

Joint inversion of drone-based semi-airborne data measured in two frequency ranges with scalar and vector magnetometers

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1) Leibniz Institute for Applied Geophysics, Hanover, Germany
2) University of Münster, Germany
3) Sandfire MATSA, Huelva, Spain

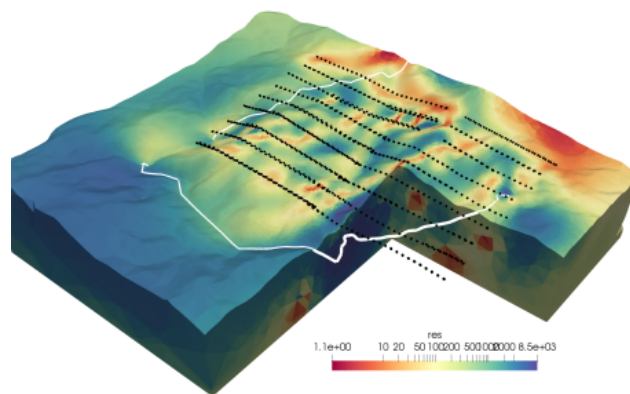


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Survey ○○○○○	Data ○○○○	Inversion ○○○○○	Discussion ○○○○○
Content			

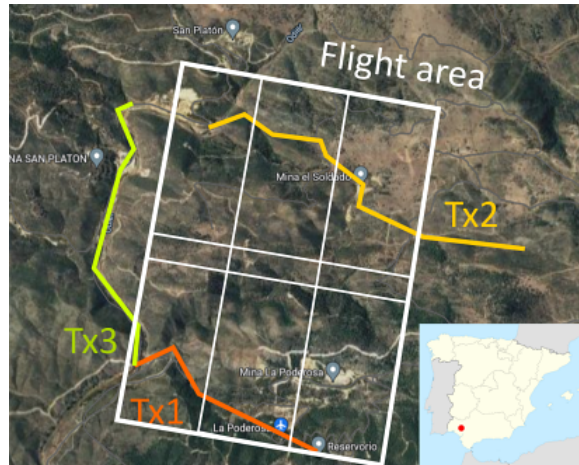
Outline

- Survey
- Data
- Inversion
- Discussion



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Survey area @ MATSA mining for semi-airborne measurements

- 6 drone flight patches in complete area
- 3 Transmitters
- 2 Receiver systems: SHFT & MagArrow
- Overall $2 \times 3 = 6$ overlapping data sets



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Survey area - Impressions



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Survey area - Impressions



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Survey area - Impressions



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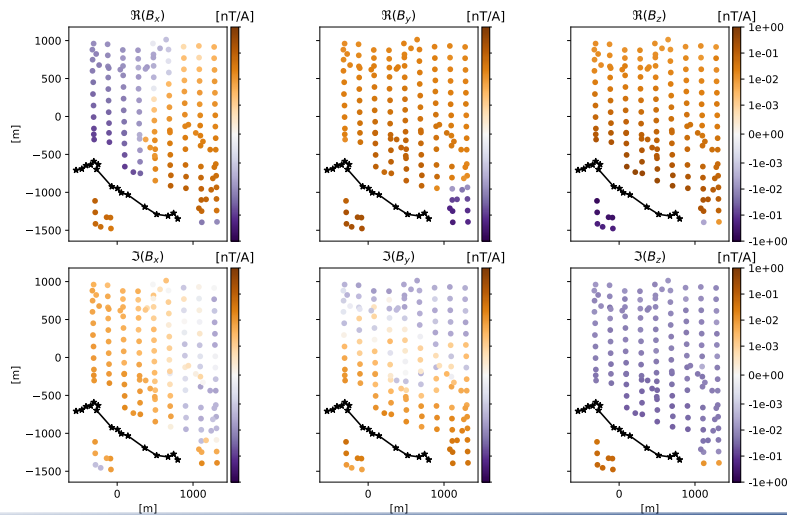
Survey Summary

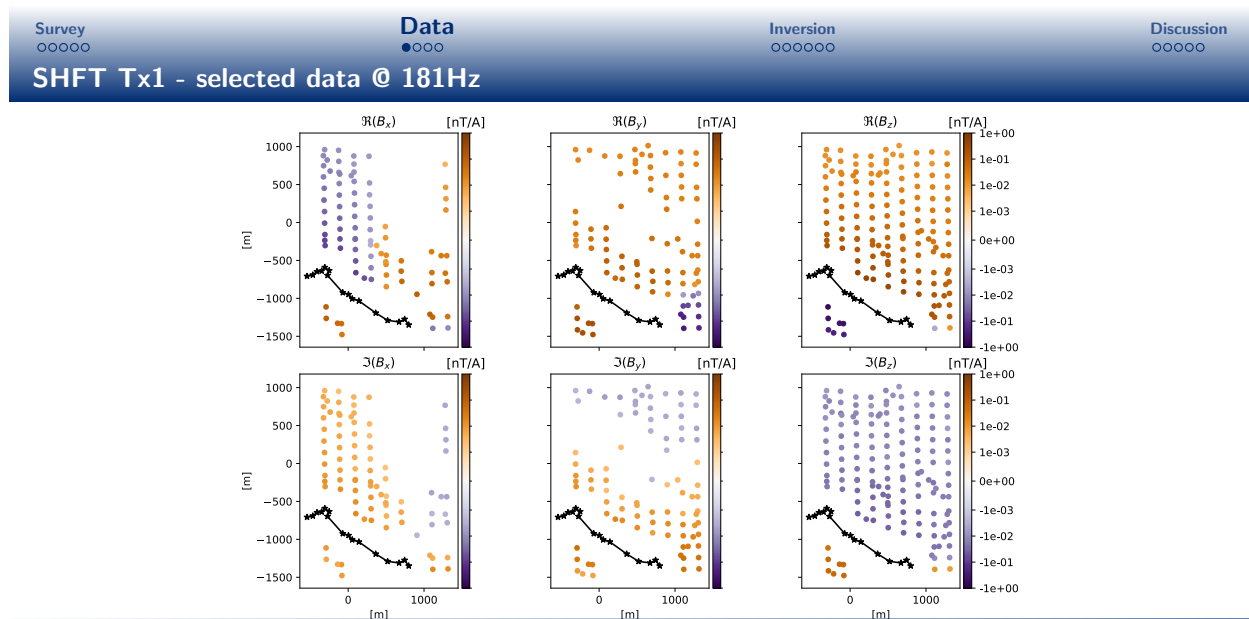
- Comparatively heterogeneous data set
- 2 different Rx systems, 2 SHFT configurations
 - SHFT: 9 freqs {32 Hz, 724 Hz}
 - MagArrow: 9 freqs {1 Hz, 64 Hz}
- Complete coverage with MagArrow, SHFT data have some gaps
- 2 different Transmitters (LIAG High-power Tx @Tx1 and Zonge GGT-10 @Tx2/3)



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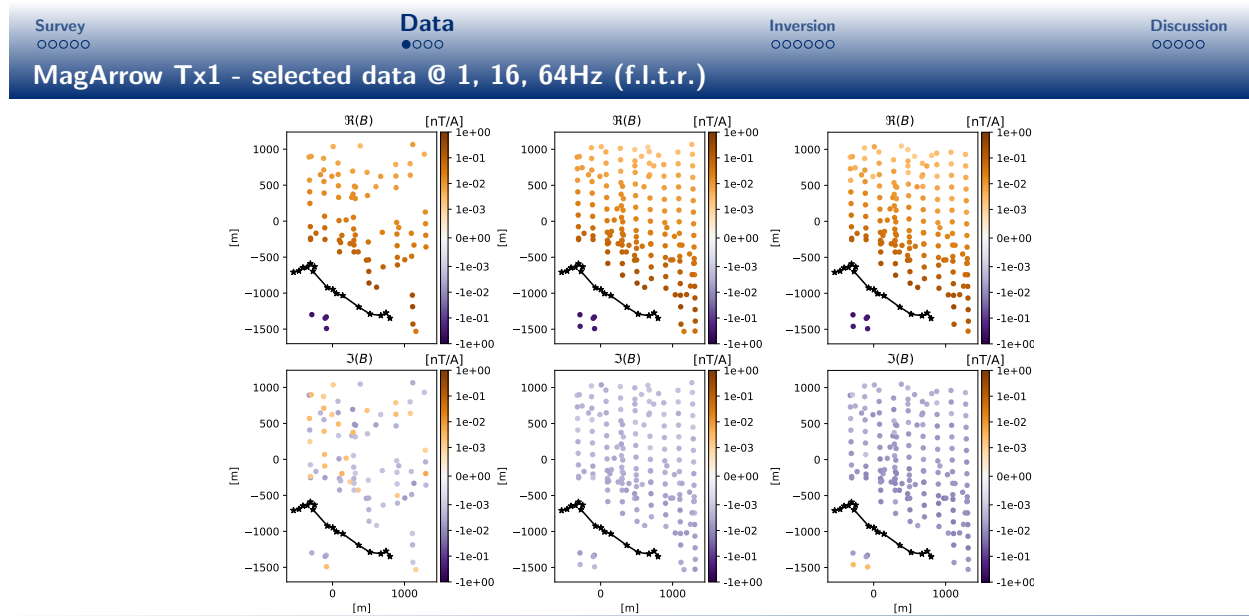
SHFT Tx1 - all data @ 181Hz





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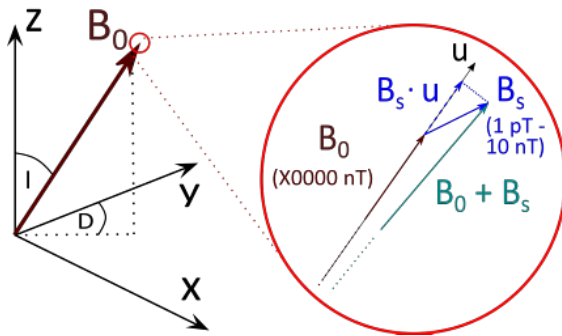
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Data comparison - Tx1

Total field measurements with Magarrow and relation to cartesian coordinates

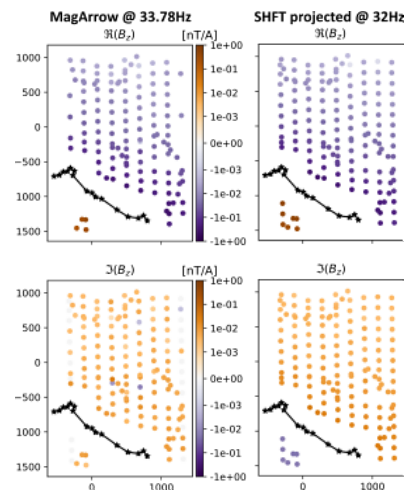
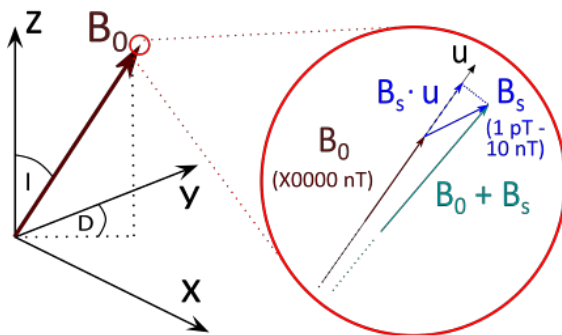


Becken et al. (2022)

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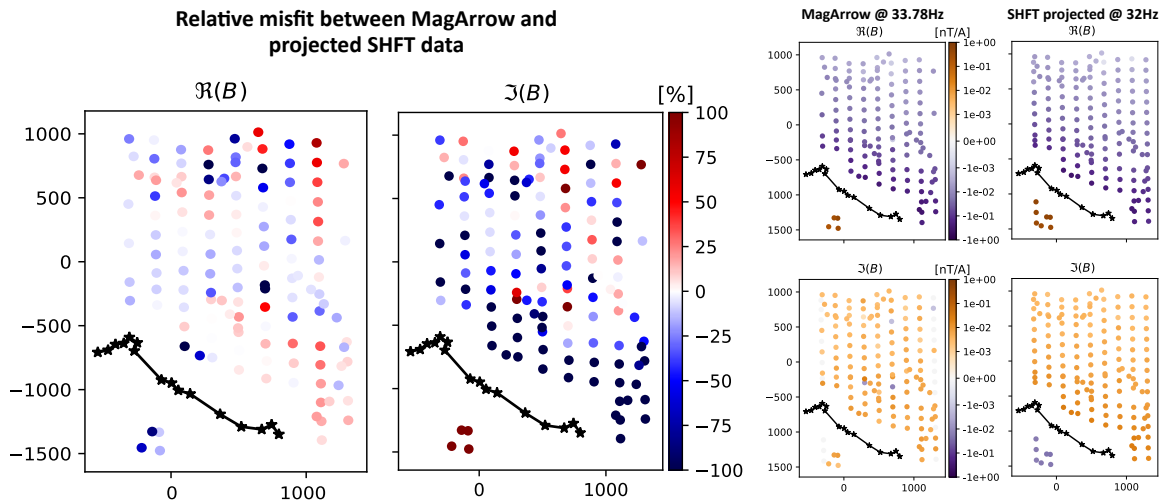
Data comparison - Tx1

Total field measurements with Magarrow and relation to cartesian coordinates



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Data comparison - Tx1



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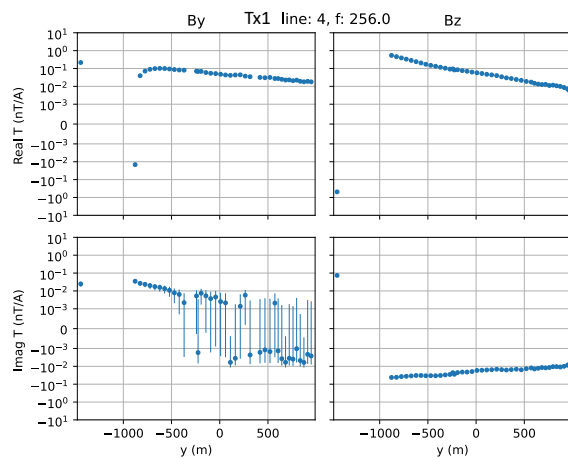
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Data Summary

- Overlapping 1-component MagArrow and 3-component SHFT data for 3 Tx
- Mixed data quality, removed a few systematically distorted parts for both receivers and very noise single points
- Data systematically distorted and excluded in 200 m (SHFT) or 300 m (MagArrow) distance to the Tx
- In total, 20600 selected data points available for inversion



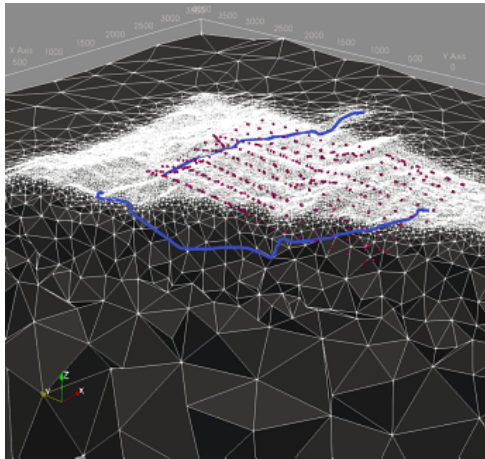
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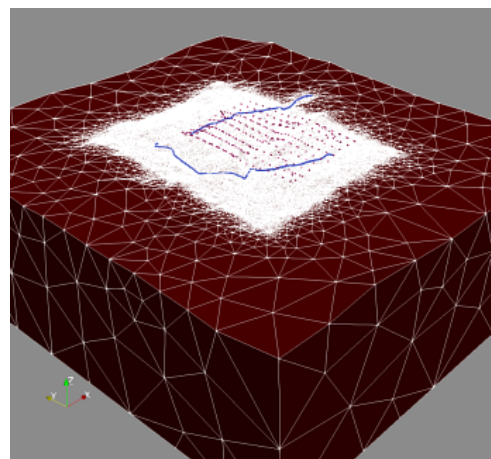
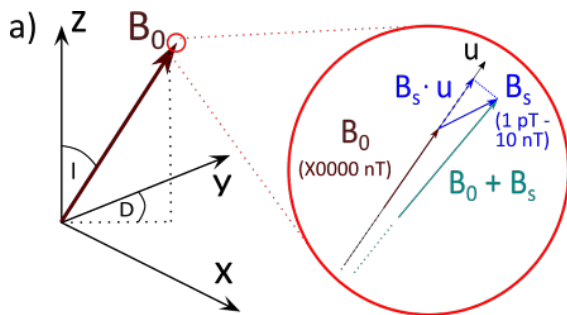
Methodology & Meshes



- Methodology: Gauss-Newton minimization with explicit Jacobian calculation (Rochlitz et al., 2023)
- Identical mesh for all final inversion results
- Tx segments: 20 m, Rx triangular refinement: $r = 5$ m
- Max. surface cell area: 400 m^2 , max. cell volume in central area: 600.000 m^3
- 234.000 cells = model parameters in inversion domain

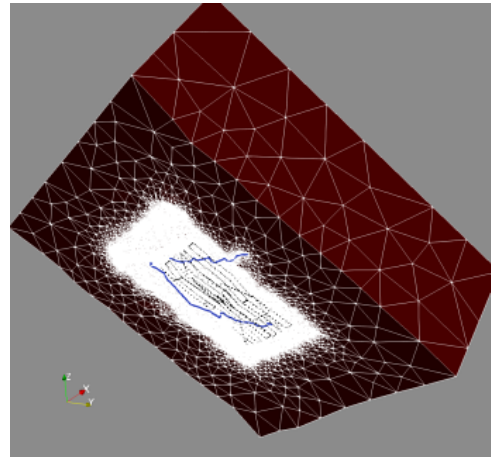
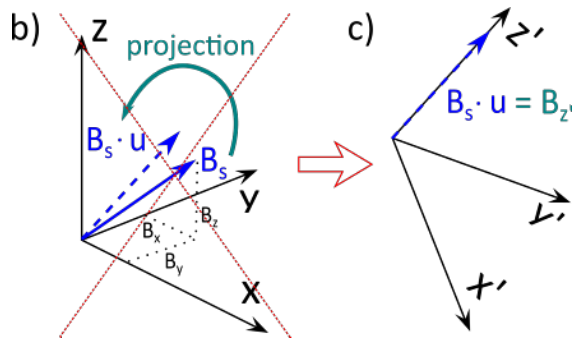
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Mesh rotation for MagArrow data inversion



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Mesh rotation for MagArrow data inversion



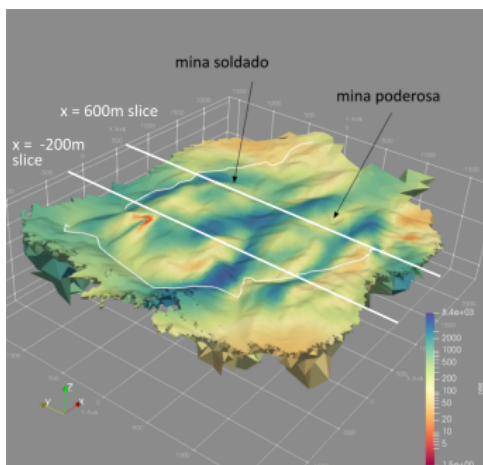
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Final resistivity model based on joint-inversion of all data



- coverage threshold for visualization = $2e-6$
- 20 k data \times 234 k model parameters
- 5% error + 2 pT/A noise level
- runtime: 24 h, max. memory requirement: 260 GB @ 72 cores
- 9 iterations, $\lambda = 1$, λ -iteration-factor = 0.8
 - iteration 0 : $\chi^2 = 21.03$
 - iteration 1 : $\chi^2 = 8.76$
 - iteration 2 : $\chi^2 = 5.08$
 - iteration 3 : $\chi^2 = 2.94$
 - iteration 5 : $\chi^2 = 1.74$
 - iteration 7 : $\chi^2 = 1.44$
 - iteration 9 : $\chi^2 = 1.26$

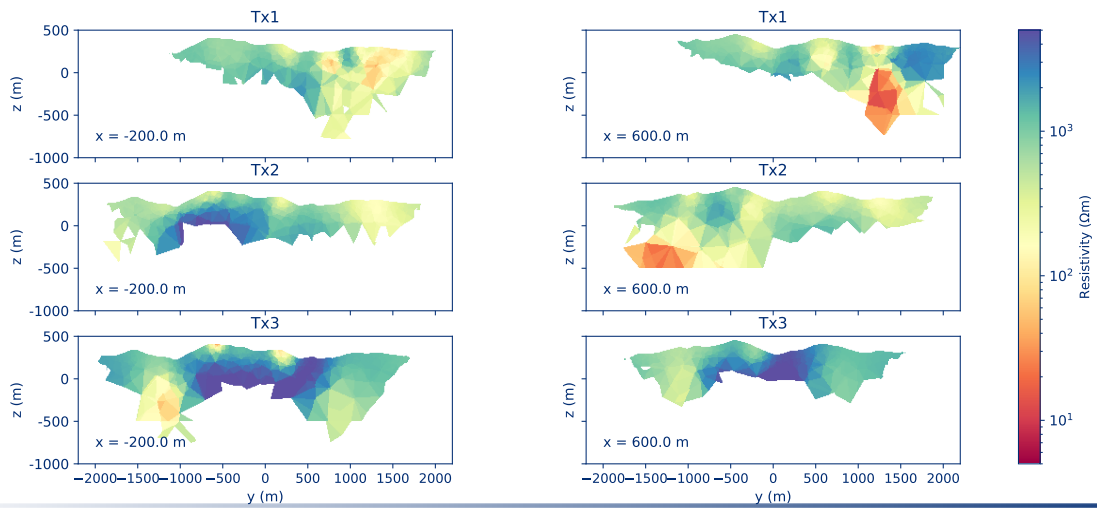
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3-component SHFT data results for single Tx



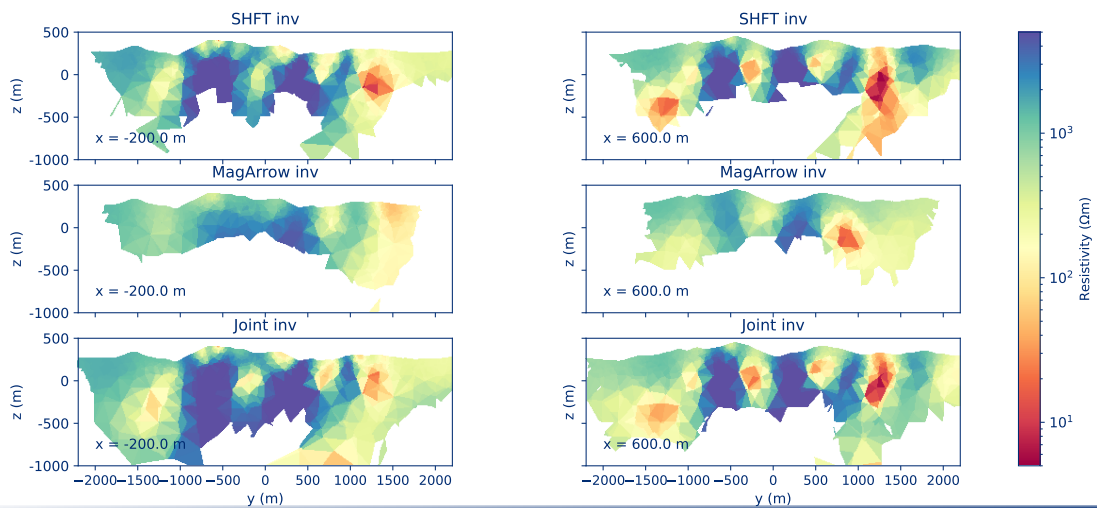
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Comparison of SHFT(3-comp.)/MagArrow/Joint results, all Tx



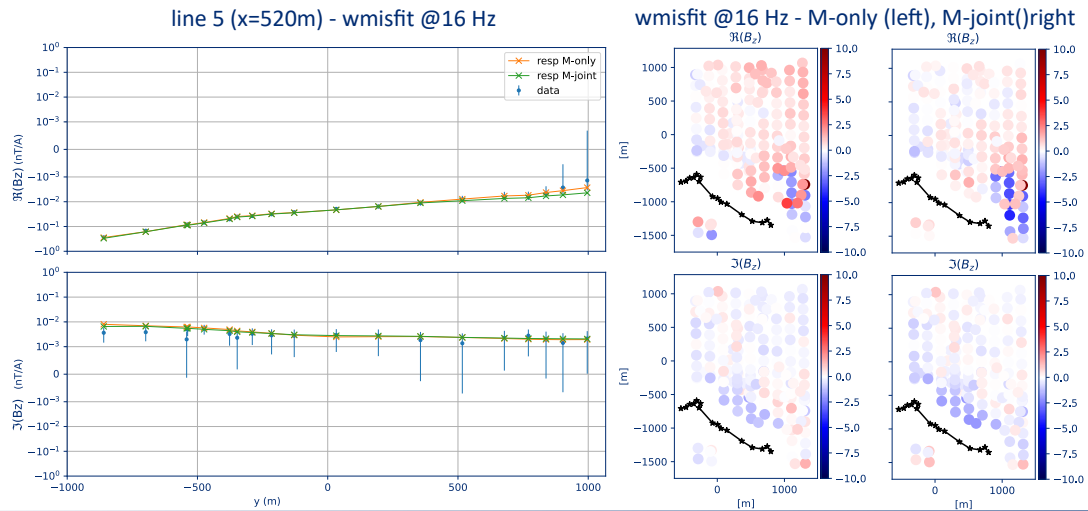
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MagArrow - weighted misfit after final iteration for Tx1



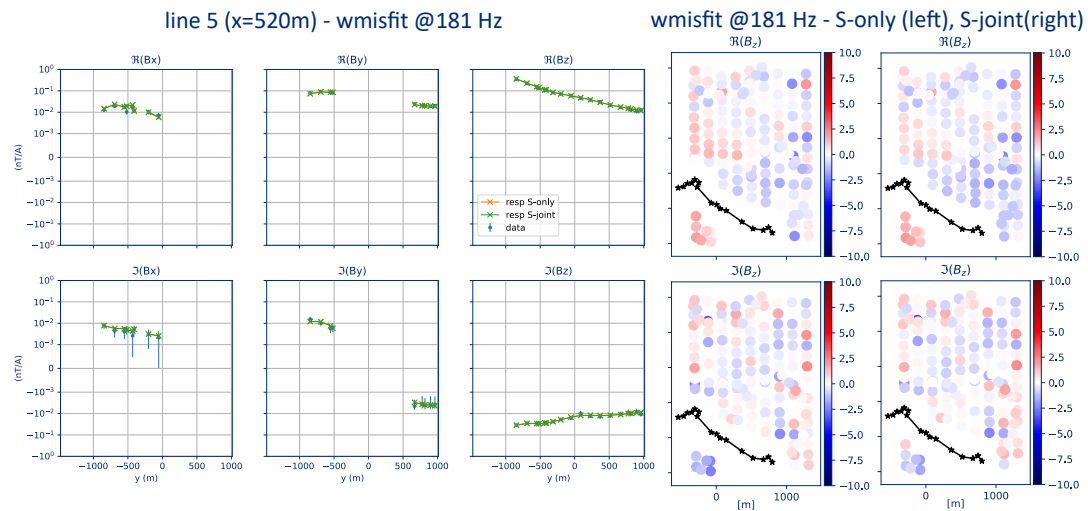
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SHFT - weighted misfit after final iteration for Tx1



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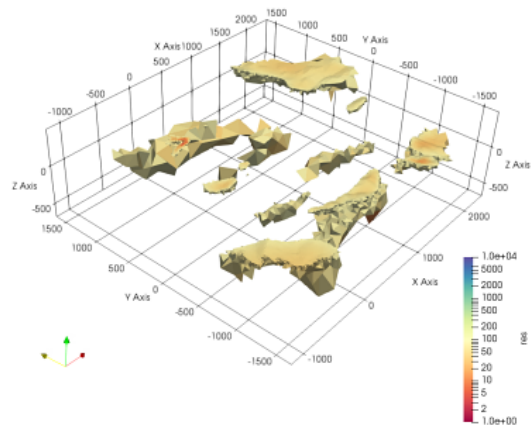
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Inversion Summary

- Joint inversion dominated by SHFT data (equally weighted)
- Significantly higher equivalence for MagArrow data only compared to single or multi-component SHFT data
- More than 100 inversion runs computed - proper data selection, optimized error models, understanding influence of different data
- Error models/mesh design/data selection have no critical influence on occurrence of major conductive structures



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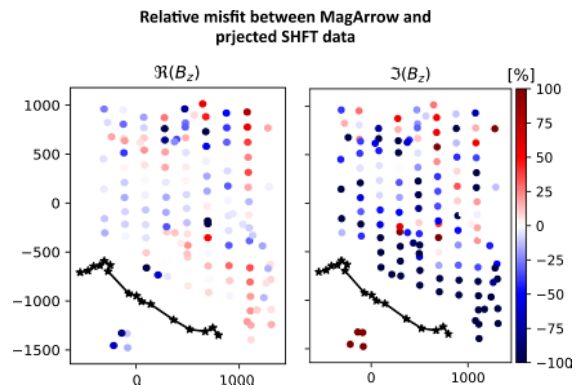
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Data quality, data handling, inversion design

- Error sources (e.g. IMU, current clamps, possible time shifts, UAV noise, position accuracy etc.)
- Comparison of SHFT and MagArrow data - frequency difference and interpolation issues
- Interpolation - common Rx for all Tx?
- p1 or p2? relation to model complexity
- error models, data selection (SHFT < 100 %, MagArrow < 200 % error), data set weights for joint inversion, resolve systematic data distortion above Tx



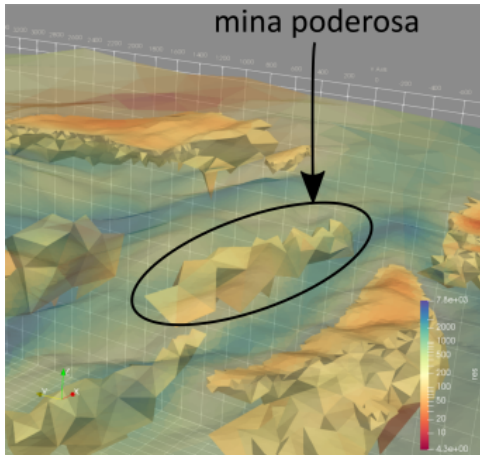
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Geological interpretation



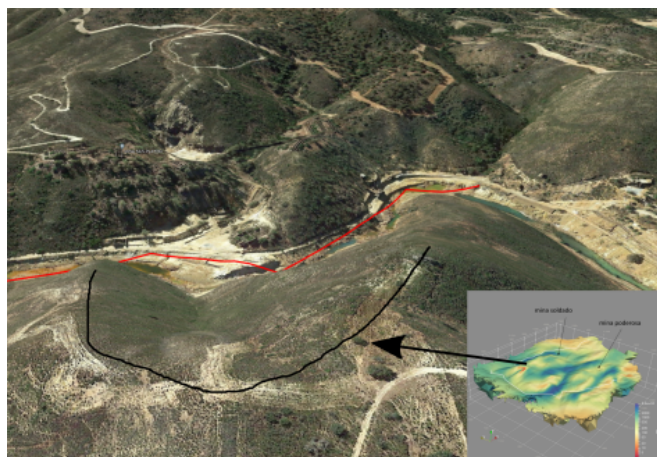
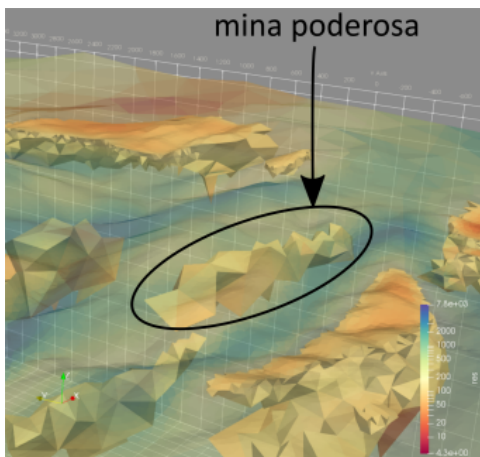
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Geological interpretation



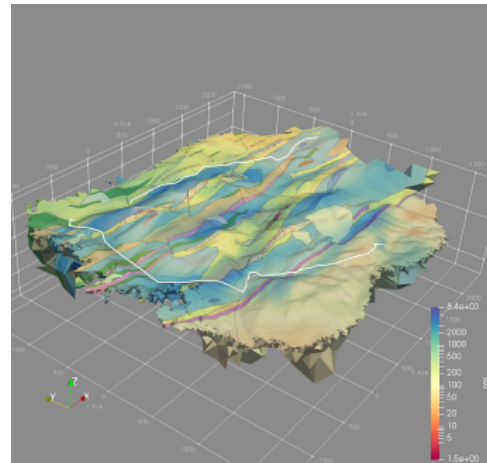
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Outlook			

- Geological integration with MATSA
- Identify source of systematic data distortion above Tx
- Further develop joint-inversion procedures with custEM/pyGIMLi
- Evaluate SHFT/MagArrow/other sensor capabilities in other areas (Hope deposit - Namibia, Kropfmühl deposit - Germany)
- UAV-based SAEM works and features unique exploration options!



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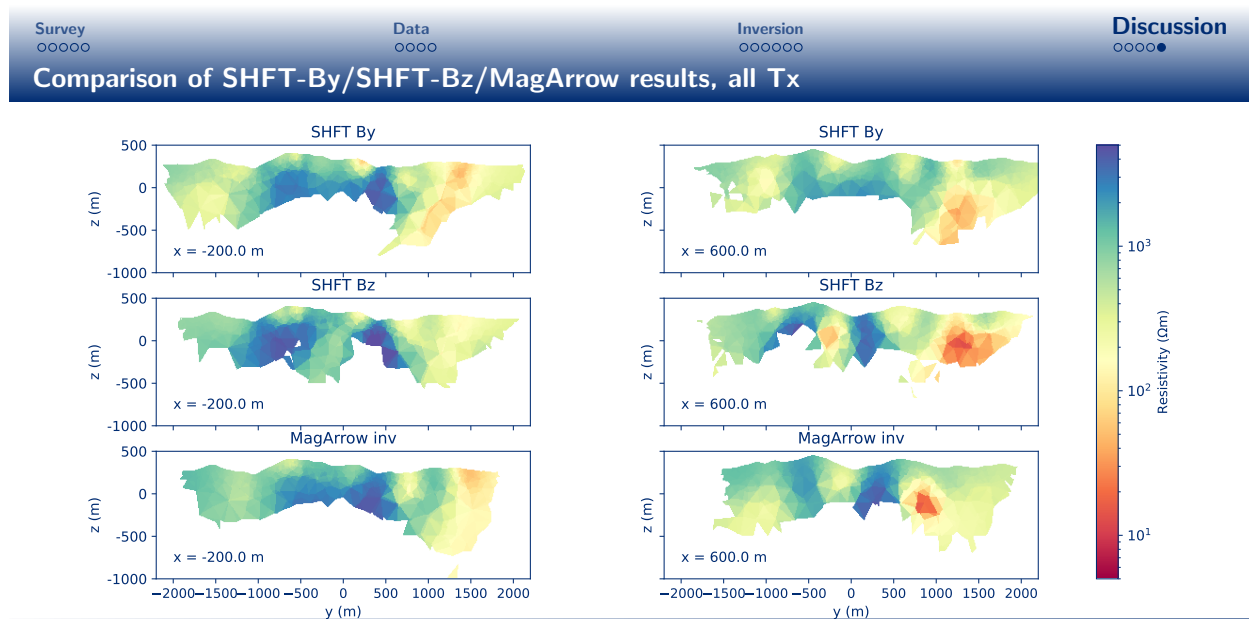
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Acknowledgements

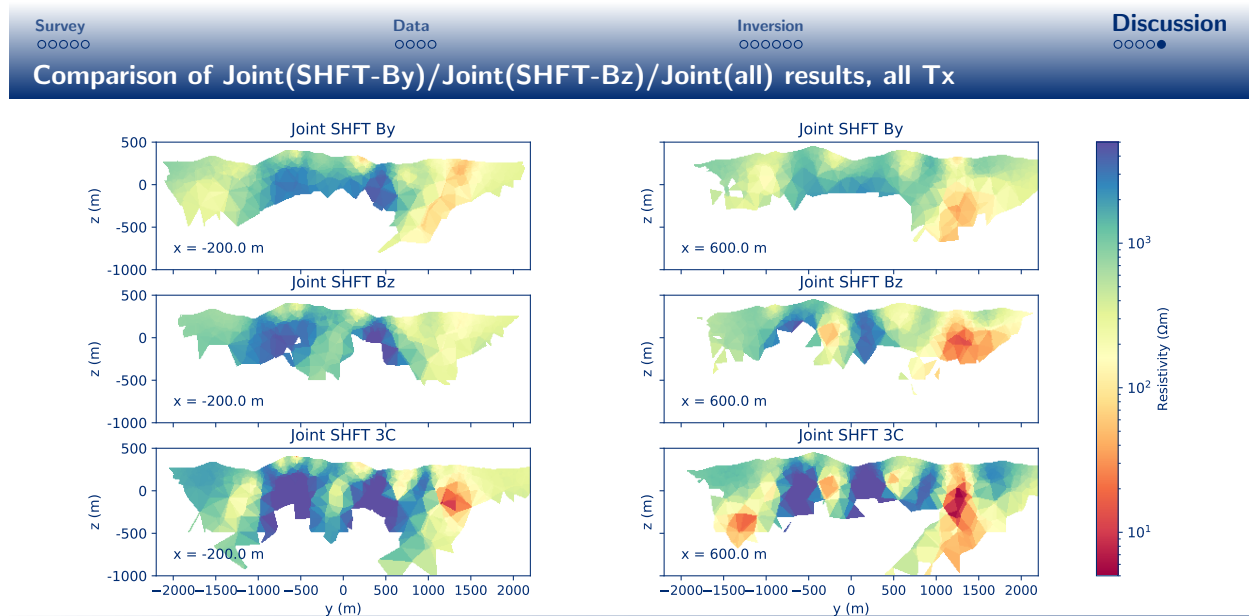
We thank all involved colleagues for successfully acquiring this valuable semi-airborne data set under very challenging conditions!

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