Inversions of MobileMT data and forward modelling

from innovations to discoveries

I. Massive and fast inversions
II. Detail and goal-oriented inversions
III. Forward Modeling

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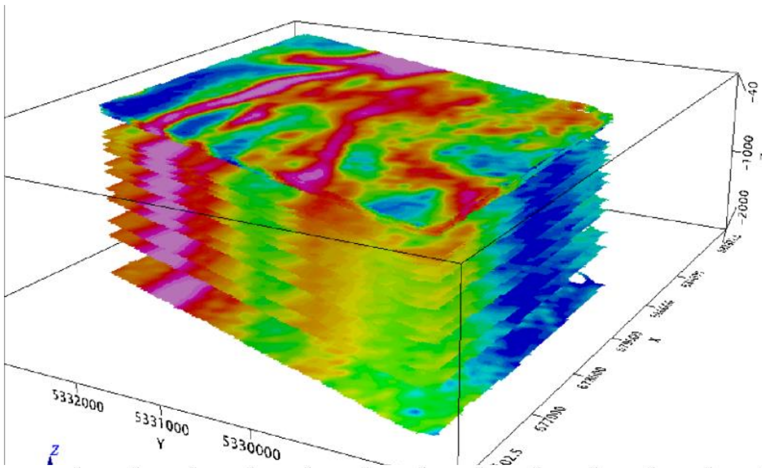
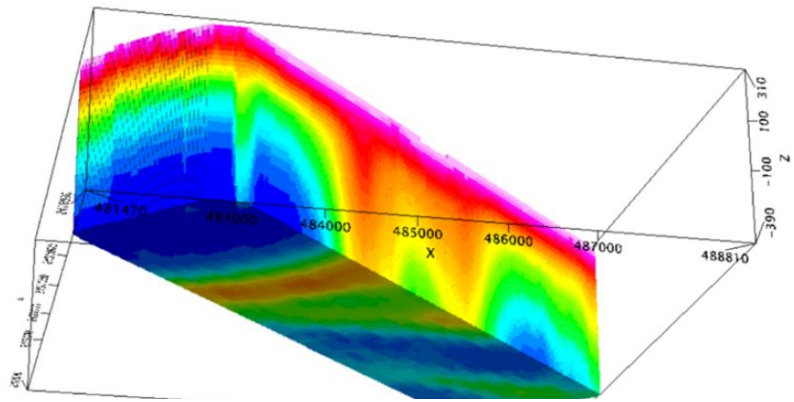
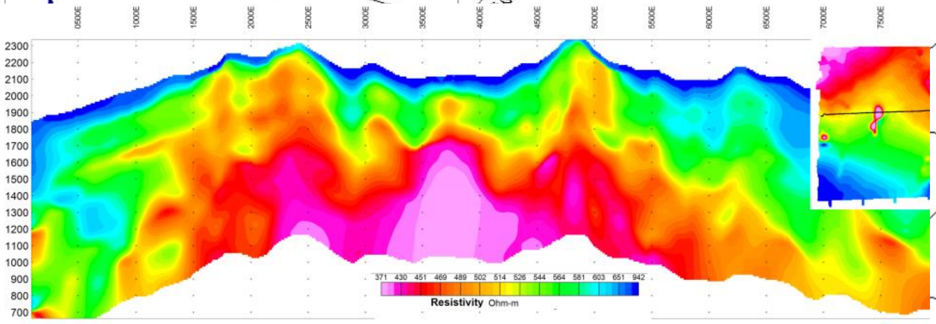
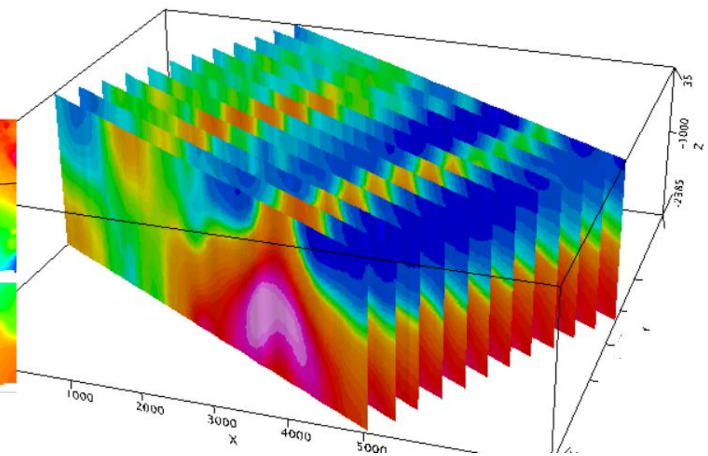
EM data inversion capability is the top of EGL service offering

Except standard databases, grids and maps of acquainted data we provide with inversion of EM data into resistivity-depth products – sections, depth slices, 3d voxels:

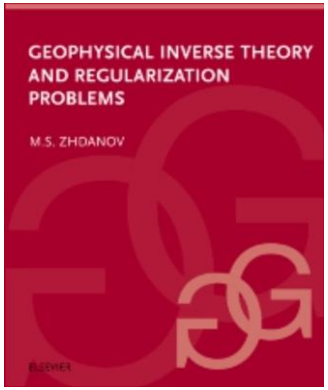








I. Massive and fast inversion



The first stage of the data inversion process is applying a nonlinear least-squares iterative 1d inversion algorithm based on the conjugate gradient method with the adaptive regularization (*M.Zhdanov, 2002*). The algorithm uses weighting of the inverted parameters, so sensitivity of the data to resistivity of each layer is remaining equal for different depths. This way provides high resolution in the deep part of a model as well as in the upper part. *(the software development by N.Golubev)*
An inversion is an ill-posed problem, and the algorithm uses regularization to get stable and geologically meaning solution. We minimize parametric functional **P** which consists of data misfit **ϕ** and stabilizer **S** (**L2** norm of difference initial and fitted model) multiplied on parameter of regularization **α.**

$\mathbf{P(m)=\phi(m)+\alpha S(m)}$ where

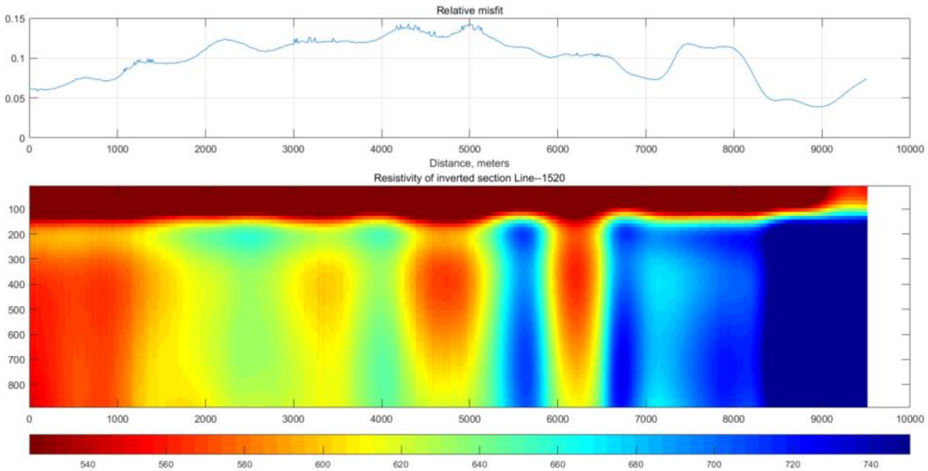
$\mathbf{\Phi(m)=\|d_{obs}-d_{mod}\|^2}$ is a data misfit and $\mathbf{S(m)=\|m-m_{ini}\|^2}$ - stabilizer

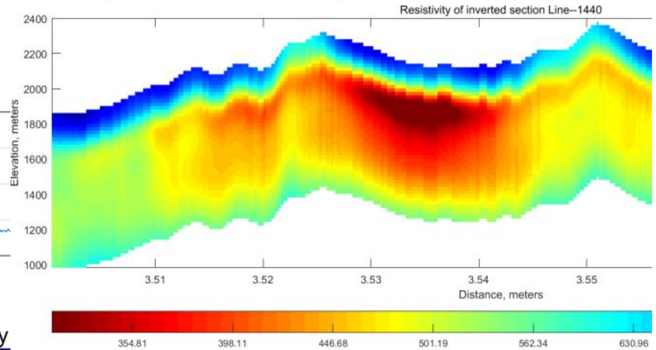
The inversion is applied to each station without any resampling manipulations and without any limitations in frequencies number and stations number along a line.

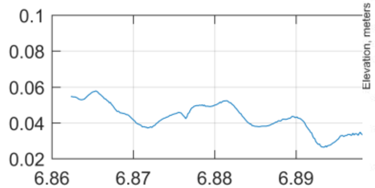
The fast inversion results are used for:

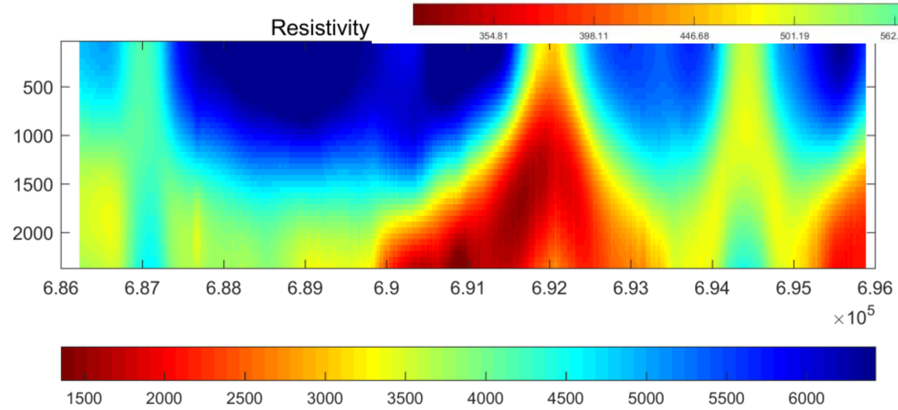
- Estimation of data quality and noise, if any, in particular frequency windows and stations;
- Compiling 3d resistivity-depth databases, voxels, 2d sections along lines, depth slices;
- Choosing anomaly zones and structures for detail and goal-oriented inversions;
- Developing optimal mesh-grids and starting model parametrization for further detail and goal-oriented inversions.

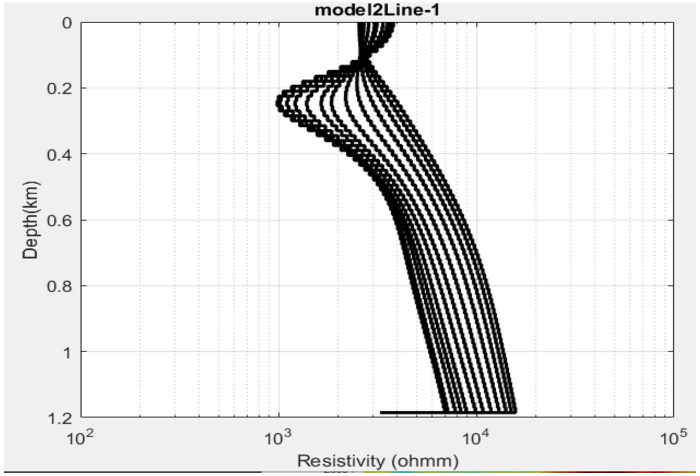
Examples

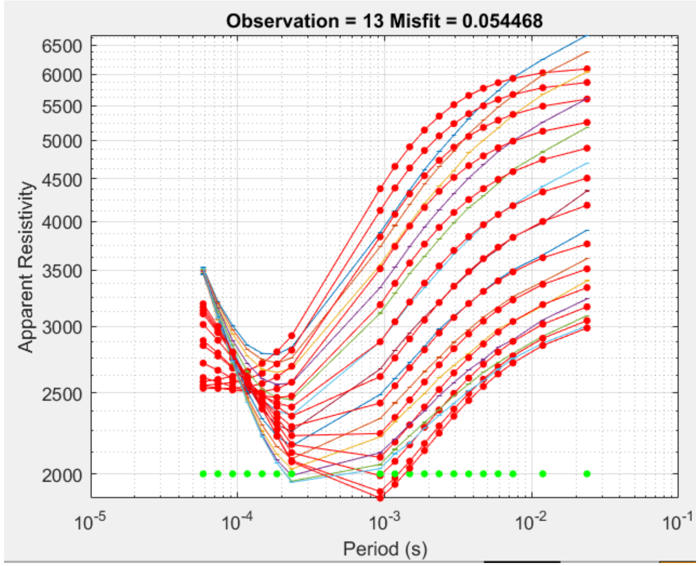

Relative misfit
Distance, meters
Resistivity of inverted section Line--1520


Resistivity of inverted section Line--1440
Elevation, meters
Distance, meters




Resistivity
$\times 10^5$

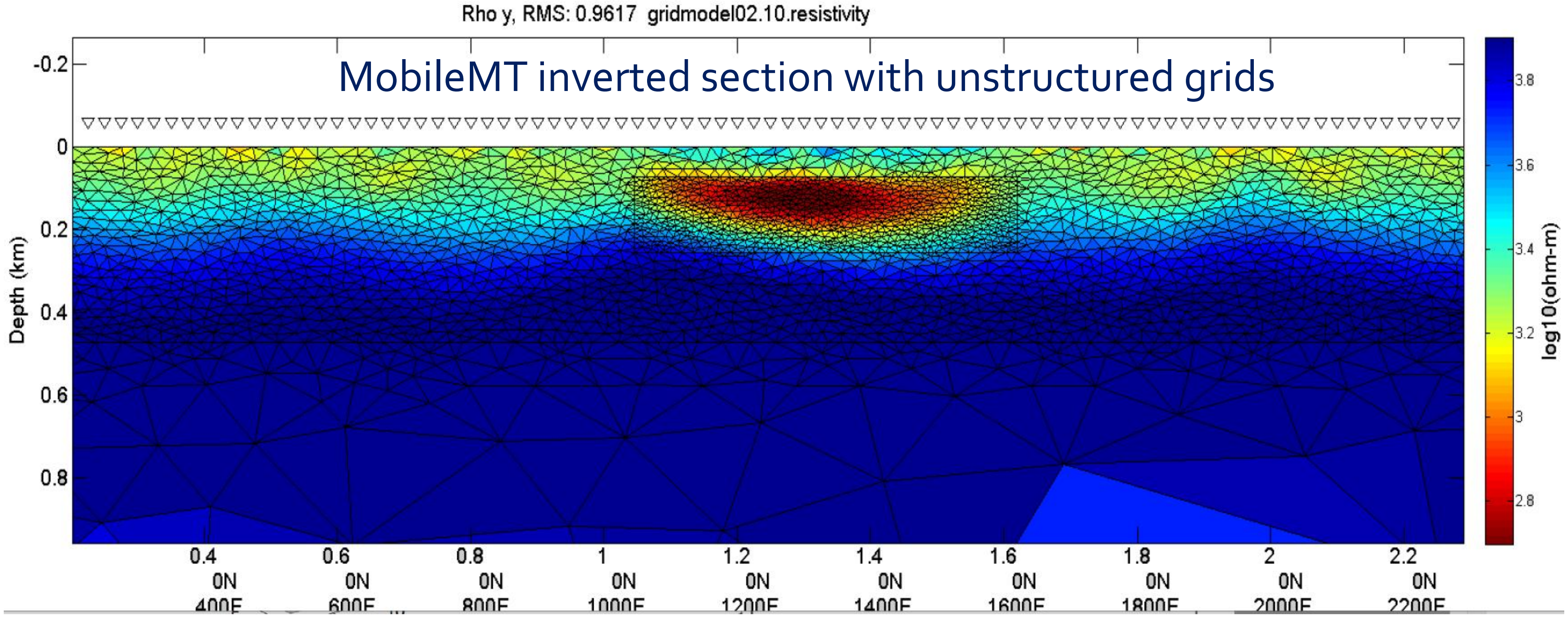

model2Line-1
Depth(km)
Resistivity (ohmm)


Observation = 13 Misfit = 0.054468
Apparent Resistivity
Period (s)

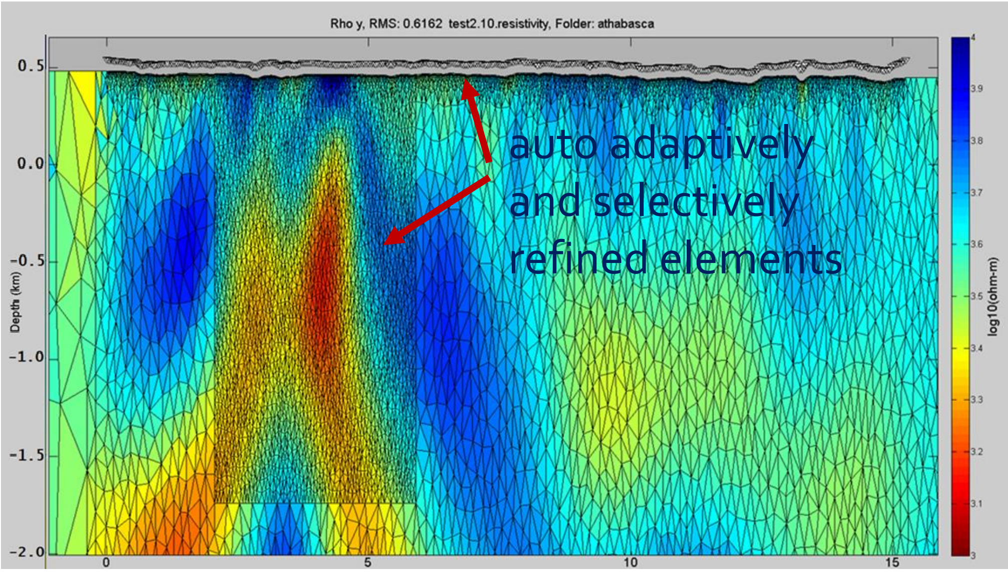
II. Detail and goal-oriented inversions

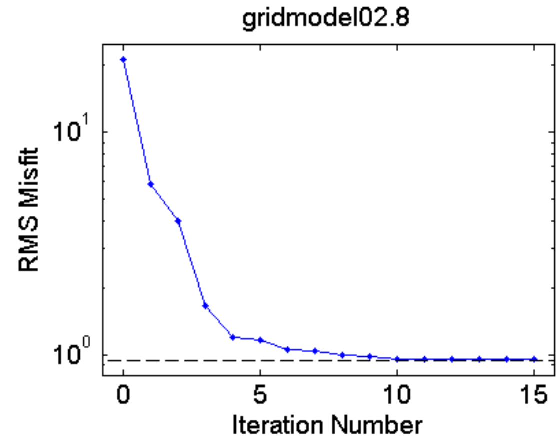
The next stage is detail and goal-oriented inversions based on adaptive finite elements and regularized non-linear MARE2DEM, focusing on specific zones of interest (*Kerry Key, Jeffrey Ovall. A parallel goal-oriented adaptive finite element method for 2.5-D electromagnetic modelling. Geophysical Journal International. Vol.186, Issue 1. 2011.*).
The spatial domain fields are computed by solving the finite element system for a spectrum of wavenumbers (about 30 logarithmically spaced wavenumbers), then using the inverse Fourier transform.

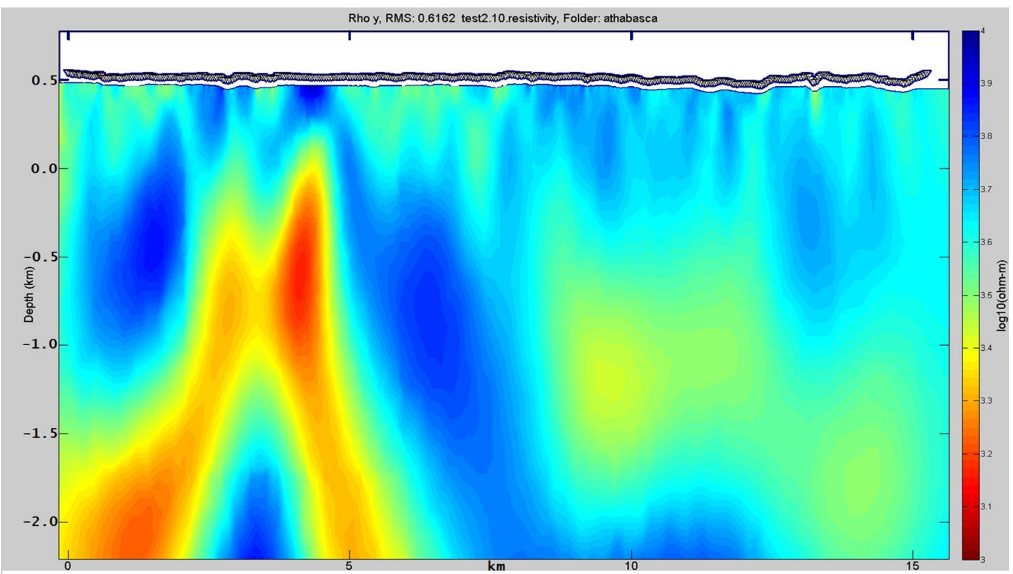
The used by MARE2DEM unstructured grids are very efficient for representing complex structures and discrete targets.

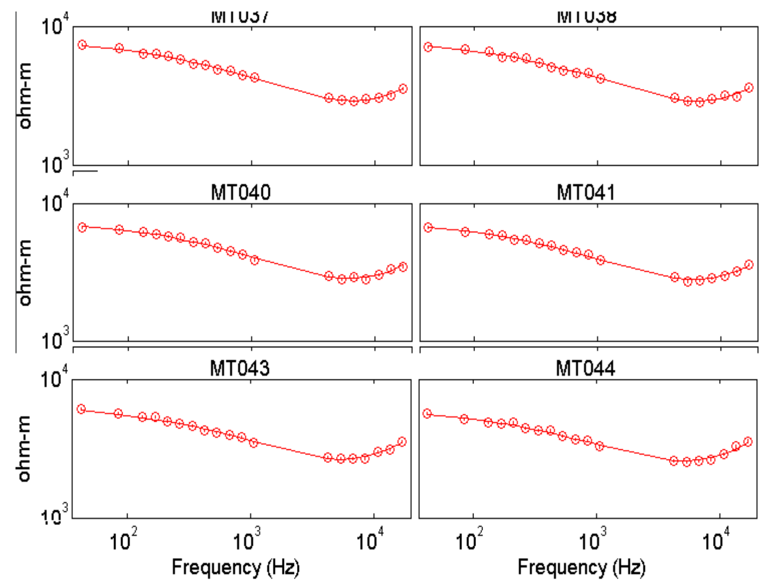


Examples


Rho y, RMS: 0.6162 test2.10.resistivity, Folder: athabasca
auto adaptively
and selectively
refined elements
Depth (km)
log10(ohm-m)


gridmodel02.8
RMS Misfit
Iteration Number


Rho y, RMS: 0.6162 test2.10.resistivity, Folder: athabasca
Depth (km)
km
log10(ohm-m)


MT040
MT041
MT043
MT044
ohm-m
Frequency (Hz)

III. Forward Modeling

Objective of the forward modeling based on a geologic model and petrophysical parameters of the model is estimation of detectability of an exploration target using MobileMT airborne EM.
Method: using MARE2DEM forward code to obtain MobileMT synthetic forward apparent conductivity/resistivity data and then invert the calculated data with added noise into a resistivity section.

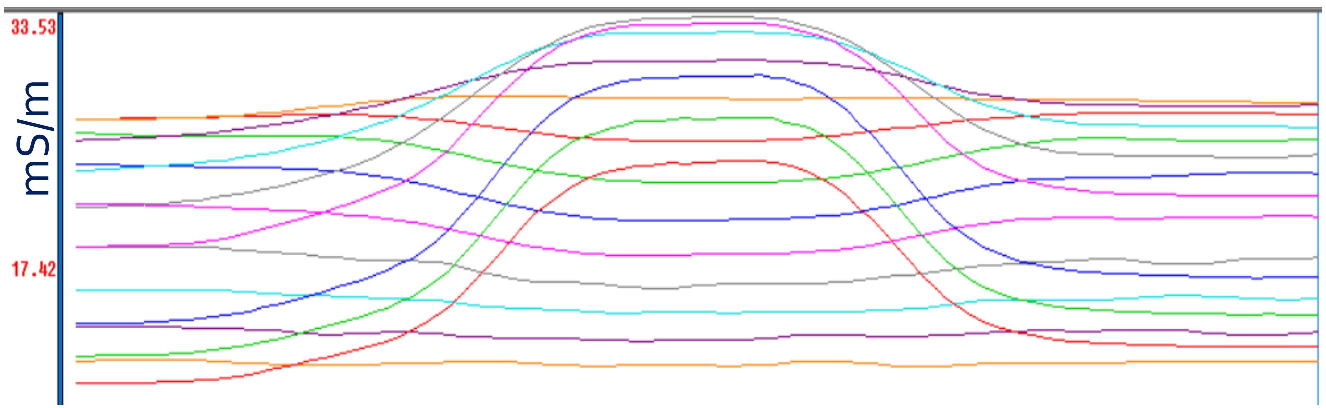
Forward modeling is a useful tool for feasibility of a method and equipment in geology characterization and in a specific exploration task solving. EGL is open to investigate MobileMT capability with forward modeling for qualitative estimation of the technology if clients provide with, even basic, geoelectric scenarios.
Below there is an example of forward modeling exercise for very challenging case for airborne EM systems based on other principles.

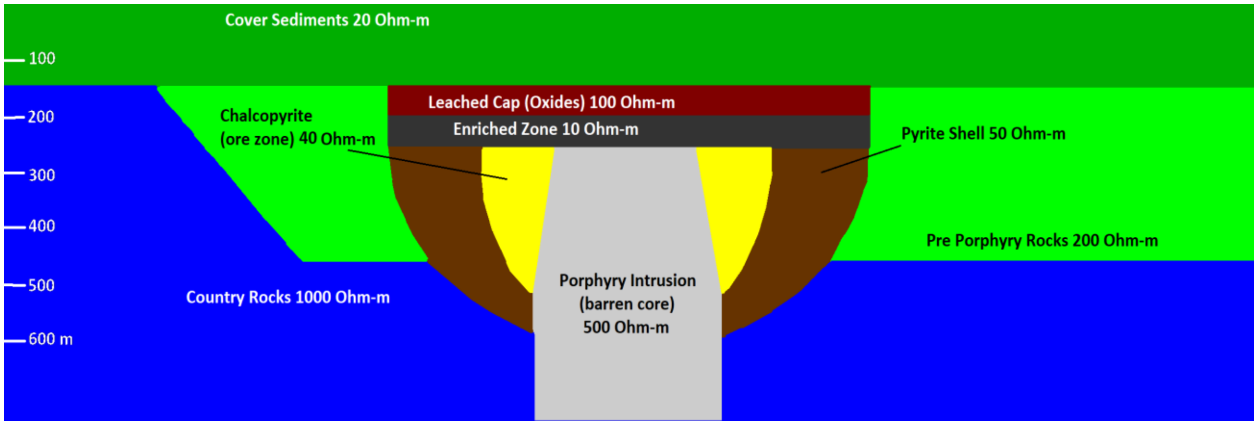
Example

The model is taken from "Electromagnetic modeling based on the rock physics description of the true complexity of rocks: applications to study of the IP effect in porphyry copper deposits" *AbrahamM. Emond, Michael S. Zhdanov, and Erich U. Petersen, University ofUtah.* SEG/New Orleans 2006 Annual Meeting.

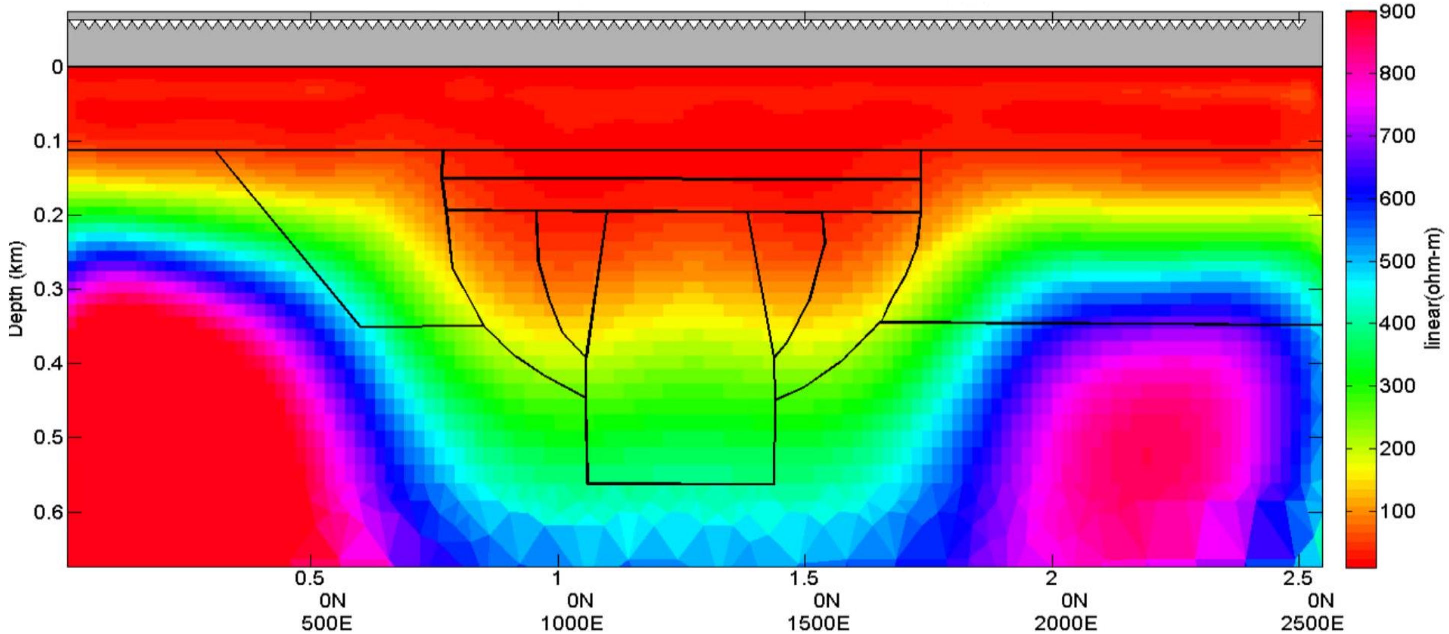
This model scenario, developed by the authors, is typical in the southwestern U. S. and incorporates the classic zones of a porphyry copper system. One of challenges for AEM is the presence of thick (>100 m) conductive (6.5 S of conductance) overburden. The forward modeling results demonstrates great potential of MobileMT in detecting these types of targets with the complicating conductive overburden factor.

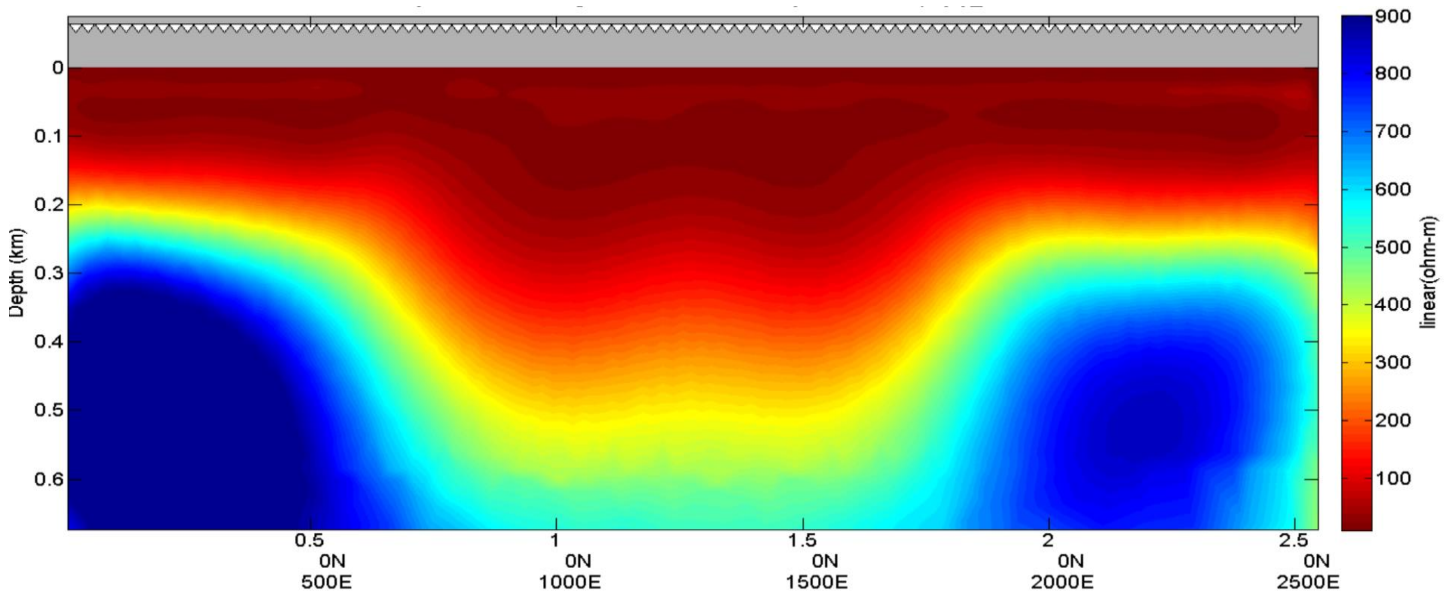
Model and MobileMT apparent conductivity calculated response





Inverted resistivity section with projected model boundaries (unconstrained inversion with half space initial model)





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