

*From ground to skies – Geophysical
investigation of Otanmäki mine site in
UOMARI project*

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UOMARI project (2023-2026)

- Novel Technologies for Stream Channel and Mining Pond Mapping – UOMARI Project
- This presentation covers measurements in Otanmäki mine site:
 - Drone
 - GPR, Dual Wavelength Bathymetric Scanner
 - Ground
 - GPR, Electromagnetic, Magnetic

More!



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Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute



Kajaanin
Yliopistokeskus



OULUN
YLIOPISTO



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PAIKKA-
TIETO-
KESKUS FGI

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OTANMÄKI MINE



Energiateollisuus



Hannukainen
Mining



GEO-WORK



radai

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D



Co-funded by
the European Union



Elinkeino-, liikenne- ja
ympäristökeskus

Otanmäki mine – history and future

- Otanmäki mine in Kajaani was once Finland's largest iron mine operating from 1949 to 1985
- Plans to open mine again in two phases:
 1. Tailings area ilmenite sands project
 - Recovery of ilmenite with simple gravity and magnetic processing → main source for titaniumdioxide TiO_2 and titan metal
 - 9.8 million tons with ~16 % ilmenite
 - 1.3 Mt of tailings sand per year producing 110 000 tons of ilmenite per year. - Total production time estimated ca. 7 years.

Otanmäki from a bird's eye view

Photographer: Veljekset Karhumäki Oy,

1956

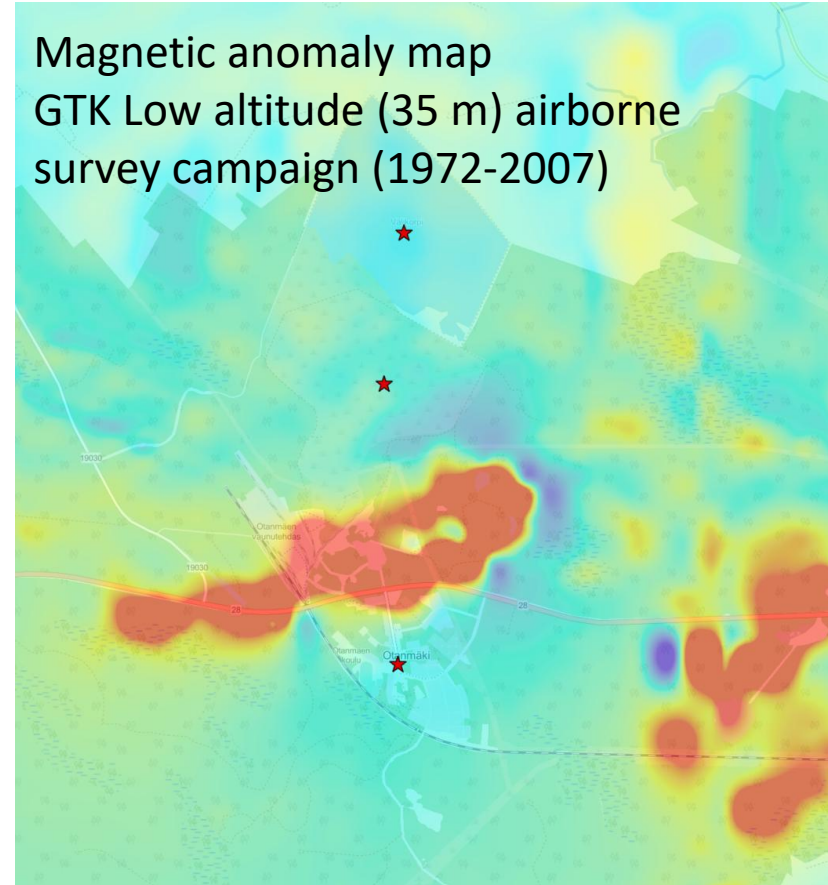
Ilmenite is a black, metallic oxide mineral ($FeTiO_3$) rich in iron and titanium, serving as the most significant ore for **titanium dioxide (TiO_2)** and titanium metal, used in pigments, plastics, paints, and sunscreen, found in igneous rocks and heavy mineral sands, often associated with beach sands. It's **weakly magnetic** and named after the **Ilmen Mountains in Russia**, its discovery site.



Otanmäki mine area



Magnetic anomaly map
GTK Low altitude (35 m) airborne
survey campaign (1972-2007)

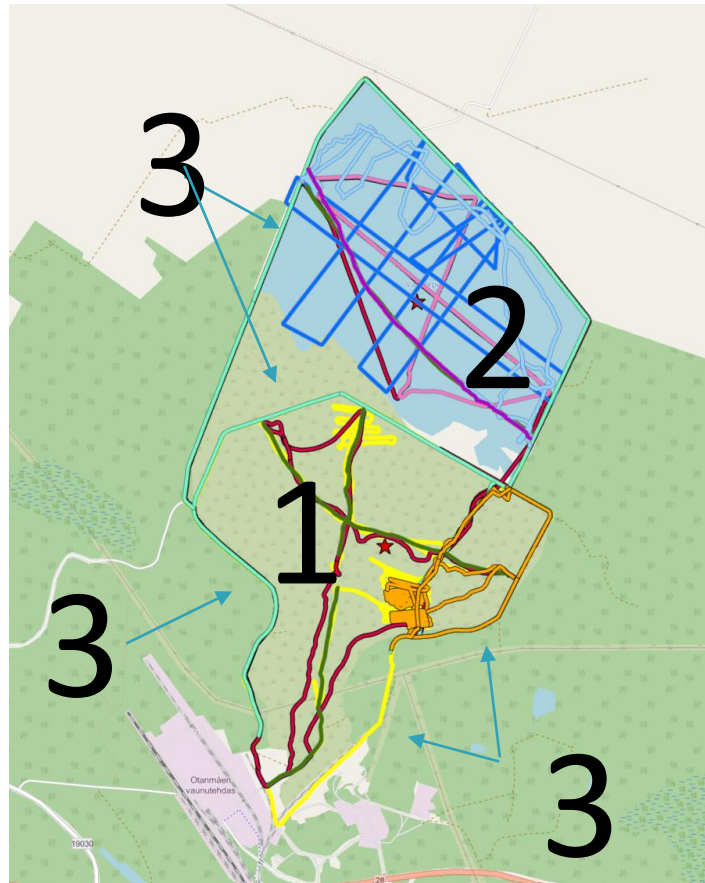


UOMARI measurements in Otanmäki

Tailings pond:

- GPR
 - 100 MHz, 200 MHz
- DroneGPR
 - 100 MHz, 150 MHz
- Electromagnetic
 - tTEM and GEM-2
- Magnetic
- Pointwise dielectric measurements
- Pointwise Wenner resistivity

1



Settling pond:

- GPR:
 - 100 MHz, 300/800 MHz
- DroneGPR:
 - 100 MHz, 150 MHz
- Dual Wavelength Bathymetric Scanner (ABS)
- Electromagnetic
 - GEM-2

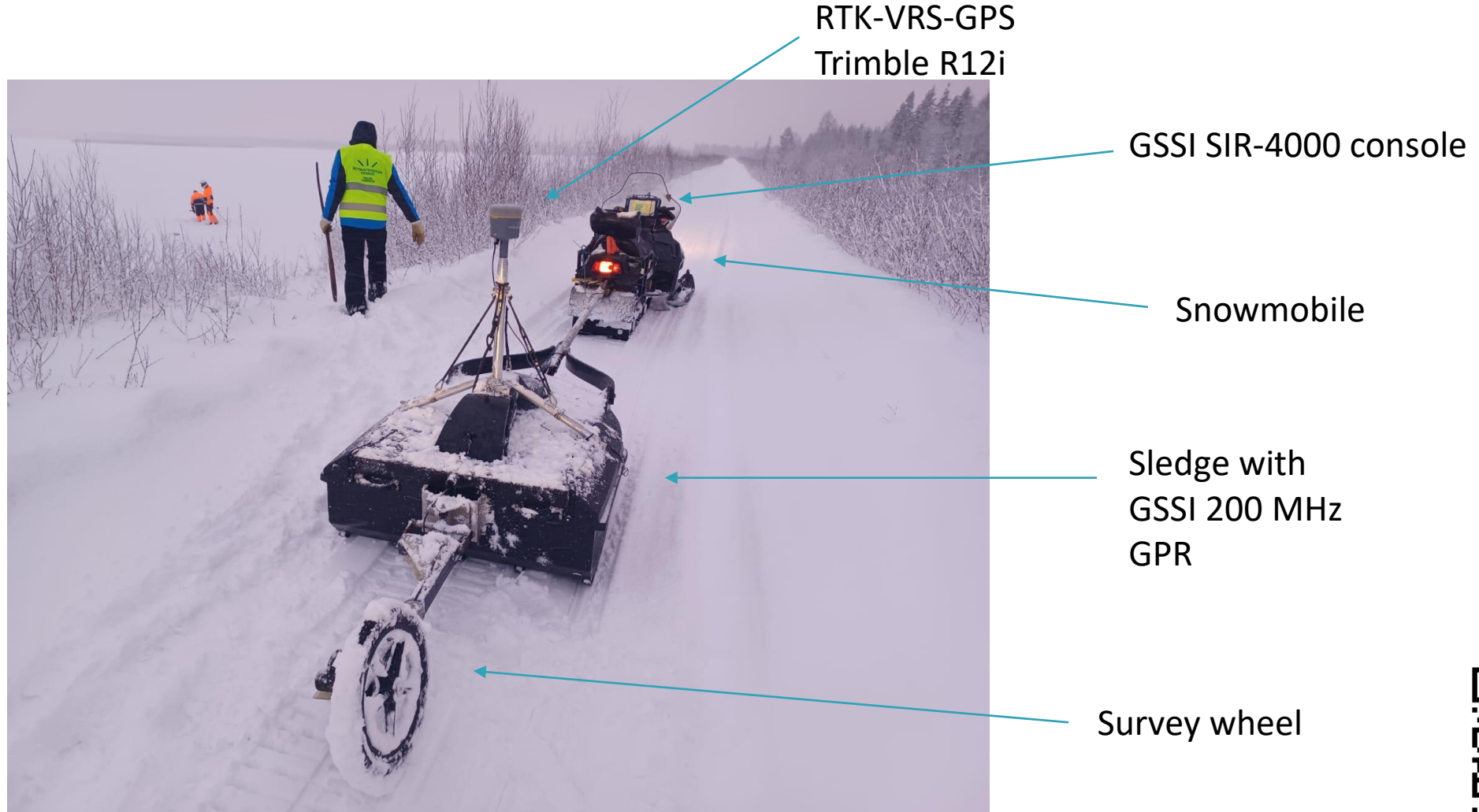
2

Dams:

- GPR
 - 200 MHz
- DroneGPR
 - 100, 150 MHz)
- Electromagnetic
 - tTEM and GEM-2
- Magnetic

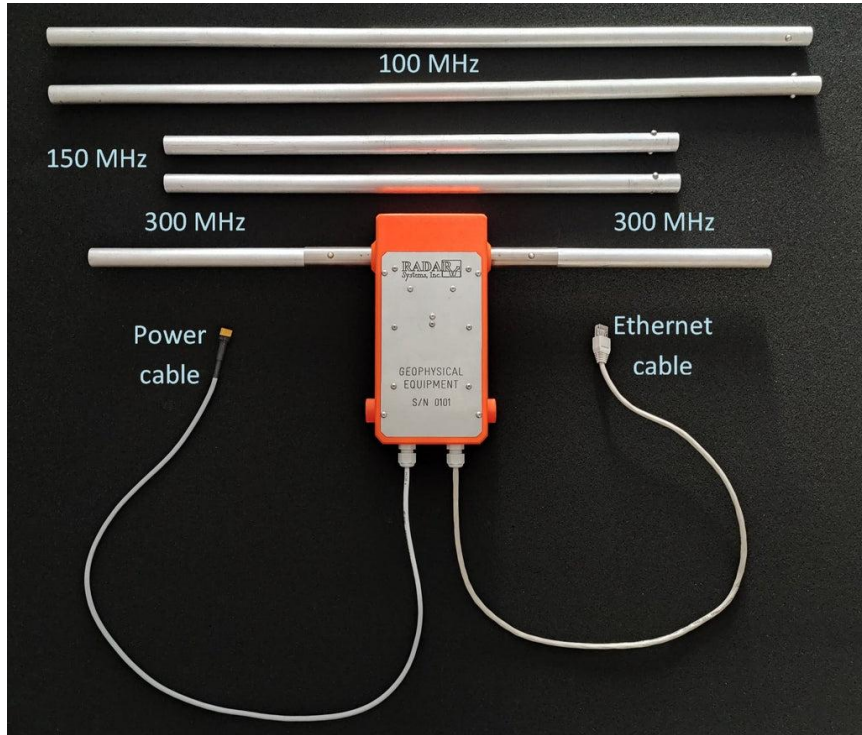
3

Snowmobile was used for GPR measurements



Drone GPR: 100, 150, 300, 1000 MHz

Radar Systems Zond Aero LF: 100, 150 and 300 MHz



0.75 m

0.5 m

0.25 m

- 0.8 kg – GPR controller with mountings for the drone
- 0.1 kg – 300MHz antenna
- 0.2 kg – 150MHz antenna
- 0.4 kg – 100MHz antenna

DJI Matrice 350 RTK



Depth: Up to 20 meters from the ground in average normal soil, up to 10 meters with an antenna elevation < 3 m

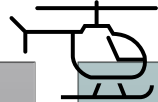
-20°C to 60°C internal temperature

Standard Geophysical SEG Y Data Format (.s gy) **with traces geotagging**

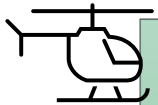
Guideline for DroneGPR Measurements



Flight area must have permit for GPR (Traficom)



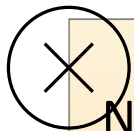
Airspace must be free (<https://flyk.com>)



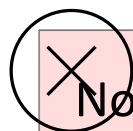
Height only max. 1 m above ground



VLOS must be maintained



No metallic parts in the mounting!

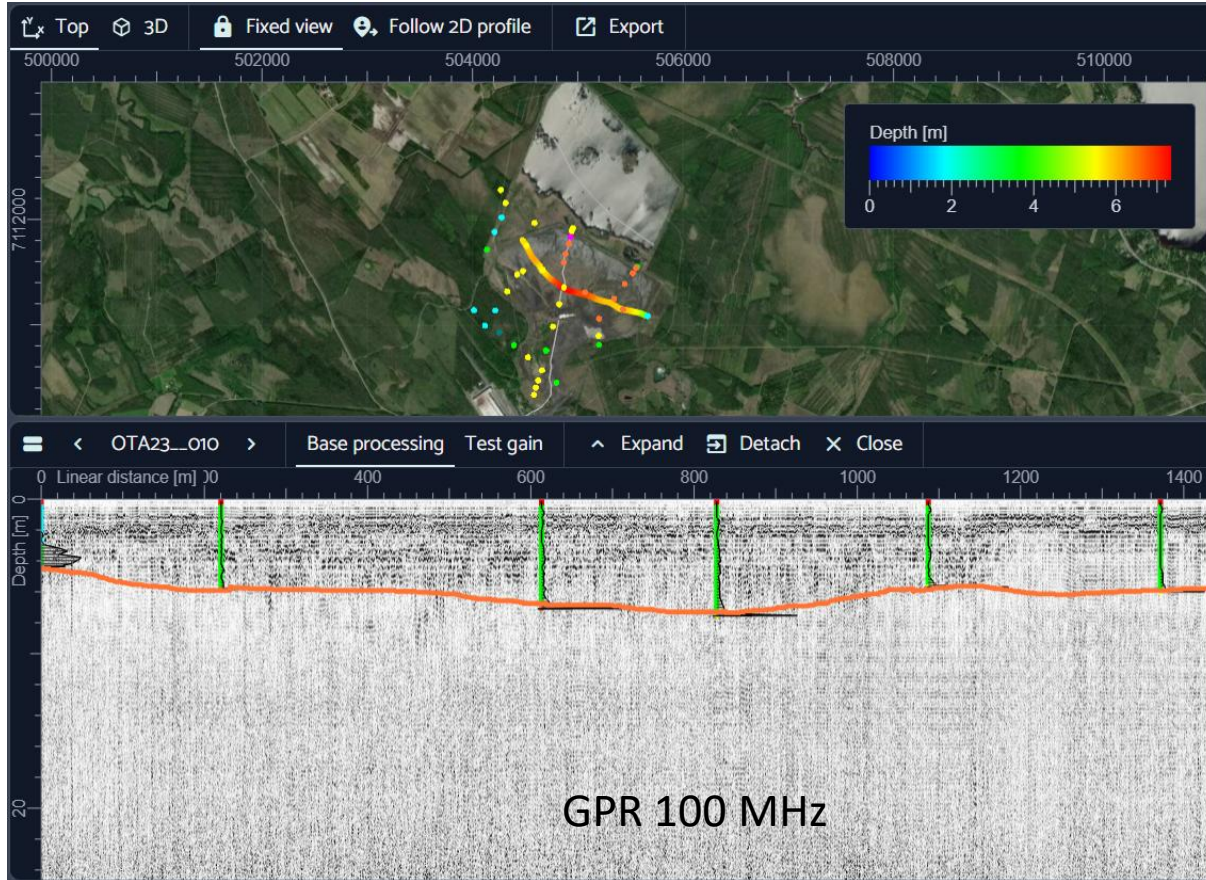


No pulse formed signals (LEDs, velocity control)

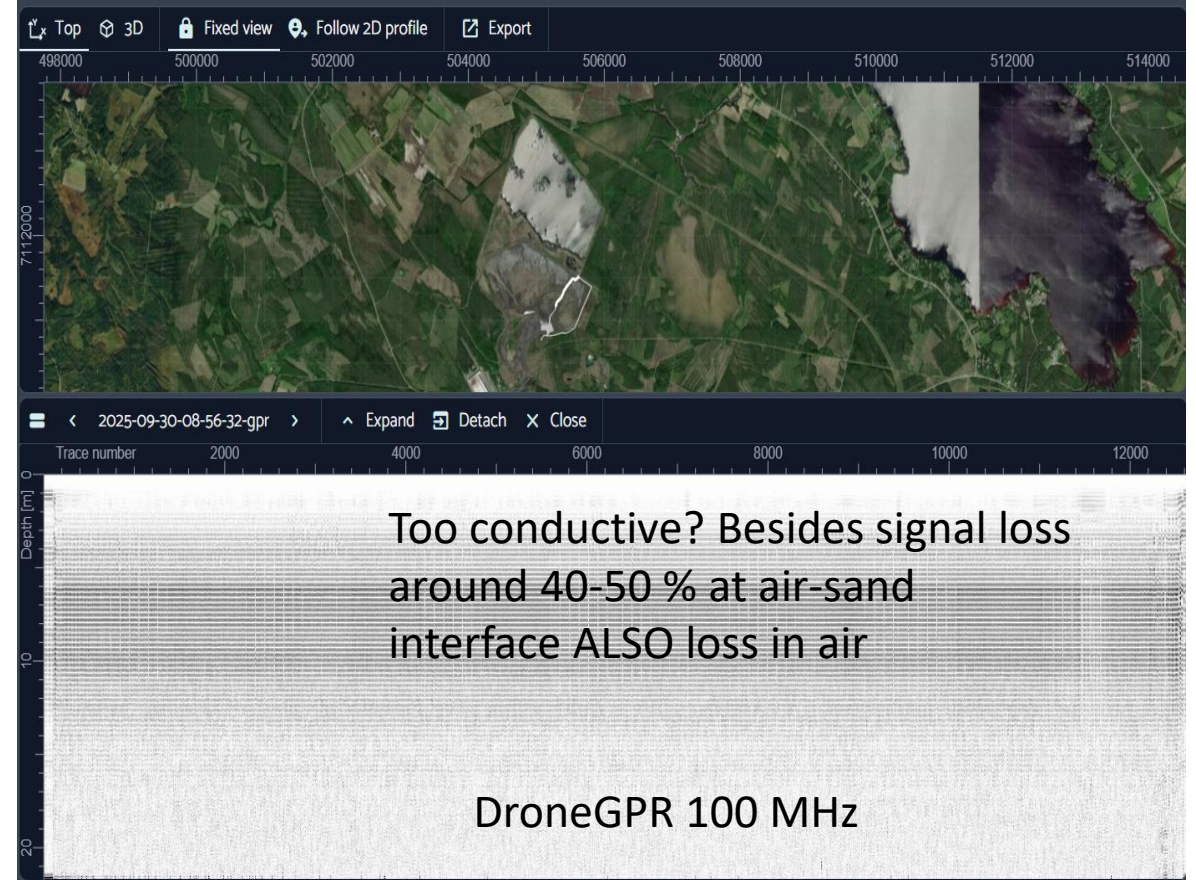


Tailings pond: GPR vs DroneGPR

$\epsilon_r = 6.0$

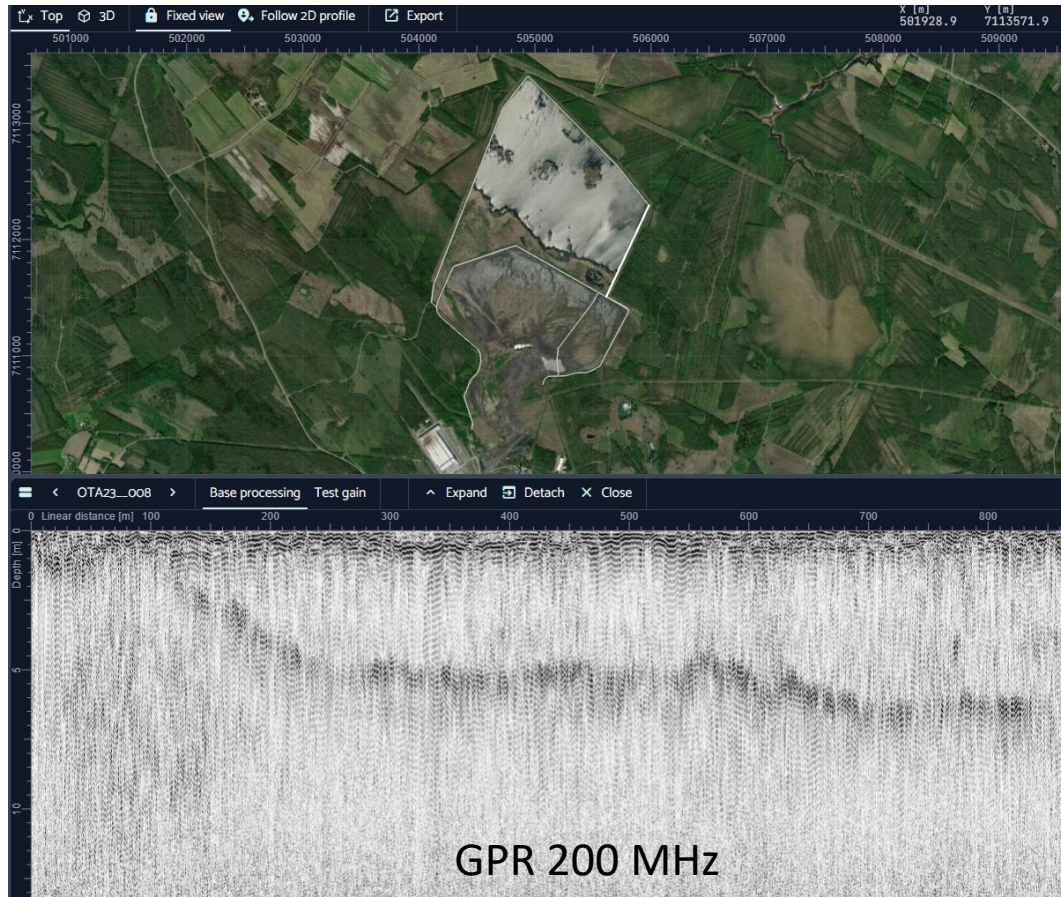


$\epsilon_r = 6.0$

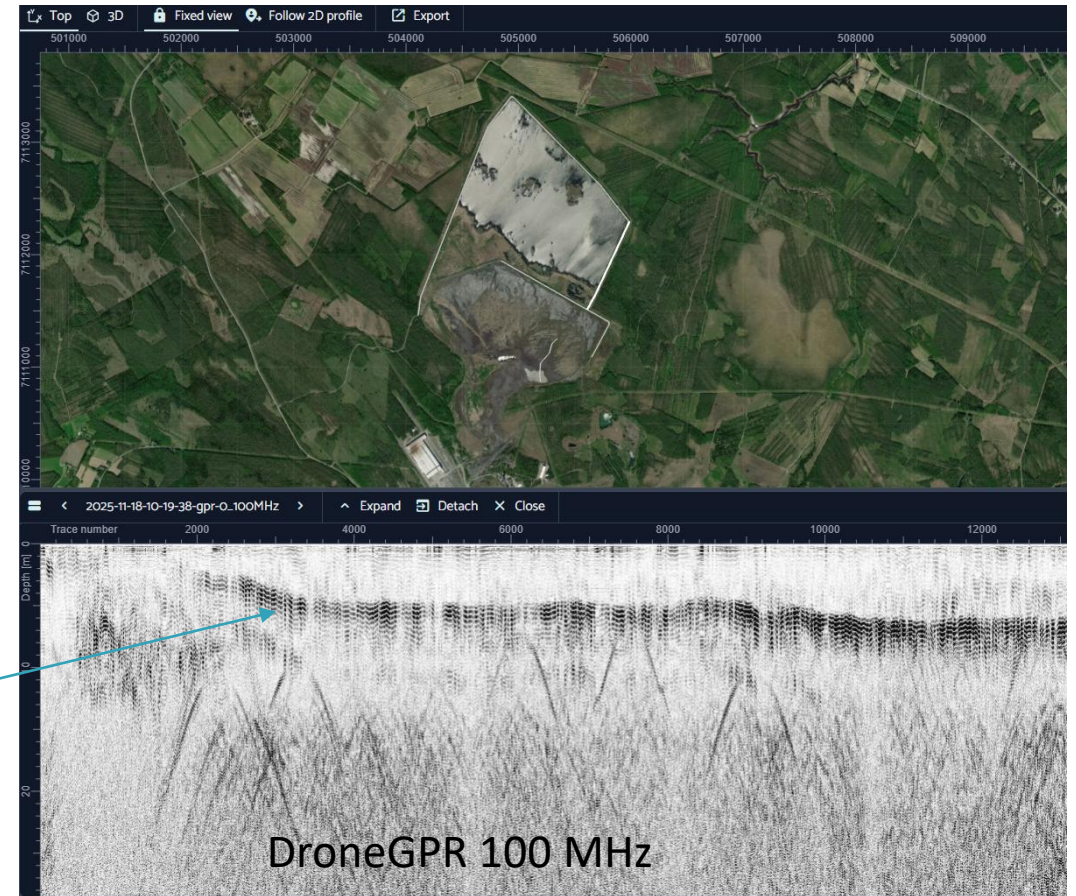


Settling pond dam: GPR vs DroneGPR

$$\epsilon_r = 6.3$$



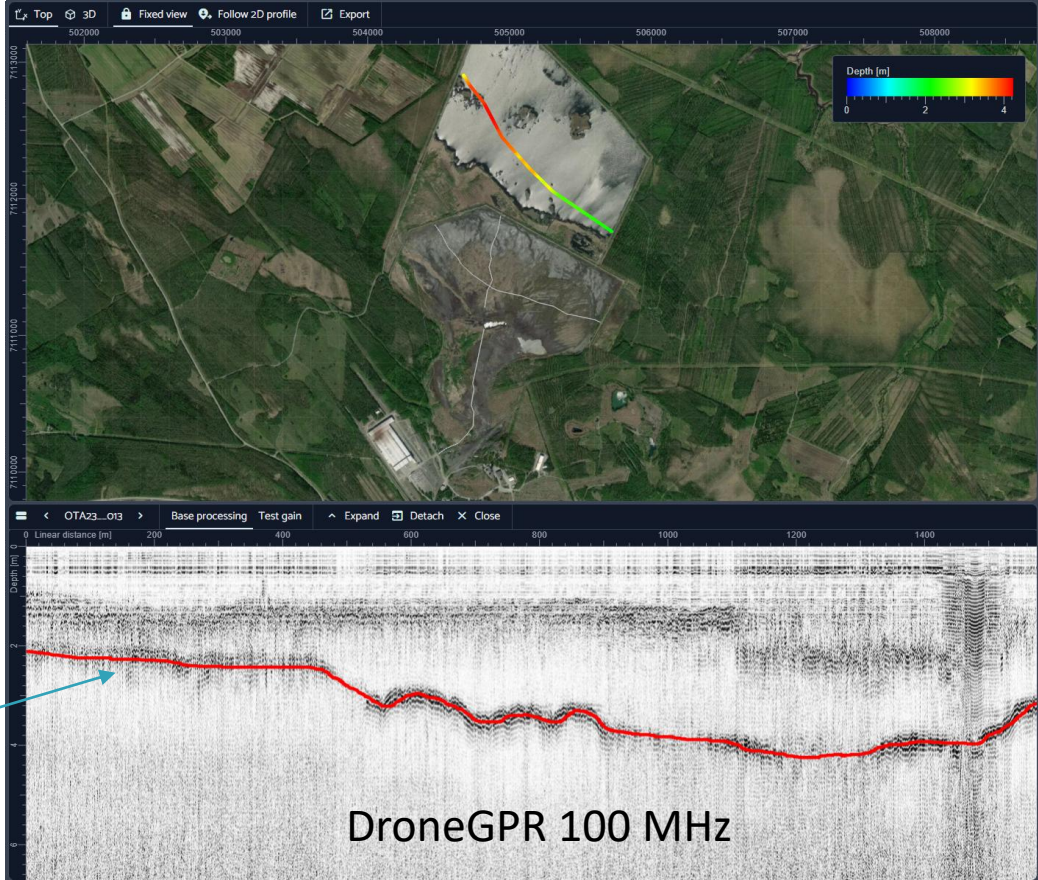
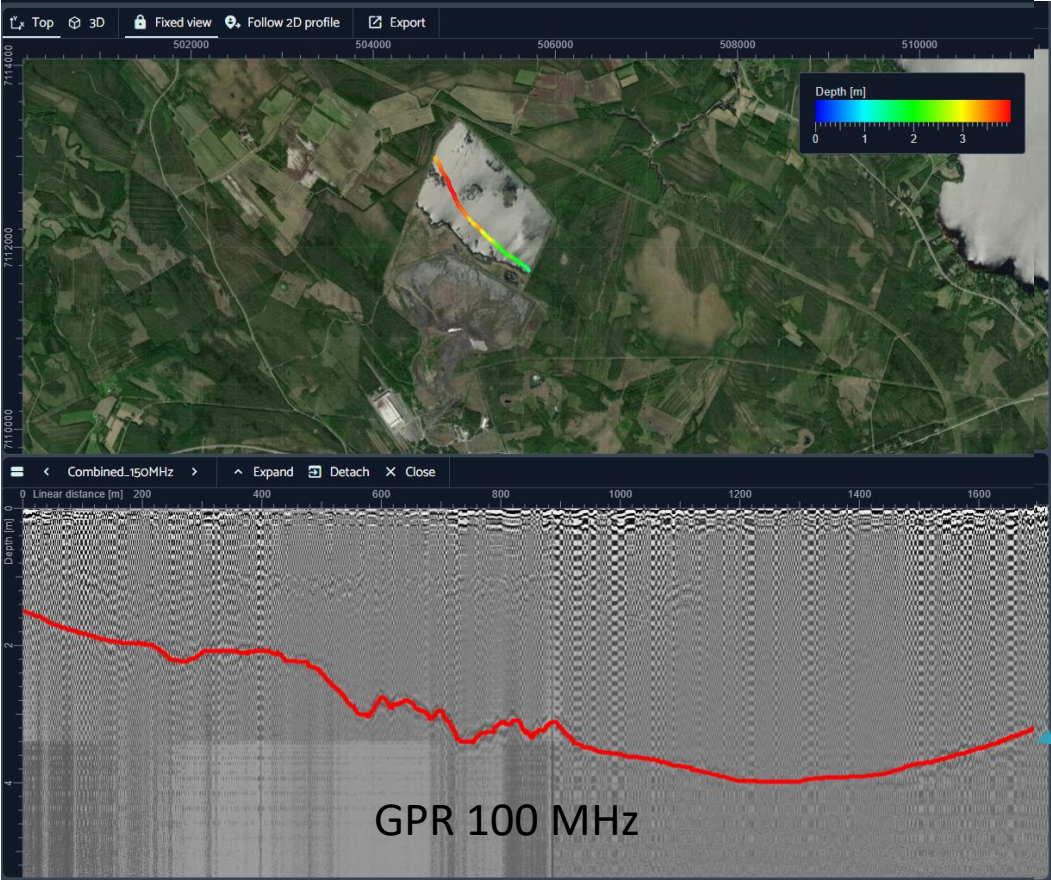
$$\epsilon_r = 6.3$$



Settling pond: GPR and DroneGPR

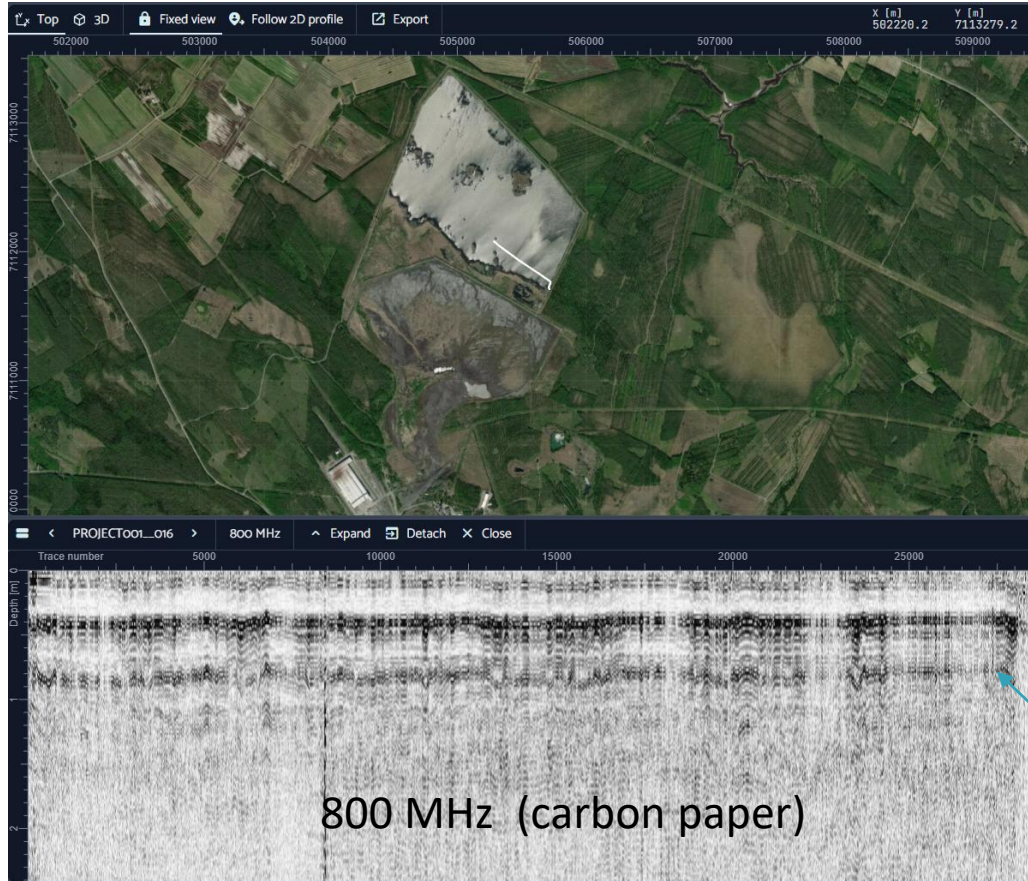
$$\epsilon_r = 81$$

$$\epsilon_r = 81$$



Settling pond: Ice thickness

$$\epsilon_r = 3.4$$



Lower ice surface
~40 cm

Double
reflection

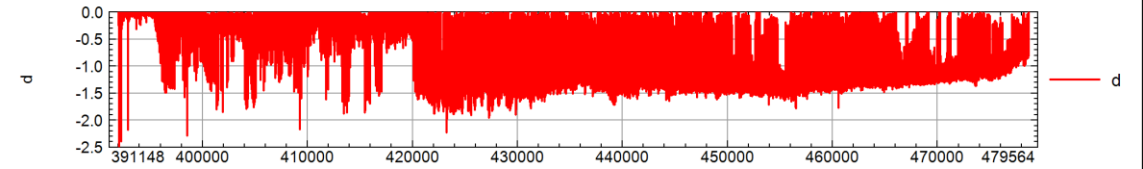
Verified from ice
hole

1000 MHz droneGPR measurement
still coming

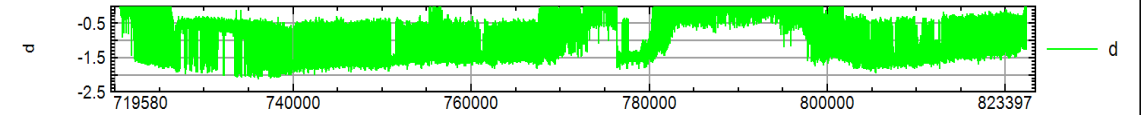
Dual-wavelength airborne bathymetry for drone from Fraunhofer IPM



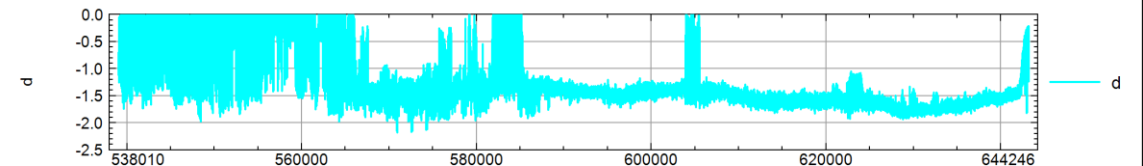
Otanmäki Settling Pond Dual Frequency Laser Line 1



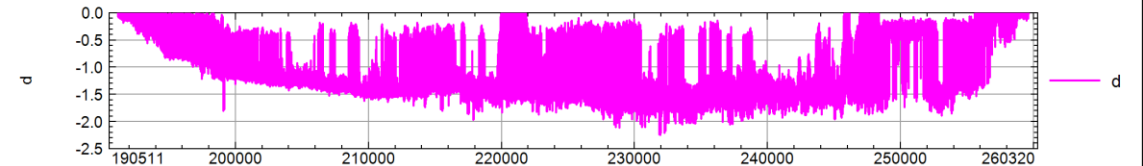
Otanmäki Settling Pond Dual Frequency Laser Line 2



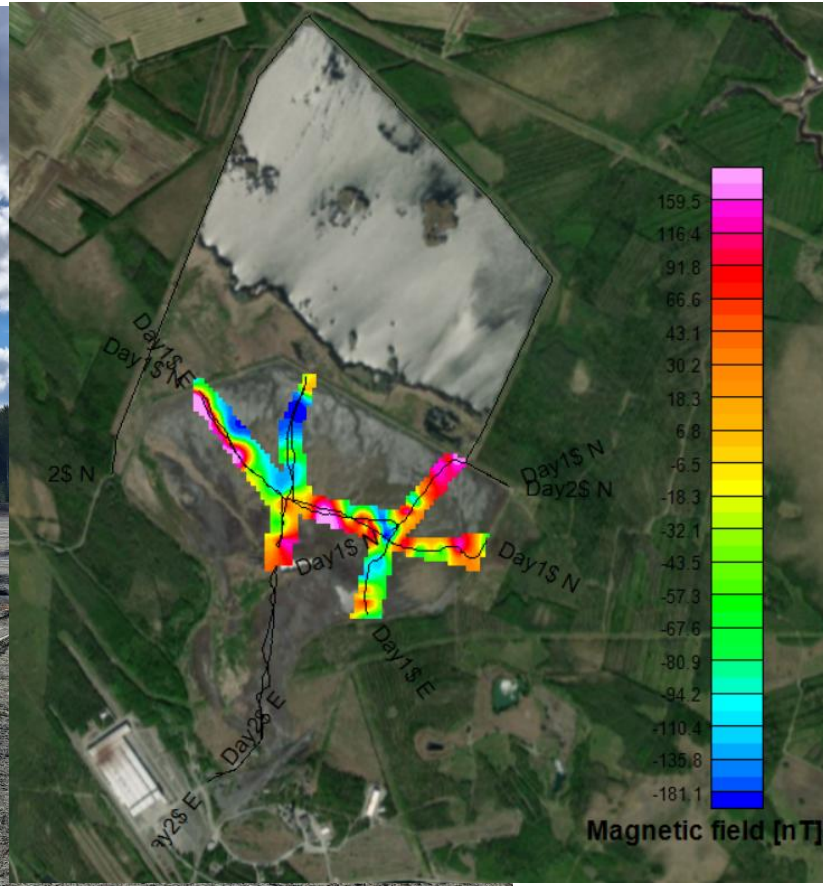
Otanmäki Settling Pond Dual Frequency Laser Line 3



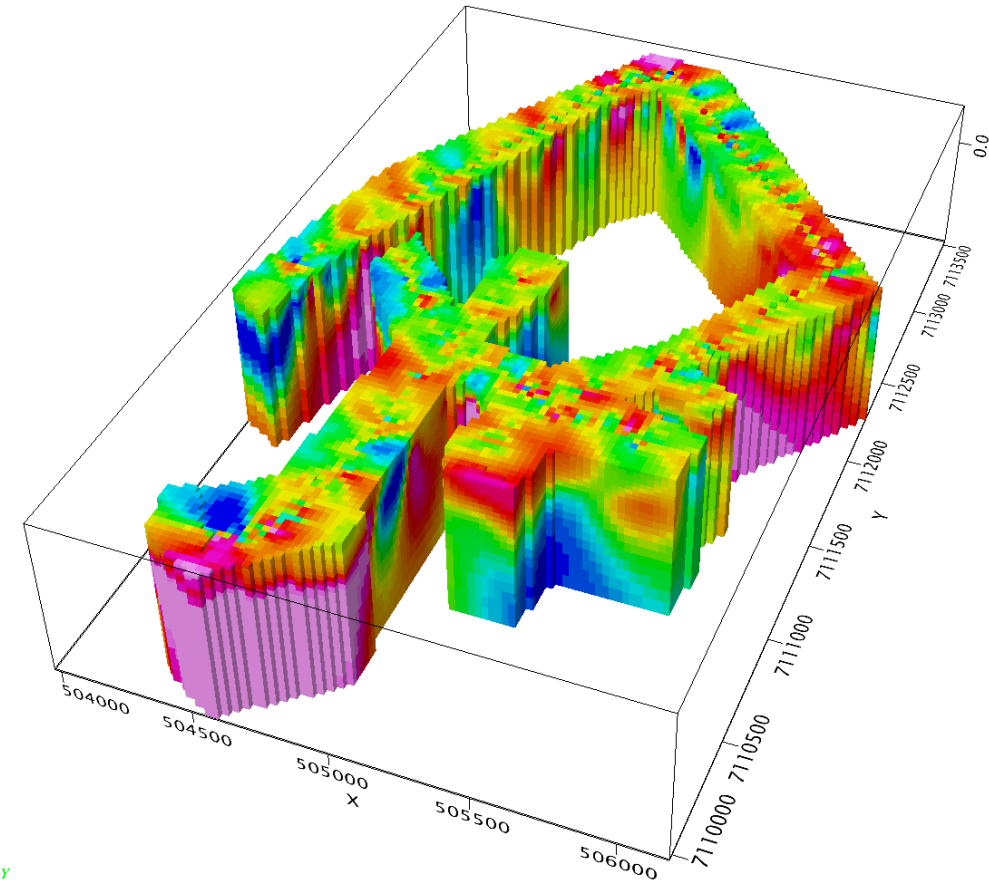
Otanmäki Settling Pond Dual Frequency Laser Line 4



Magnetometer measurements

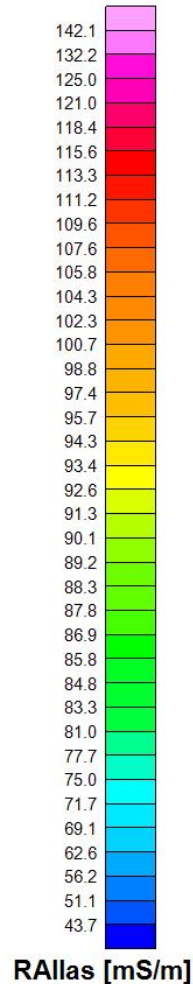


Magnetic map



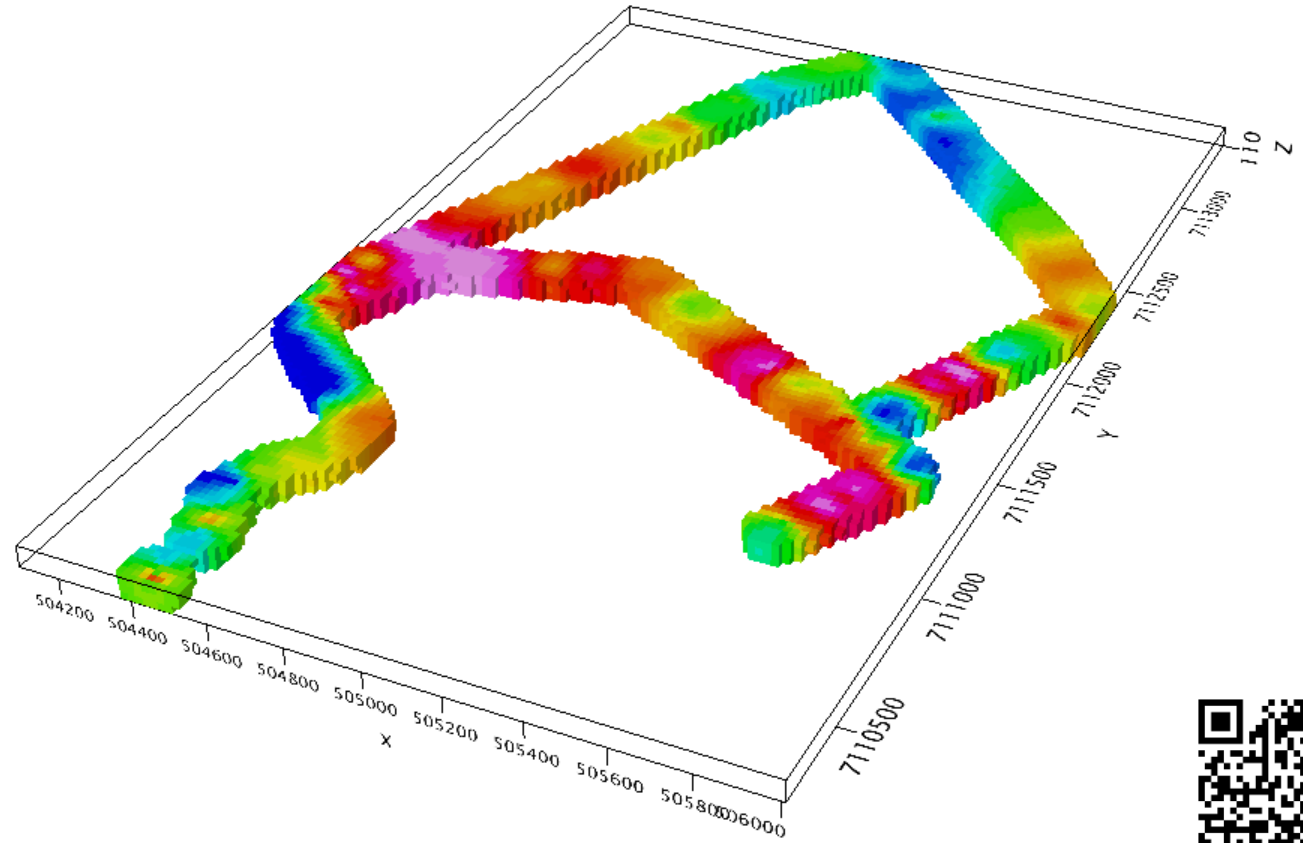
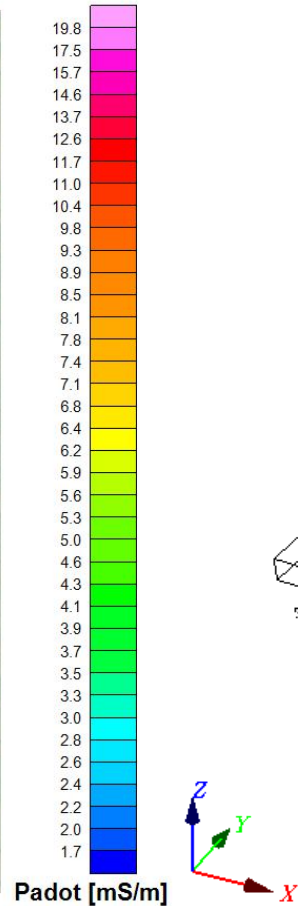
Susceptibility voxel

Electromagnetic measurements: Tailings pond



tTEM

Electromagnetic measurements: Dams



Conductivity map

Conductivity voxel



In summary

- Encouraging experiences from droneGPR
 - Good experiences from dams and settling pond where structures showed clearly, not so good in tailings pond
 - Operates in various environments that might not be easily accessible (ponds, swamps, rivers)
- Dual frequency bathymetric scanner (ABS) gave independent information about bottom topography of settling pond
 - Not affected by conductivity as GPR
- Electromagnetic methods (tTEM and GEM-2) and magnetic methods gave relative variation of conductivity and susceptibility, respectively, inside tailings pond and dam areas offering useful information for mine planning
- UOMARI project ends on 03/2026
 - Still under process: combining different models to some kind of synthesis and writing reports
 - Final seminar in Kajaani on the 24th of March

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GeologiantutkimuskeskusGTK

Thank you Lauri Nurmi,
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Jouko Jylänki, Roope
Koponen, Kyösti Karttunen,
and all others!

UOMARI



NOTICE! Next UOMARI
presentation at 15:45 @GOTO33

*Drone-based bathymetric
measurements in the assessment
of the Impounded Riverbed of
Rautuvaara*

By Joonas Kahiluoto