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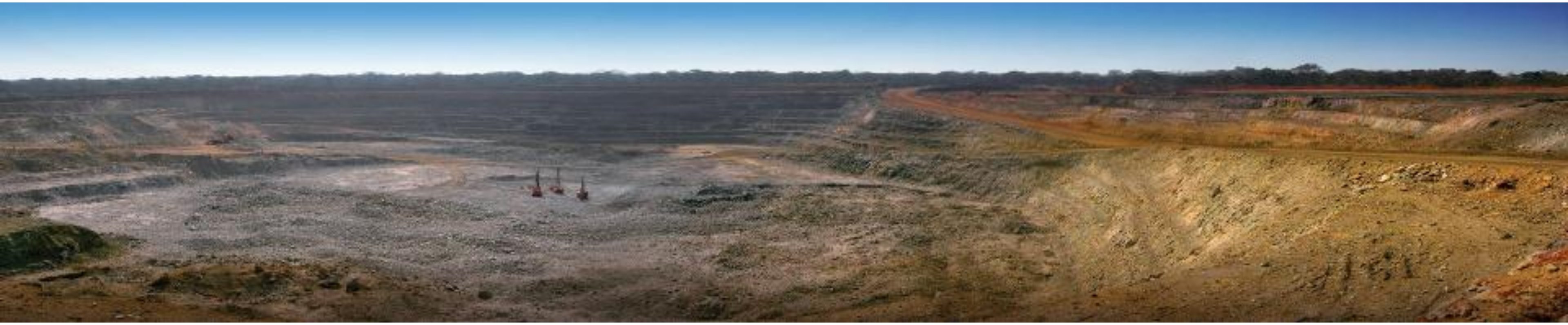

Wanted: earlier times and shallower information from airborne EM

Geotechnical and regolith mapping

ASEGWA AEM Workshop, Perth, 7 November 2012

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Group Geophysicist, First Quantum Minerals

Outline

- The difficulty with getting very shallow information
- Electrical properties of the overburden/regolith
- Case studies in overburden mapping
  - Geotechnical: siting the crusher
  - Exploration: planning base of till drilling
- Conclusions: factors in success

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Shallow EM information

- Shallower information comes from earlier measurement times
- Earlier measurement times (off-time) come from faster shut-off times of the transmitter current
- Faster current shut-off comes with lower current and smaller loops
- Not what the industry is generally striving towards
- Current optimal systems cannot image much less than 10m depth

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Electrical properties of the overburden

- Usually more conductive than bedrock below
- Salt lakes, weathered regolith, glacial till all offer greater conductivity than the fresh rock below
- Exceptions: unconsolidated sand (desert), permafrost

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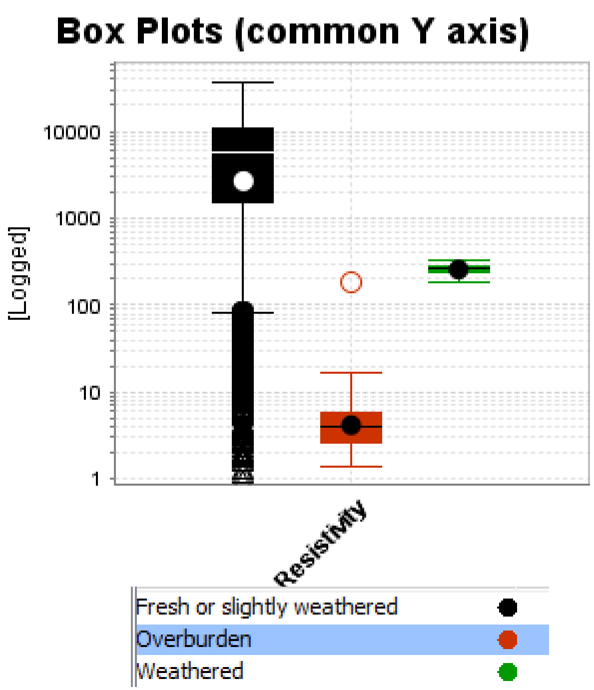
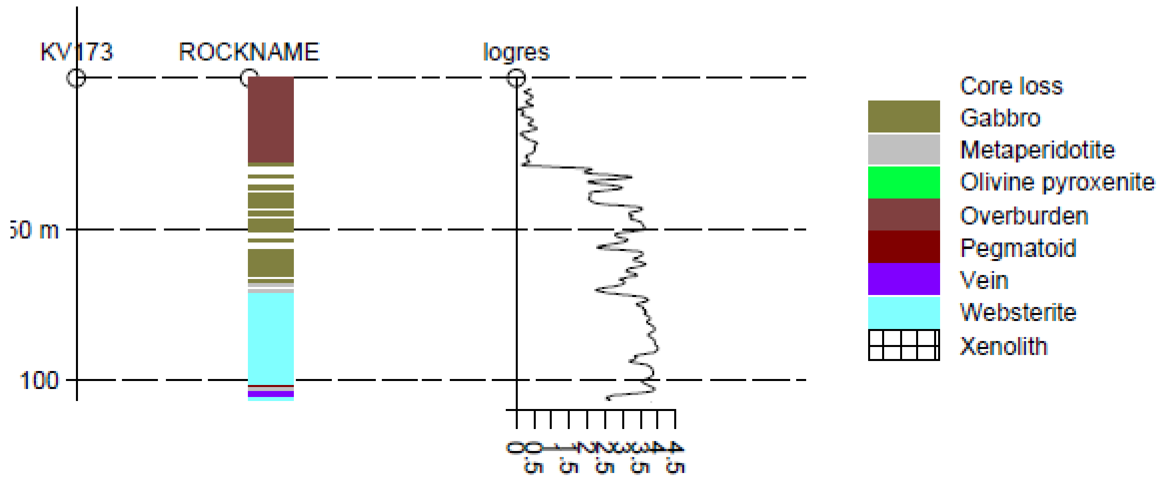
Glacial till in central Lapland

- Sandy (not clay)
- No permafrost
- More conductive than bedrock except when highly fractured and weathered





Case study 1: siting mine infrastructure

- Problem: glacial till and peat needs to be excavated down to solid bedrock at crusher site
- Solution: find shallow bedrock site to minimise excavation

Overburden depth calculation

- SkyTEM (2010) system, first low-moment channel starting at 7.9 μs
- Multilayer resistivity inversion of each sounding point, laterally constrained
- Choose a resistivity marking the overburden – bedrock interface and find the depth of this resistivity (300 Ωm, 500 Ωm)

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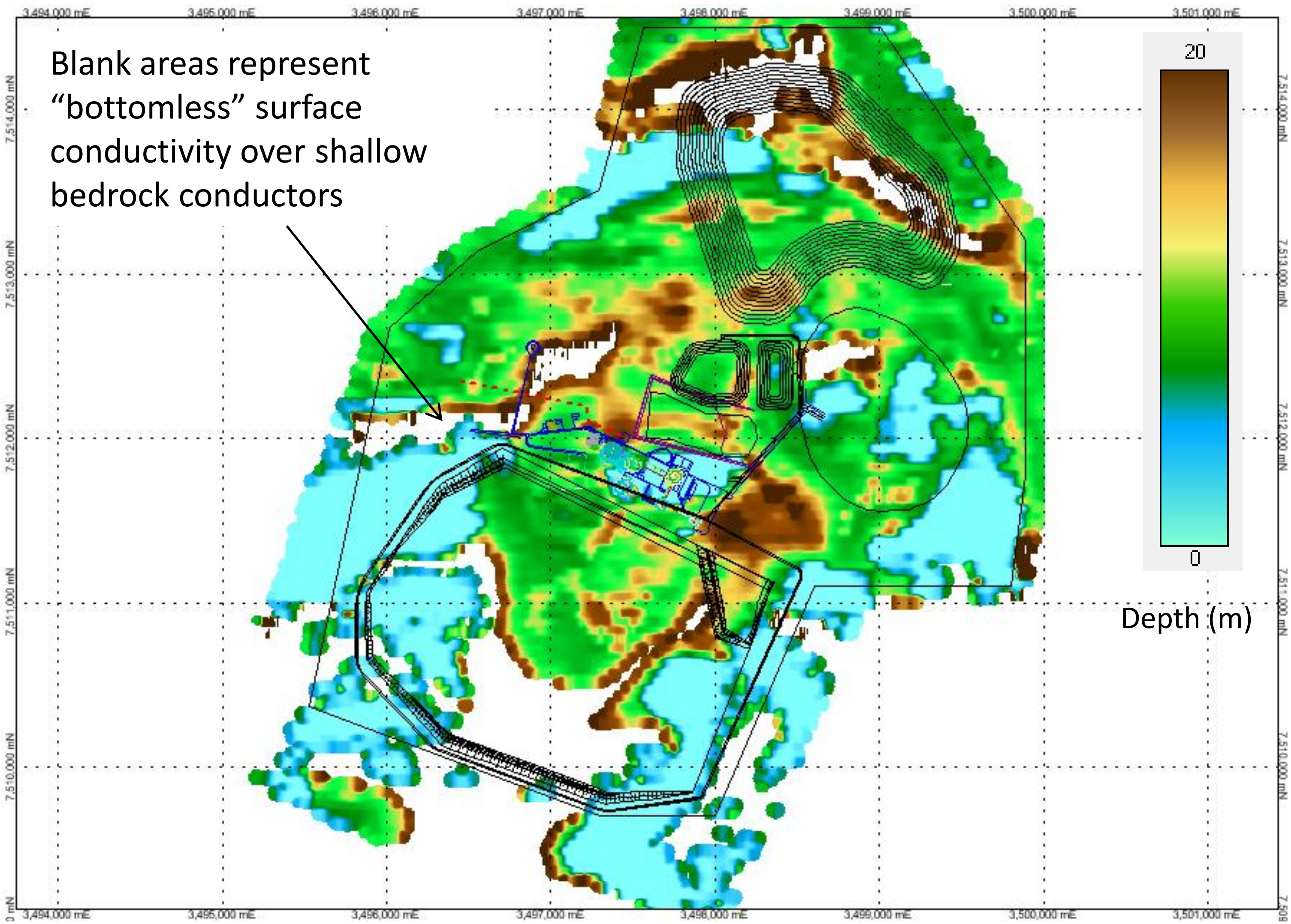
Overburden depth for 500 Ωm



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Statistical inversion

- 30-layer model
- Posterior covariance matrix relates all layer resistivities
- Covariance matrix is multiplied with Gaussian distributed random number vector (zero mean and standard deviation one) to produce model perturbations
- Repeated 1000 times to produce a set of equivalent models (all fit the data)
- 1000 models are queried to determine statistical likelihood of each layer, starting from the surface and working down, being less than a certain resistivity – e.g., < 300 ohm.m for overburden-basement interface (> 50% likelihood)

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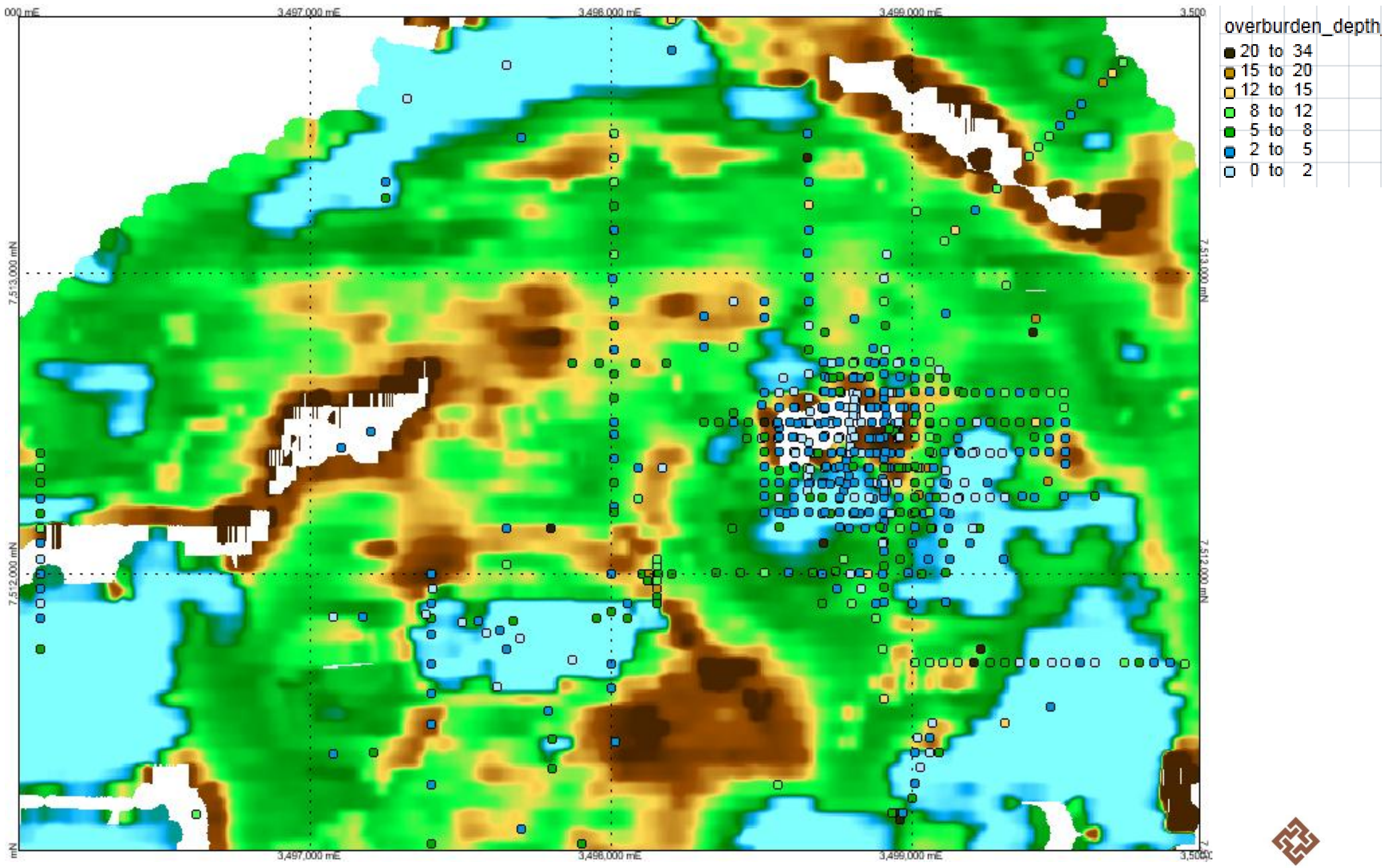
Overburden depth: drilling vs AEM



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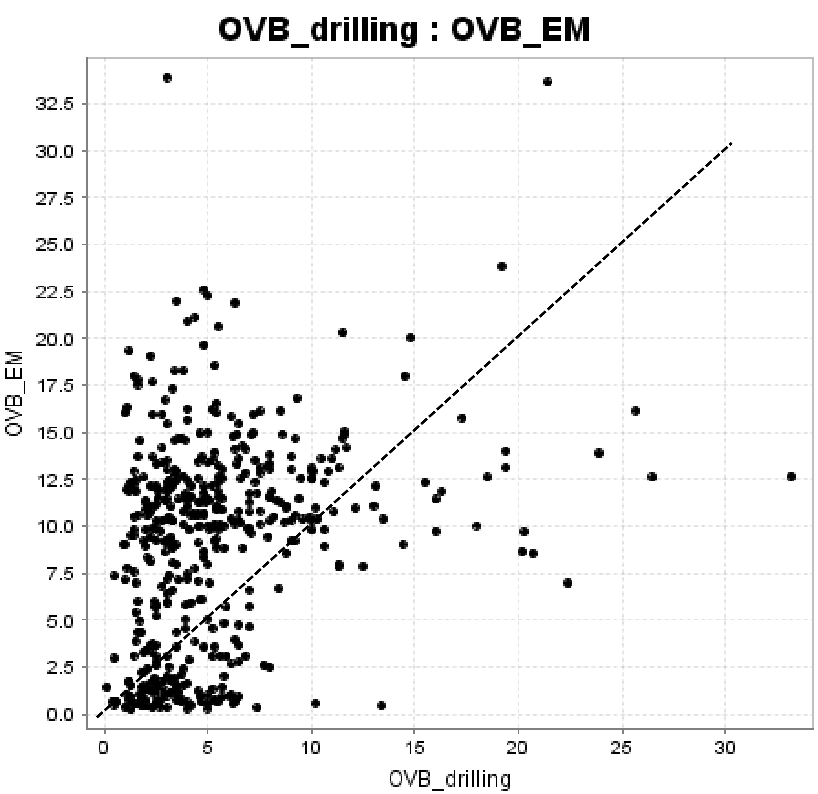
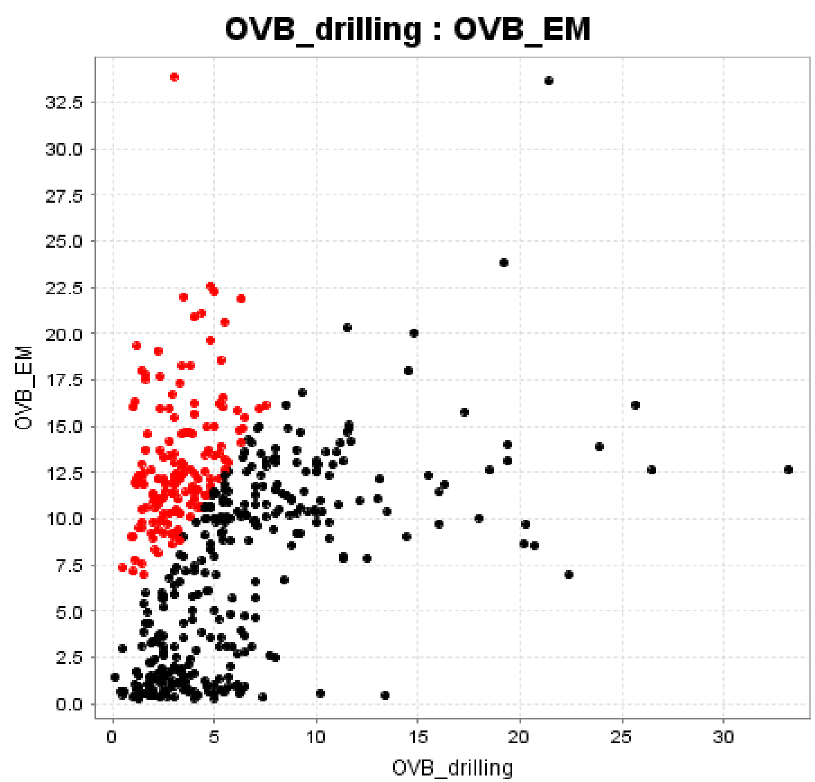
EM vs drill logging

- Poor quantitative correlation, a lot of overestimation by the AEM (red points > 2 x logged depth)





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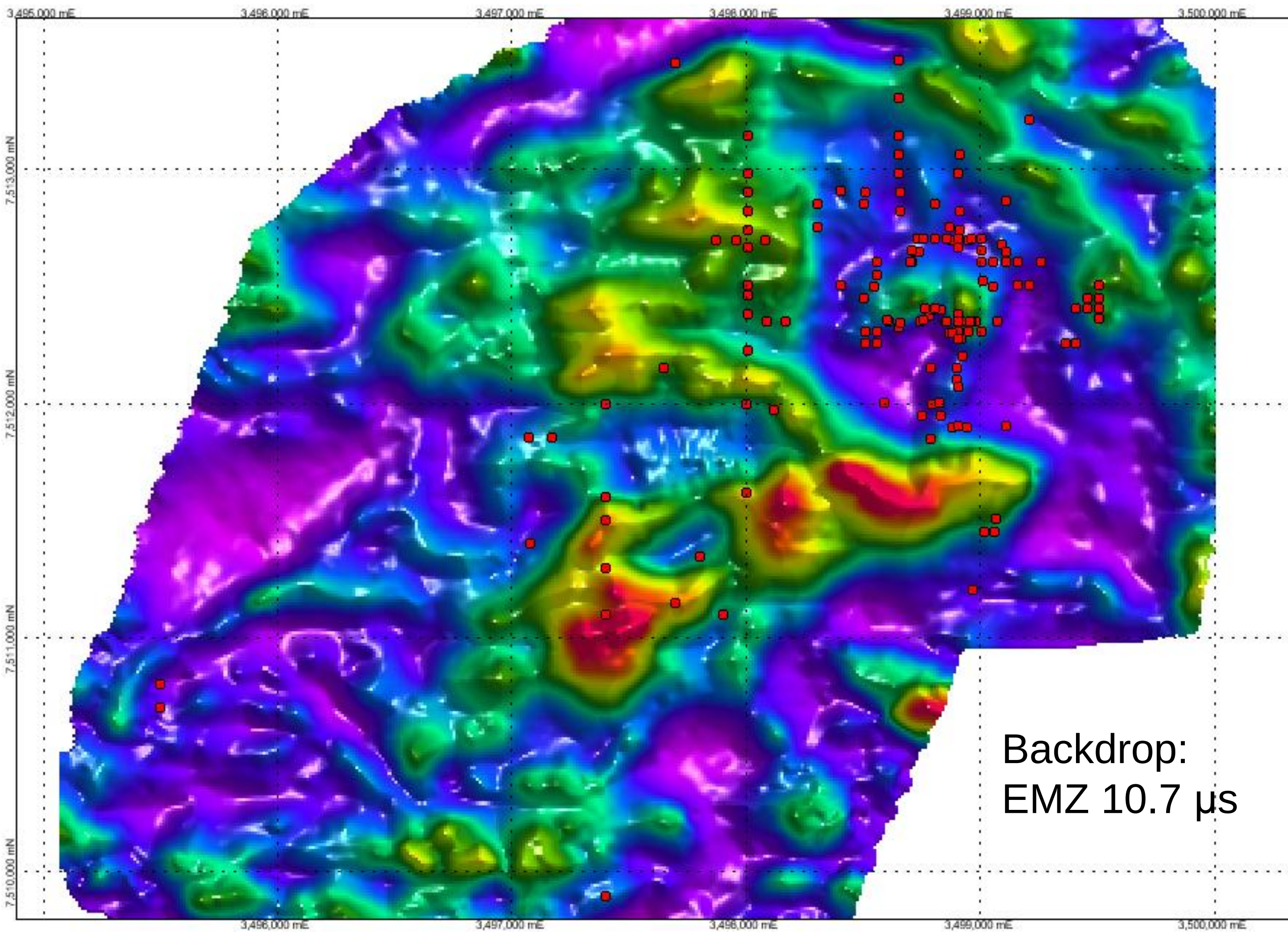
EM depth >> logging: surface conductors?



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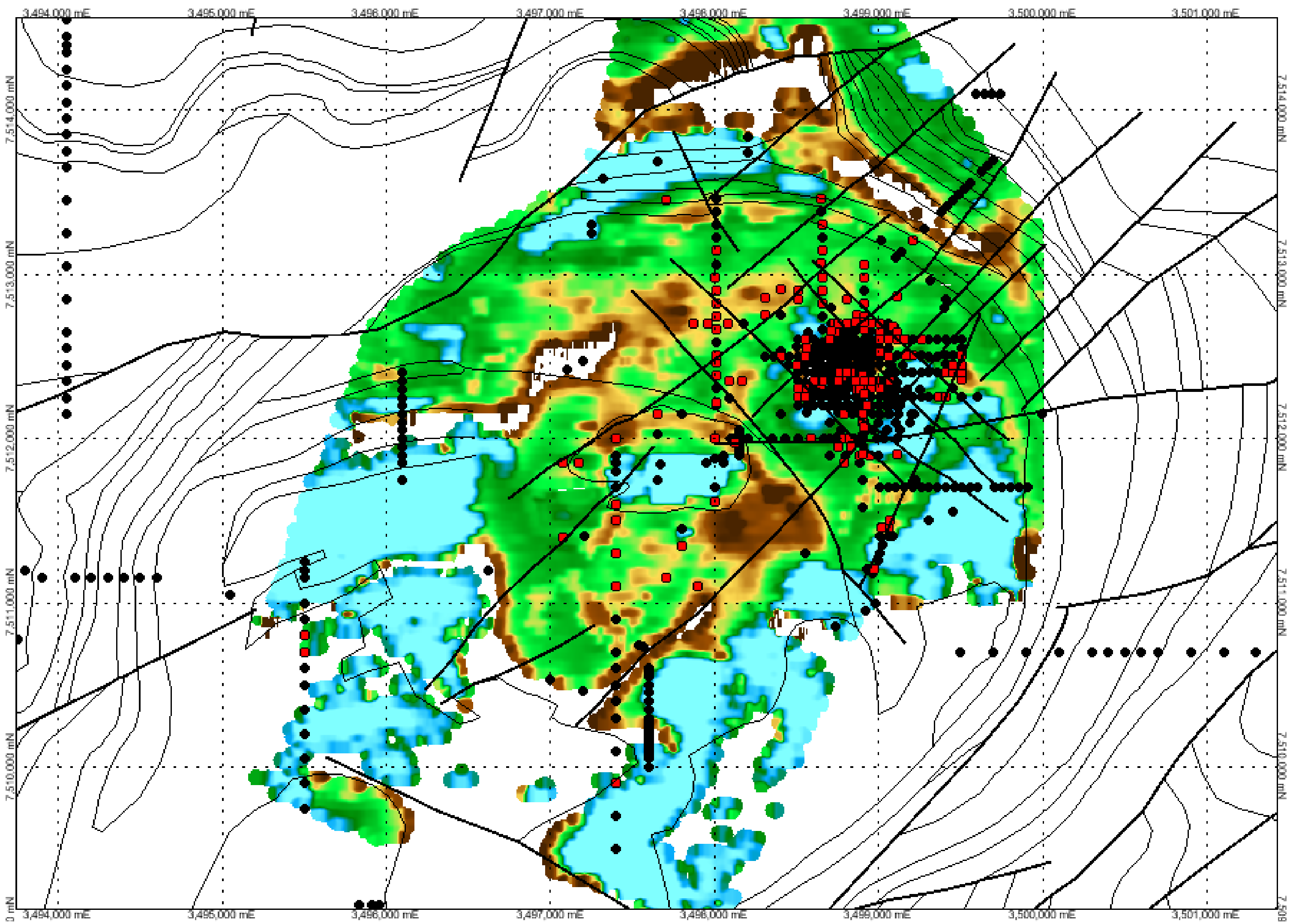
EM depth >> logging: structure?



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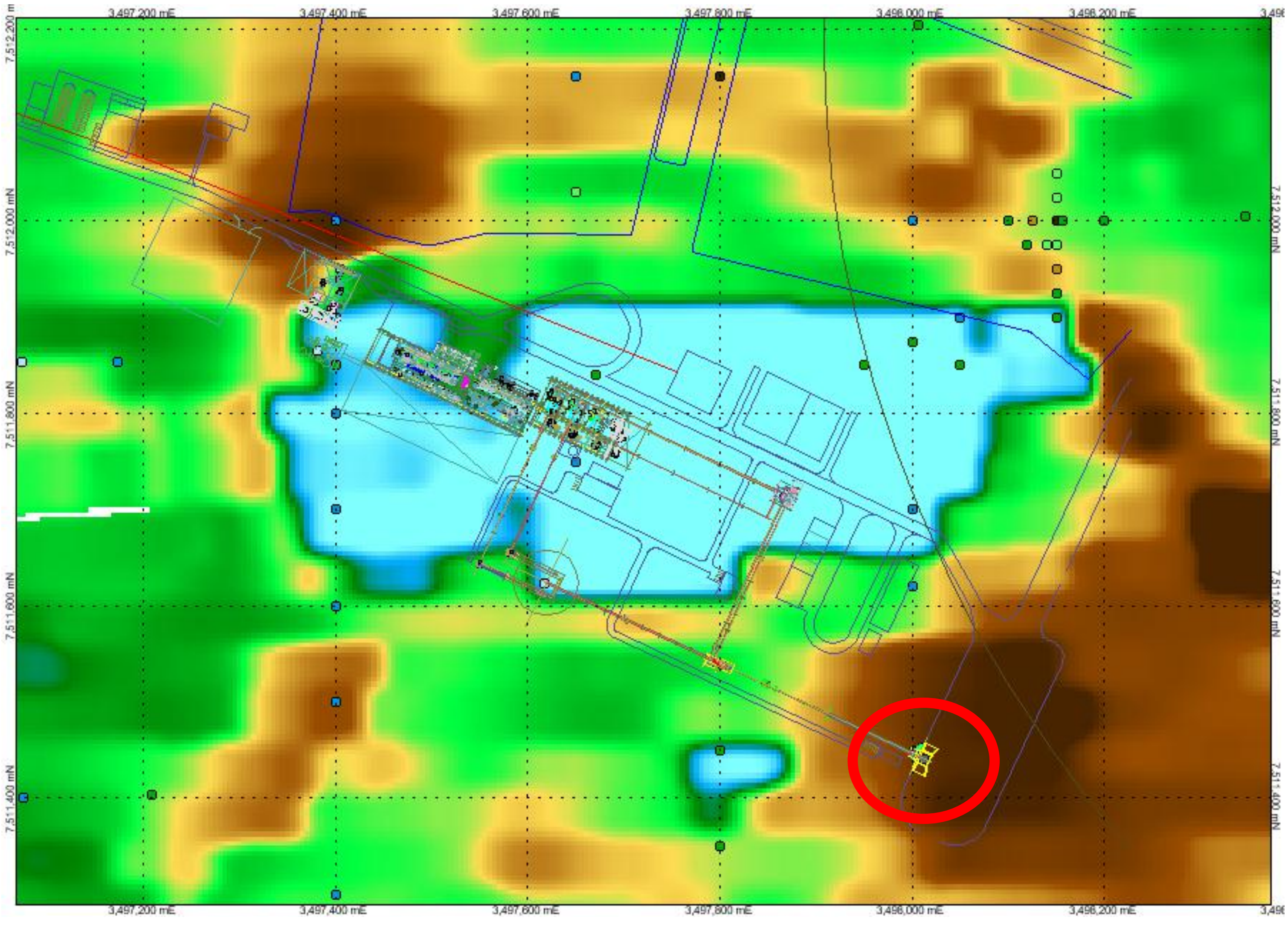
Initial crusher location vs EM ovb depth



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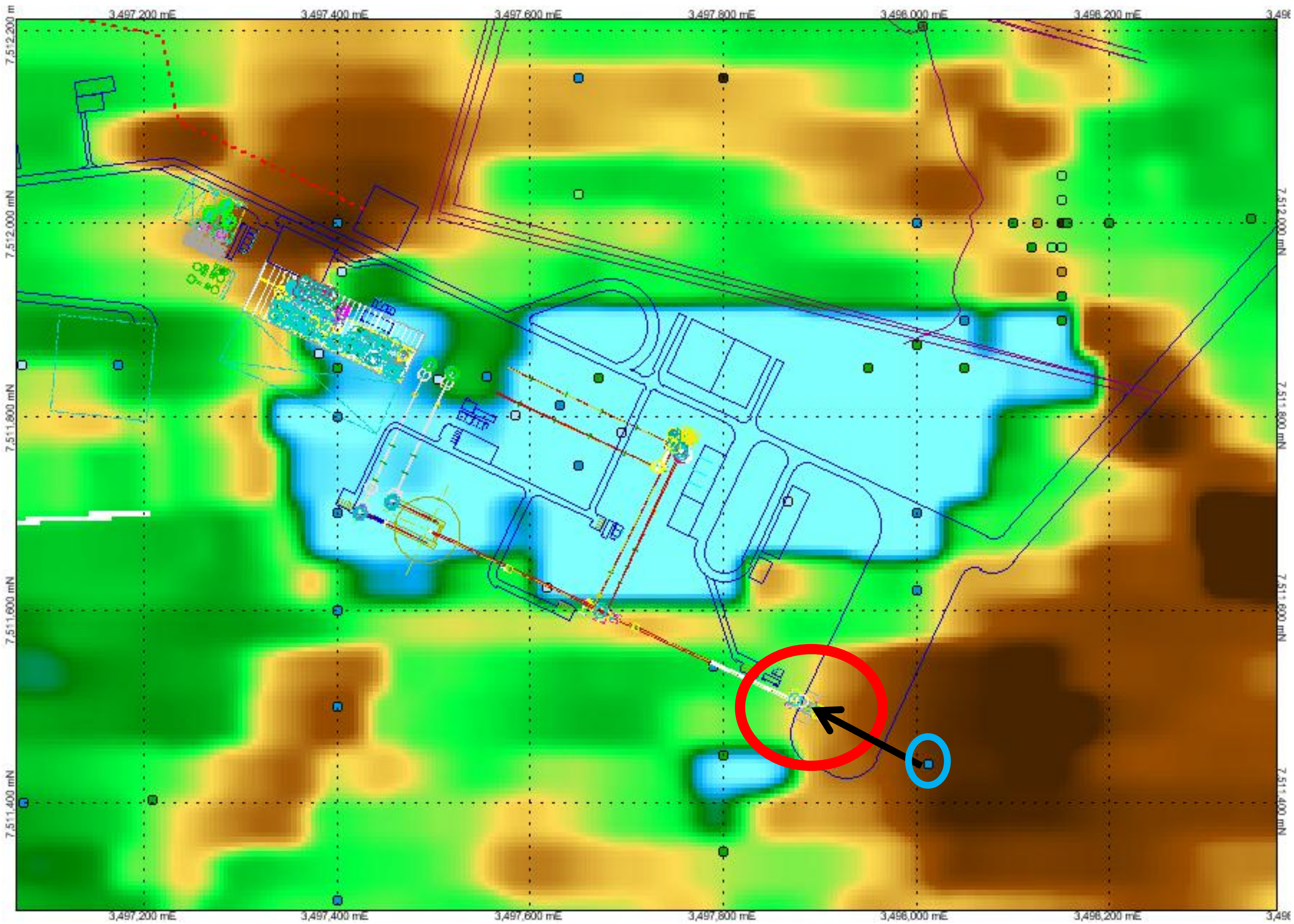
Final crusher location vs EM ovb depth



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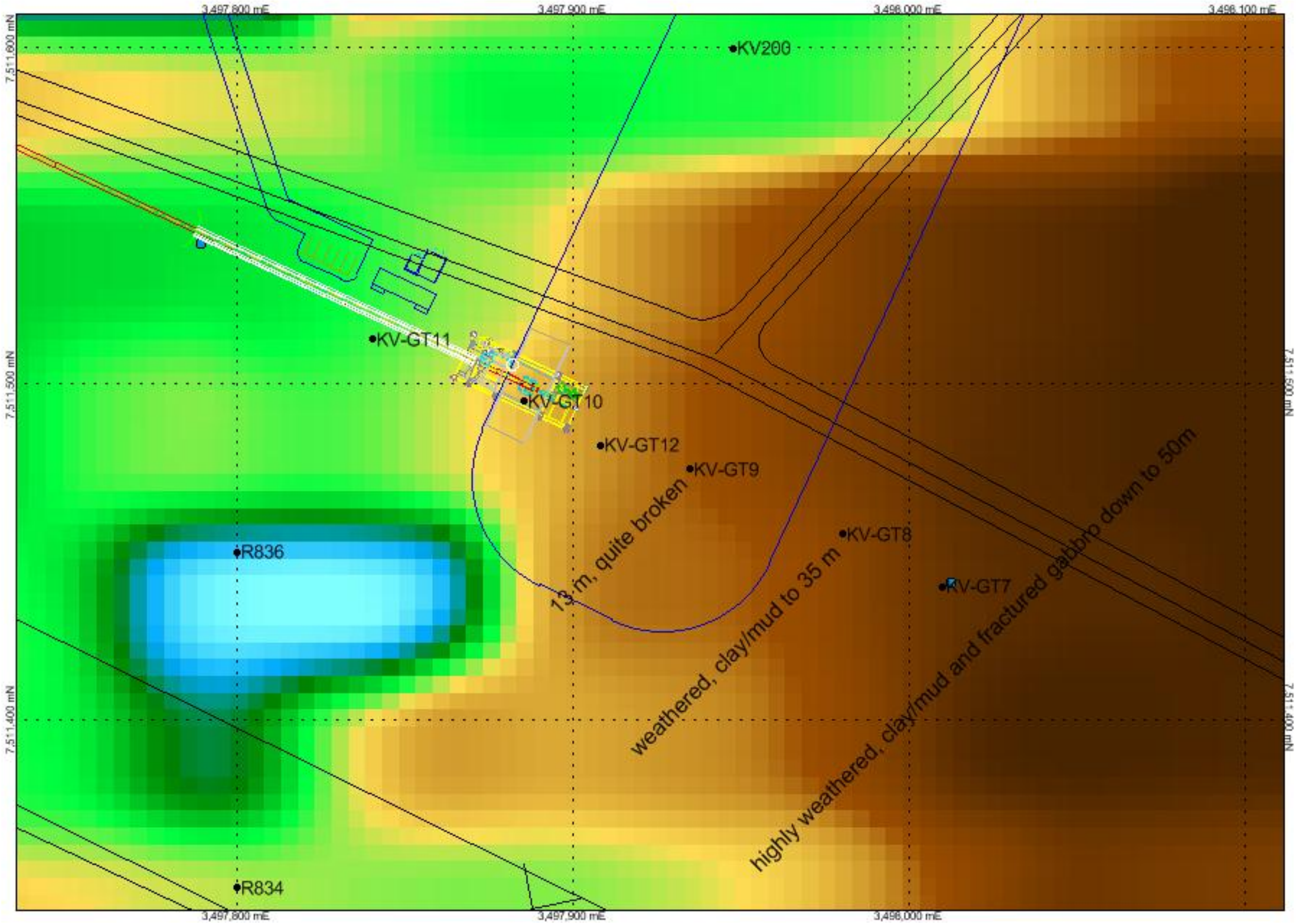
Geotechnical drillholes confirm AEM



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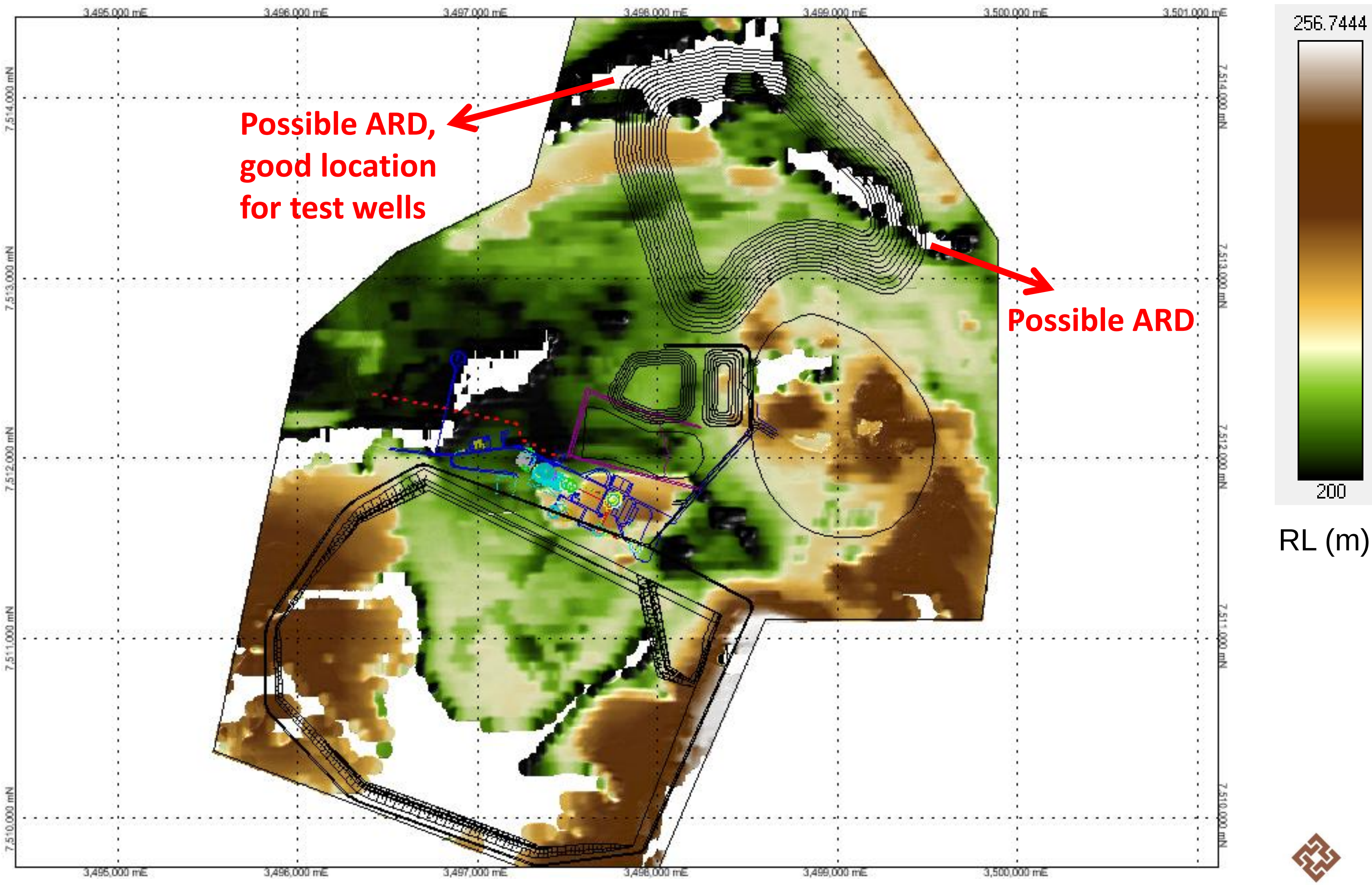
Bedrock topography: hydrological pathways



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Case study 2: planning base of till drilling

- Problem: BoT rig cannot drill much more than 15-20m through glacial till. Beyond this, a more expensive scout drill is required
- BoT rig success has varied from 20% to 100% in different prospects
- Solution: map depth of till in order to plan where to send scout rig vs BoT rig
- Note: BoT costs roughly €77 per sample (<€90) excluding analytical costs, scout drilling costs roughly €400 (<€680)

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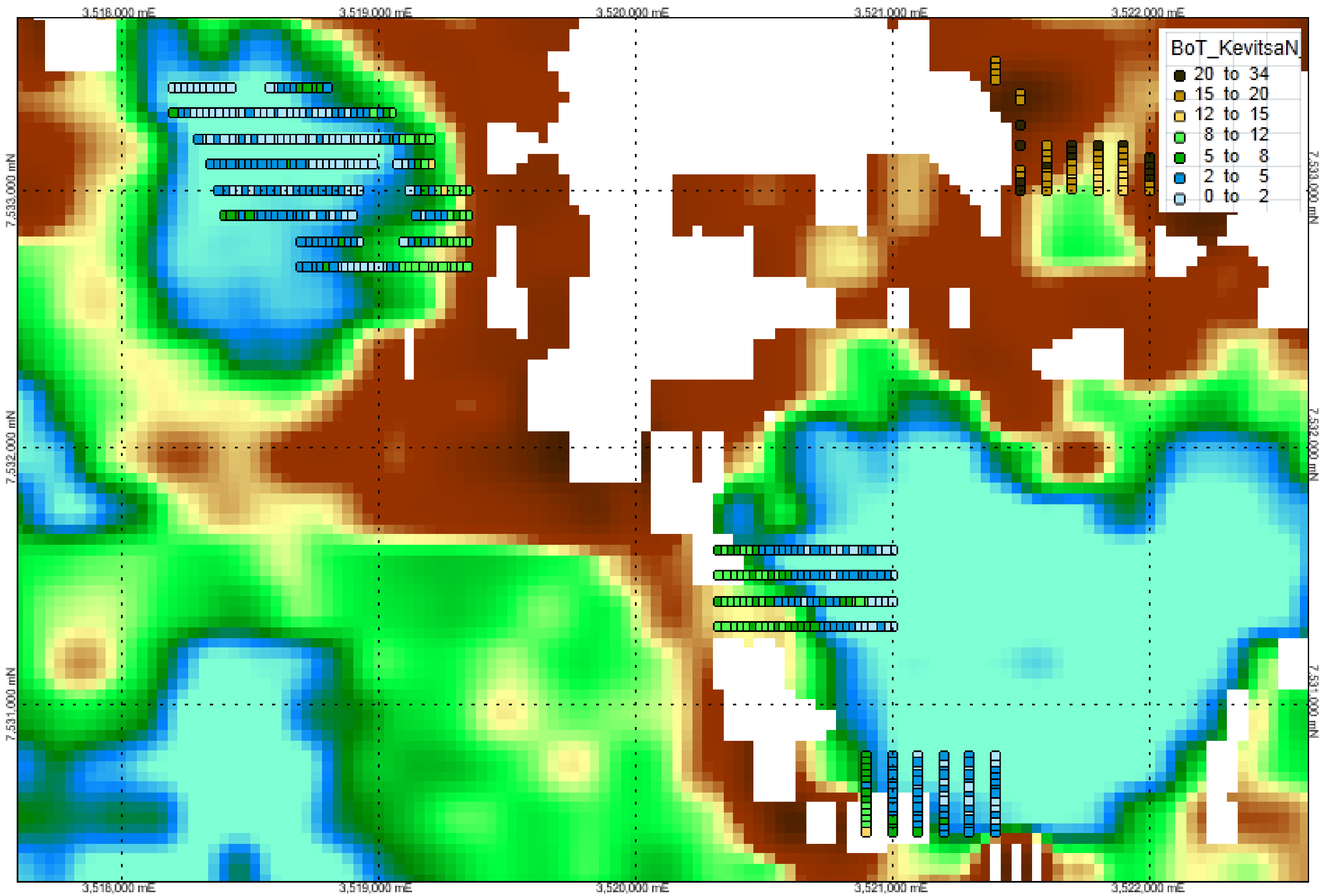
BoT drill depth vs AEM overburden depth



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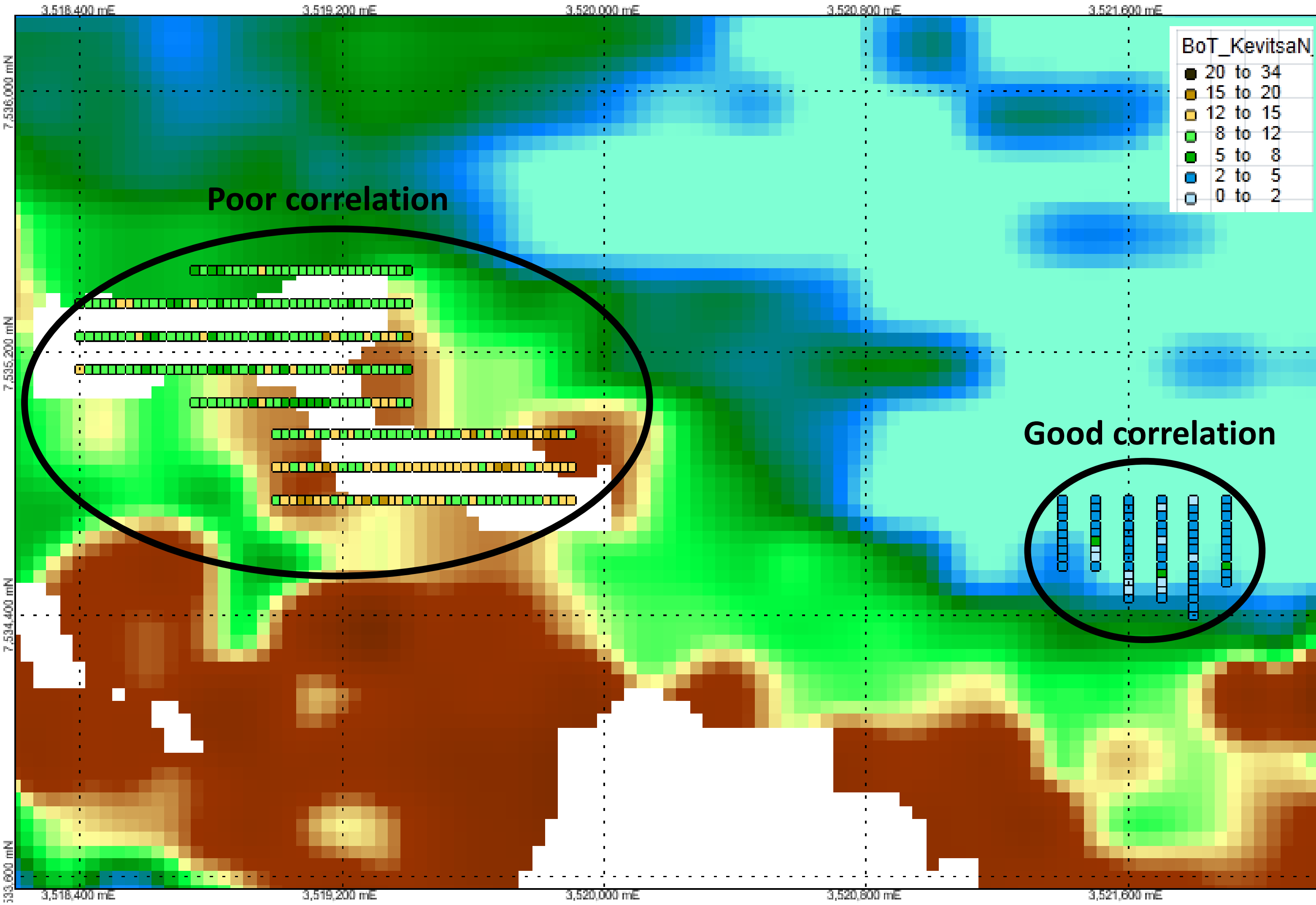
AEM fails over near-surface conductors



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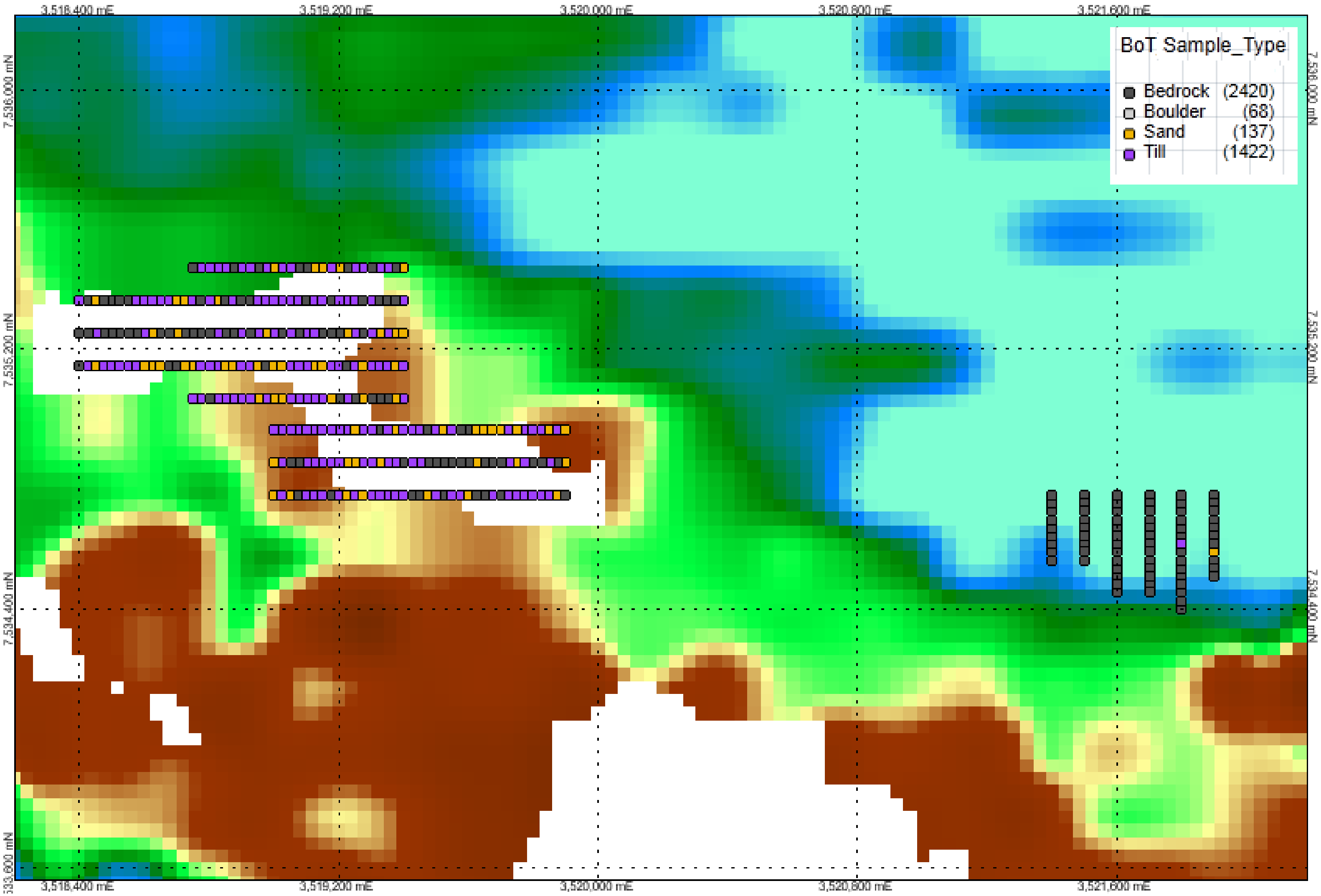
Sample type shows failure to reach bedrock



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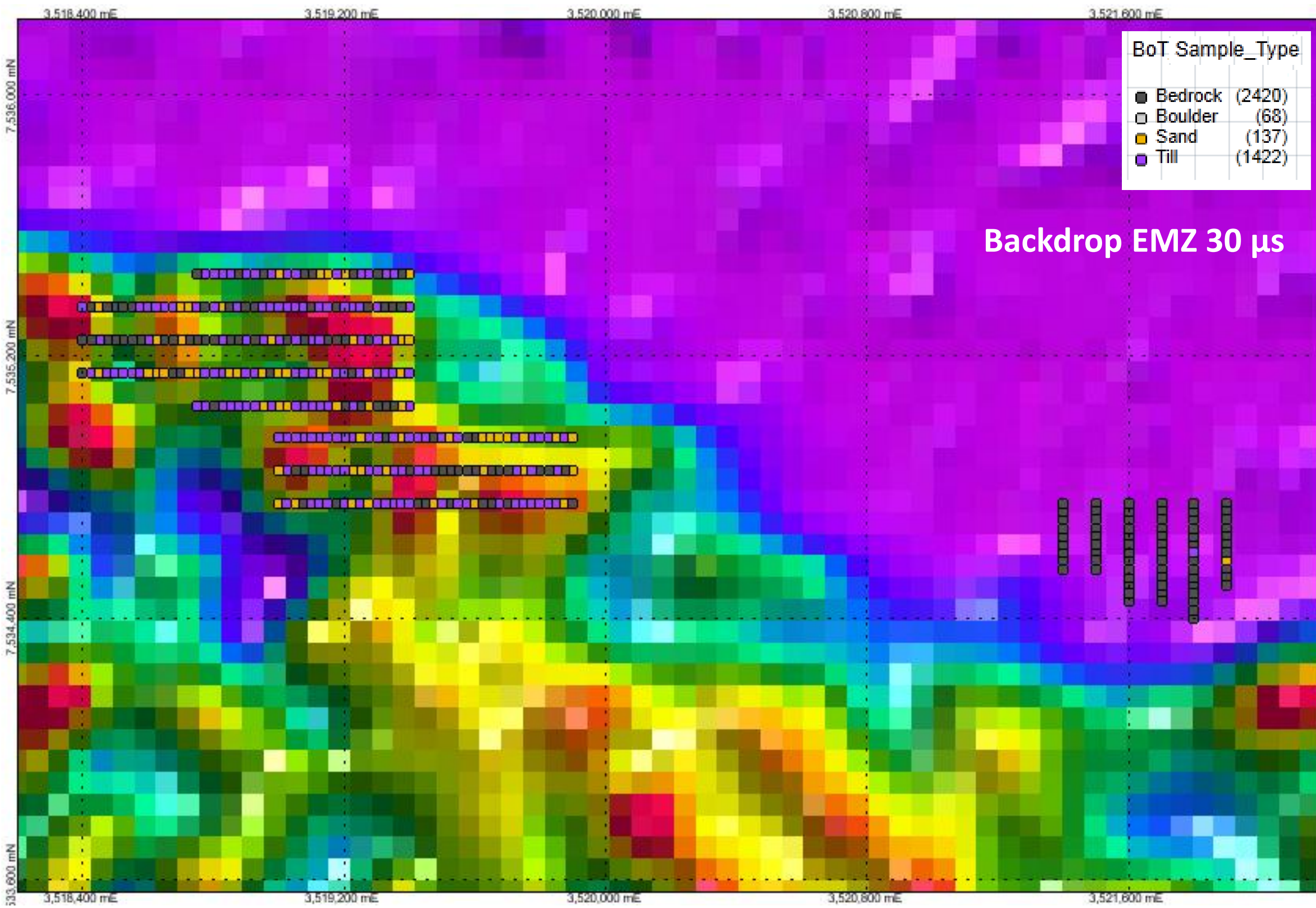
Sample type vs upper bedrock conductivity



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Less success with SkyTEM 2011 system

Parameter	SkyTEM 2010 (LM)	SkyTEM 2011 (LM)
Tx area	314 m^2	494 m^2
Peak current	10 A	10 A
Peak Tx moment	~3140 Am^2	~4940 Am^2
First time gate used	7.9 – 9.5 μs (ch 3)	34.4 – 42 μs (ch 6)

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Case study 3: Ni laterite resource mapping

- Problem: (1) depth of saprolite is not mapped (= base of resource), (2) carbonate pods are disastrous for the HPAL vats in the plant
- Solution: map depth of weathering and carbonate pods

- Not successful for geological and spatial resolution reasons: come and see me to hear about it

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Conclusions: success in shallow imaging

- Early turn off times
- Finely discretised early time measurement windows
- Small footprint
- Geological knowledge allows disregarding shallow bedrock conductors