Mapping and characterization of Induced Polarization in airborne TEM data from central East Greenland
Application of a Self-Organizing Map (SOM) procedure

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Induced Polarization (IP) effects in airborne Time Domain EM (TEM) data manifest by the presence of negative values and/or by a very fast or very slow rate of decay of the positive part of the dBz/dt transient sounding curves. Such phenomena are observed in SkyTEM data acquired in central East Greenland. Surveying was done for exploration of disseminated sulphides in a sedimentary basin. IP effects are generally considered good indicators of the presence of metallic particles but drilling in the area was not conclusive in terms of mineralization.

Aim of this study: locate IP effects and discriminate their possible causes; i.e. presence of sulphides, oxides, permafrost, or clay minerals.

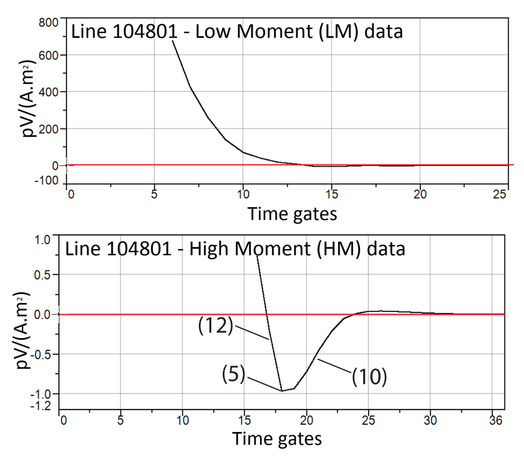
Analysis of the transient curves for High- and Low-moment data
Using a C-program written by Rasmussen
- Extraction of 15 parameters describing the negative values, the curve slopes and the timing of their appearance.

Self-Organizing Maps analysis of the 15 parameters
Using SiroSOM software (Fraser and Dickson, 2007)
- Analysis of the clusters obtained for High- and Low-moment data
- Spatial Analysis of the clusters: correlation with geology

Inversion of the TEM data for the Cole-Cole parameters (Pelton et al., 1978)
Using AarhusInv program (Auken et al., 2014)
- Analysis of the conductivity, chargeability, and time constant to discriminate the sources of IP.

1. ANALYSIS OF THE TRANSIENT CURVES: EXTRACTION OF 15 PARAMETERS

Transient curves were analysed at every 10th measurement point along the flight lines for which 15 parameters are calculated:



(1) sum of all negative values
(2) sum of negative values in the most early local minimum
(3) first negative value (4) gate of the first negative value
(5) minimum value (6) gate of the minimum value
(7) number of gates of consecutive negative values
(8) maximum descending slope in the negative part
(9) gate of the maximum descending slope in the negative part
(10) maximum ascending slope in the negative part
(11) gate of the maximum ascending slope in the negative part
(12) maximum descending slope in the entire curve
(13) gate of the maximum descending slope in the entire curve
(14) maximum ascending slope in the entire curve
(15) gate of the maximum ascending slope in the entire curve

Figure 1. Examples of transient curves from Low Moment (LM) and High Moment (HM) data (respectively top and bottom graphs) and examples of the parameters extracted. LM data were recorded over 21 gates from 12 to 1220µs (gate 7 to 28). HM data were recorded over 20 gates from 119 to 14686µs (gate 16 to 36).

2. SELF-ORGANIZING MAPS (SOM) ANALYSIS OF THE 15 PARAMETERS

Input
15 parameters representing the transient curve per data point along the flight line

SOM
Aim: cluster and provide an easy visualization of multidimensional data

Output
- Component maps with projected data (non-linear mapping)
- One component map per analysed input parameter
- Transient curves with similar characteristics are mapped to the same or adjacent position in the SOM, irrespectively of their geographic location.

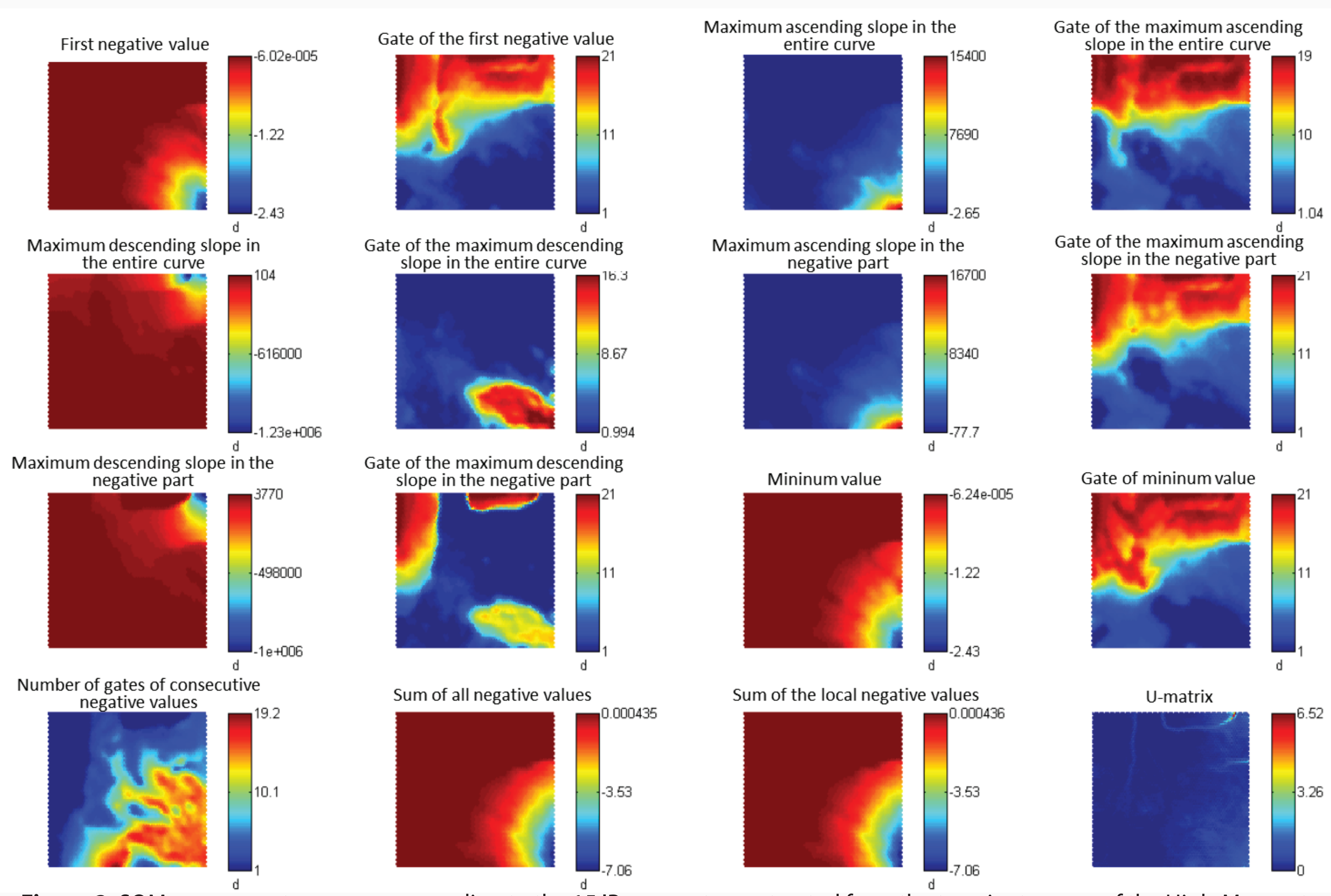


Figure 2. SOM component maps corresponding to the 15 IP parameters extracted from the transient curves of the High-Moment (HM) data. Similar data are associated with a common best matching unit (BMU) vector and the distance relation between BMUs for a particular grid location and the surrounding BMUs are visualized in the U-matrix.

CLUSTERS ANALYSIS

Group 1
Occur over outcropping sediments in almost the entire area

Group 2
Associated with alluvial fans, close to the sea or along rivers

Group 3
Almost exclusively associated with outcropping crystalline rocks

Group 4
Occur in 5 main areas over outcropping sediments. **Important IP effects** *(cf Figure 2)*

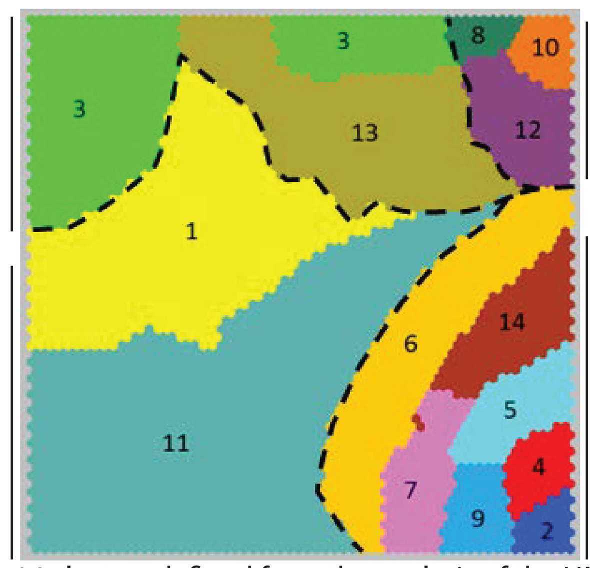
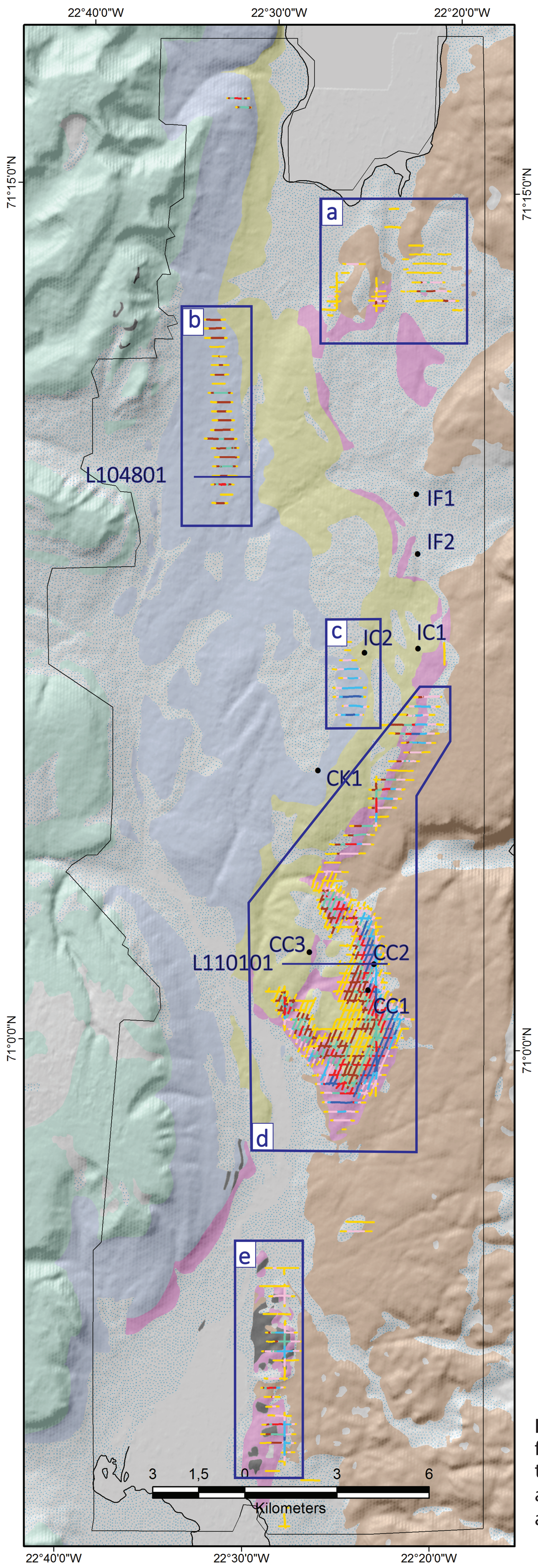


Figure 3. SOM showing the14 clusters defined from the analysis of the HM data (Figure 3). The clusters represent transient data that have similar IP parameter characteristics; i.e. similar transient curves. The signature of each cluster can be read in *Figure 2* from identical map locations in the SOM. Fours groups of clusters are defined from their transient curve characteristics and their correlation with the geology (outlined by dashed-lines). Group 1, 2 and 3 have weak IP effects indicators *(cf Figure 2).*



a. The contact between the basement and Early Triassic sediments in an area affected by faults and Tertiary dykes.

b. N-S elongated area of almost symmetrically distributed clusters describing a same transient curve pattern with the strongest IP along the N-S central part.

c. Outcropping Upper Triassic sediments

d. Strongest IP effects coincide with the boundary between Lower Triassic and Middle Triassic sediments.

e. Early Triassic sediments at the boundary with crystalline basement - area affected by Tertiary intrusions.

Negative values are also observed in the transient curves of the LM data over these 5 areas but occur at very late gates and might be related to the signal being below noise level.

Figure 4. Clusters associated with strong IP effects (Group 4) in the HM TEM data plotted with their respective colour defined from the SOM analysis on top of the simplified geology. Five areas affected by strong IP effects are outlined.

3. INVERSION OF THE TEM DATA FOR THE COLE-COLE PARAMETERS

- Laterally Constrained Inversion using a 4 layers conceptual model.

b *Line 104801 (see Figure 4b)*

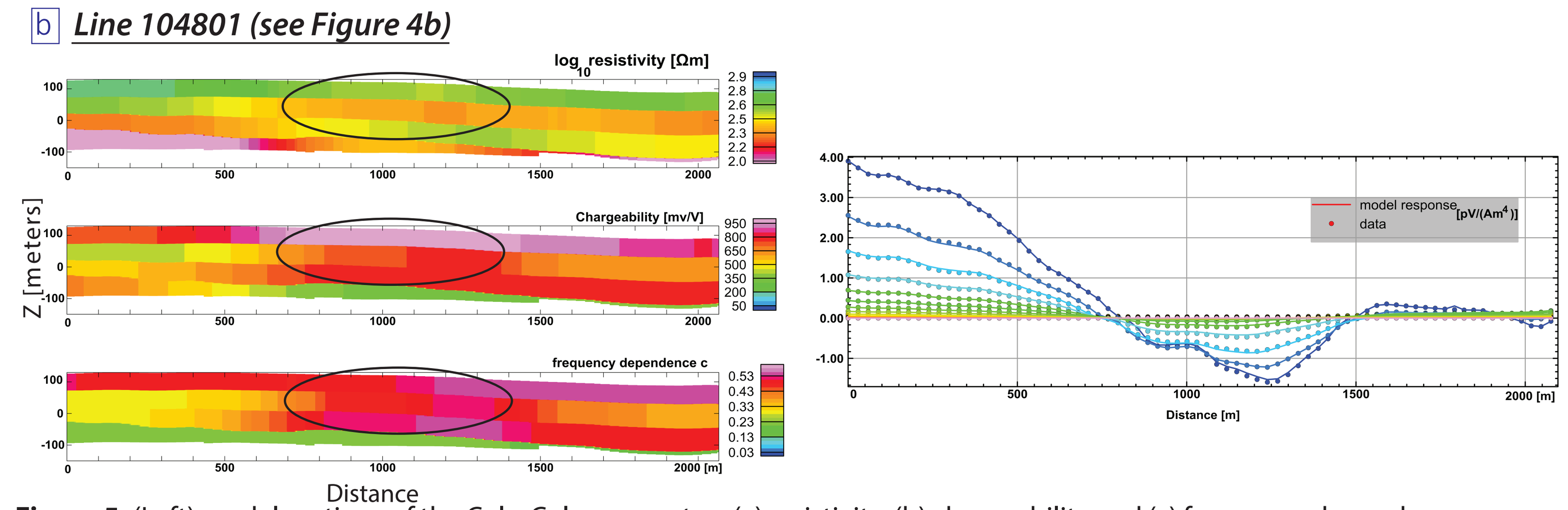


Figure 5. (Left) model sections of the Cole-Cole parameters (a) resistivity, (b) chargeability and (c) frequency dependence; (right) data used for the inversion and model reponse.

- a homogeneous resistivity around 400 Ohm.m
- high chargeability, especiallly in the uppermost part (1000 mV/V ?)
- medium frequency dependence ~0.5

permafrost ? unlikely, c is too low
disseminated sulphides ?
presence of clays ?

d *Line 110101 (see Figure 4d)*

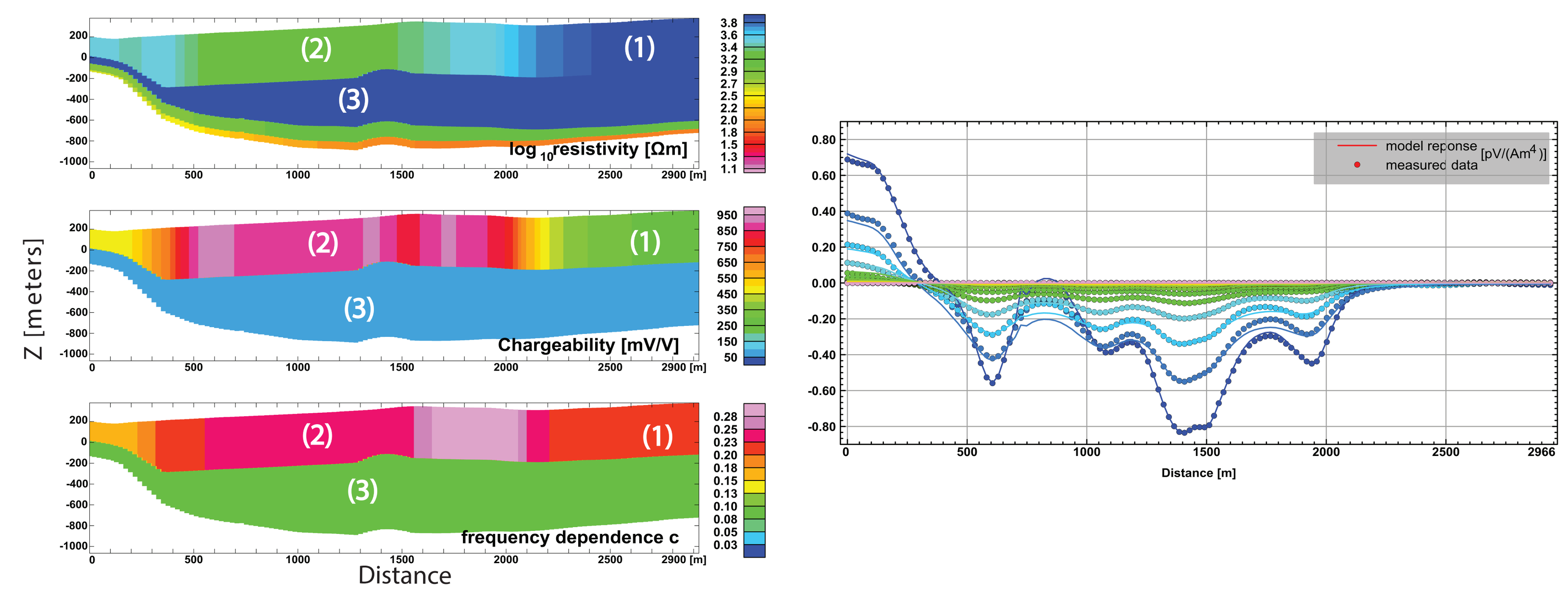


Figure 6. (Left) model sections of the Cole-Cole parameters (a) resistivity, (b) chargeability and (c) frequency dependence; (right) data used for the inversion and model reponse.

- (1) high-resistivity eastern part (4 000 Ohm.m): correspond to outcropping basement - low chargeability (300 mV/V)
- (2) more conductive layer (1 000 Ohm.m), conductivity decreases towards the West and the East. Central part is highly chargeable (900mV/V) and a low frequency dependence ~ 0.2
- (3) information about deepest layers are unreliable (>400m)

permafrost ? unlikely, c is too low
presence of clays? resistivity is too high
disseminated sulphides ?

CONCLUSIVE REMARKS

- Many signs of IP effects are observed in the TEM data
- The SOM analysis allows to sort the IP effects depending on their importance and to identify areas of interest
- 5 areas where important IP effects occur were outlined. These IP effects are:
  - unlikely to be due to permafrost as they would affect the entire area;
  - sometimes clearly correlated with the geology (Figure 4d);
  - ... need some more modelling to constrain the Cole-Cole parameters.

FUTURE WORK

Further work will be performed in the TEM data inversion in order to better understand the cause of the IP effects. Furthermore, we will model the complex resistivity measurements from the drillcore samples of this area in order to recover the Cole-Cole parameters and compare them to the Cole-Cole parameters obtained from the airborne TEM data.

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