XL3D potential field inversions

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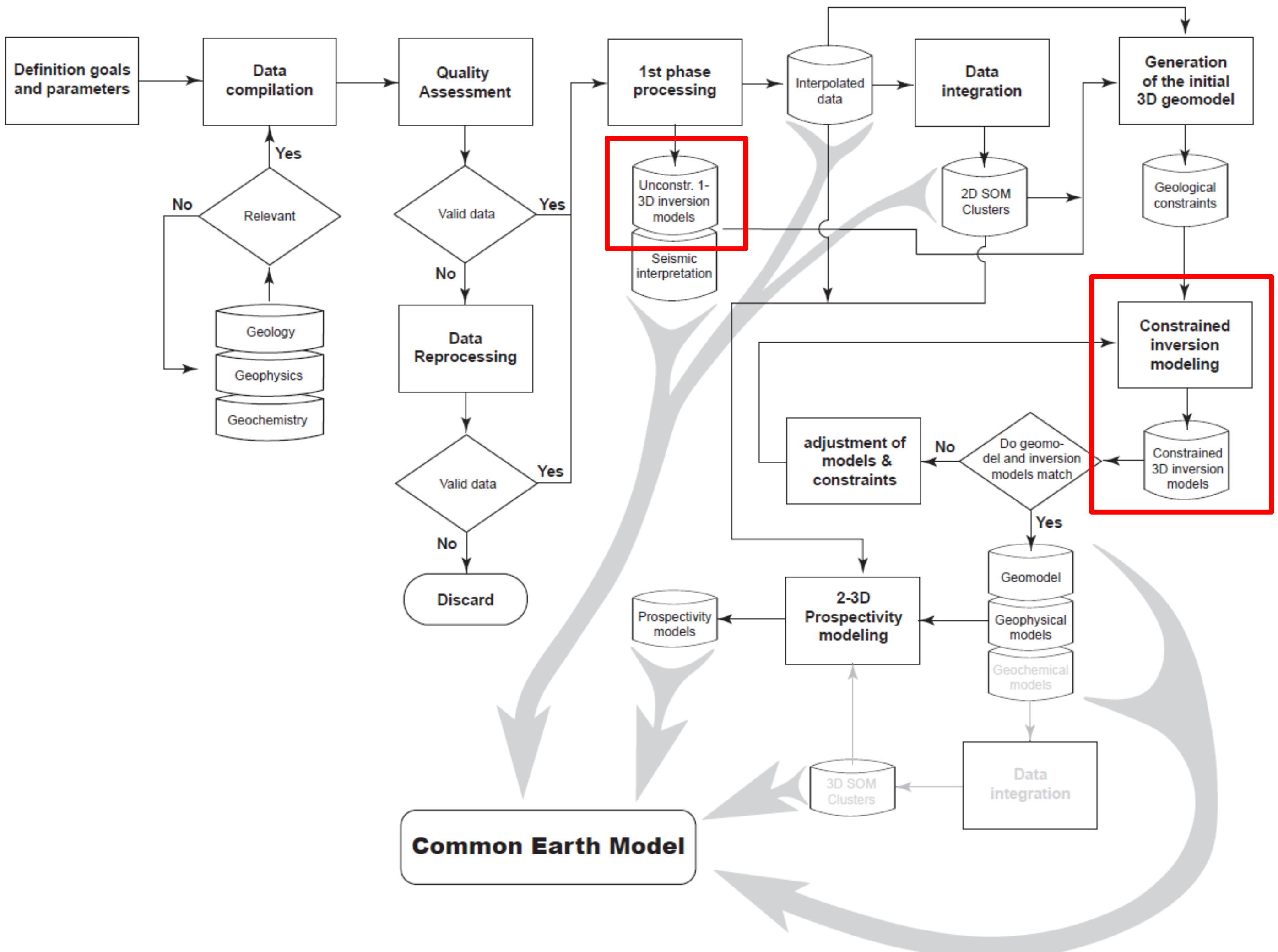
Definition goals and parameters
Data compilation
Quality Assessment
1st phase processing
Interpolated data
Data integration
Generation of the initial 3D geomodel
Yes
No
Relevant
Geology
Geophysics
Geochemistry
Valid data
Yes
No
Data Reprocessing
Valid data
Yes
No
Discard
Unconstr. 1-3D inversion models
Seismic interpretation
2D SOM Clusters
Geological constraints
Constrained inversion modeling
Constrained 3D inversion models
Do geomodel and inversion models match
No
adjustment of models & constraints
Yes
Geomodel
Geophysical models
Geochemical models
2-3D Prospectivity modeling
Prospectivity models
3D SOM Clusters
Data integration
Common Earth Model

Contents

- Introduction: potential field inversion to support geological modelling
- XL3D inversions
  - In detail: constrained gravimetric inversions in the vicinity of the Alaliesintie seismic profile
- Conclusions

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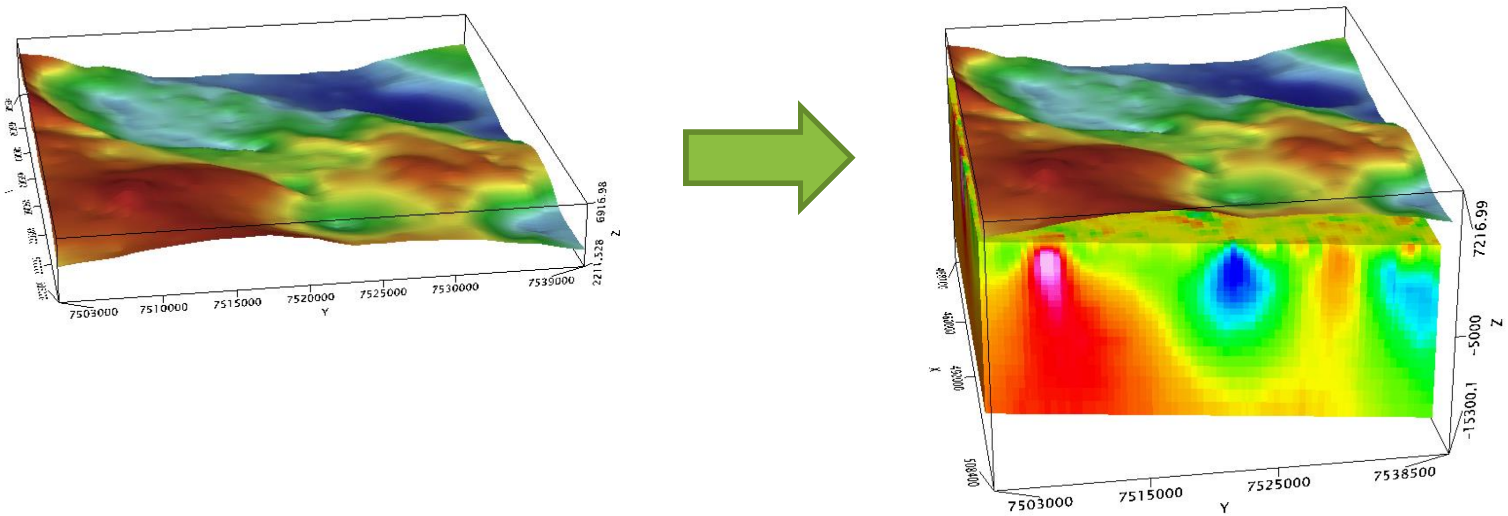
What are potential field 3D inversions?



- Finding a physical property model that would produce the observed survey results
  - Potential field: gravity or magnetic
  - Physical property: density and magnetic susceptibility / total magnetisation

3D inversion to support geological modelling

- Inversion models represent physical properties
  - ”translating” them into geology, and vice versa, requires knowledge about the geological units’ physical property distributions

- Inversions are non-unique
  - There are numerous ways the source bodies / petrophysical values can be distributed in the 3D space but still fit with the observed data
  - Recovered inversion model is a ’best estimate’
  - Non-uniqueness can be restricted by setting conditions (constraints) to the inversion

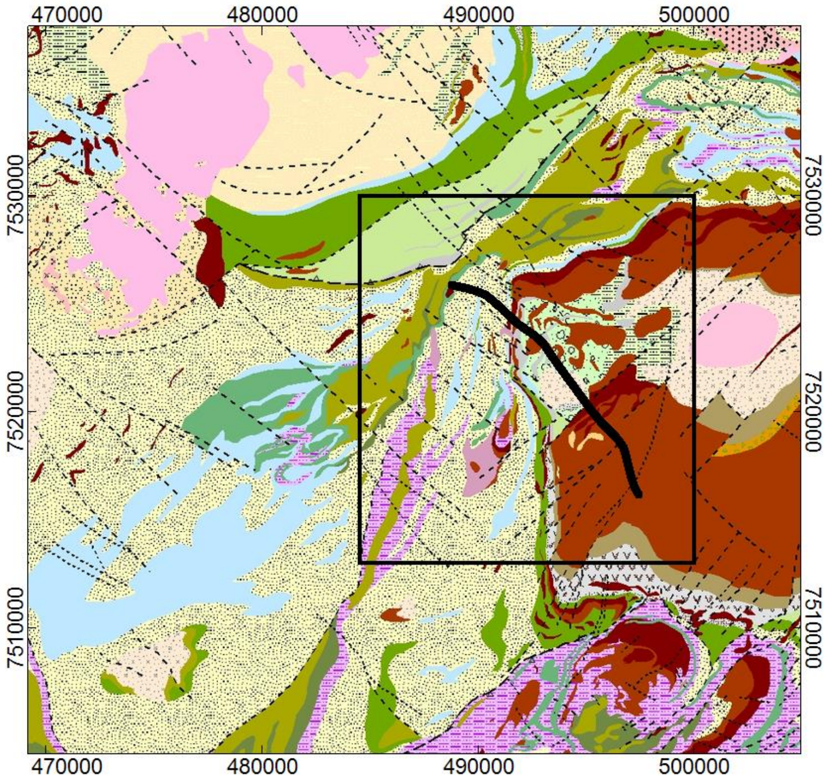
XL3D data and tools

- Gravimetric data
  - GTK regional gravimetric dataset
    - irregular station grid with 1-6 stations / km^2
  - covers majority of the study area
- Magnetic data
  - GTK airborne magnetic dataset
    - 200 m line spacing, nominal flight altitude 30 m
  - covers the study area completely
- Commercial software to produce the inversion models
  - UBC-GIF Grav3D 3.0 and Geosoft VOXI

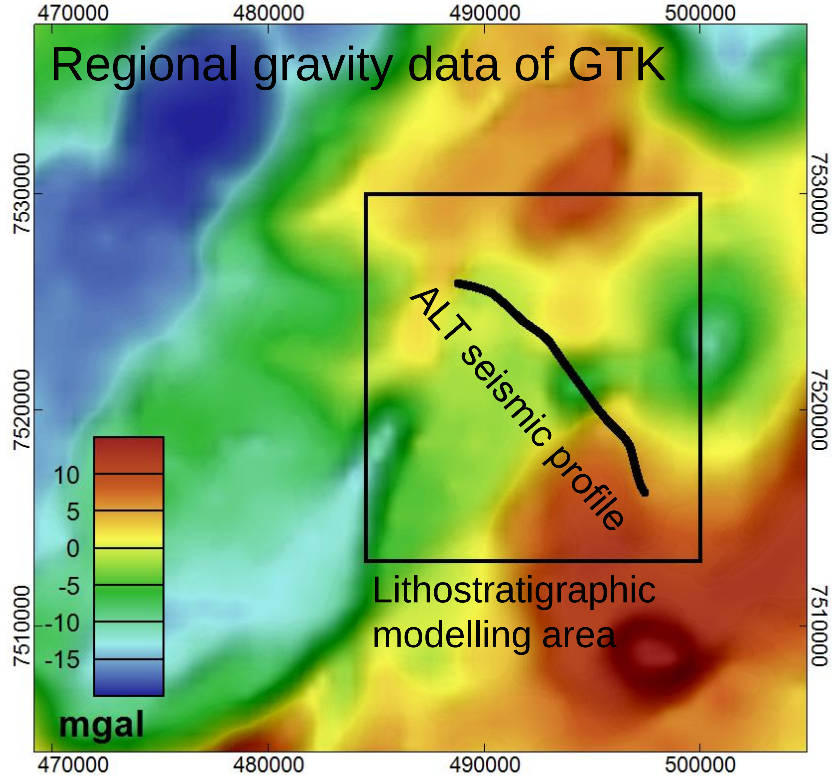
Potential field inversions in XL3D

- Regional gravity inversions
  - geologically unconstrained
- Regional magnetic inversions
  - geologically unconstrained
  - total magnetization inversion of 13 sub-areas
- Gravity inversion in the vicinity of the Alaliesintie seismic profile
  - petrophysically / geologically constrained
  - the complete study area is large → constraints tested on a area restricted in size

Alaliesintie sub-area for gravity inversion



Bedrock map



Residual Bouguer anomaly

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Types of geological constraints in potential field 3D inversions include...

1) Reference models
   - represent a ’target property model’ for the known geology (petrophysics)
   - the recovered model does not have follow the reference model completely

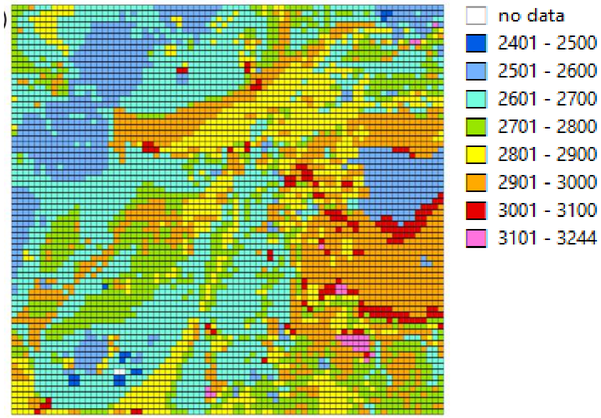
2) Bounds constraints
   - an upper and lower property value model cells
   - the recovered value of the cell will be within the bounds

Note: constraints can cover the mesh only partially

Gravity inversion constraints

- We combined outcrop density data from three sources
  - GTK petrophysical database
  - GTK rock geochemical database
  - Sampling along the seismic profiles 2017
- The constraints are based on
  - using sample data averages in cells where sampling exists
  - for other cells, using characteristic values of the lithological unit of the cell (based on the bedrock map)
- With this data we can impose constraints on the top layers of the inversion mesh

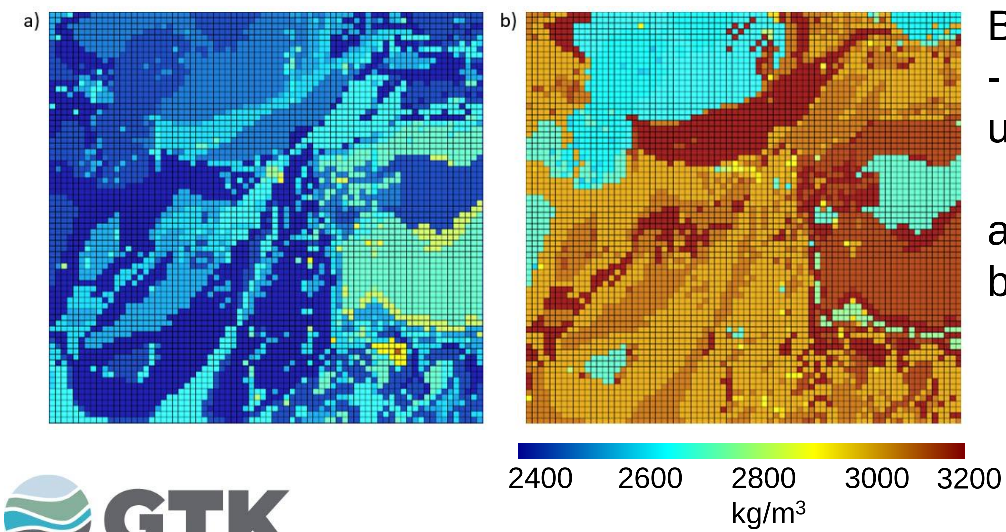
Constraints tested for the Alaliesintie inversion
(all constraint models cover the top two layers of the mesh)



Combination of sample sample densities and classified petrophysical data

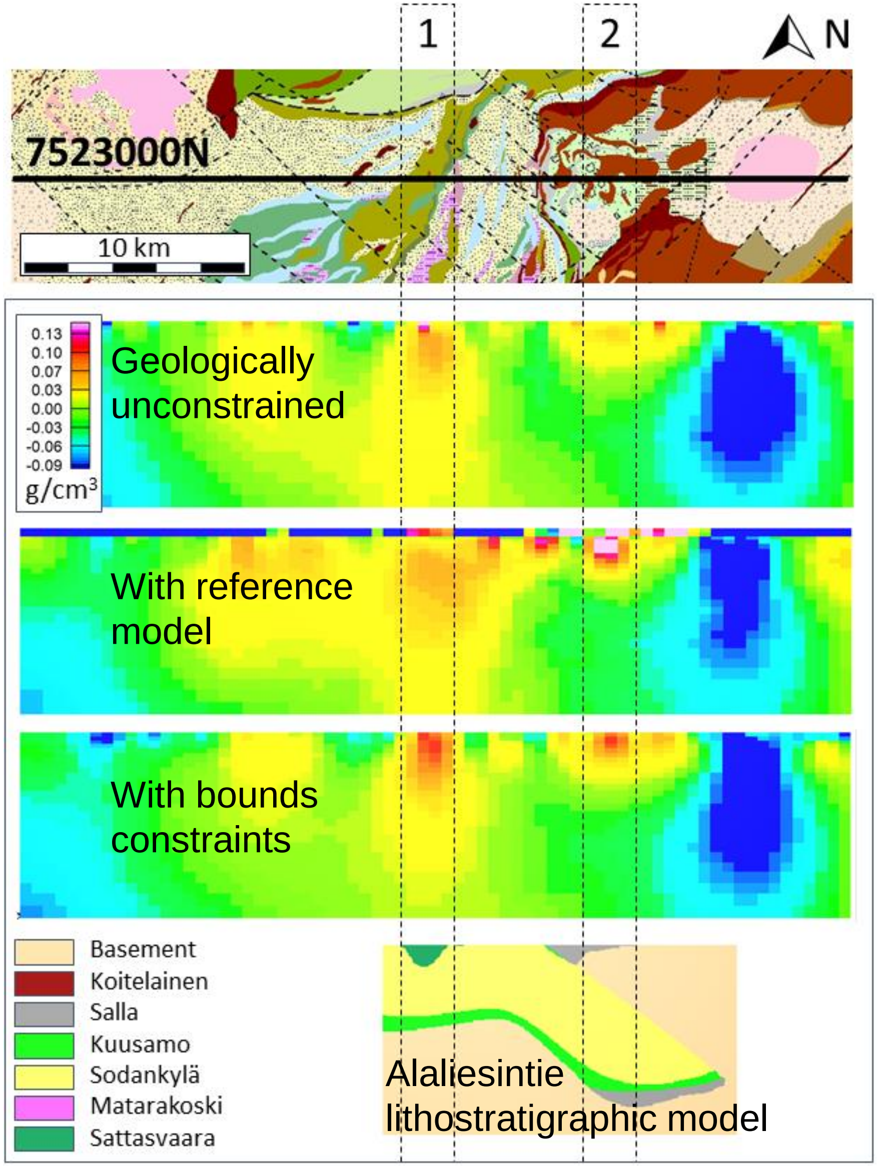
Reference model

- sample densities complemented with values characteristic of the bedrock unit (based on density distributions)



Bounds constraints
- based on sample data and lithological units' density distributions

a) lower bound density
b) upper bound density

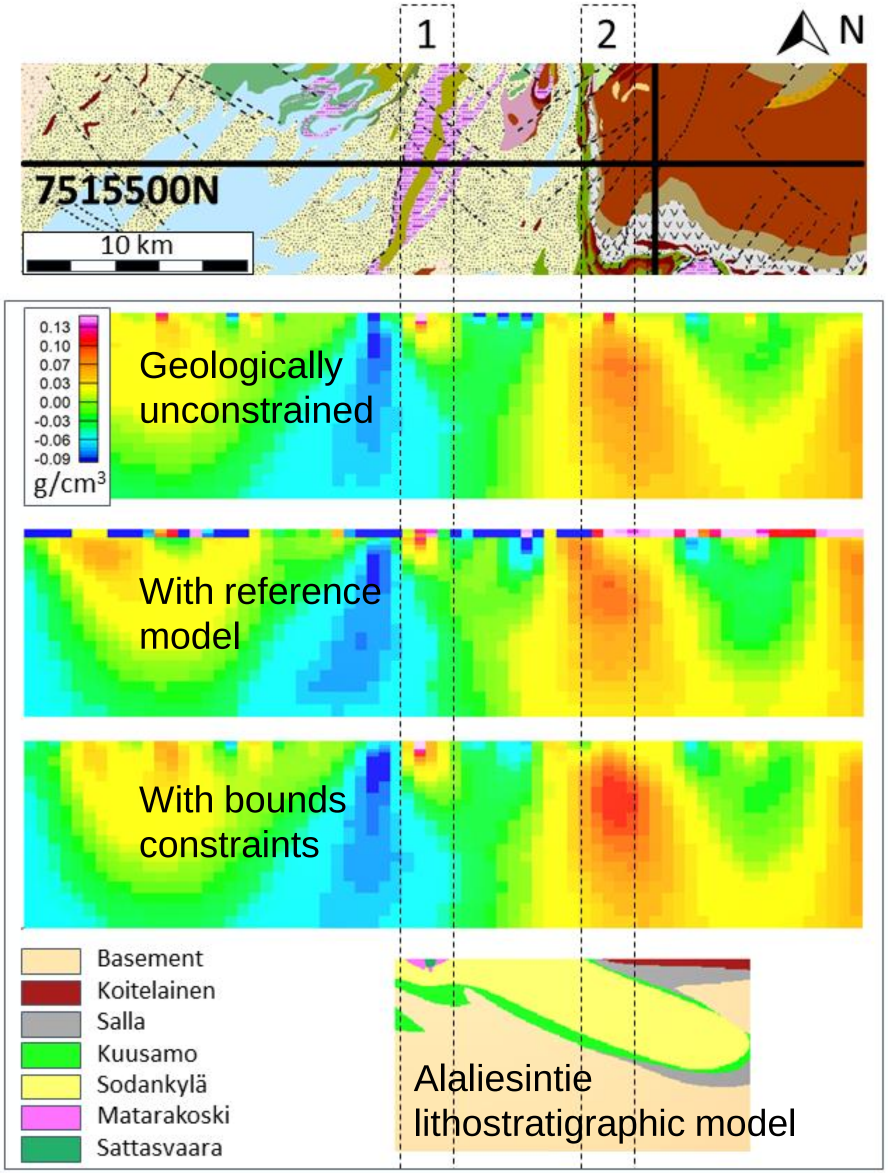


With constraints we can improve the definition of rock units in the shallow parts of the mesh

1) The ultramafic volcanite is quite shallow

2) The 'undefined' gabbro rocks within the Salla group are better defined with constrained inversion (despite the data resolution) – not included in the lithostratigraphic model separately

- Based on the available surface data, in general no large density difference between the Archean basement and the Sodankylä arkose quarzite → not well separated in inversion, but local variation may occur



With constraints we can improve the definition of rock units in the shallow parts of the mesh

1) The ultramafic volcanite is very thin

2) Assuming Koitelainen is very shallow, the high-density body at the W margin of Koitelainen may be related to the Kuusamo volcanic unit dipping under Koitelainen
   - or an unexposed unit under Koitelainen?

- The Koitelainen intrusion doesn't show well in inversion

Using geophysical inversions to support regional geological modelling

- Data resolution and petrophysical constrasts determine in part what sources we can detect by inversion
- Inversions often result in smooth models
- Adding geological constraints to inversion reduces ambiguity and improves the geological reliability of the models
- Geological constraints must be expressed as petrophysical models → mapping between geological units and petrophysical data ranges is needed
- Availability of sub-surface petrophysical data for regional models?

Thank You!

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AGNICO EAGLE FINLAND
Aurion
ASTROCK GEOPHYSICS

Project web pages: http://projects.gtk.fi/XL3D

GTK

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