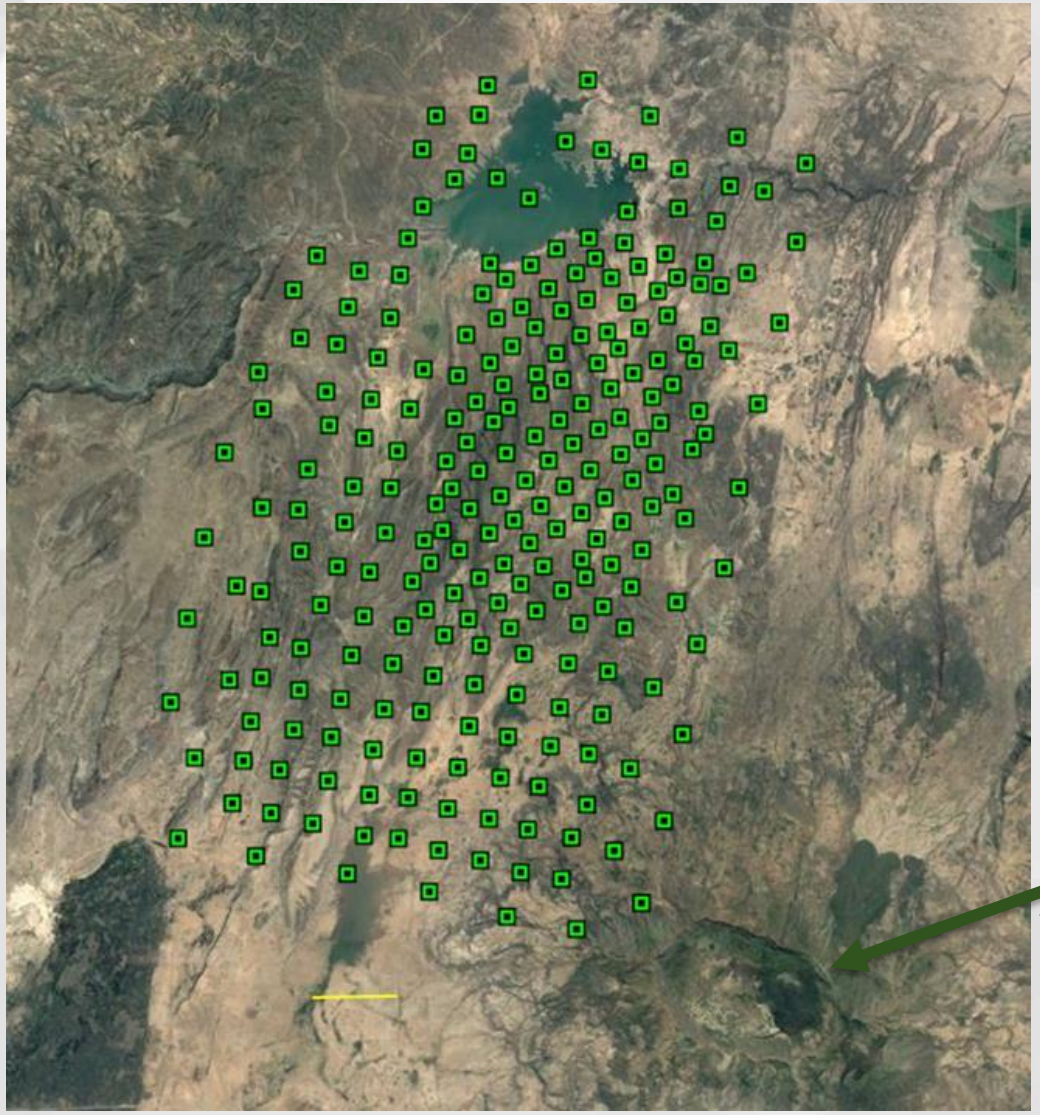
Maurice Colpron, Ph.D.
Head, Bedrock Geology

Yukon Geological Survey
PO Box 2703 (K14)
Whitehorse, YT Y1A 2C6
Canada
Ph. 867.667.8235
E Maurice.Colpron@yukon.ca

SPARTAN MT

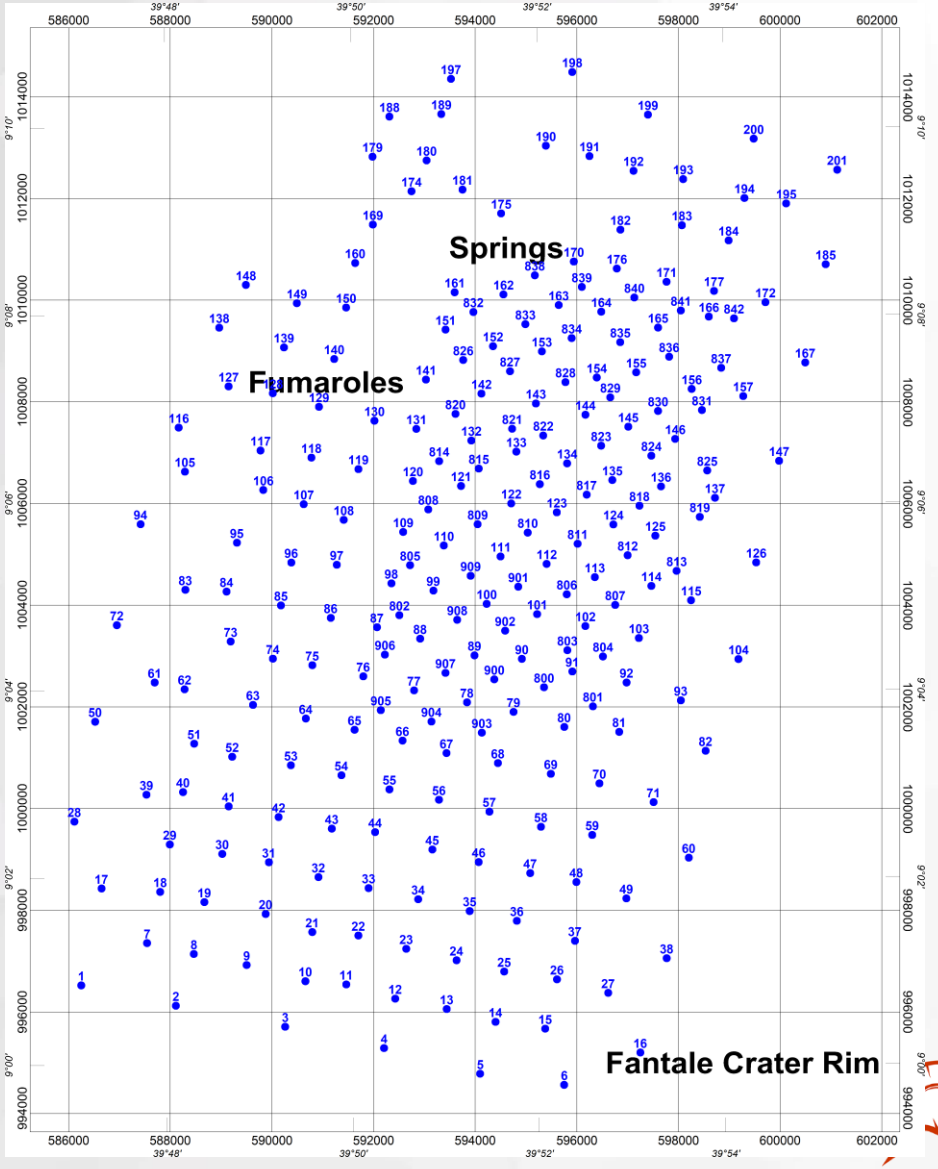
# GEOTHERMAL CASE STUDIES

# MT survey for Cluff in Ethiopia utilising nominal 700 metres



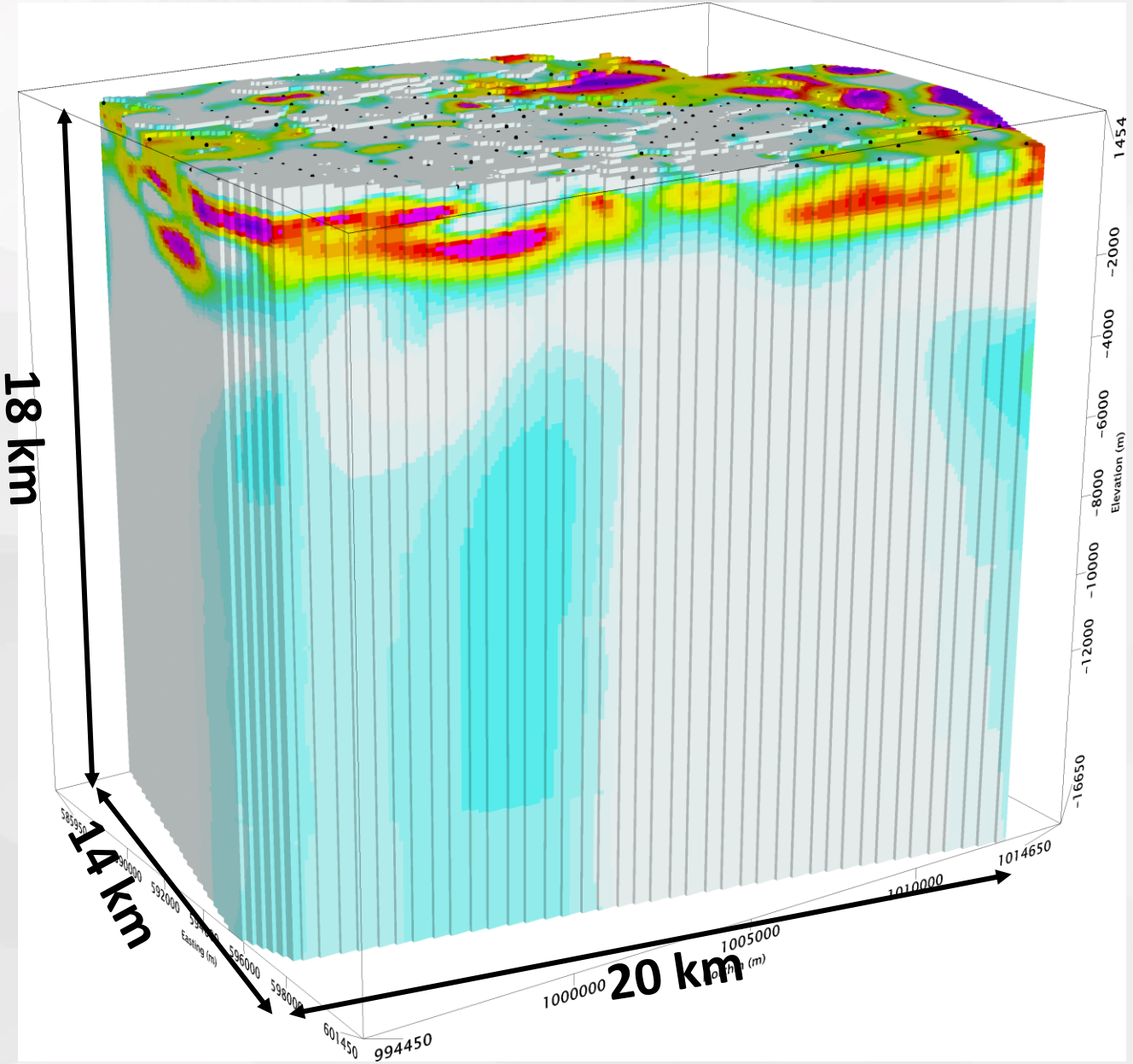
- 1 to 2 crews of 3 people deploying roughly 6-8 sites per day
- Duration roughly 25 days

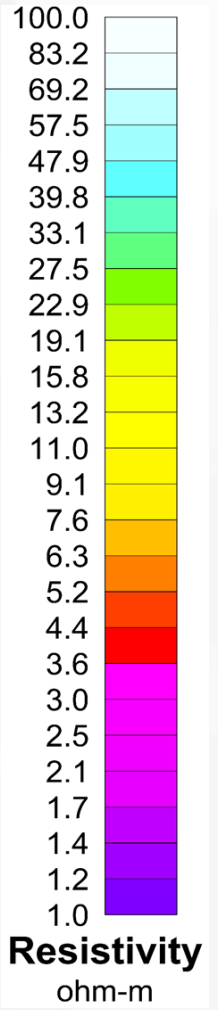
Volcano




SPARTAN MT

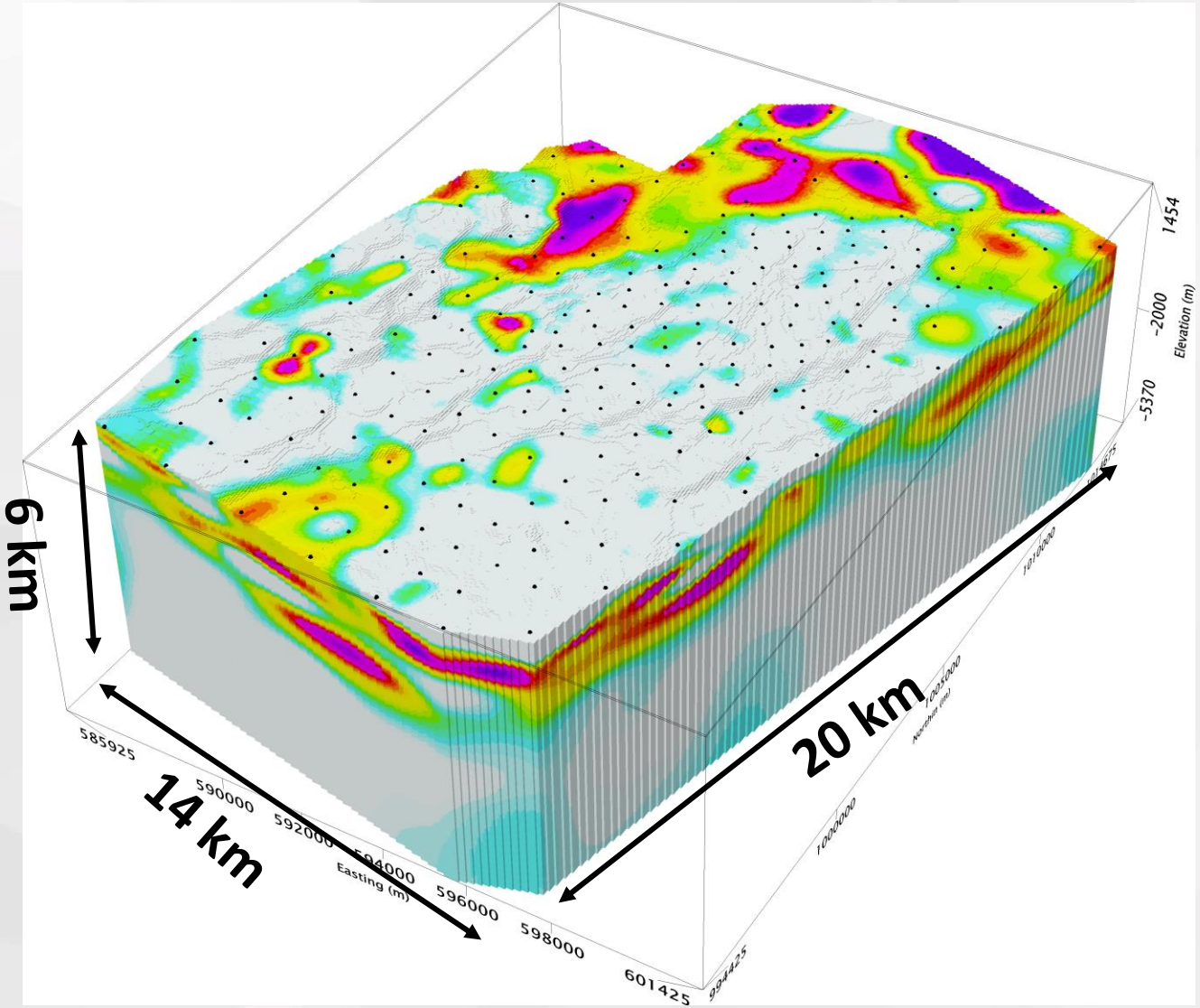
# MT 3D Resistivity Model

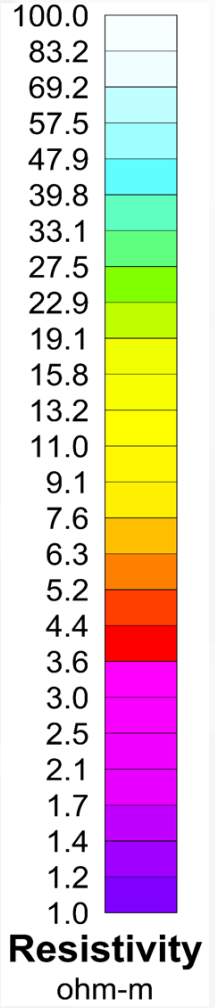



SPARTAN MT

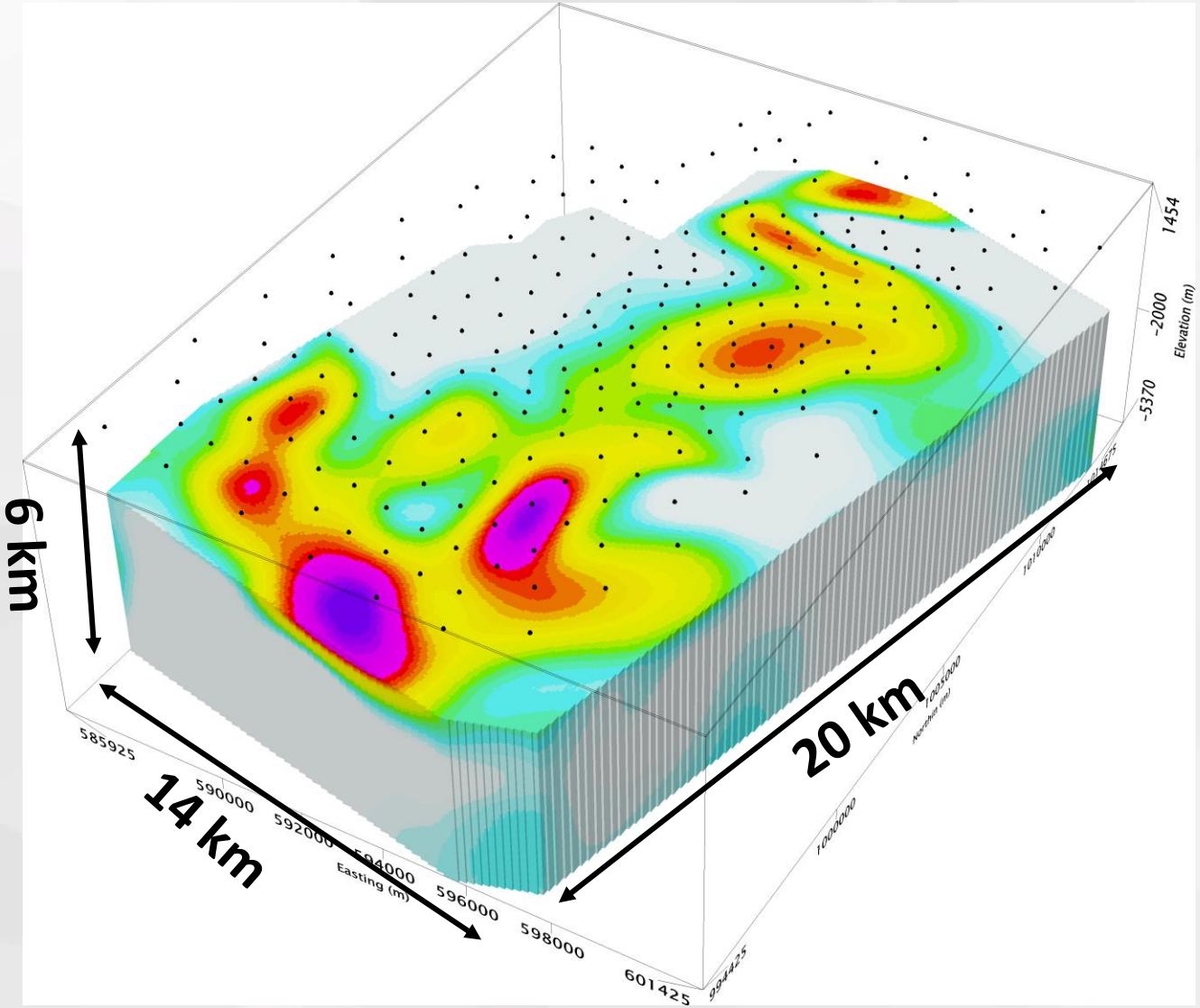
# MT 3D Resistivity Model (shown down to 6 km)

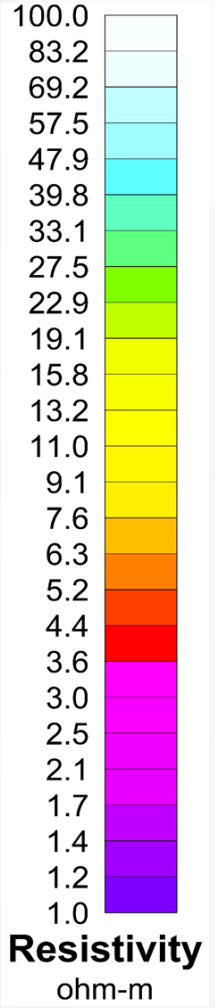



SPARTAN MT

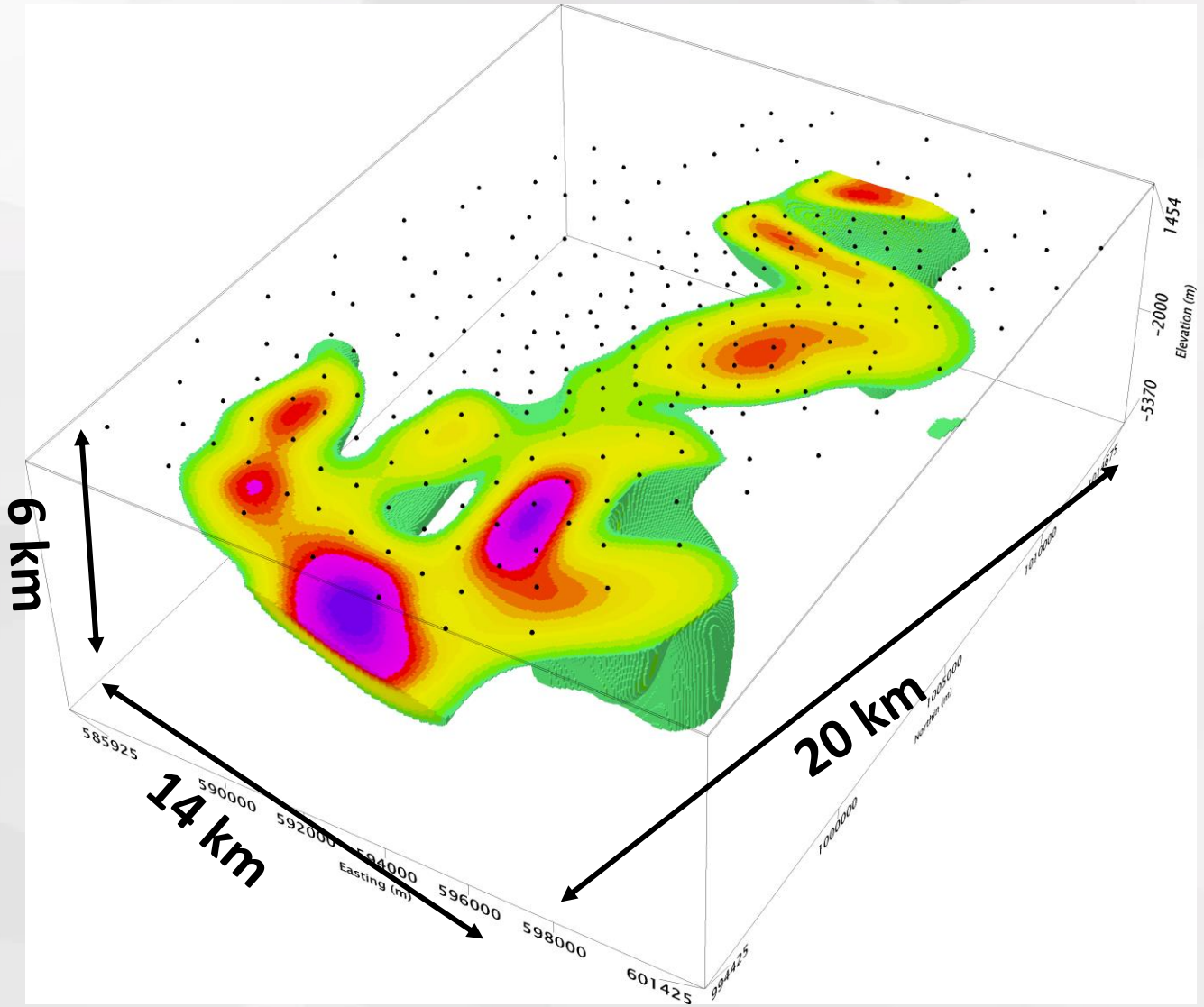
# MT 3D Resistivity Model (cut at 2 km depth)

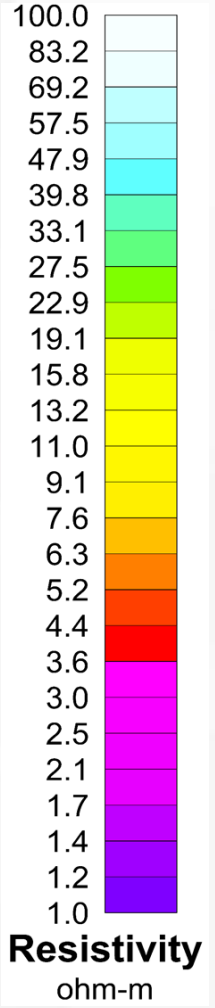



SPARTAN MT

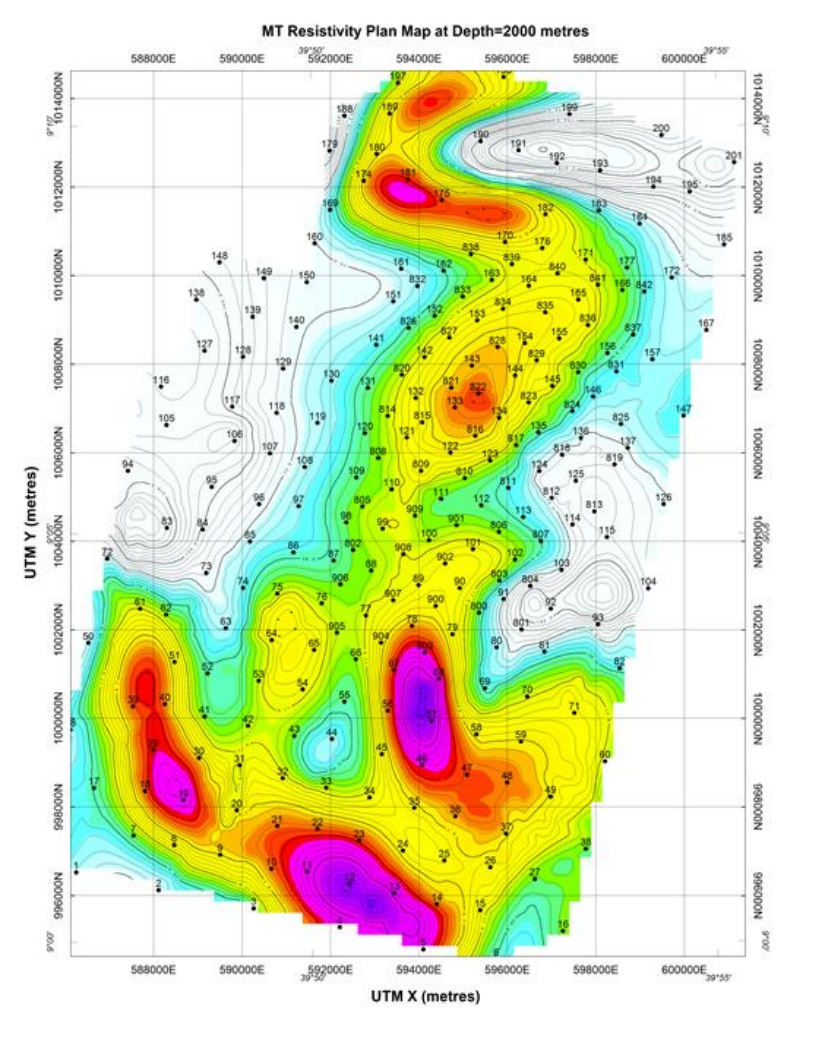
# MT 3D Resistivity Model (cut at 30 Ohm-M)

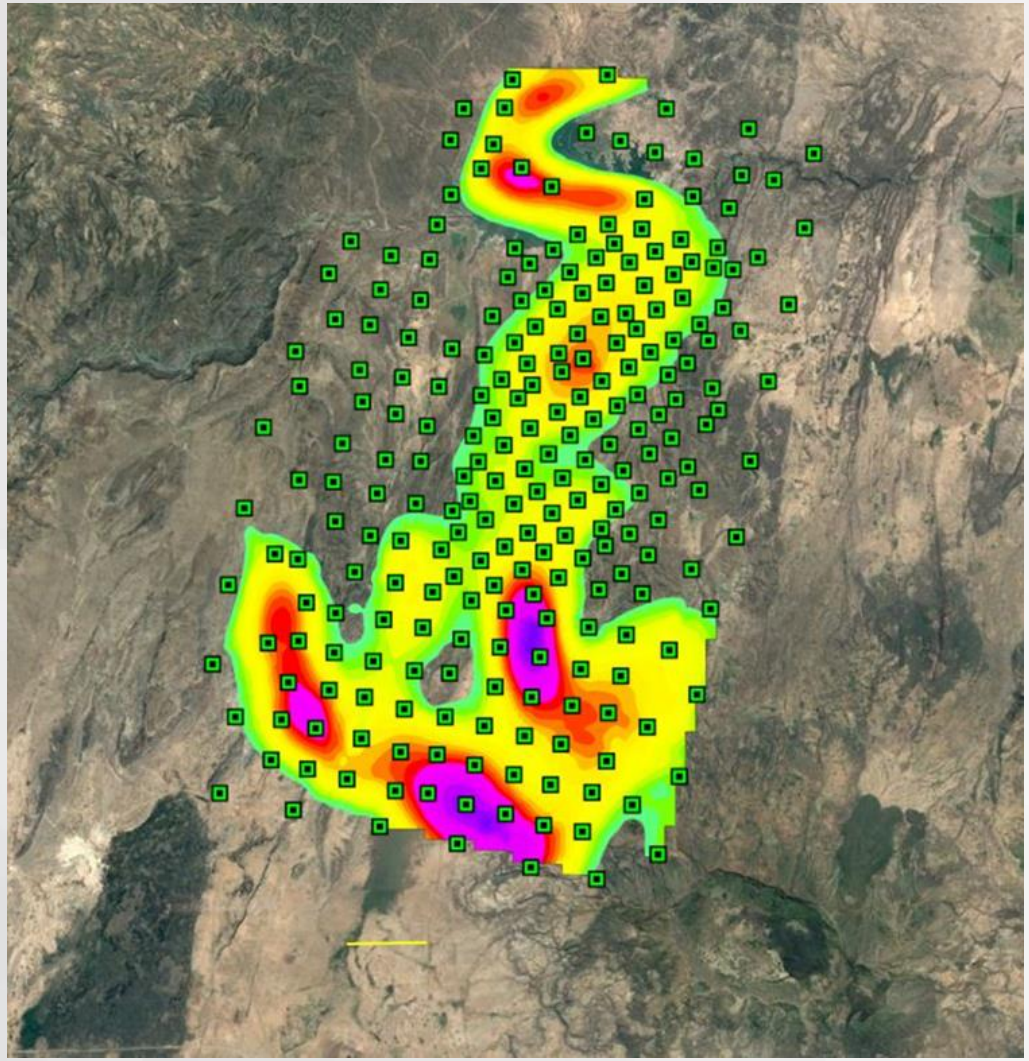


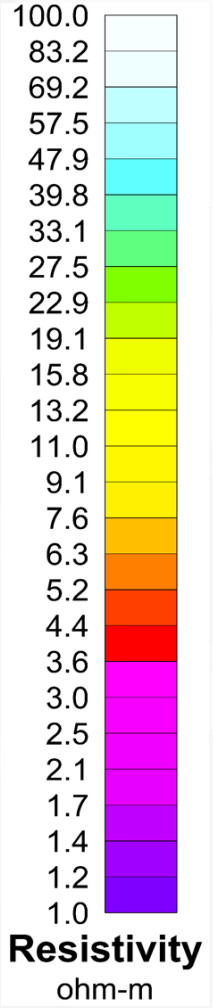




SPARTAN MT

# Resistivity plan view at 2000m depth

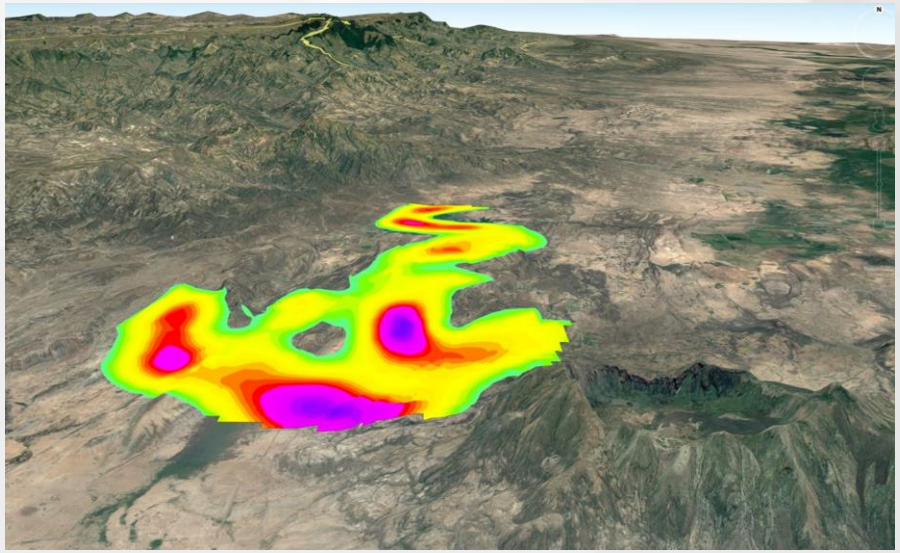


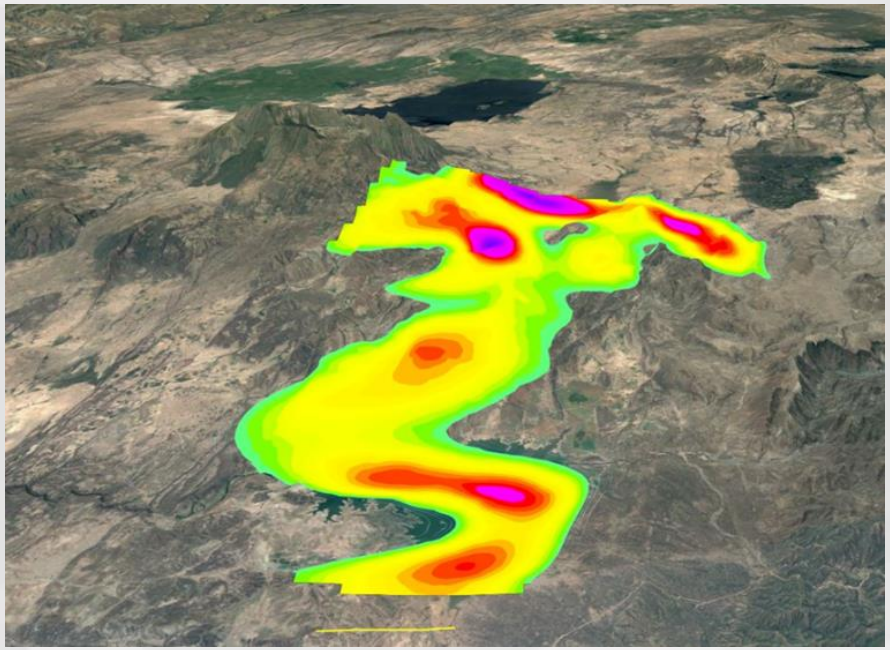



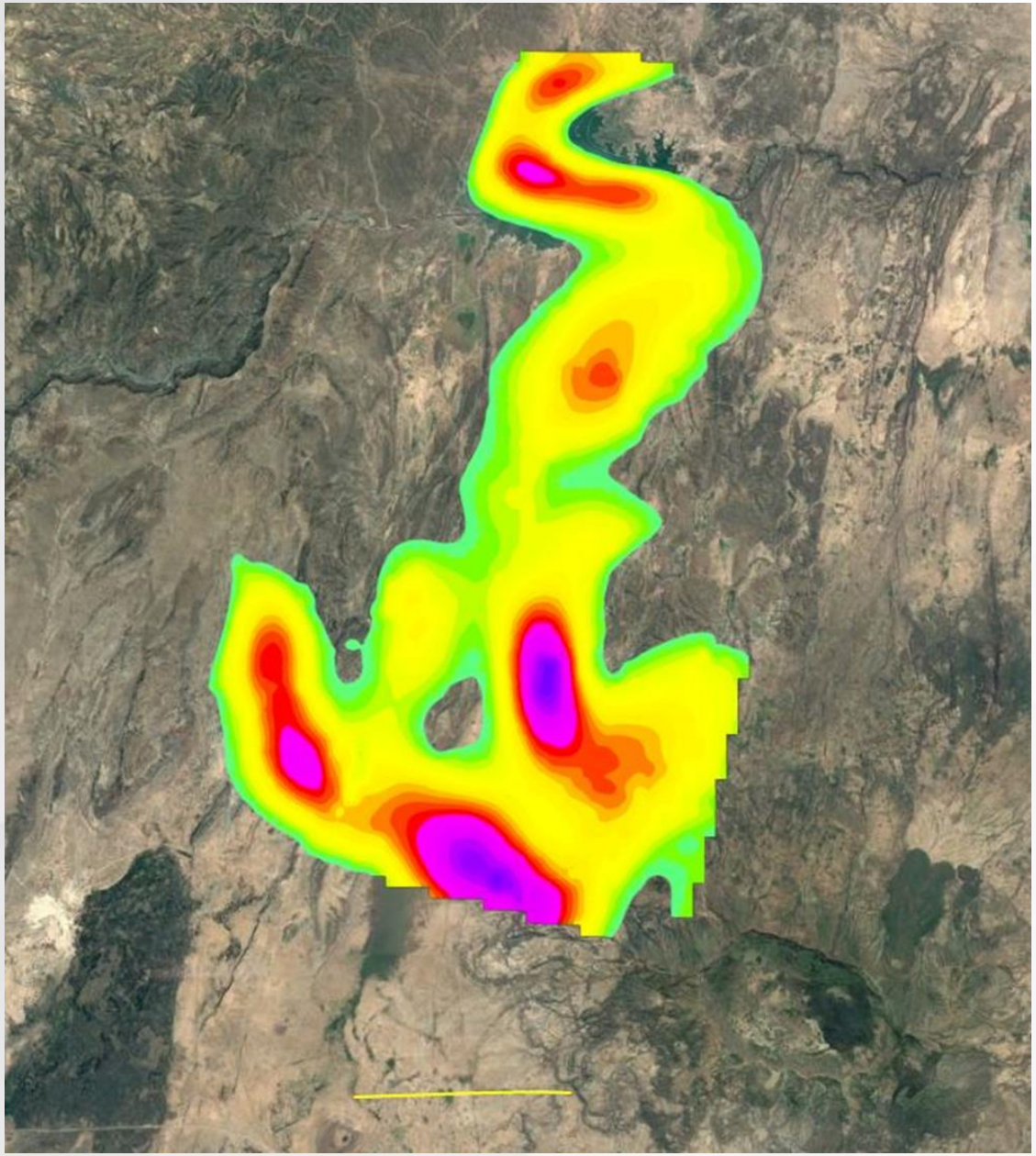



SPARTAN MT

# 2000 m Depth slice shown on surface

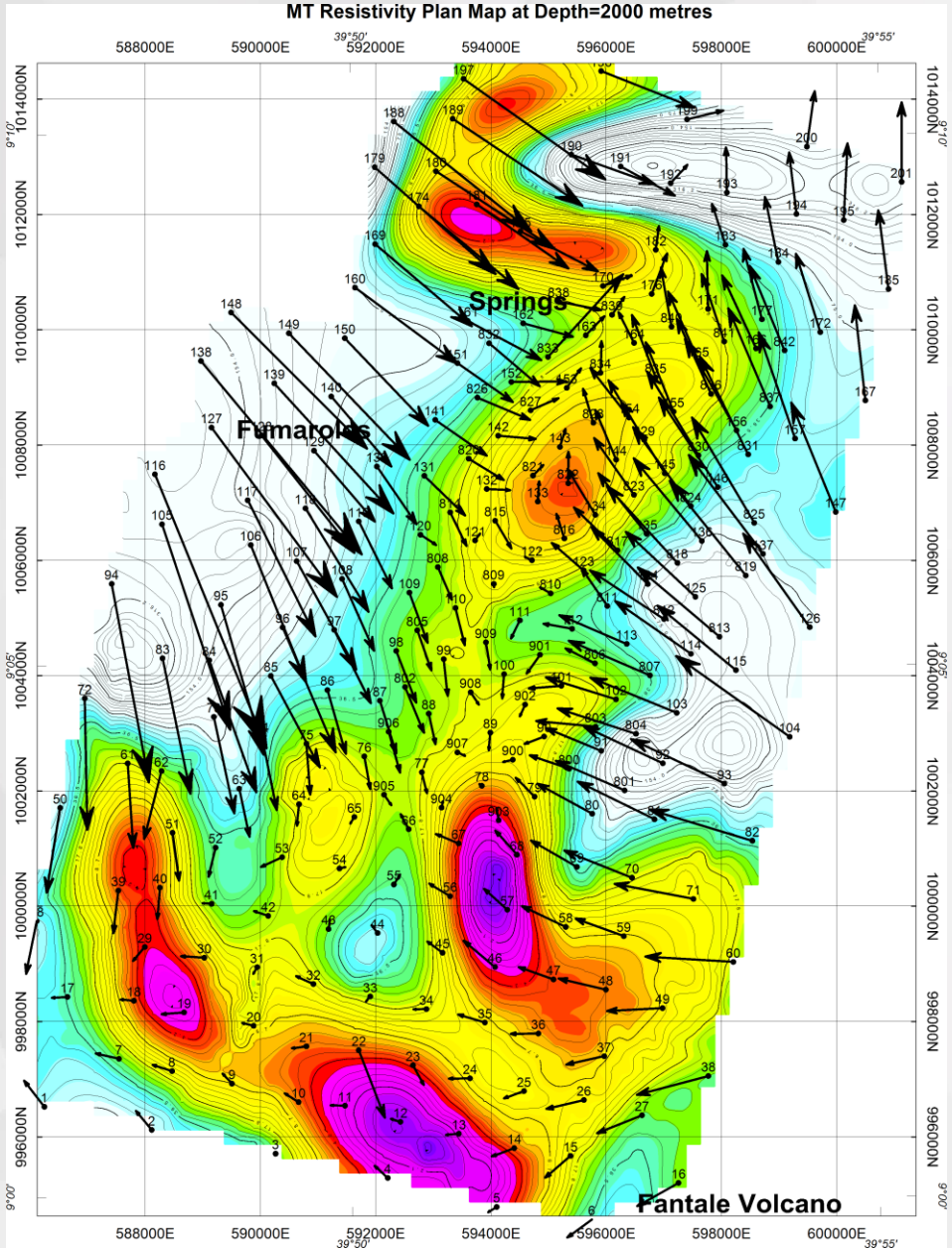


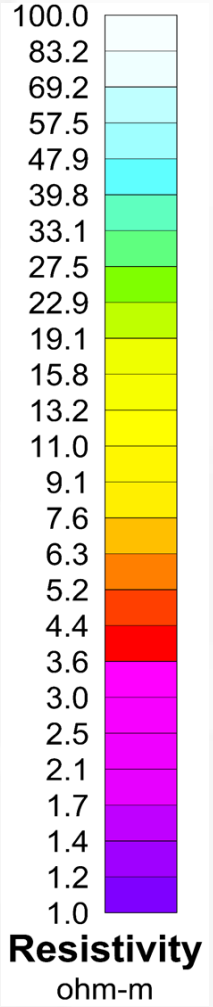




# Resistivity plan view at 2000m depth

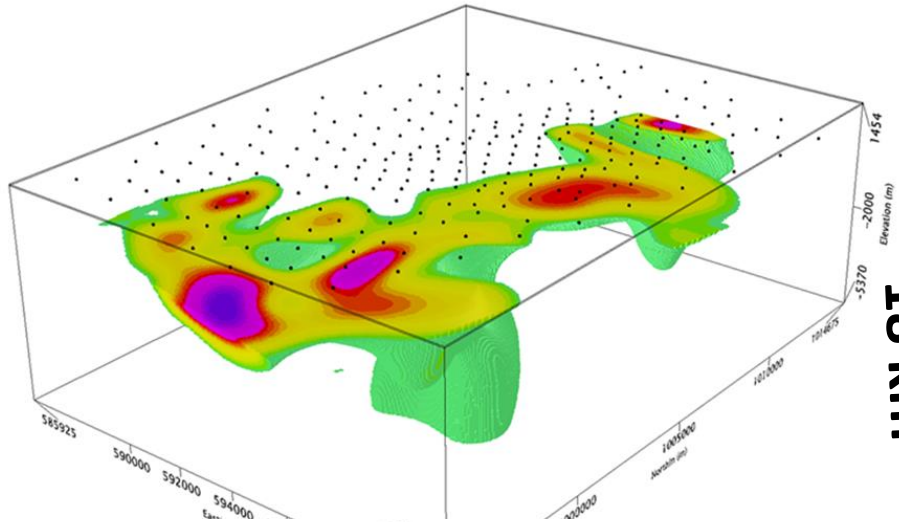
- **Induction Vectors, superimposing the resistivity model.**
- **Induction Vectors independently confirms the geometry of lava flow by pointing towards the conductor.**

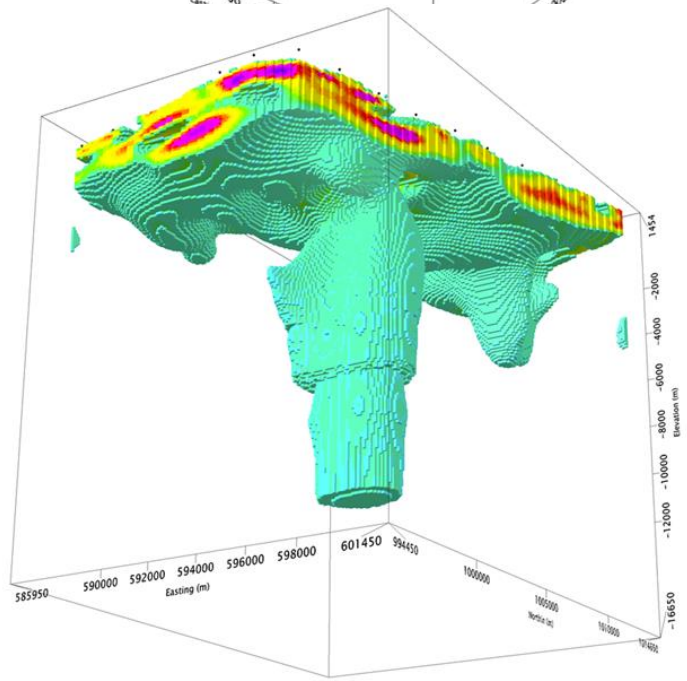


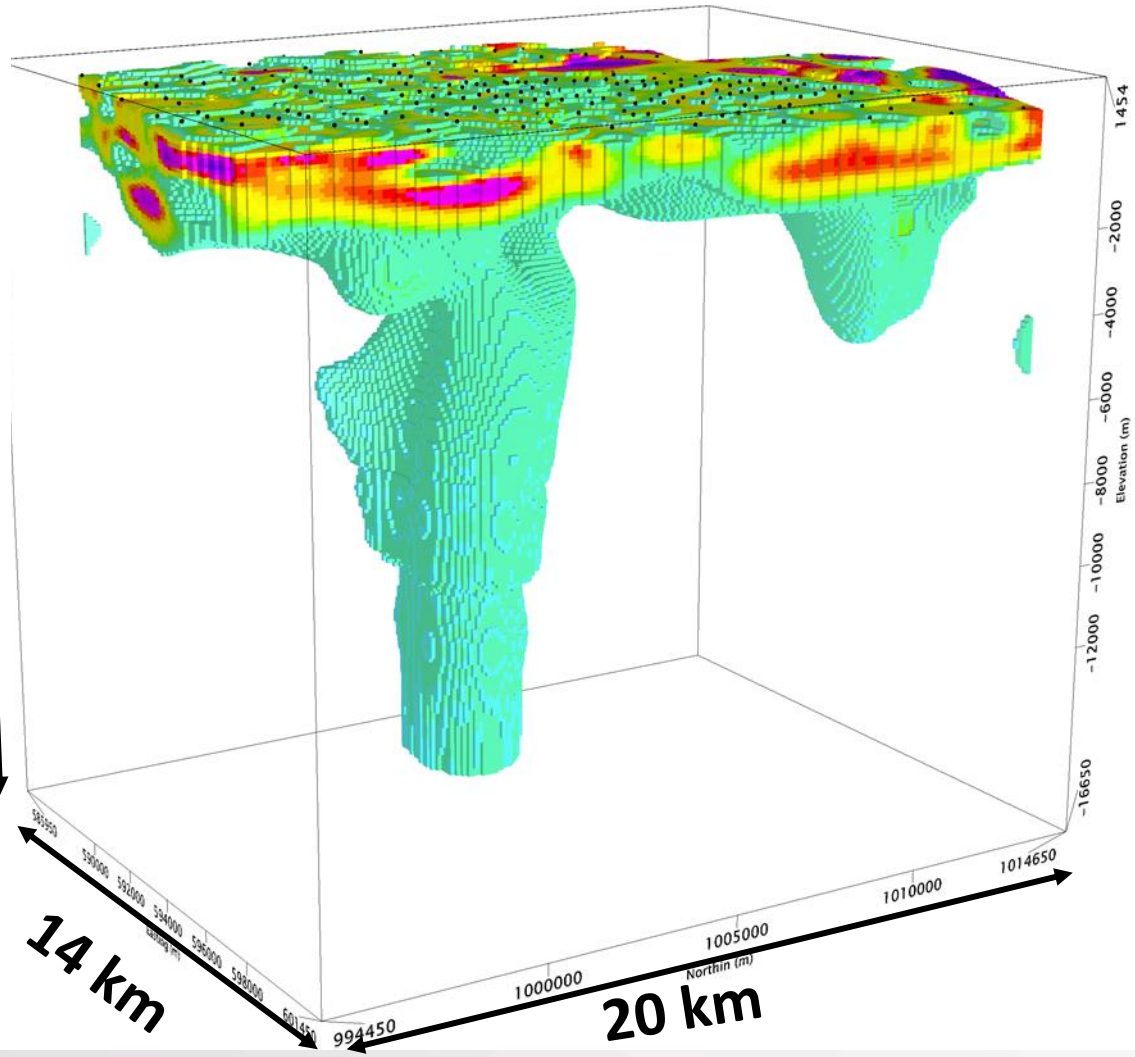




SPARTAN MT

# MT 3D Resistivity Inversion model
## (cut at 30 Ohm-M)



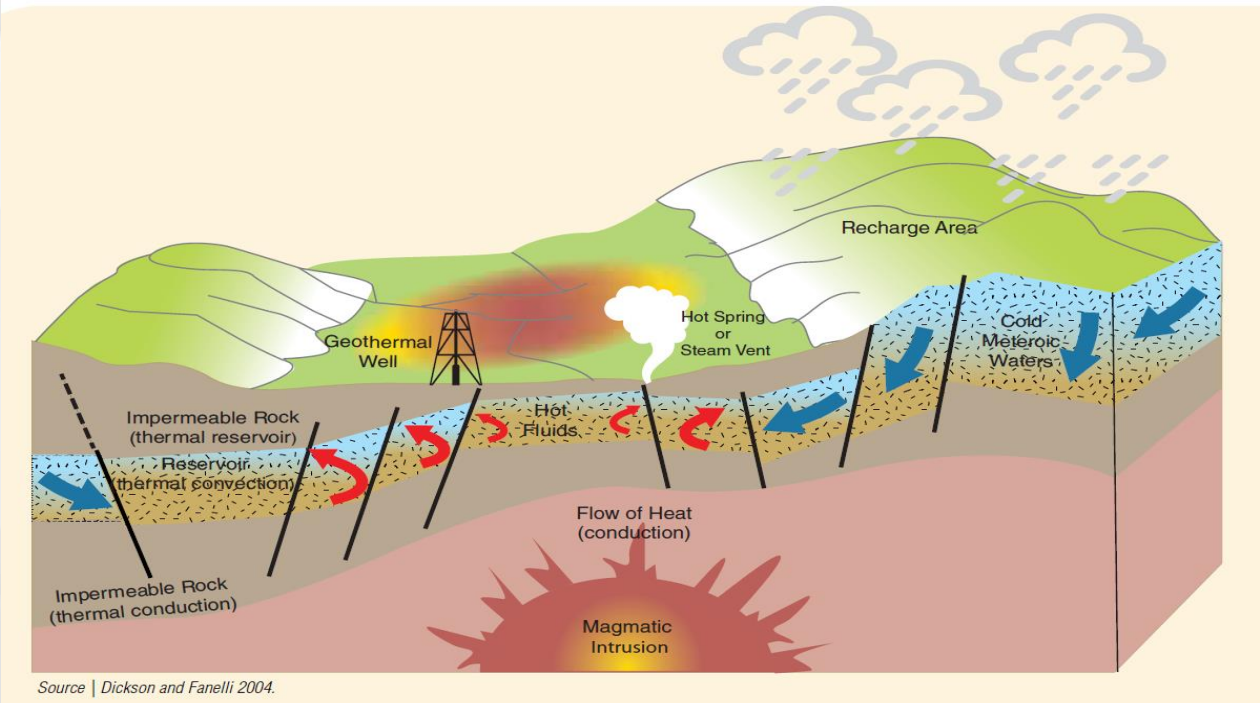




TITAN

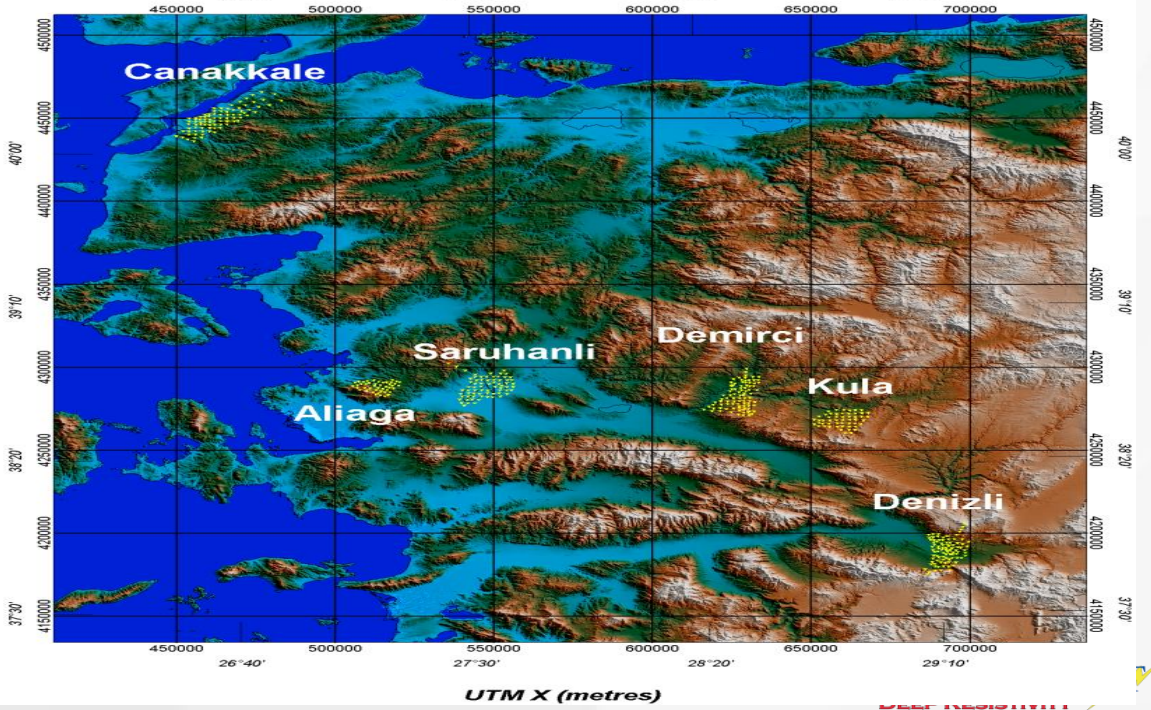
SPARTAN MT

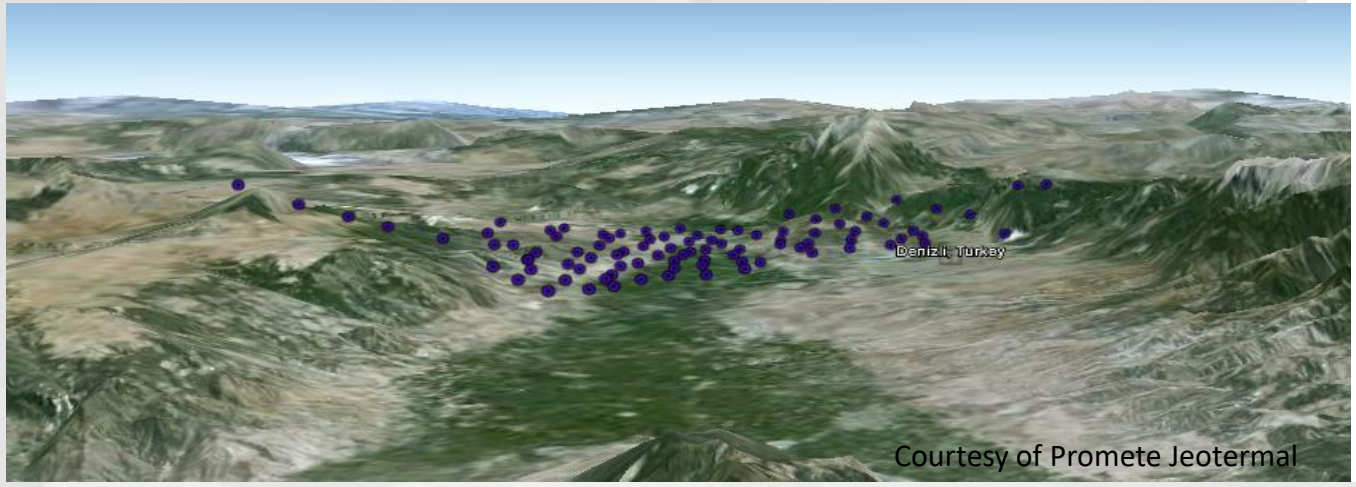
# GEOTHERMAL CASE STUDIES Turkey

# TURKEY GEOTHERMAL PROJECT




Source | Dickson and Fanelli 2004.

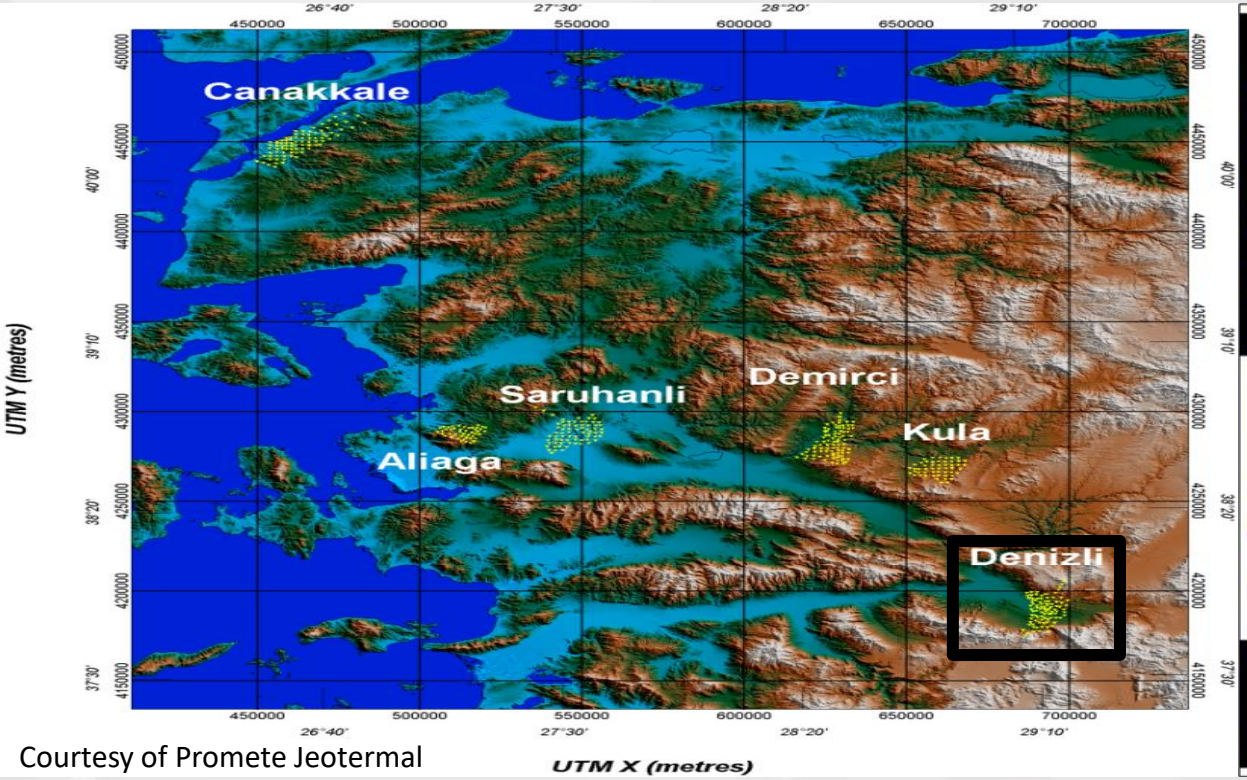




Courtesy of Promete Jeotermal

# Regional Tectonics

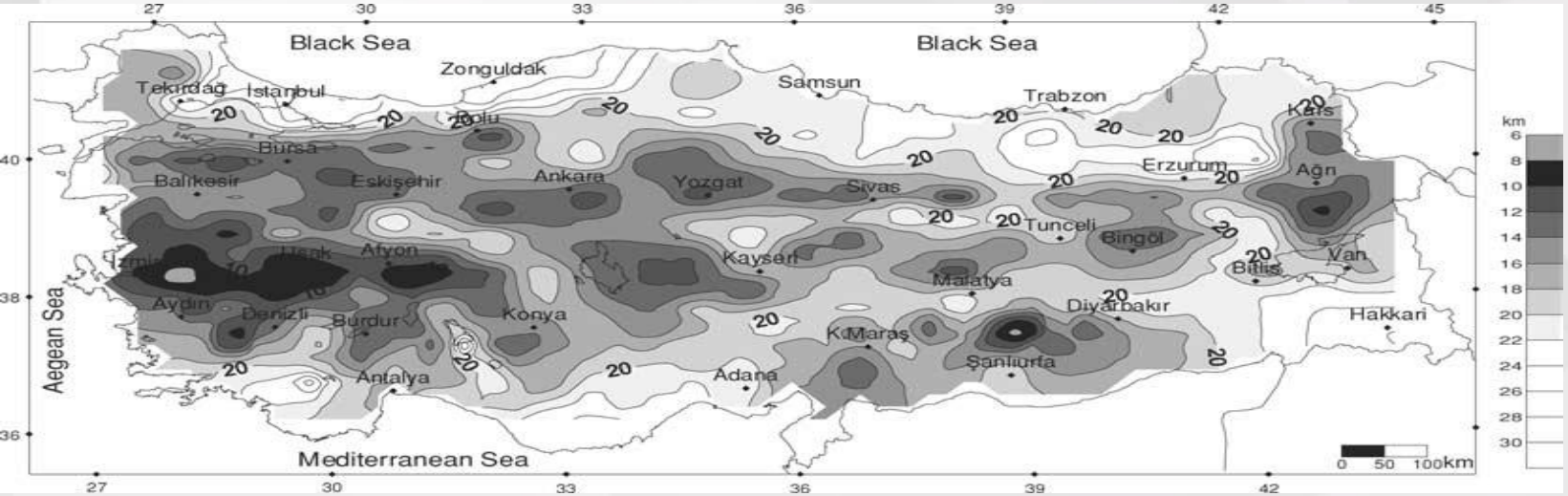
- Northward motion of African and Arabian plates
- Closure of the Tehys Ocean 13 Ma
- Arabia-Eurasia collision and uplifting

- Development of NAF and EAF
- Extrusion of Anatolian Block
- Trench roll back and extension.



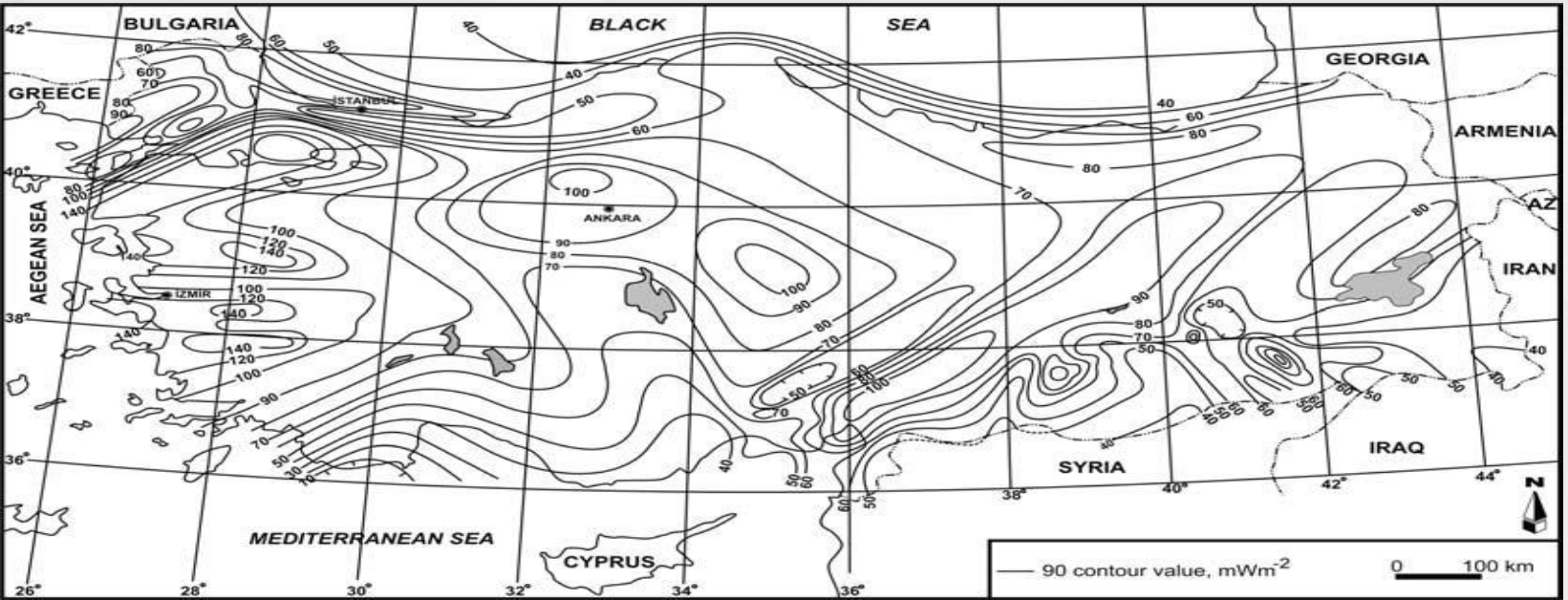

Courtesy of Promete Jeotermal

# Heat distribution




Curie point (580 C) depth and heat flow maps of Turkey (Aydin, et al., 2005).

Note that the Curie depth in western Anatolia is ~10 km. This is significantly shallower than the rest of the country.




Higher heat flow values >100 mW/m$^2$ are also coincident with shallow Curie depth

SPARTAN MT
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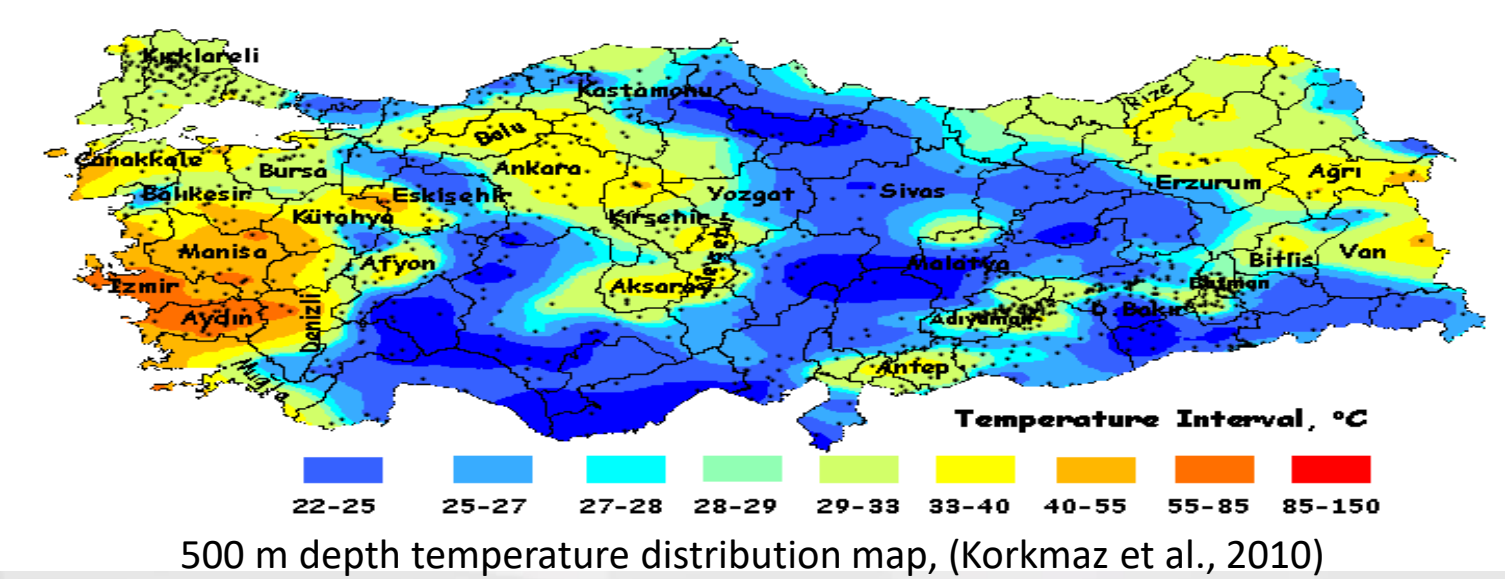
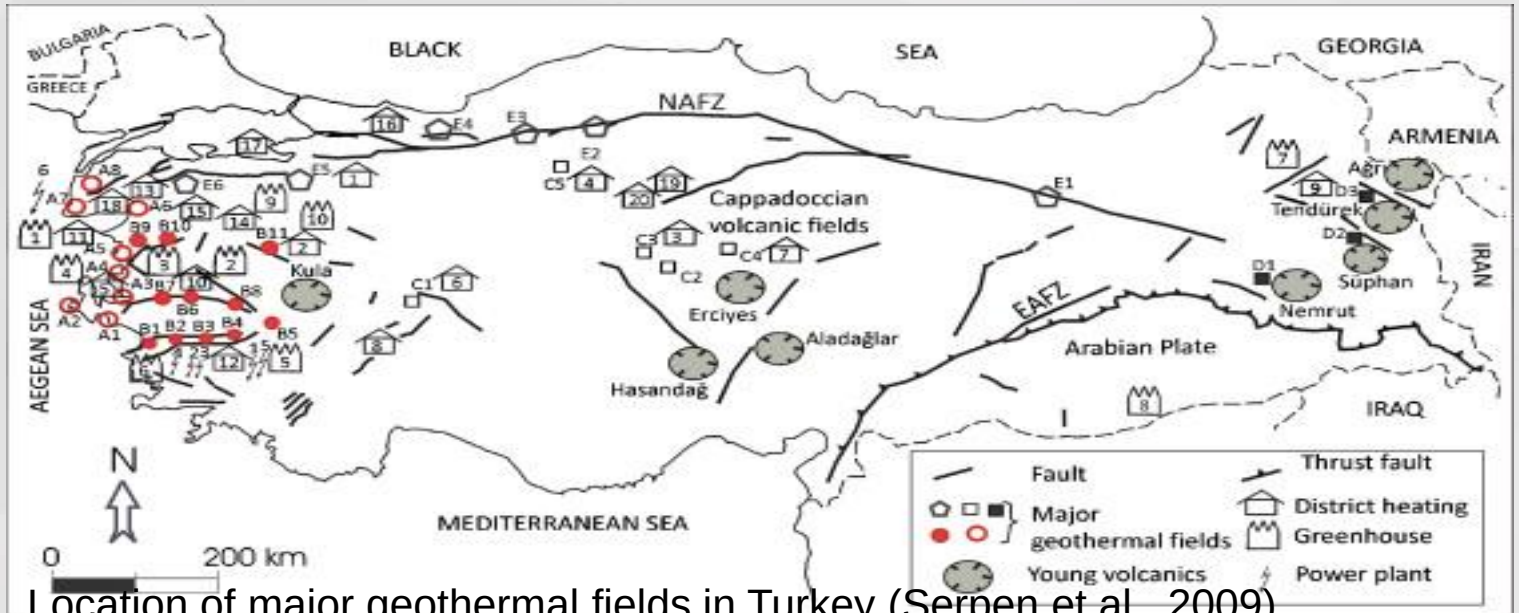
DEEP RESISTIVITY

# Targeting Regional Heat Indications




500 m depth temperature distribution map, (Korkmaz et al., 2010)




Location of major geothermal fields in Turkey (Serpen et al., 2009)

The geothermal systems associated with volcanism are common in the central and eastern part.

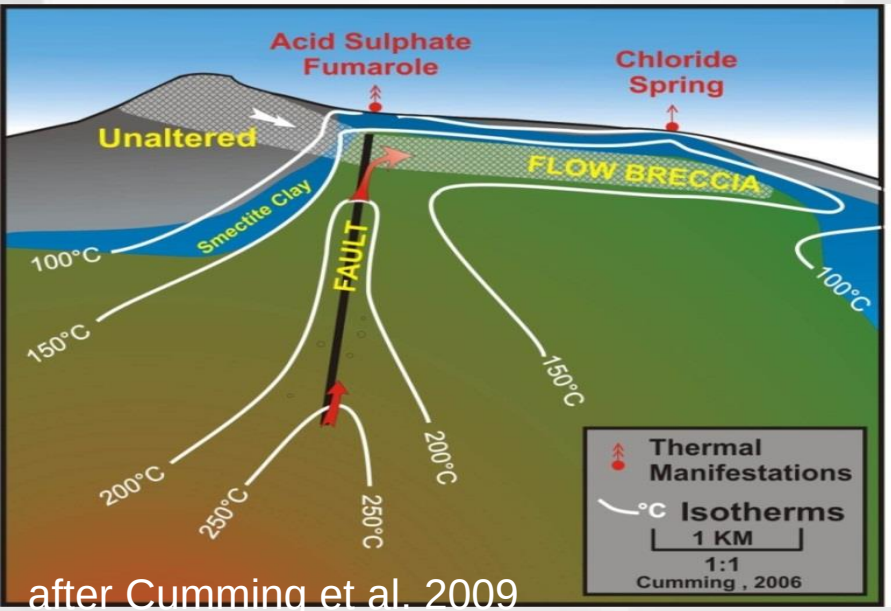
Many hot springs and wells with temperatures >200°C are indicating the geothermal potential in western Turkey. Faults play an important role as well as the reservoir in western Turkey.

Delineating of the basement structure and the faults is direct interest to geothermal exploration in western Turkey

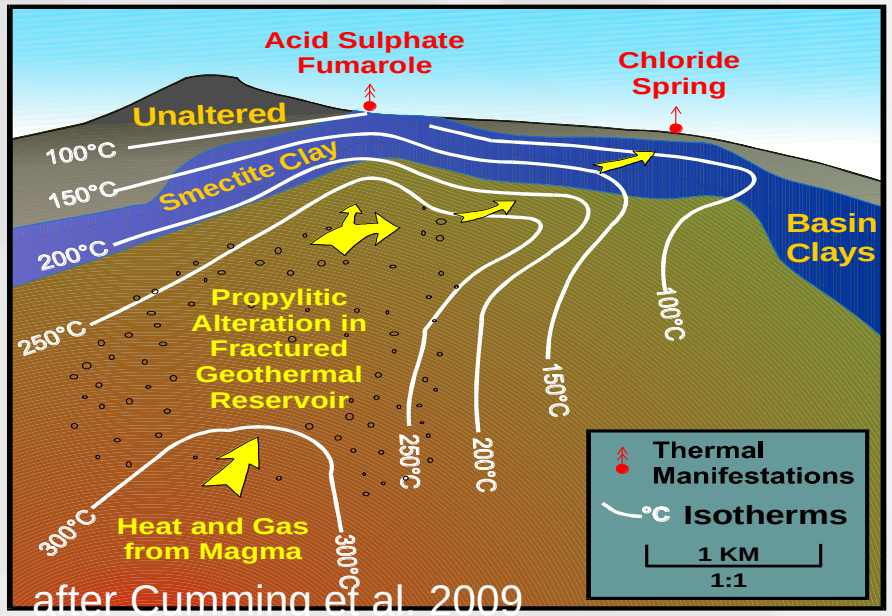
SPARTAN MT
DEEP RESISTIVITY

# SPARTAN MT site preparation

# MT maps deep resistivity

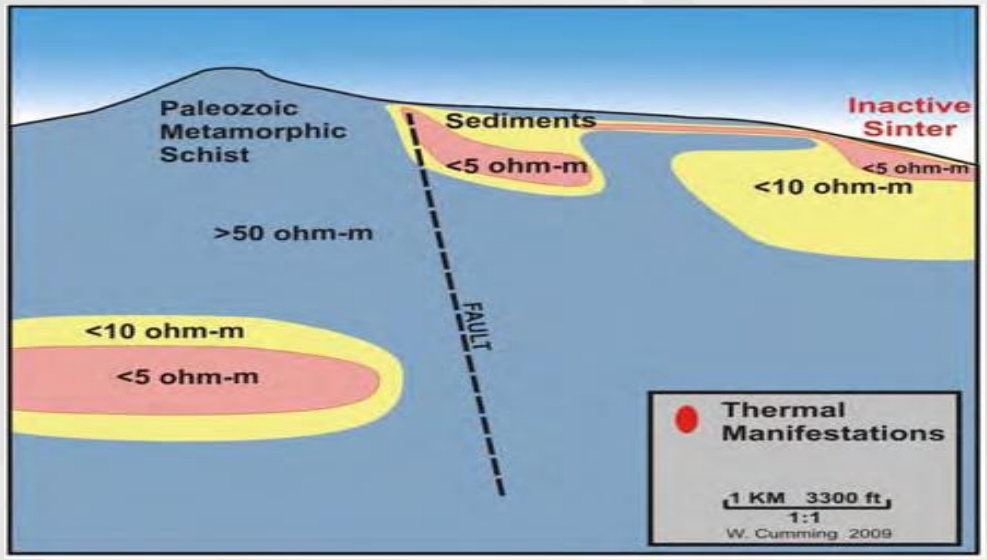


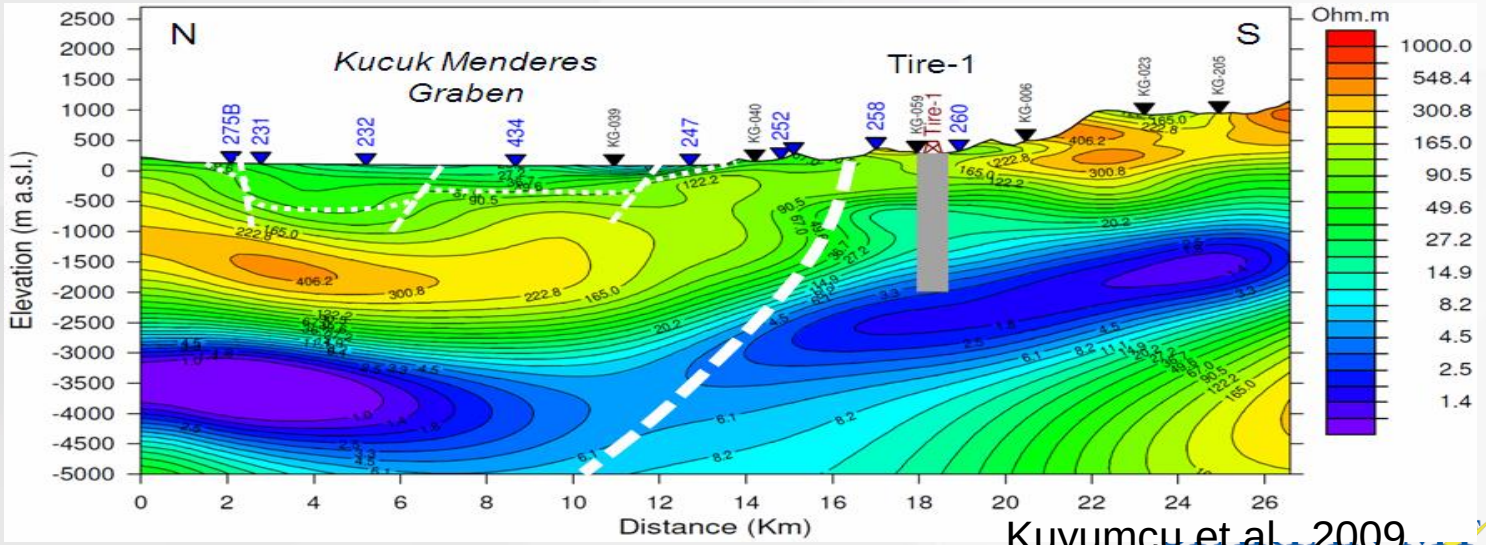

after Cumming et al. 2009




after Cumming et al. 2009

- High resistivity contrast
- Deep penetration
- Portable
- Non-invasive
- “Lower” cost




Kuyumcu et al., 2009

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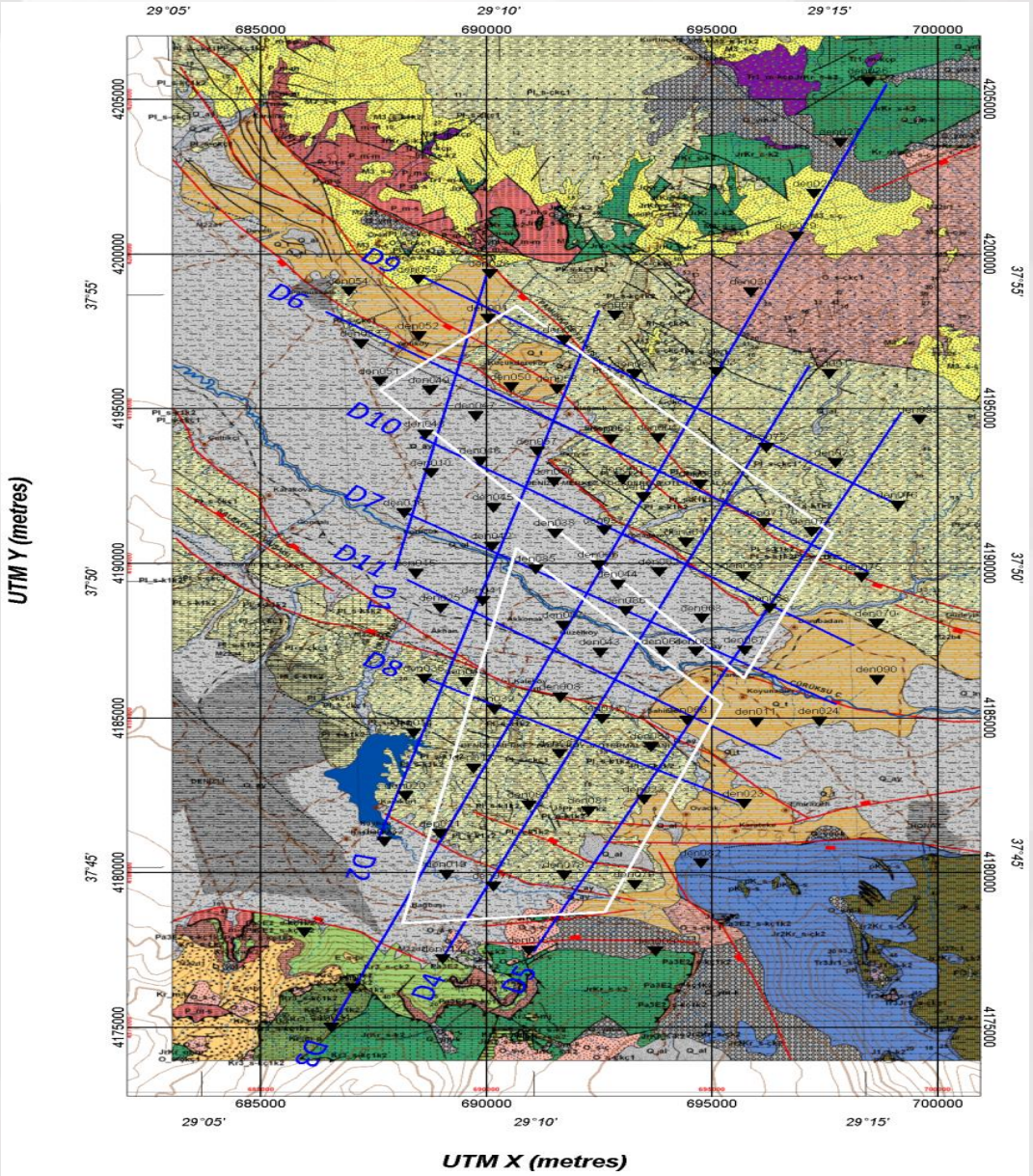
# Case – Denizli, Turkey

# Survey Layout




- 92 MT sites were collected in April, 2013. Survey area is highly industrialized mainly within the graben.
- Remote site was located 60 km away from the grid.
- 48kHz, 12kHz and 1kHz (continuous) sampling rates were used for data acquisition.

SPARTAN MT
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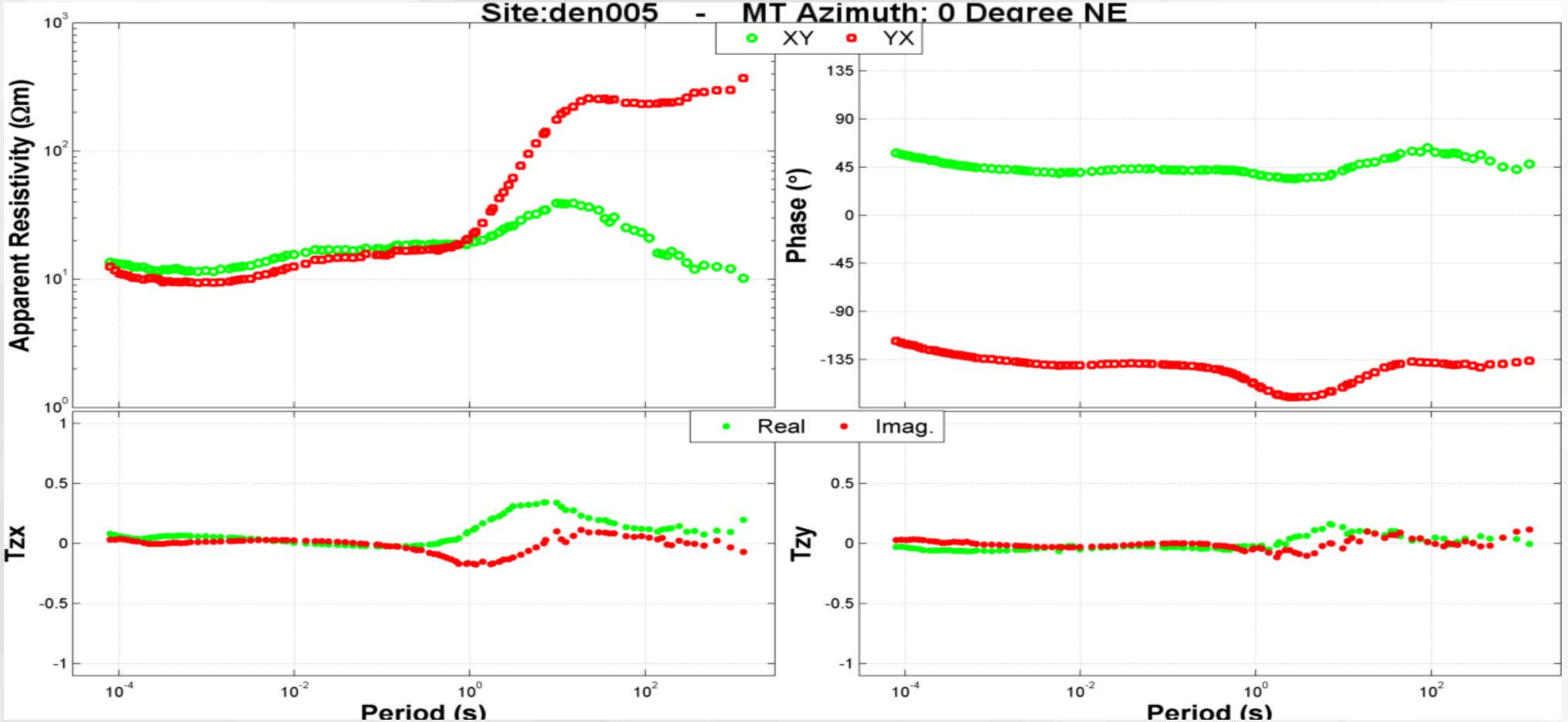
DEEP RESISTIVITY

# High Quality data required for deep imaging accuracy

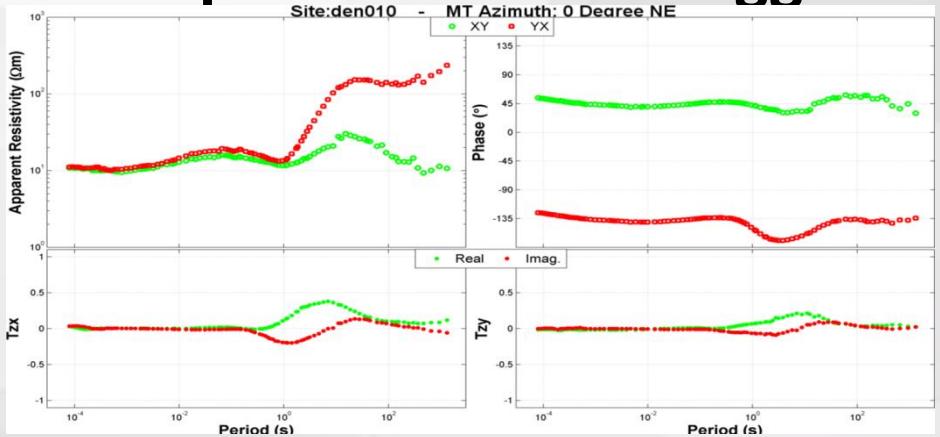
- **High quality 5-channel MT data were acquired by using Spartan MT data loggers.**

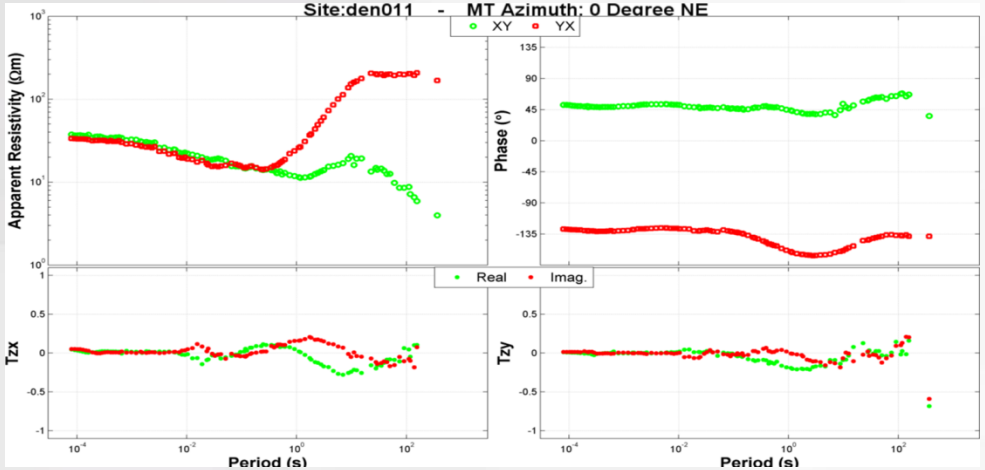


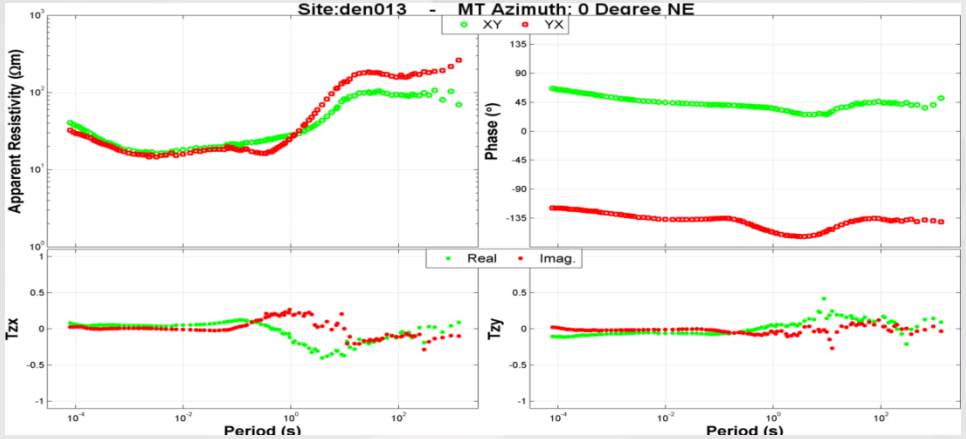

SPARTAN MT
DEEP RESISTIVITY

# Varying responses at different sites

- **High quality 5-channel MT data were acquired by using Spartan MT data loggers.**

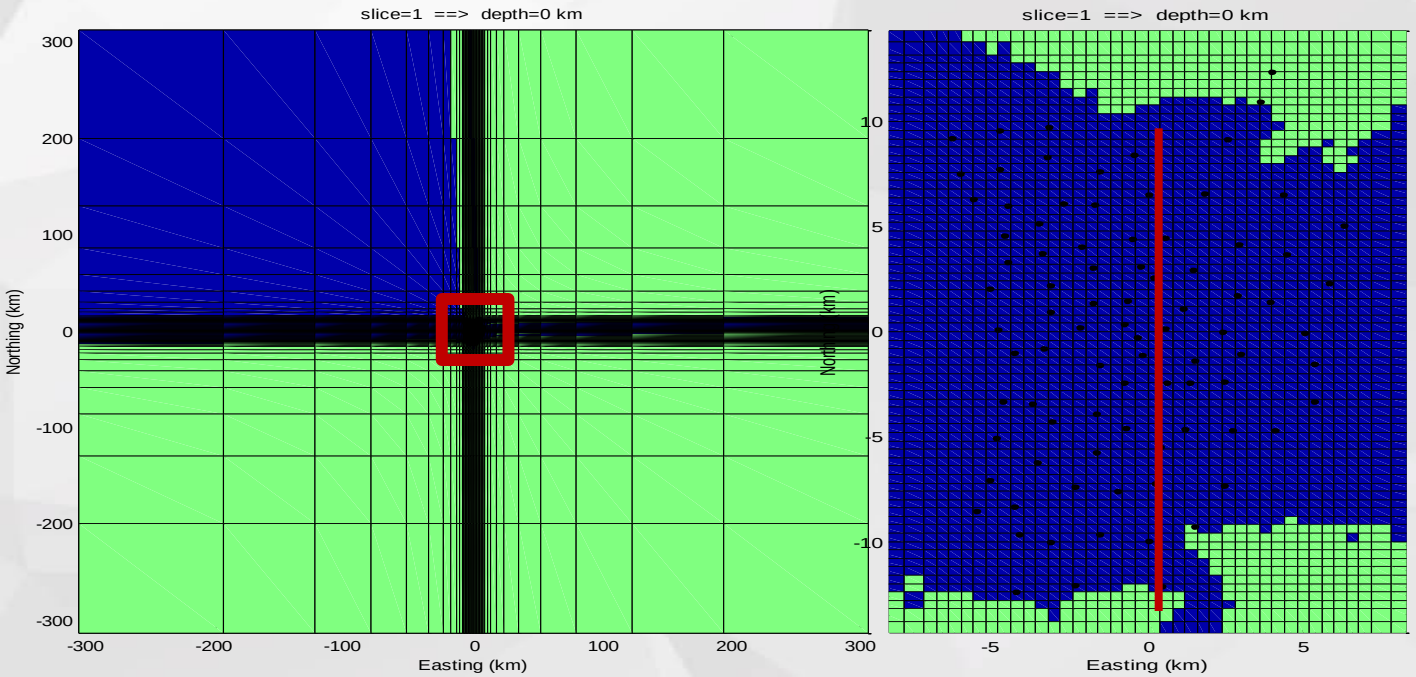


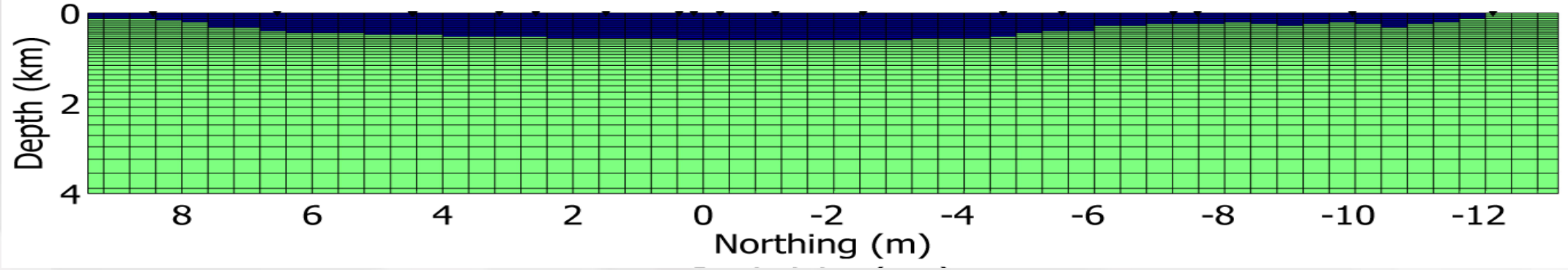




SPARTAN MT

# Data processing and Inversion

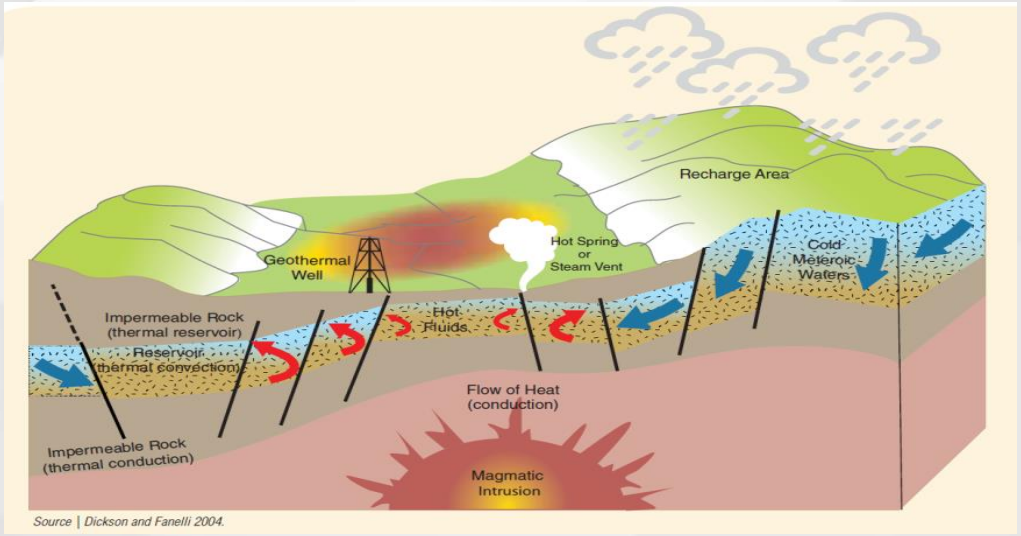


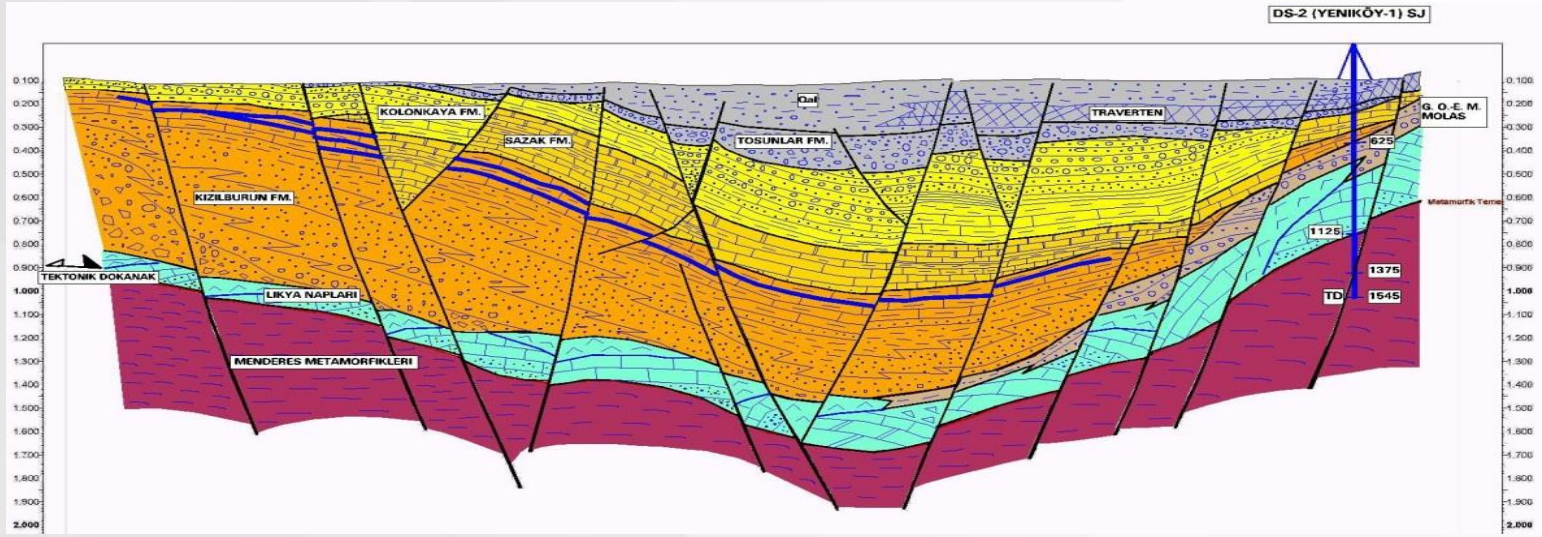

- Average site spacing is 1-2 km
- 87 sites used for 3D inversion
- Full MT tensor (Zxx, Zxy, Zyx, Zyy)
- 8% error floor
- Topography was included
- 30 Ohm-m half-space initial model
- Dx, Dy, Dz: 400m, 400m, 40m
- 1000 Hz to 0.002 Hz frequency band
- Total of 18 frequency
- Final RMS was 1.25
- WSINV3DMT (Siripunvaraporn etal., 2005)




SPARTAN MT

# Geological Model of Denizli




**Expected cross-section (2 km) of the Denizli Graben (Akman, 2013)**

**Denizli graben contains two types of infills.**

1. **Ancient: 660 m thick Middle Miocene-Middle Pliocene deposits controlled and deformed by ~N-S extension then compression in the latest Pliocene (Kocyigit, 2005).**
2. **Modern: 350 m thick, undeformed Plio-Quaternary deposits (Kocyigit, 2005).**

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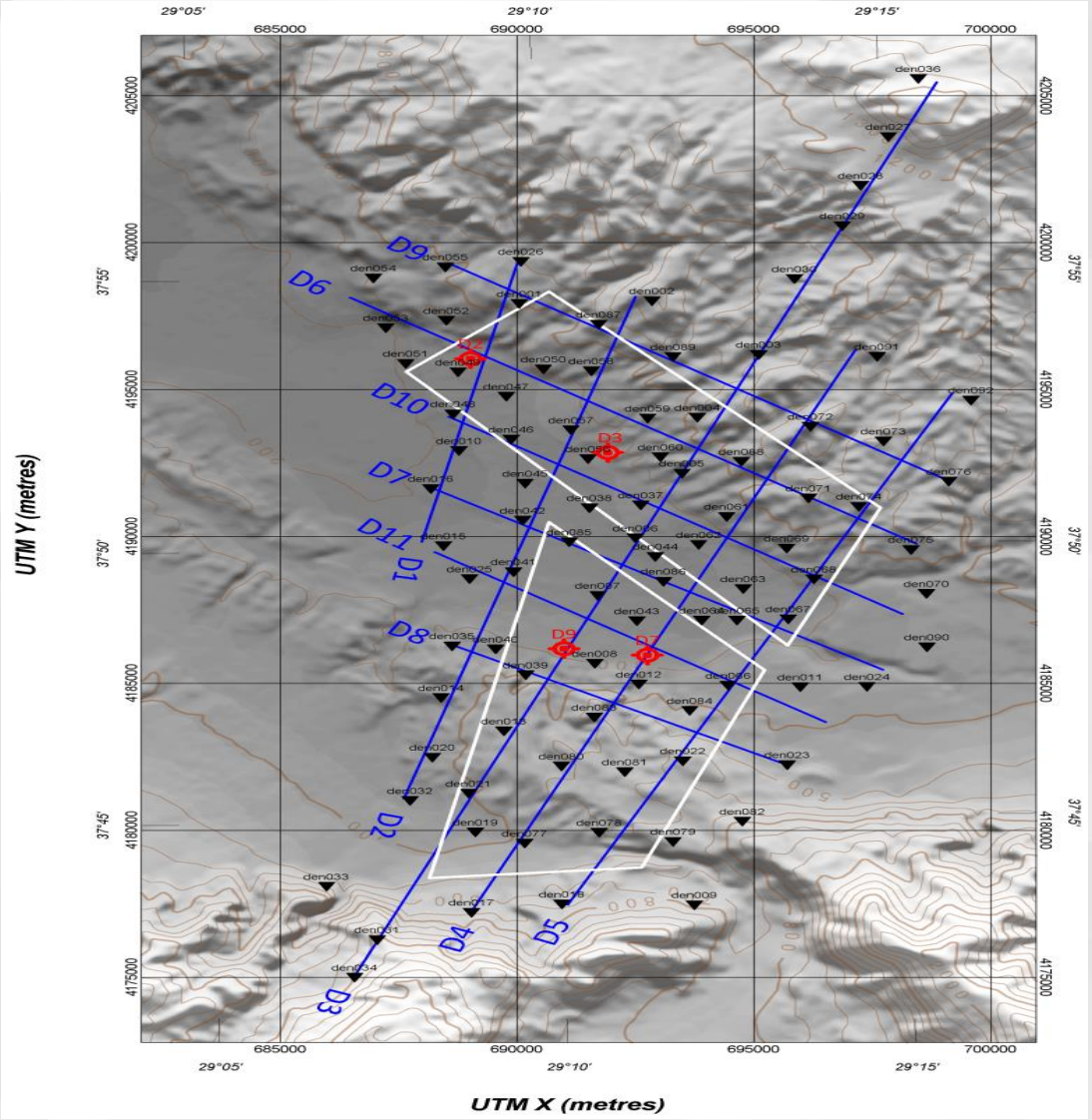
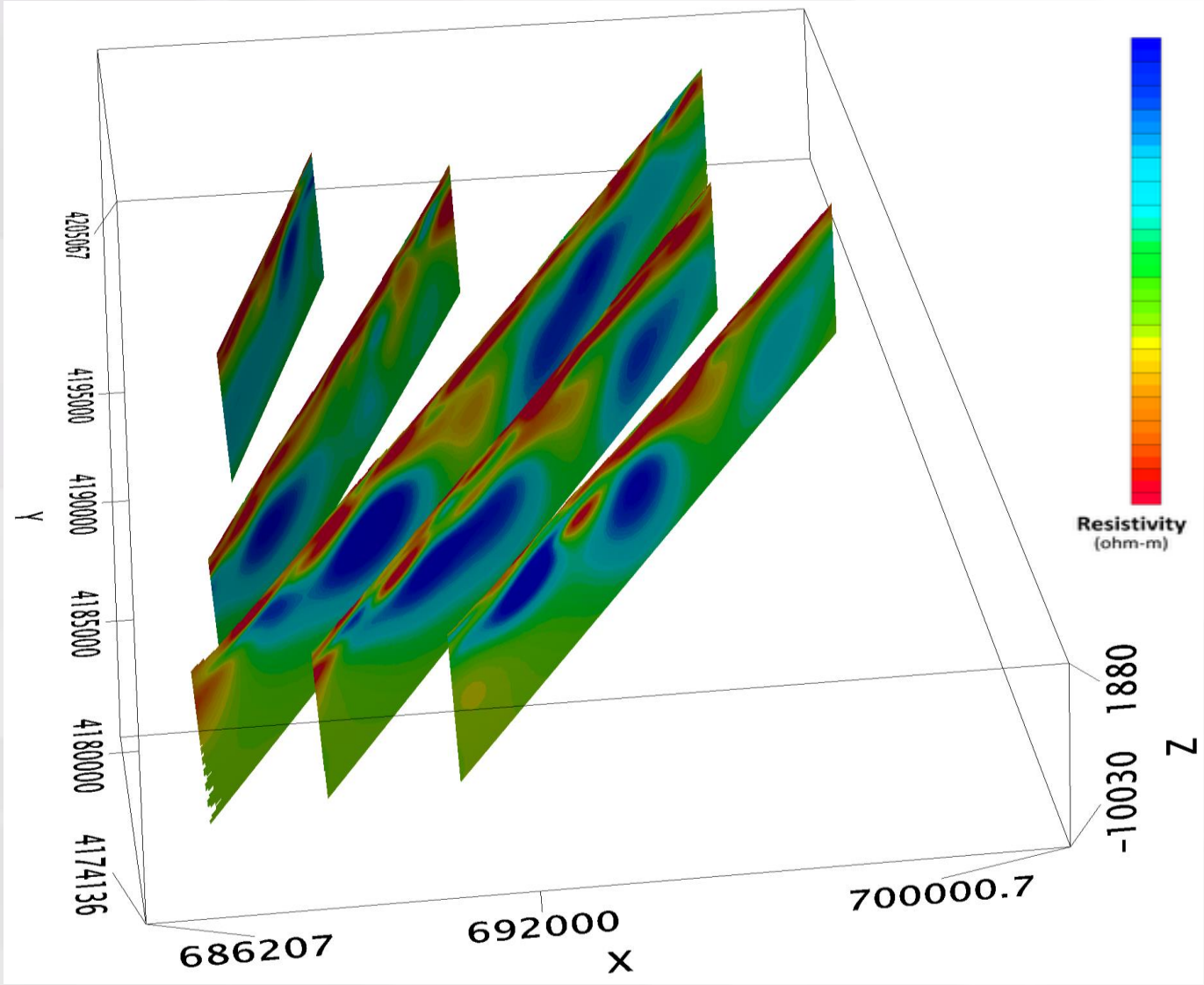
# 2D resistivity sections

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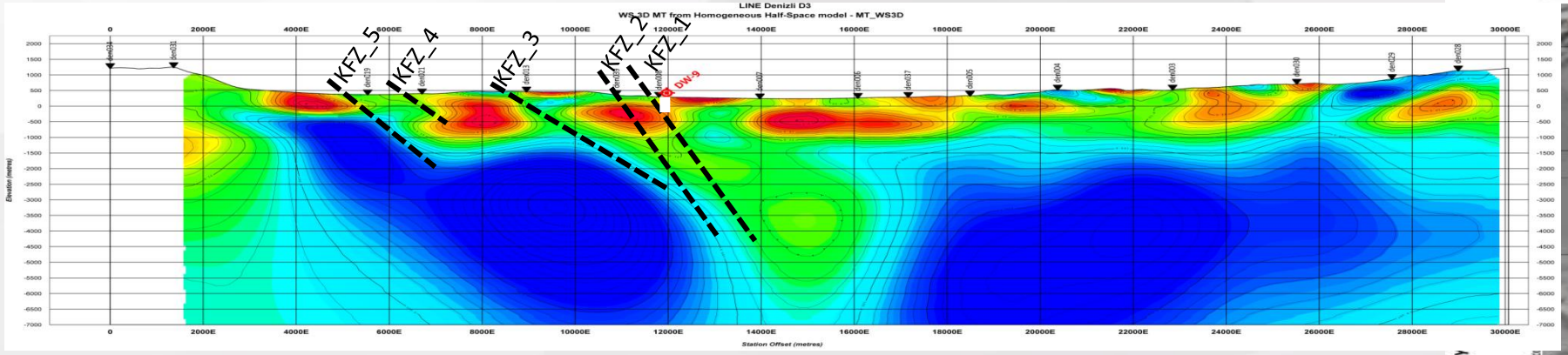
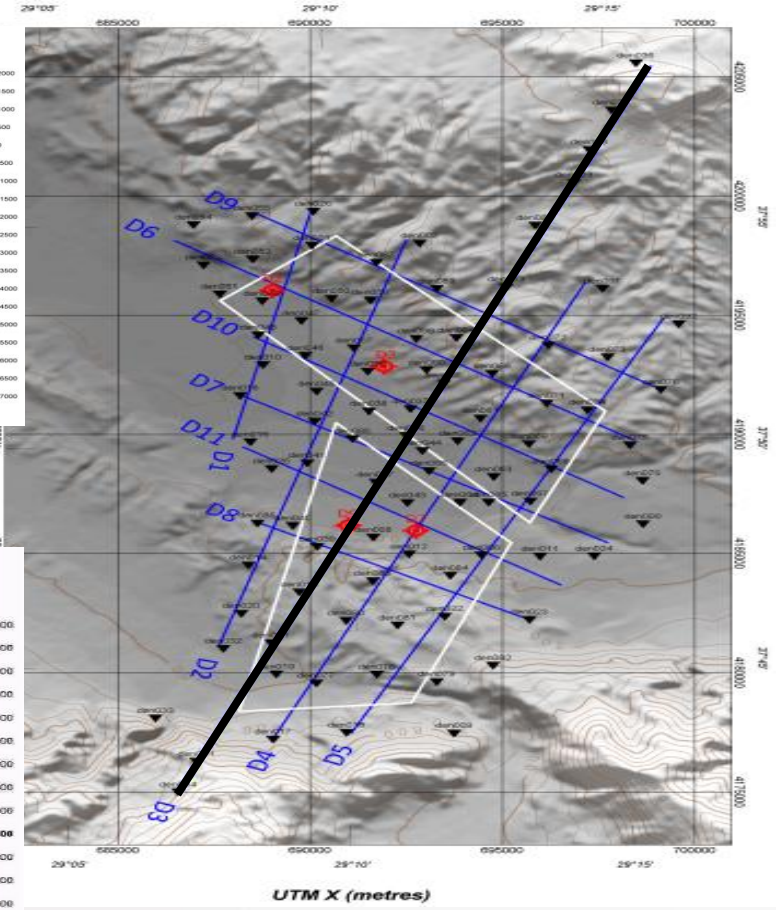
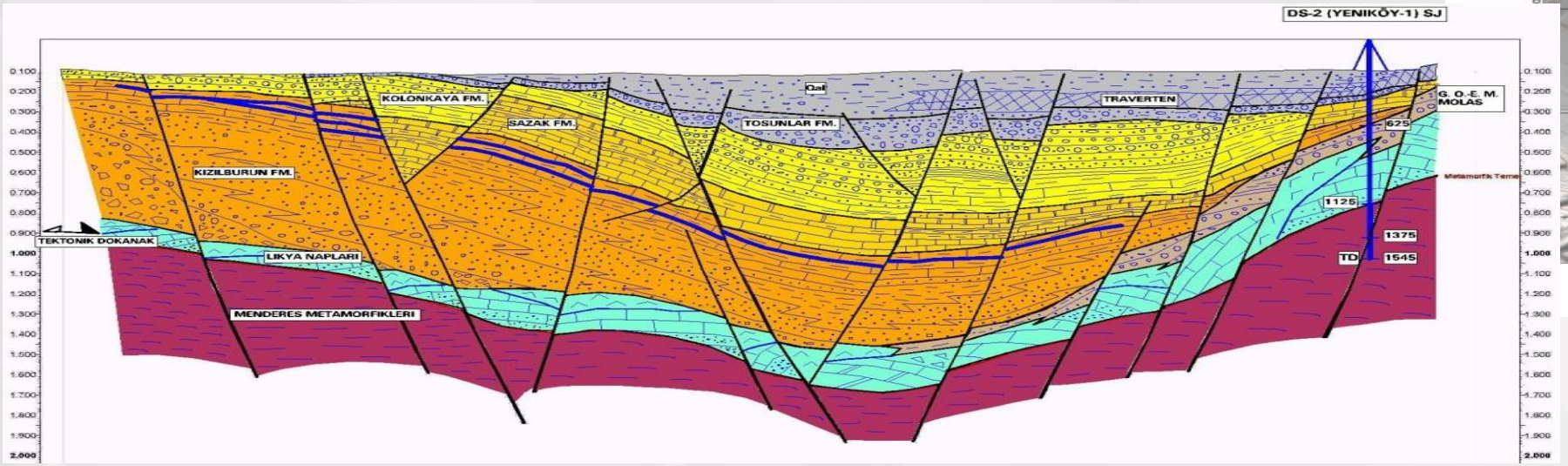
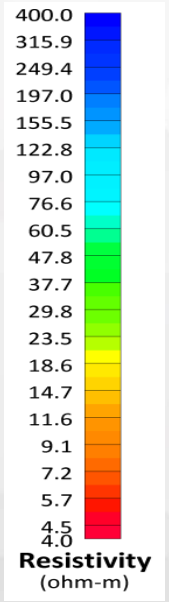
# Good geological correlation

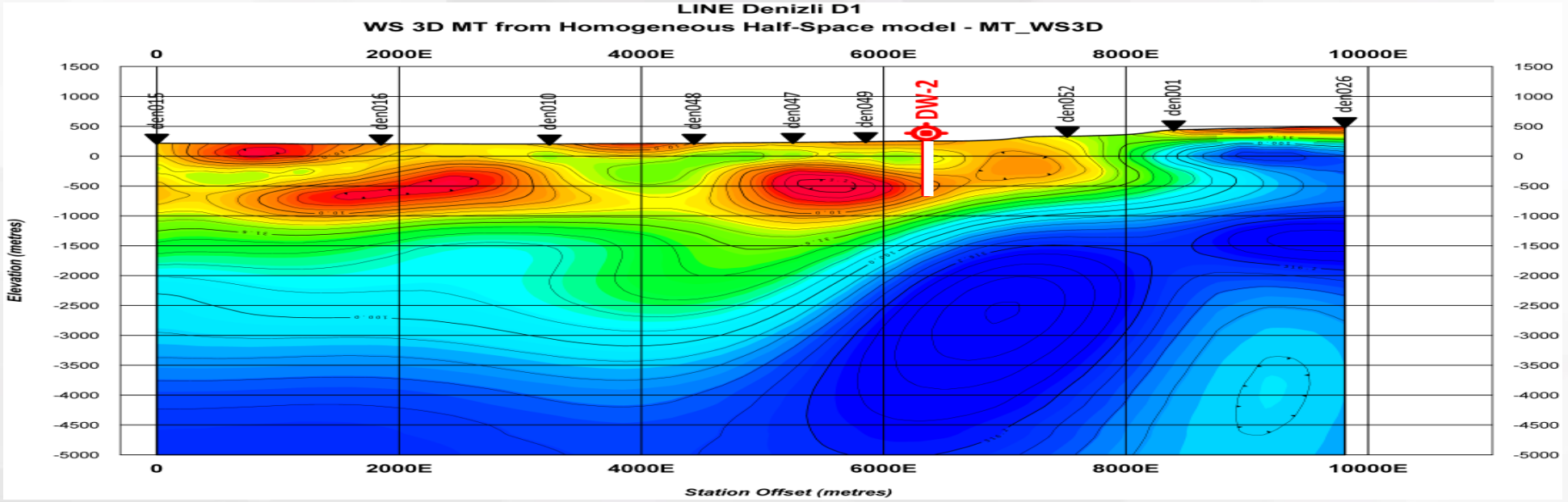


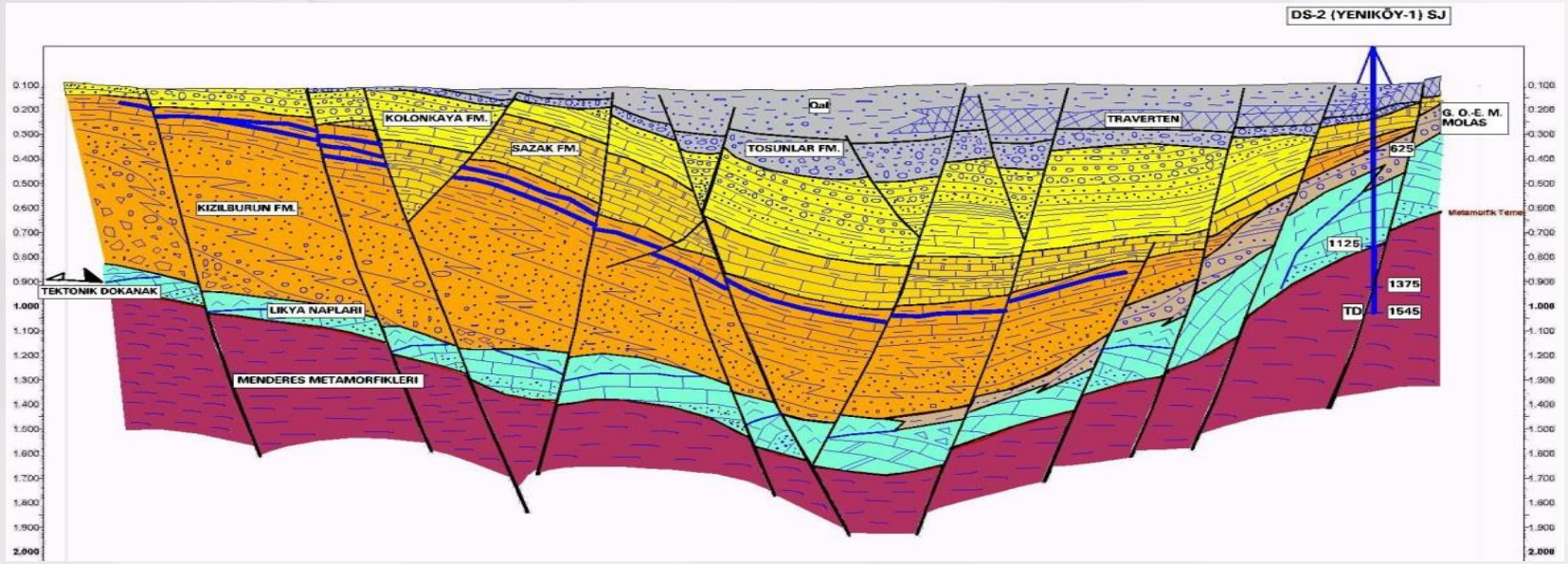



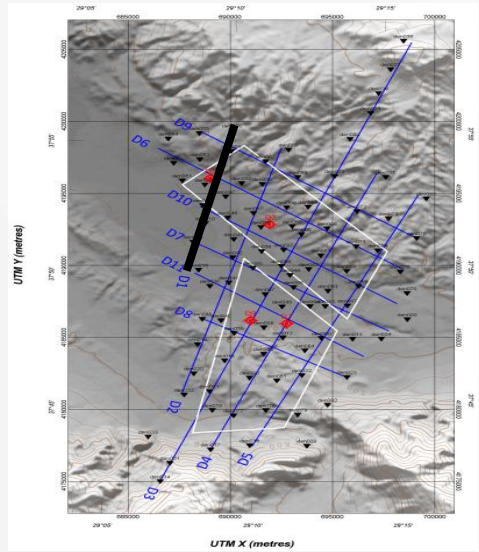




SPARTAN MT



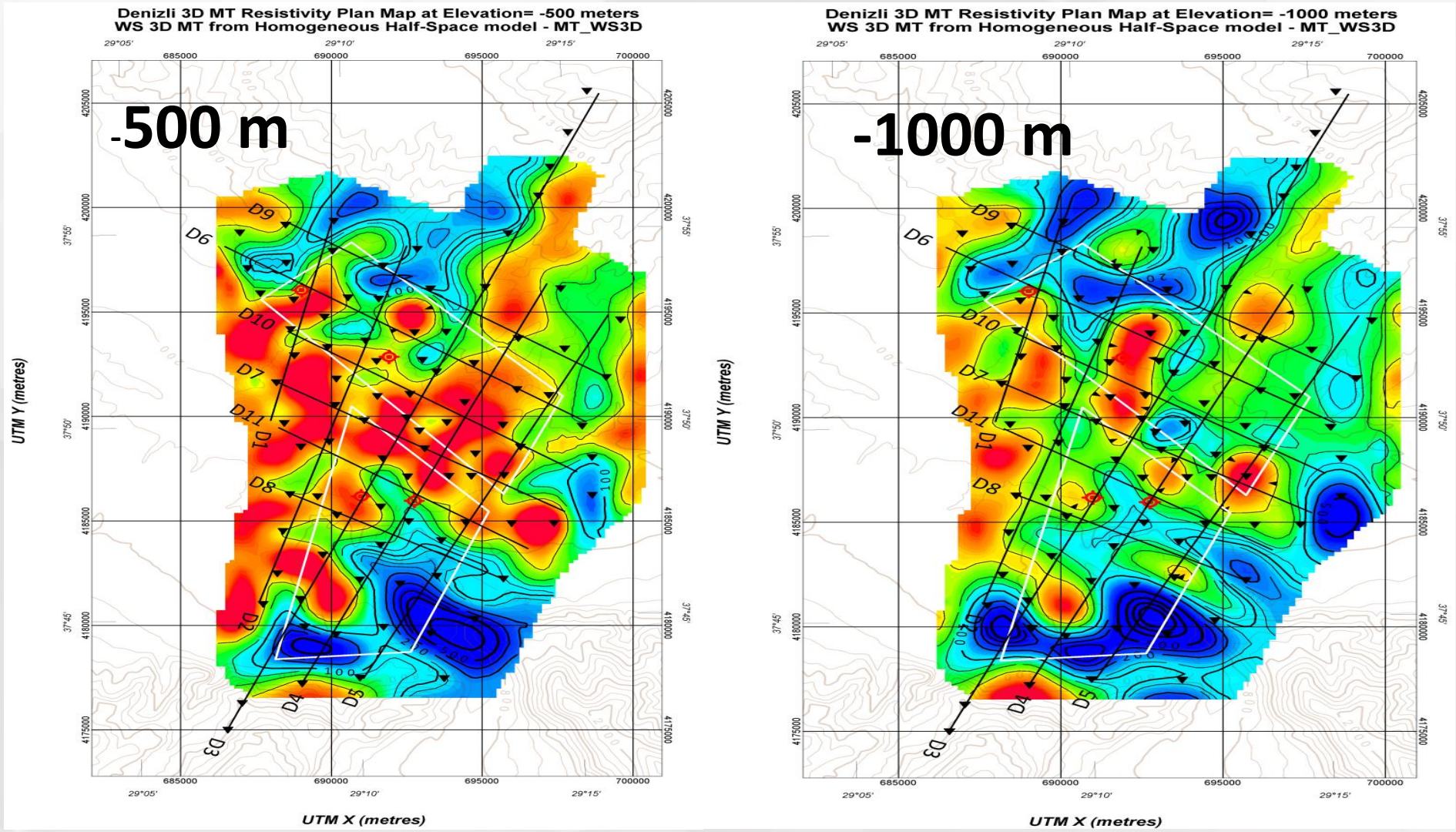



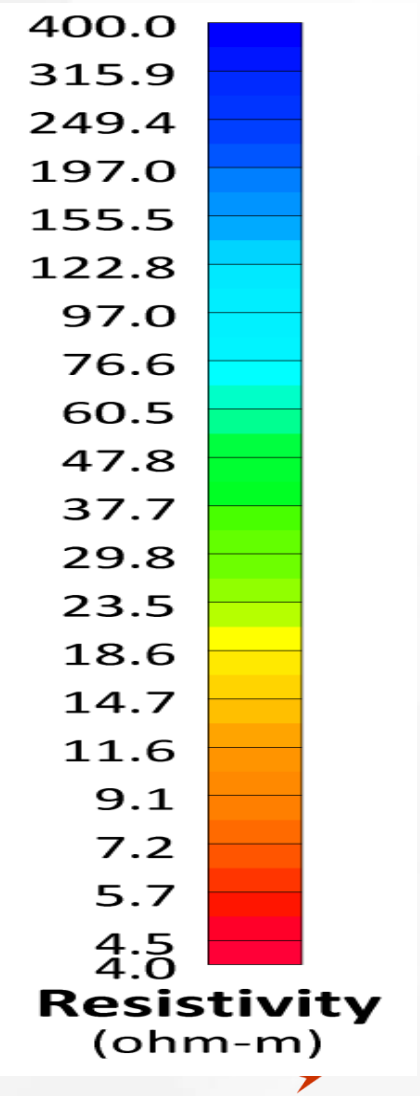

SPARTAN MT
DEEP RESISTIVITY

# Resistivity Depth Slices







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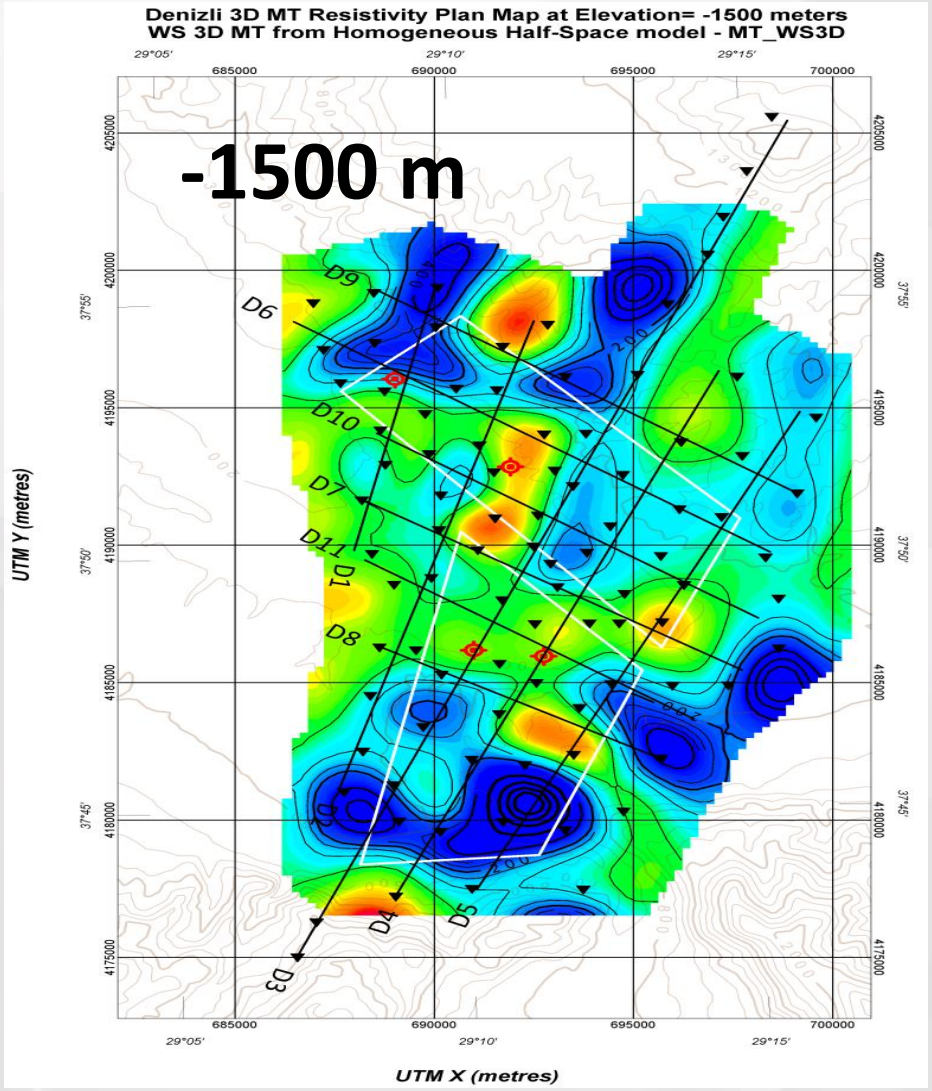
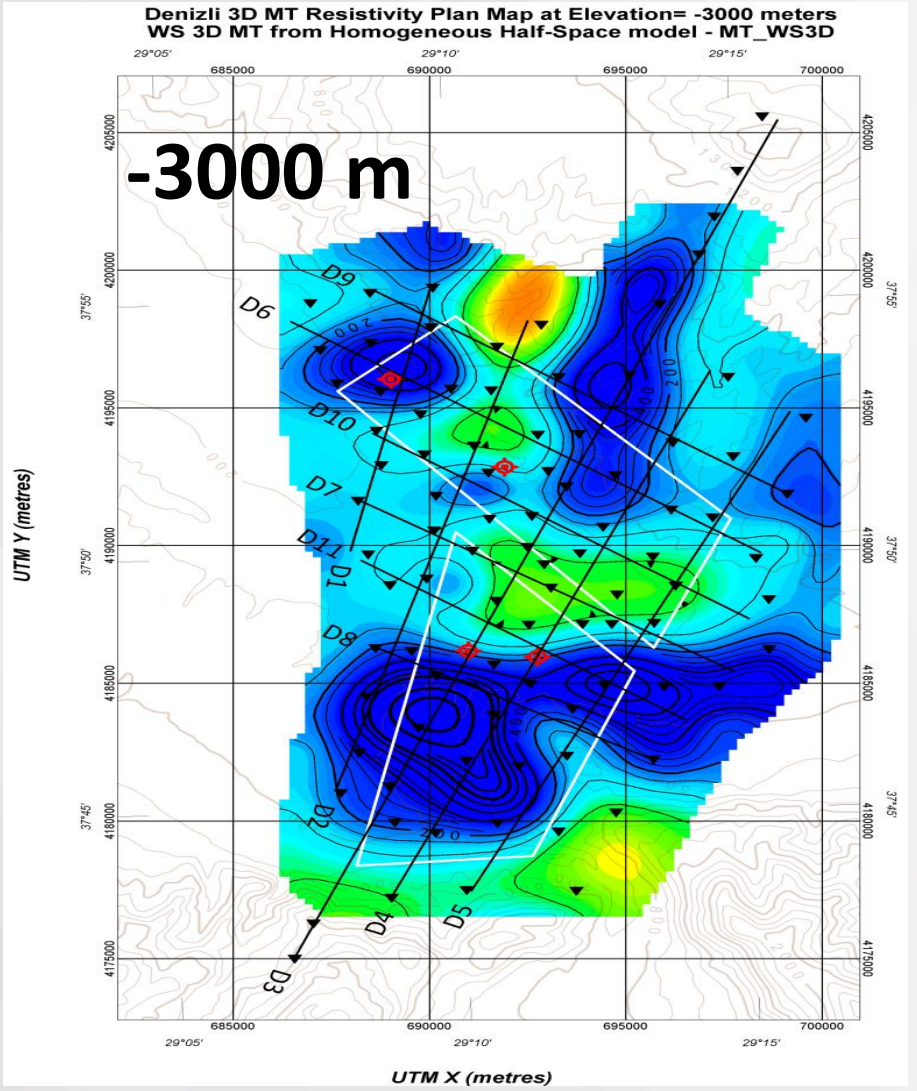
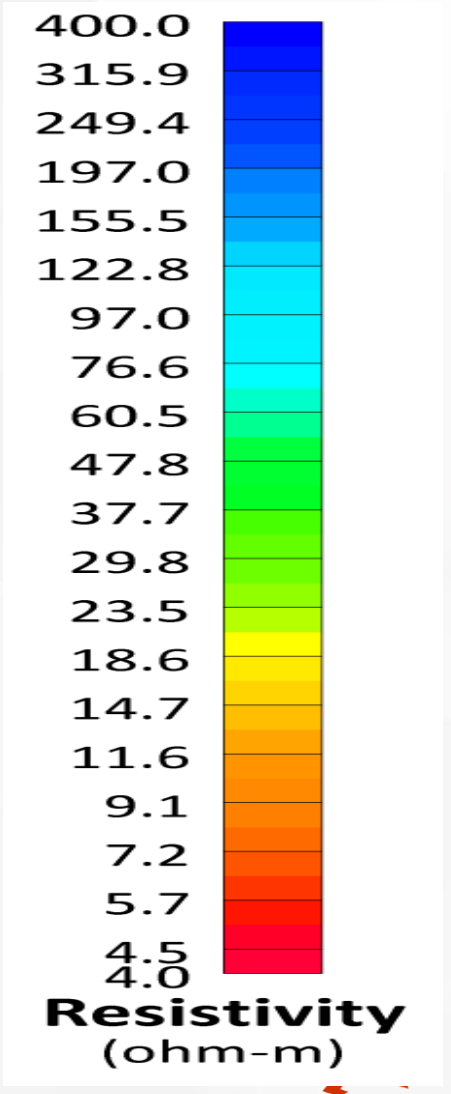
# Resistivity Depth slices

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DEEP RESISTIVITY

# Conclusions

- MT imaged the sedimentary fill of the Denizli graben and underlying Menderes metamorphics.
- Well locations were determined by use of MT, seismic and structural geology to reduce drilling risk.
- Computational requirements for 3D inversion has been matched by recent developments on computer clusters. However, most MT surveys are designed as a grid and more MT stations are collected than ever before.
- Closely spaced MT sites required to build better constrained models as well as static shift control.
- Good quality MT data can be collected - ***EVEN AROUND INDUSTRIALIZED AND POPULATED AREAS.***

SPARTAN MT
SPARTAN MT
DEEP RESISTIVITY

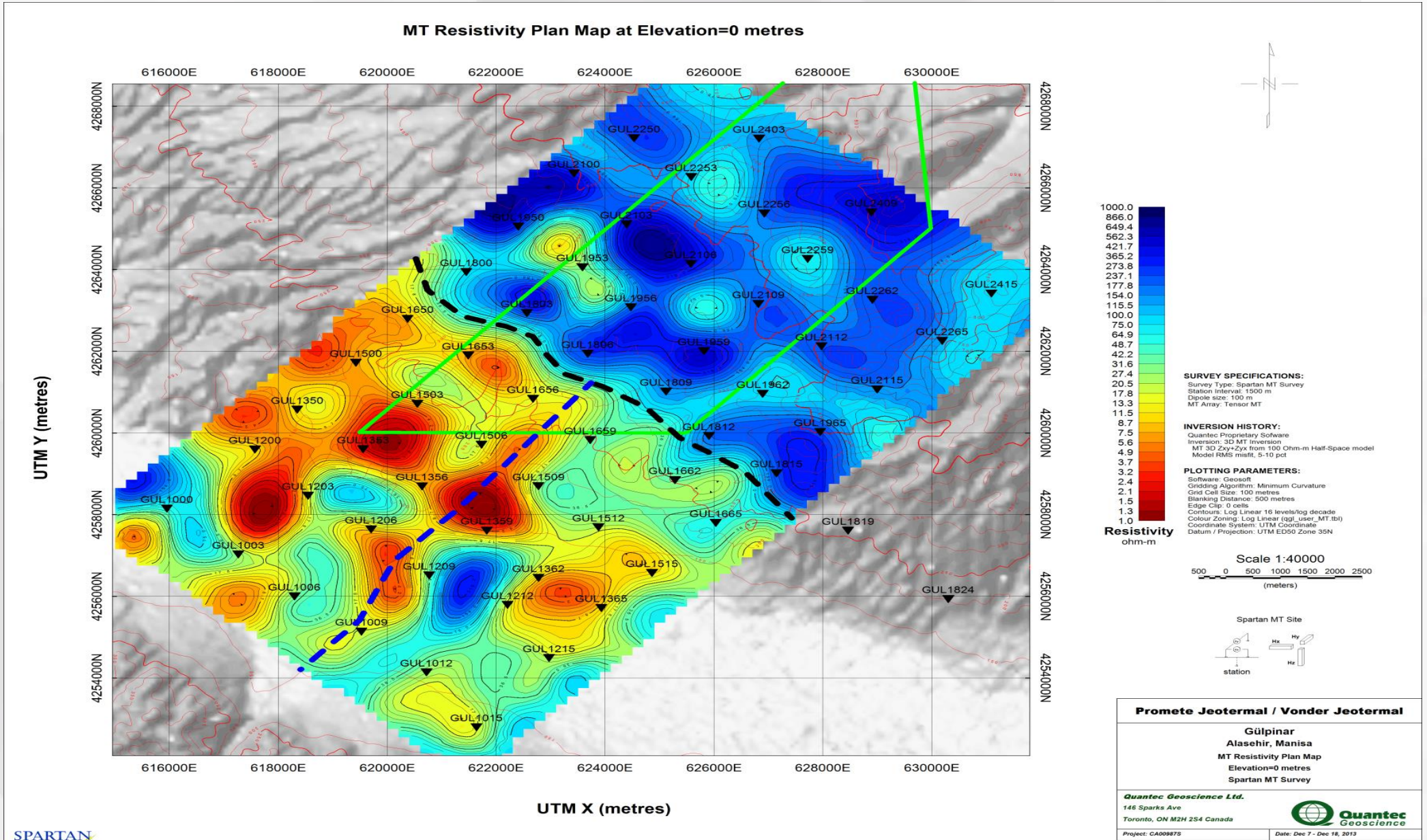
# SPARTAN MT (SENSOR TESTING AT START OF SURVEY)

SPARTAN MT

SPARTAN MT

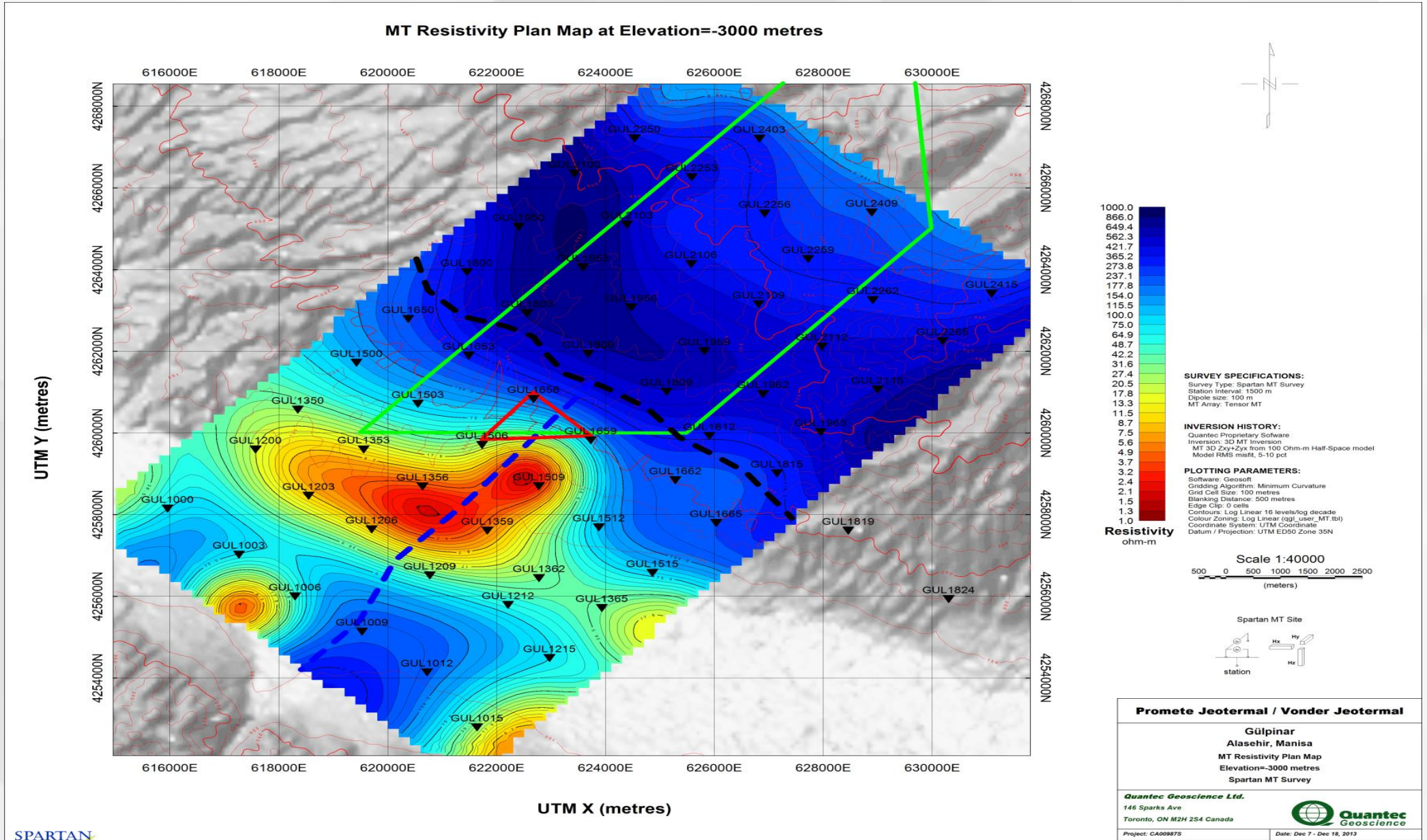
# Case Study Gulpinar Turkey

# Gulpinar MT study



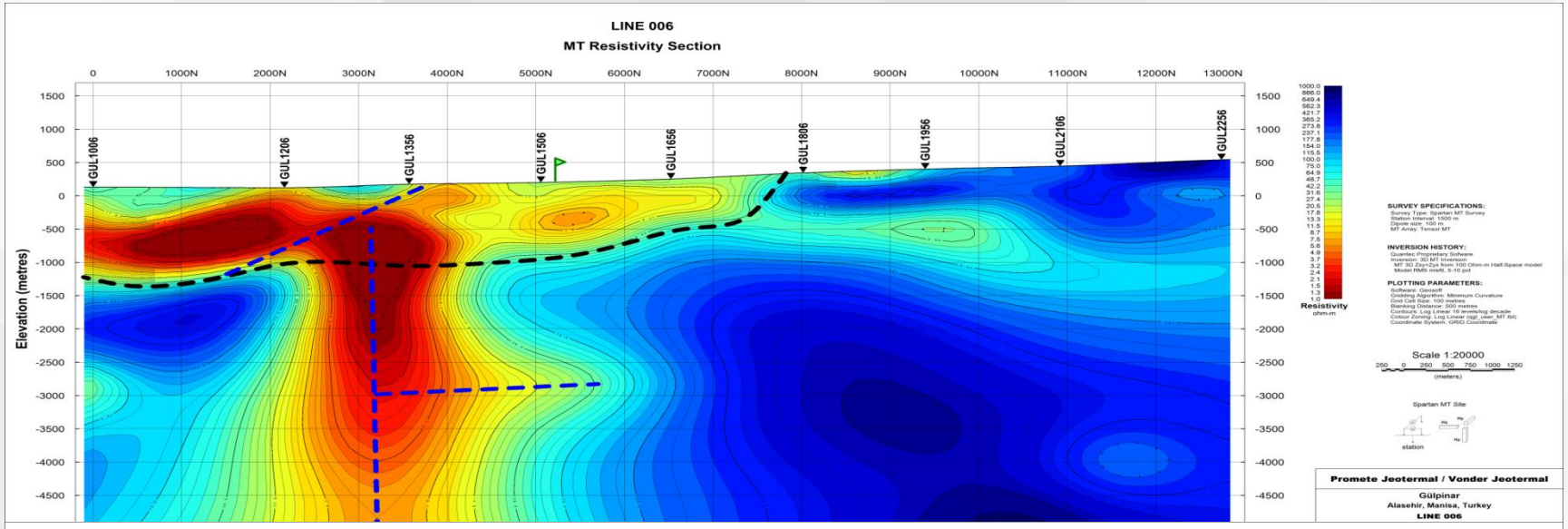

SPARTAN MT

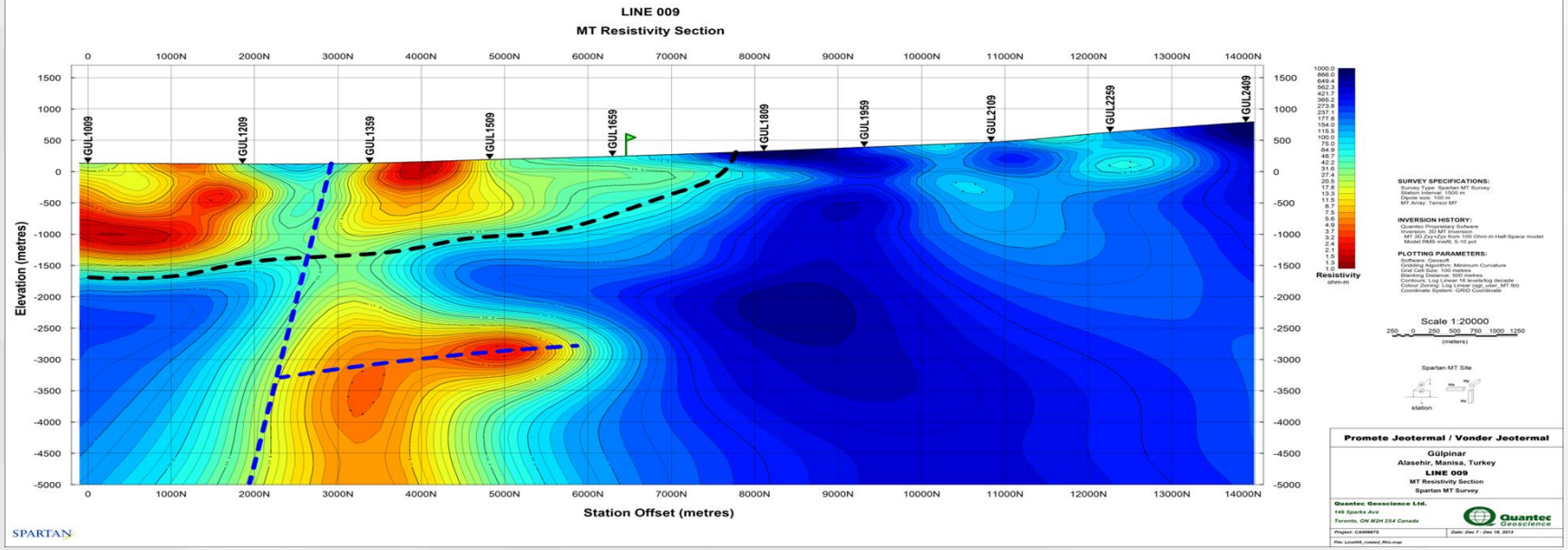
# Depth slice 3000 metres




SPARTAN MT

# Resistivity Sections (shown to 5000 metres)



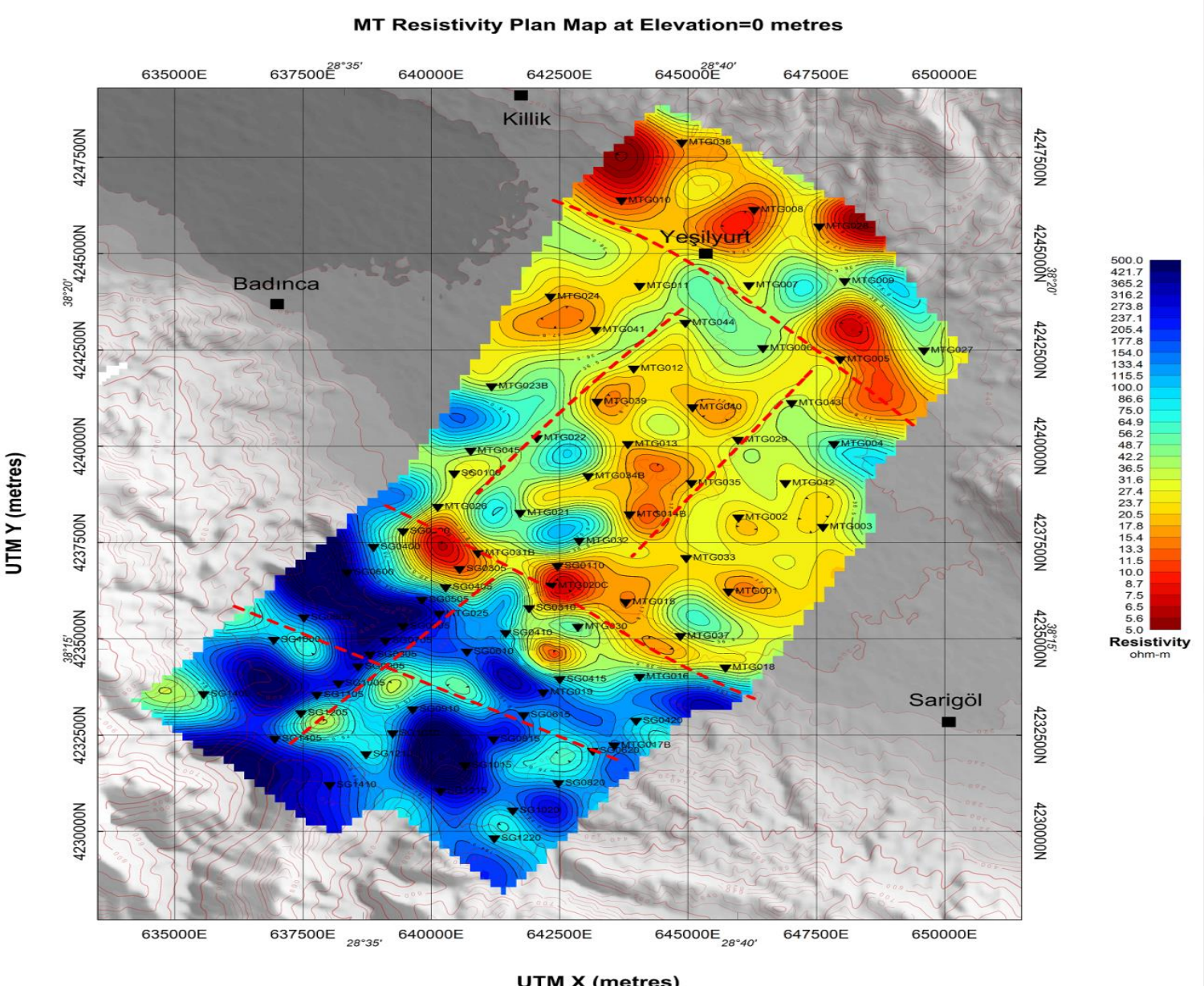




SPARTAN MT

SPARTAN MT

# Case Study Sarigol Turkey

# Sarigol, Turkey

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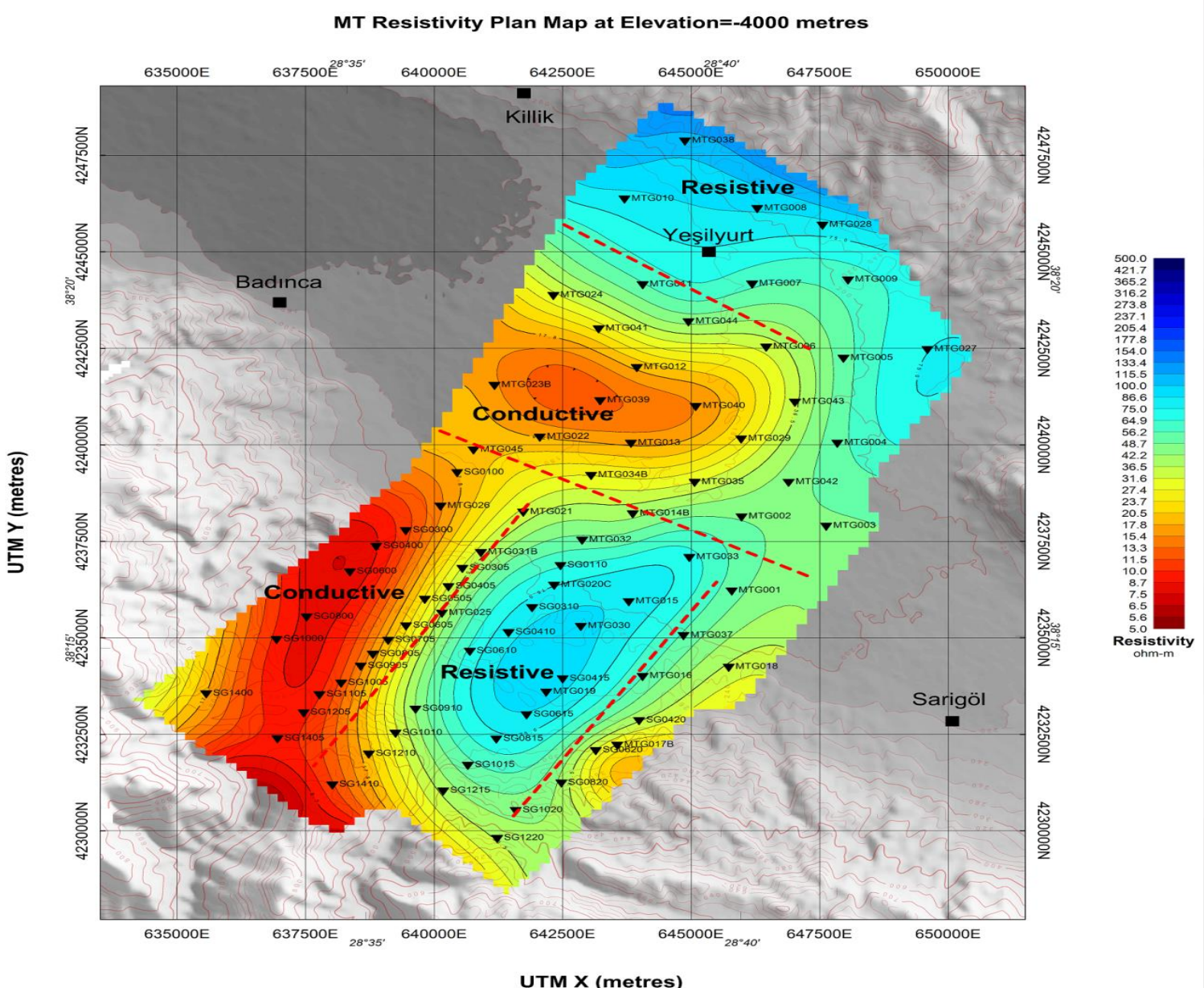
# Sarigol, Turkey

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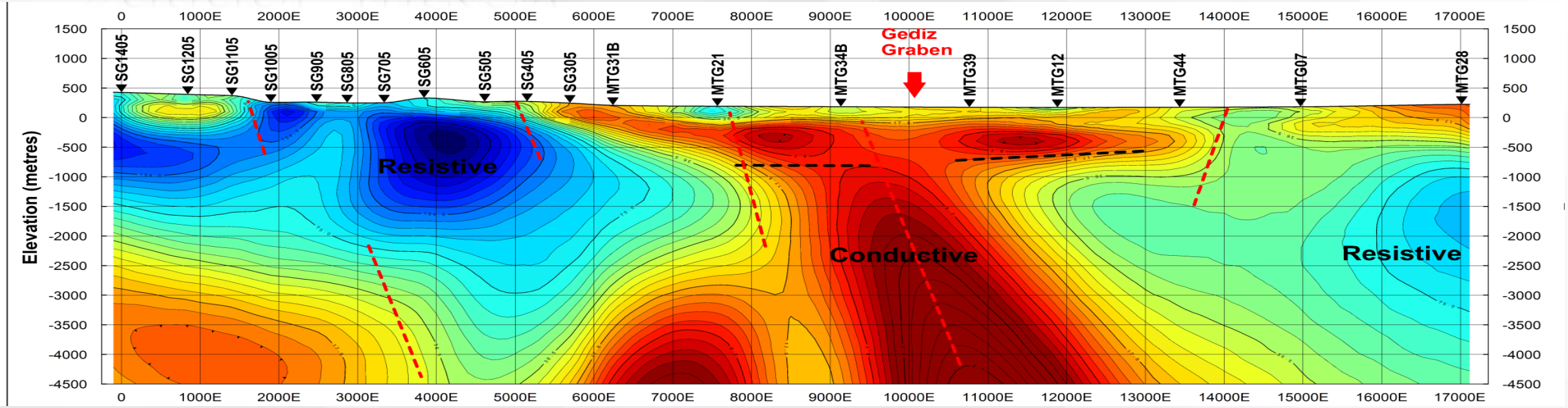
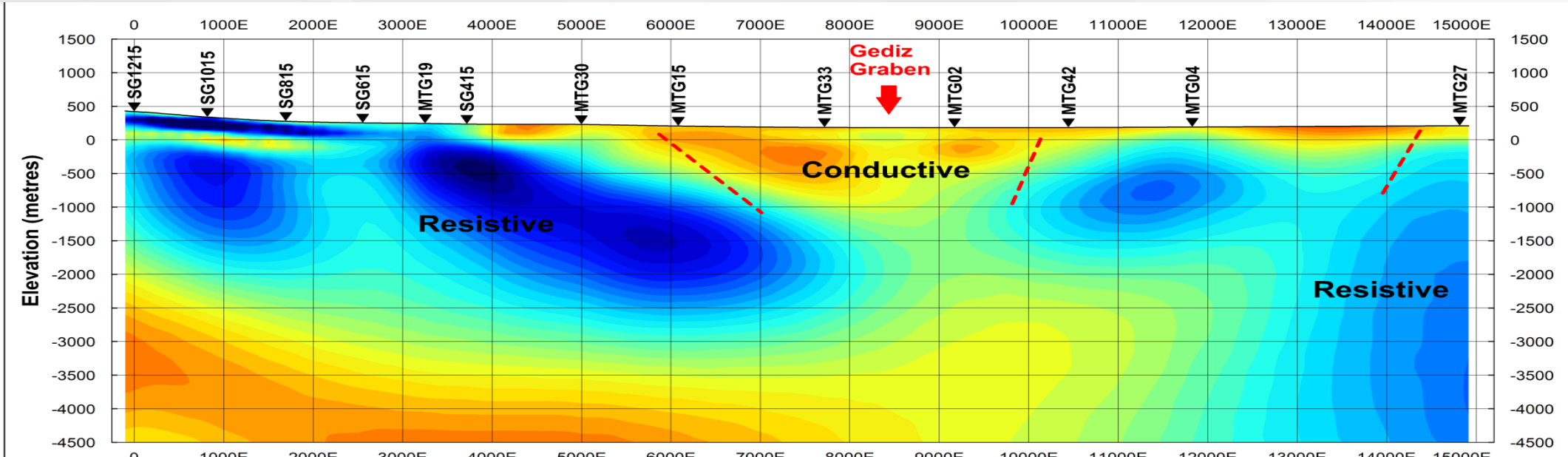
# Sarigol, Turkey




SPARTAN MT

# Some Geothermal Clients

- Yukon Geological Survey
- Blackrock Geoscience
- Baseload Power
- Ormat Technologies
- Geoscience Australia
- AltaRock Energy
- Magma/Alterra
- Mighty River Power
- Hot Rock Ltd.
- Ram Power
- University Of Utah
- Energy and Geoscience Institute
- Panax Geothermal
- Energy Source LLC.
- Transmark Renewables
- Sierra Geothermal Power Inc.
- Promete Jeotermal
- Turkerler Jeotermal
- Cluff Geothermal Ltd.
- Lawrence Berkeley National Laboratories
- Bereket Jeotermal
- Geologica
- Blackrock Geoscience
- Sonsuzluk
- Vonder Jeotermal
- Cyrq Energy
- Zorlu Jeotermal
- Enerco

SPARTAN MT

QUANTEC
Geoscience

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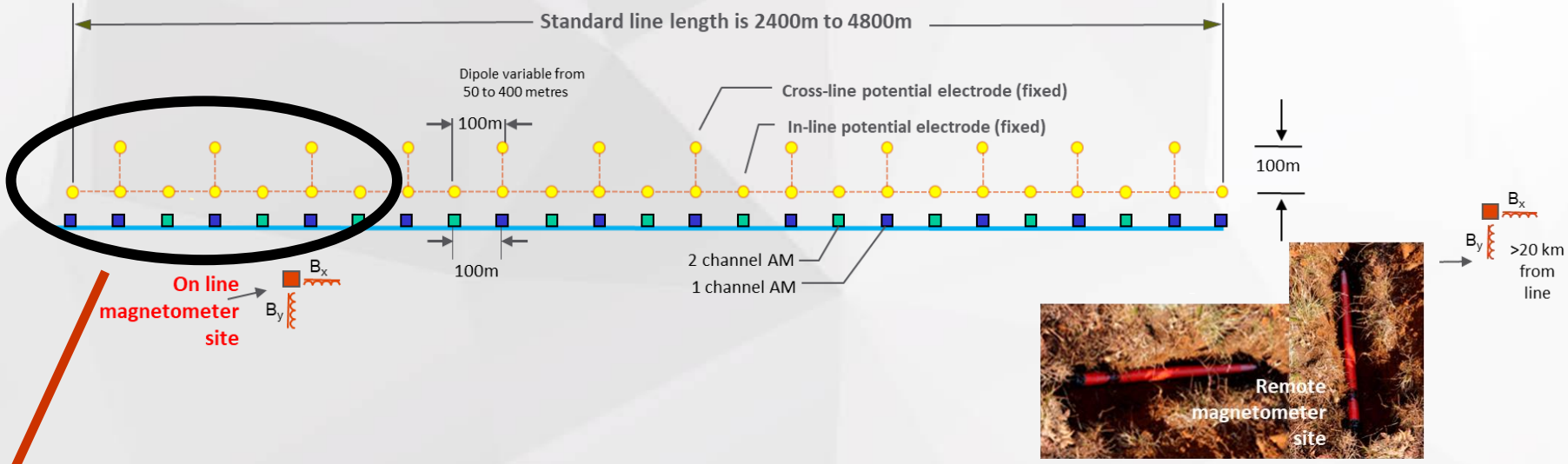
# TITAN is multi parameter - this means it can also be used to collect MT data

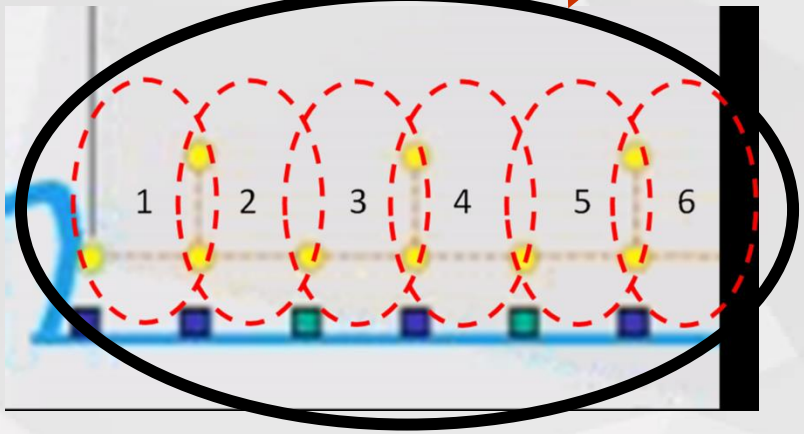
Typical station set up

Multi channel acquisition module

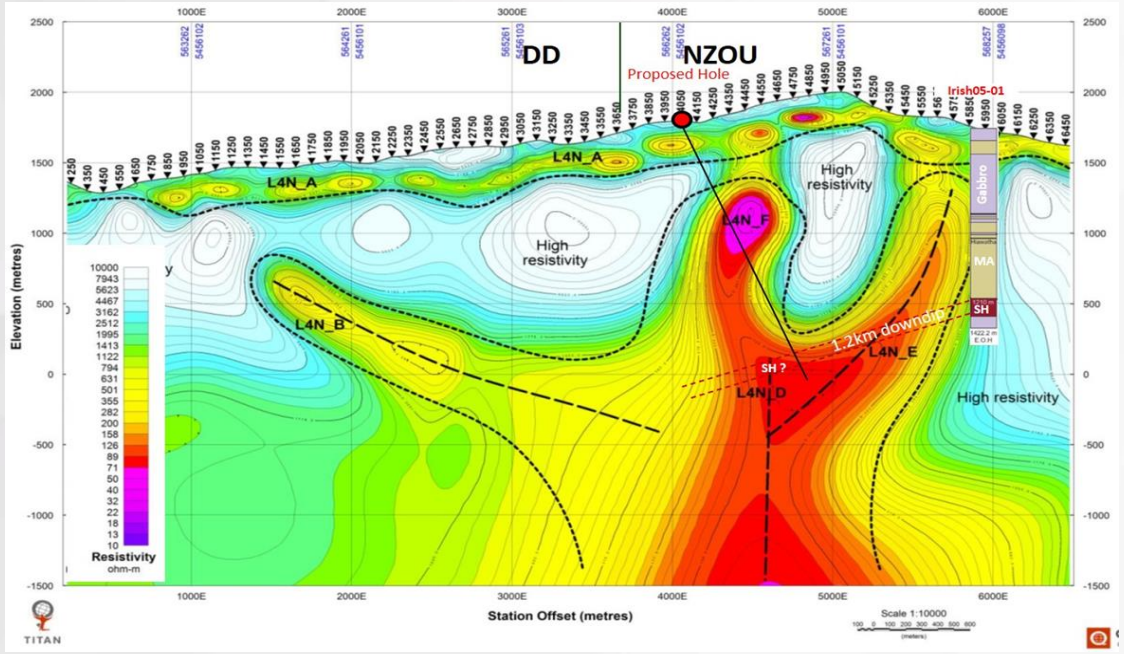
Battery




Multiple MT sites, collected simultaneously

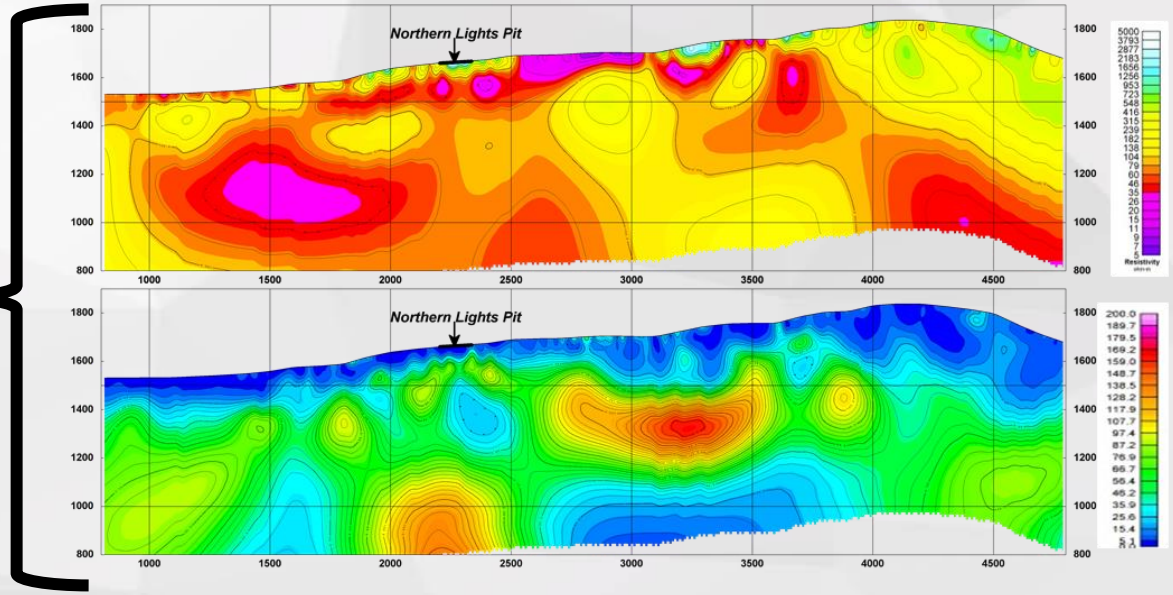



High lateral resolution and deep



# 2 significant surveys DCIP in the DAY + MT at night

DCIP

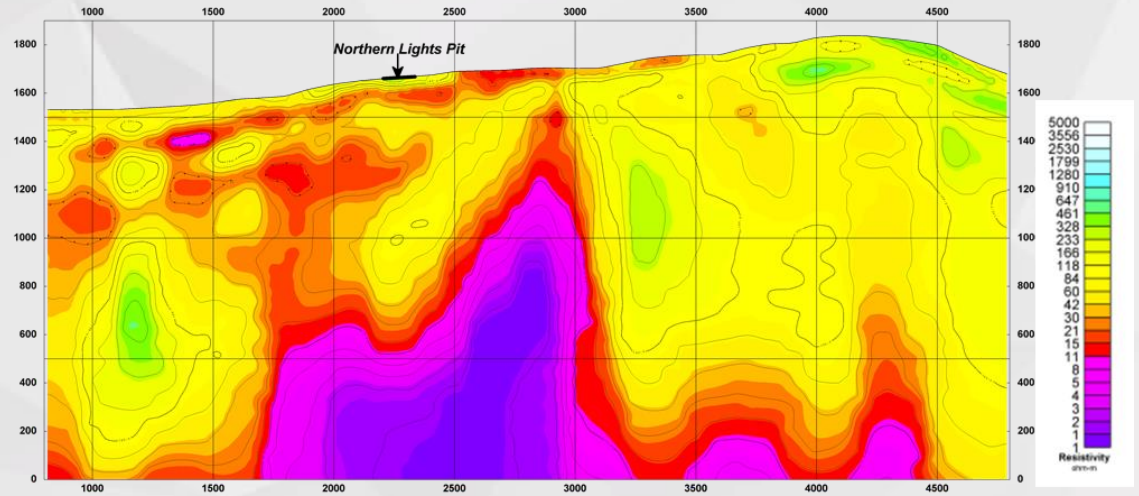



Top panel: DC Resistivity

Typically 500-750 metres

Middle panel: Chargeability

+ MT




Typically 1500 - 2000 metres

Bottom panel: MT Resistivity

TITAN DCIP & MT

TITAN