AEM 2026

Extended and short Abstract Collection

9th International Airborne Electromagnetics Workshop

6–11 September 2026 · Favignana, Italy

Ordered strictly according to AEM_2026_Complete_Programme (4): oral presentations first, followed by extended-abstract posters.

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Stand	Programme presenter	Title
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Stand	Programme presenter	Title
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What have we done? A global AEM catalog to democratize data access and enable synthesis studies

Day 1 · 09:40–10:00 · Oral presentation

B. Minsley [1], K. Singha [2], P. Sullivan [3], J. Read [4], S. James [1]

[1] *US Geological Survey*

[2] *Colorado School of Mines*

[3] *Oregon State University*

[4] *CUAHSI*

Abstract

We describe the development of a global AEM catalog to capture the locations and basic metadata for AEM surveys worldwide. Surveys are submitted to the catalog using a simple email template with shapefile attachment. Submissions are processed to establish uniform metadata fields before being added to the catalog, and summary maps are produced to highlight survey coverage. Maps will be publicly accessible for users to find surveys including access to metadata fields and links to download published data. By making a global AEM catalog accessible to a broad community of researchers and managers, we aim to grow the use and impact of these high-value datasets.

A multiscale approach to managing a potable water supply in the Eyre Peninsula, South Australia

Day 1 · 10:00–10:20 · Oral presentation

T. Munday [1], K. Hyland [2], C. Sorensen [3], K. Invararity [2], K. Cahill [1]

[1] *CSIRO*

[2] *Department for Environment and Water*

[3] *Subsurface*

[4] *Department for Environment and Water*

[5] *CSIRO*

Abstract

Groundwater on the Eyre Peninsula of South Australia is scarce with potable resources primarily limited to shallow aquifers, which recharge rapidly, located on the western coastal margin and the southern tip of the Peninsula. Around the town of Coffin Bay on the west coast, the “Coffin Bay A Lens” has assumed particular significance as a source of reticulated public water supply; however, it is affected by increased demand, climate change and the threat of salt-water intrusion (SWI). Recent monitoring of the town water supply has indicated an upward trend in the salinity of the extracted water. To better understand the threat of the SWI to the town water supply a multi-scale geophysical study was undertaken to better define the geometry and extent of the SWI. This involved the modelling and interpretation of both of airborne and ground EM. Model results indicate that the SWI extends from the coast, beneath the Coffin Bay township and the town water supply. The geometry of the SWI modelled with the AEM is generally matched by the geometry observed in the ground data, although the latter has also defined finer scale evidence of localised up-coning associated with the production water bores.

Characterizing the Columbia River Basalt Group for geologic carbon sequestration using airborne EM

Day 1 · 10:20–10:40 · Oral presentation

M.L. Oristaglio [1], P. Tilke [2], P. Berardelli [3], J. Legault [3]

[1] *Carbon Containment Lab*

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[3] *Geotech Ltd*

Abstract

Project TrapRock is a multidisciplinary research project designed to characterize the Columbia River Basalt Group over a region large enough to sequester millions of tons of carbon dioxide (CO2). The 'CRBG' is a sequence of flood basalts created by episodic lava-flows in the U.S. Pacific Northwest between 16.7 and 5 million years ago. The formation underlies much of Washington State, with a thickness up to 5 km in the central basin.

Unlike with standard forms of geologic carbon sequestration—in which CO2 injected into depleted petroleum reservoirs or saline aquifers is expected to be trapped by impermeable rock bounding the reservoir—when CO2 mixes with water in the pore space of basalt, it reacts with minerals in the rock matrix to precipitate solid carbonate minerals such as calcite, locking carbon into the matrix.

Detailed characterization of shallow reservoirs usually requires drilling many wells and taking rock and water samples. This study aims to show that modern geophysical remote sensing—anchored by a large-scale airborne EM survey and tied to logs from a small set of existing wells—can create a 'digital twin' of the CRBG with enough fidelity to realistically simulate reactive fluid flow and carbon mineralization in the formation's permeable flow tops.

Further lessons learned in AIP modelling

Day 1 · 11:20–11:40 · Oral presentation

A. Viezzoli [1], F. Dauti [2], G. Fiandaca [2]

[1] *emergo srl*

[2] *Unimi- geology Department*

Abstract

Modelling IP effects in AEM data has become the industry standard because it brings tangible positive impact on its applications. Almost 15 years of R&D together with experiments on real and synthetical data support enough evidence that AIP can help direct targeting mineralization and improve mineral prospectivity modelling, it effects both helicopter, fixed wing and semiairborne EM systems, it can complement ground IP.

Airborne Induced Polarization effects in the TEMPEST fixed-wing system

Day 1 · 11:40–12:00 · Oral presentation

F. Dauti [1], T. Munday [2], Y. Ley Cooper [3], A. Viezzoli [4]

[1] *The EEM Team for Hydro and eXploration - Univeristy Of Milan*

[2] *The Commonwealth Scientific and Industrial Research Organization | CSIRO Mineral Resources*

[3] *Geoscience Australia*

[4] *EMergo s.r.l.*

Abstract

This study evaluates the capability of the TEMPEST fixed-wing time-domain airborne electromagnetic (AEM) system to retrieve induced polarization (IP) effects, relevant to continental-scale IP mapping within the AusEM project involving over 2 million line-kilometres surveyed across the Australian continent. This approach was tested across two regional datasets in South Australia. In a 20,000 line-km subset of the Musgrave Province, incorporating IP into the inversion significantly reduced data misfit compared to non-IP models, revealing localized resistivity variations up to 100% where strong IP effects were mapped. In the Kimba region, a joint inversion of contiguous helicopter SkyTEM and fixed-wing TEMPEST datasets over a 5,696 line-km area yielded low data misfits and seamless spatial continuity of both resistivity and IP parameters across the boundaries between helicopter-borne and fixed wing acquisitions. These results confirm that fixed-wing platforms share a common field of sensitivity to ground chargeability, enabling the extraction of IP parameters from regional-scale and continental-scale AEM datasets.

Inductive IP time-constant to characterise AEM data

Day 1 · 12:00–12:20 · Oral presentation

J. Macnae [1,2]

[1] *CD3D Pty Limited*

[2] *RMIT University*

Abstract

Inductive IP is ideal for the characterisation of chargeability for materials whose conductivity time-constant is slightly (but not much) longer than the local duration of the 'smoke ring' current induced in the earth by a step-off current. The conductivity time-constant estimated using an inductive source is therefore ideal for permafrost characterisation and good for clay identification, particularly in the near surface. The conductivity time-constant excited by an inductive e source provides a chargeability independent estimate of time constant.

Automated Processing and Probabilistic AEM-IP Imaging of Large-Scale Airborne Electromagnetic Data Using Machine Learning

Day 1 · 12:20–12:40 · Oral presentation

J. Chen [1], F. Dauti [1], S. Panepinto [1], S. Galli [2], N.A.L. Sullivan [2], C. Compostella [1], G. Fiandaca [1]

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[2] *The EEM Team Spin-Off company*

Abstract

Large-scale airborne electromagnetic surveys provide regional subsurface information but generate data volumes that are difficult to process and interpret manually. This is especially challenging when the objective is not only resistivity imaging but also the extraction of induced-polarization information from airborne time-domain electromagnetic data. We present a machine-learning-assisted workflow that combines automated quality control, spatially stratified training-data selection, conventional AEM-IP inversion of representative subsets, and probabilistic neural-network imaging. The workflow is demonstrated using a large TEMPEST subset from the AusAEM program, comprising approximately 38,015 line-km of data and about 631,000 soundings with a nominal along-line spacing of approximately 60 m. Using automated tessellation in EEMStudio, the survey area was partitioned into 2.5 km by 2.5 km spatial cells. Approximately 15–20% of the tessellated blocks were selected for expert processing and conventional AEM-IP inversion. These processed data were then used to train both an automated quality-control model and a probabilistic AEM-IP imaging network. The resulting workflow rapidly processes the full dataset and predicts resistivity and polarization parameters over the larger survey area, while also providing uncertainty products.

Exposing a blind nickel sulphide discovery masked by induced polarisation effects in AEM data

Day 1 · 12:40–13:00 · Oral presentation

R. Neroni [1], K. Blundell [2], A. Viezzoli [3]

[1] *NewGen Geo Pty Ltd*

[2] *Geophysical Consultant*

[3] *Emergo*

Abstract

Induced Polarisation (IP) effects commonly distort time-domain Airborne ElectroMagnetic (AEM) data, resulting in atypically fast decaying transients and non-monotonic decay curves. These effects are not always easily recognisable, and can subdue, negate, or even overturn the localised expression of potential bedrock conductive sources worthy of exploration focus. The inclusion of such affected data in inversion routines can result in misleading resistivity models.

Simultaneously solving for chargeability and resistivity during inverse modelling can drastically improve the models produced, honouring both the measured AEM data and the geology more closely. These enhanced resistivity models can then be used to simulate what the AEM data would have looked like in absence of IP effects and form the basis for finer interpretation of the profile AEM data.

This innovative workflow has been successfully applied to a historical heliborne EM dataset where several new distinct weakly conductive features originally masked by IP effects could be recovered and accurately delineated. Drill testing of one of these IP-corrected AEM anomalies intersected disseminated nickel sulphide mineralisation at a depth predicted by traditional thin-plate modelling. The mineralised occurrence has no surface expression or discernible response in the raw AEM data.

Advanced Technologies for three-dimensional Airborne EM inversions

Day 1 · 14:20–15:00 · Oral presentation

C. Yin [1], Y. Su [1], Y. Liu [1], B. Zhang [1], X. Ren [1], X. Guo [1], Y. Gao [1]

[1] *Jilin University*

Abstract

AEM is being widely used in the mineral exploration, groundwater detection, and environmental & engineering investigation. However, the AEM data inversions in three dimension still face big chanllenges with the model characterization. The key issue with it is the regularizations in the objective function. In this extended abstract, we present three regularization schemes respectively based on sparse shearlet transform, the TV-norm, and the adaptive Lp-norm for the model constraint in AEM data inversions, with the aim to well resovle the geometry and the electric properties of the structure in the subsurface. Numerical experiments with both synthetic and field data have validated the effectiveness of our regularized inversion schemes.

Airborne Electromagnetic Modelling Using a Physically Informed Architecture

Day 1 · 15:00–15:20 · Oral presentation

E. Haber [1]

[1] *UBC*

Abstract

Airborne electromagnetic surveys require many forward simulations over complex 3D conductivity models, especially during inversion or survey interpretation. Full 3D modelling is accurate but too expensive when thousands to millions of source locations must be evaluated. This paper proposes a physics-informed neural surrogate based on a primary-secondary decomposition. A fast primary calculation is first computed in a simple background model, such as a full space, half space, or layered Earth. This primary response captures the transmitter waveform, flight height, source-receiver geometry, receiver component, and dominant background-earth response. The neural network is then trained only to predict the secondary correction caused by 3D conductivity variations.

The architecture reflects the structure of the electromagnetic equations: it is nonlinear in conductivity but linear in field-like inputs for fixed conductivity. Since the AEM forward map is deterministic, the goal is not statistical averaging but accurate approximation of a well-defined response map. Active learning is used to add training examples where the current model has the largest error. Numerical experiments using more than 50,000 synthetic 3D conductivity models show that the learned surrogate can reproduce full 3D decay curves, with validation error decreasing as more training samples are used.

Fast 3D transient electromagnetic forward modeling using compressed sensing solver

Day 1 · 15:20–15:40 · Oral presentation

W. Zhong [1], T. Lin [1], H. Zhao [1], P. Wang [1], Y. Liu [1], Z. Wang [1]

[1] *College of Instrumentation and Electrical Engineering, Jilin University*

Abstract

To address the heavy computational burden caused by enormous coefficient matrices in 3D transient electromagnetic (TEM) forward modeling, this research proposes an efficient solver based on compressed sensing (CS) technology. This method utilizes electric field data from previous time steps as prior knowledge to construct a sparse transform matrix, and reconstructs the spatial electric field using the orthogonal matching pursuit algorithm. To ensure stability and computational accuracy under a multi-stage variable time-stepping scheme, the algorithm innovatively introduces a dynamic re-baselining mechanism and an alternating strategy with a direct solver. Numerical simulation results of a 3D model with two anomalous bodies demonstrate that, compared to traditional direct solvers, the CS solver drastically reduces the calculation time from 186.46 seconds to 100.44 seconds. This improves computational efficiency by 80%, while strictly keeping the maximum relative error within 1.5%. This research lowers computational costs without sacrificing accuracy.

New Methods for Three-Dimensional Airborne EM Inversions

Day 1 · 15:40–16:00 · Oral presentation

B. Zhang [1], C. Yin [1], Y. Pan [1], Y. Wang [1], G. Fiandaca [2]

[1] *Jilin University*

[2] *Università degli Studi di Milano, Milano*

Abstract

This extended abstract presents several innovative techniques to accelerate and stabilize three-dimensional (3D) airborne electromagnetic (AEM) inversion, which is traditionally limited by high computational costs and memory demands. The authors first review conventional 3D inversion theory based on the Gauss-Newton method, then introduce four advanced methods developed by their team.First, unstructured local meshes using tetrahedral grids handle complex topography by dividing large models into smaller subproblems. Second, a triple mesh approach accelerates sensitivity calculations on a coarse mesh while preserving forward accuracy on a fine mesh, increasing speed by 3–5 times. Third, flight altitude correction inverts for altitude errors to avoid spurious anomalies. Fourth, block coordinate descent reduces memory usage to 60% of conventional methods by decomposing large inversions into smaller subproblems. All methods are validated with field data from Norway or synthetic data.

Noise Estimation from Repeat Flight Lines with a Non-linear Inversion Based Height Correction

Day 1 · 16:20–16:40 · Oral presentation

T. Scarr [1], A. Ray [1], R. Brodie [2]

[1] *Geoscience Australia*

[2] *Brodie Geophysics*

Abstract

The most widely used noise model for airborne electromagnetic (AEM) surveying was formulated by Green and Lane (2003). In the presence of appreciable earth response, they propose that the dominant source of noise at survey altitude is proportional to signal amplitude at early-to-mid times, and dominated by additive noise at late times. We detail an inversion based, non-linear height correction for the AEM data that allows us to derive the multiplicative noise model for all channels. A variant of this method has been used internally at Geoscience Australia since the Southern Thomsons Orogen Project report (Roach 2015), but the details are not available in the literature. In a novel development, we find a "most-Gaussian" data variance by forcing the multiplicative noise per time channel to be as closely distributed to a Gaussian cumulative distribution function (CDF) as possible. This is achieved through a nonlinear optimisation process. Lastly, we examine the effect of correlated noise in the data misfit function.

Analysis of topographic effects on AEM data

Day 1 · 16:40–17:00 · Oral presentation

M. Combrinck [1], J. Silic [2], D. Fitzgerald [3]

[1] *NRG*

[2] *Jovan Silic & Associates*

[3] *Geomodeller*

Abstract

In survey areas with large topographic variations, it is challenging to produce smooth grids and while the significant influence of altitude variations on AEM responses are well documented, the effect of topographic features themselves on the data has not received much attention. The question is whether grids derived through 1D inversions or depth transforms should always be smooth, or whether chasing this ideal can result in incorrect processing and subsequent incorrect interpretation of data.

The strategy of this study was to produce 2.5D synthetic data using a historic Xcite survey digital terrain model (DTM) for different conductivity models. The resulting data and 1D conductivity products, were analysed for biases introduced by topographic features against the known model conductivities.

In areas with severe topography and realistic helicopter flight paths neither the modelled AEM channel data or the derived conductivity products gridded up smoothly.

Understanding the effects of topography on AEM data is critical for distinguishing between valid geological responses and processing artefacts which can manifest as similar patterns on grid images and data profiles. In areas with severe topography even perfectly processed AEM channel data and 1D conductivity products should not grid up smoothly, even though the sections may be 1D.

From Experience to Automation: A Pragmatic Supervised CNN Approach for Airborne EM Data Processing

Day 1 · 17:00–17:20 · Oral presentation

M. Ciaffarafa [1], A. Viezzoli [1]

[1] *Emergo*

Abstract

The purpose of this study is to present a practical, experience-driven application of supervised convolutional neural networks (CNNs) to the processing of Airborne Electromagnetic (AEM) data. In recent years, the growing availability of large AEM datasets has increased the demand for efficient and reliable processing methodologies capable of delivering high-quality results while significantly reducing processing time. Traditionally, this task relies heavily on expert operators who manually inspect the data and remove portions affected by noise and distortions. While effective, this approach is inherently time-consuming and difficult to scale. A fundamental challenge in AEM processing lies in the high variability of data. Differences in acquisition systems, signal-to-noise ratios, flight altitude, and geophysical conditions—combined with coupling effects (galvanic and capacitive), induced polarization (IP), and varying preprocessing strategies—result in datasets that are rarely comparable and often require tailored treatment. Rather than developing a universal algorithm, this study adopts a pragmatic approach based on flexibility and adaptability. The CNN is trained case-by-case on representative subsets processed by an expert operator, enabling the learned processing strategy to be efficiently transferred to the full dataset. With limited further refinement.

3D hybrid-parametric inversion of AEM data accelerated by tiling

Day 2 · 09:40–10:00 · Oral presentation

L. Heagy [1], J. Capriotti [2], S. Kang [3], D. Fournier [4], J. Weis [1], J. Kuttai [1], S. Soler [1]

[1] *University of British Columbia*

[2] *Colorado School of Mines*

[3] *University of Manitoba*

[4] *Mira Geoscience*

Abstract

Airborne electromagnetic (AEM) surveys collect dense, high-quality data, yet are most often inverted under a 1D layered-earth assumption that breaks down over geologically complex targets. Full 3D inversion can resolve these settings but is computationally expensive. We present a tiled 3D inversion workflow, implemented in the open-source SimPEG framework, in which each source is simulated on a small local OcTree mesh, and the per-source simulations are distributed in parallel. In our example, a single-sounding forward runs about an order of magnitude faster than on the global mesh, and distributing the solves accelerates the full survey by roughly two orders of magnitude. Sensitivities are propagated through composable mappings, so the Jacobian is only ever computed on the small local meshes. The same code supports both voxel and parametric models. On a synthetic dipping conductor beneath a conductive overburden, a stitched 1D inversion smears and under-recovers the target and a naive cold-started 3D inversion stalls above the target misfit, whereas a two-stage hybrid-parametric inversion, warm-started from a recovered ellipsoid, converges quickly and recovers a coherent dipping conductor with the overburden. The framework also enables an efficient 3D forward check on 1D results, indicating where 1D suffices and where 3D is warranted.

2D inversion of airborne electromagnetic data with deep neural networks

Day 2 · 10:00–10:20 · Oral presentation

C. Scholl [1], J. Kosky [1], T. Kimura [1]

[1] *Viridien*

Abstract

Conventional approaches to rigorous multidimensional inversion of airborne electromagnetic (AEM) data are computationally demanding, currently limiting their adoption for large surveys. Instead, simple data transforms or 1D inversions are often performed, despite known limitations, particularly in the presence of multidimensional structures in the subsurface. Deep learning (DL) has the potential to increase the efficiency of geophysical inversions and has been successfully applied to a range of subsurface problems, including that of AEM

Many existing DL-driven AEM inversion approaches rely on the construction of a synthetic dataset for training, however, which itself presents a challenge. Following a similar approach applied to the inversion of surface waves, we use conventional 2D inversion results on a subset of the data to train a deep neural network (DNN). This way, the training data set is automatically tailored to the specific system parameters as well as the geological structure in the area while avoiding 1D distortions.

The trained DNN then provides an efficient means by which to perform inversion across the entire survey area. Results are shown for a VTEM dataset provided by the CSIRO from the Musgrave area in Australia.

Tessellated Multi Mesh-Cycle-Norm (TMMCN) 3D Inversion of AEM-IP data accelerated by 3D U-Nets deep-learning

Day 2 · 10:20–10:40 · Oral presentation

G. Fiandaca [1], J. Chen [1]

[1] *The EEM Team for Hydro & eXploration, Department of Earth Sciences, University of Milano*

Abstract

Large-scale airborne electromagnetic (AEM) surveys are commonly inverted within a single linearized workflow, but this strategy may become trapped in local minima. Consequently, the recovered global model can fit the data less accurately than models obtained from smaller inversions performed on survey subsets. This issue is particularly relevant for 3D AEM inversions that include induced polarization (IP) effects, which are becoming increasingly feasible due to recent advances in computational electromagnetics.

To address this challenge, we developed the Tessellated Multi Mesh-Cycle-Norm (TMMCN) inversion, accelerated by deep learning. The method is based on four main components: (1) tessellation of the model space into tiles of uniform lateral extent, enabling tile-specific damping; (2) global model meshes combined with tessellated 3D forward meshes to reduce computational cost; (3) multiple inversion cycles, consisting of 1D computations followed by deep-learning-based 3D predictions and full 3D solutions; and (4) multiple norms in the objective function, including a new IRLS formulation of cross-gradient-like constraints among IP parameters.

The effectiveness of TMMCN inversion is demonstrated on a VTEM survey from Valen, where it reduces both the final inversion misfit and the iteration number. These results suggest that TMMCN represents a step forward for 3D AEM-IP inversion of large datasets.

Bridging the Gap: Different Pathways for Translating Airborne EM Data into Groundwater Models

Day 2 · 11:20–11:40 · Oral presentation

F. Schaars [1], A. Rapiti [2], S. Galli [3]

[1] *Artesia*

[2] *EMergo*

[3] *The EEM Team Spin-Off Company*

Abstract

Integrating airborne electromagnetic (AEM) data into groundwater models involves a diverse spectrum of methodologies, the selection of which depends entirely on data availability, project circumstances, and the specific hydrogeological questions being addressed. Localized point data, such as borehole logs, can be used as direct inversion constraints, though irregular data distribution can introduce spatial imbalances. To mitigate this bias, inversions can be guided by interpreted surfaces (e.g., bathymetry) or structural horizons derived from expert geological knowledge to map complex features like fresh-saltwater transitions. Advanced workflows can even anchor the entire inversion grid to an existing geological model or employ fully coupled joint inversions.

Ultimately, increasing structural or deterministic complexity does not guarantee superior predictions. Grounded in decision-support principles, groundwater models must remain strictly fit-for-purpose. To support robust risk management, spatial ambiguities and parameter uncertainties introduced by the AEM integration workflow must be explicitly quantified. This process demands parsimonious, computationally efficient model frameworks that minimize CPU run-times to keep highly demanding uncertainty analyses feasible.

Borehole and geological constraints in AEM inversion: a workflow test at a Dutch coastal groundwater site

Day 2 · 11:40–12:00 · Oral presentation

S. Galli [1], F. Schaars [3], L. Borst [4], M. Groen [5], G. Fiandaca [1,2]

[1] *The EEM Team Spin-Off Company*

[2] *Unversity of Milan*

[3] *Artesia Water*

[4] *PWN*

[5] *Wiertsema & partners*

Abstract

This work presents a workflow for jointly inverting airborne SkyTEM, ground-based sTEM, borehole, and geological data at a Dutch coastal groundwater site. The approach is geology-led, not geology-forced: geological information guides the inversion toward sharper, meaningful structures, while the model stays free to depart from the prior wherever data indicate otherwise.

The study integrates legacy SkyTEM surveys, new sTEM data, borehole lithology logs, saltwatcher observations, known infrastructure causing EM coupling, and the Dutch national subsurface geological framework. Data mismatches in this coastal setting may arise from inversion uncertainty, differing resolution between methods, uncertain geological parameterization, simplified lithology-resistivity relationships, or genuine salinity changes from groundwater dynamics and pumping.

A regular 3D mesh underlies the inversion, allowing direct transfer of results into groundwater models. Multiple forward meshes combine SkyTEM, sTEM, and borehole data within one framework, with borehole logs converted to resistivity constraints and treated as data rather than fixed priors. A GeoMesh parameterization defines geological domains with distinct bounds, starting values, and prior behavior, enabling sharper interfaces without over-constraining the model.

Where geology and data agree, results are refined; where they disagree, conflicts are revealed, yielding groundwater-ready volumes and flagging where models need revision.

Salinology: Joint Interpretation of Lithology and Salinity Using Airborne Electromagnetics and Borehole Observations

Day 2 · 12:00–12:20 · Oral presentation

B. Hoogenboom [1], B. Minsley [2], S. James [2]

[1] *U.S. Geological Survey, Sacramento, CA*

[2] *U.S. Geological Survey, Denver, CO*

Abstract

Airborne electromagnetic data is just one of many geophysical methods increasingly utilized to infer hydrogeologic properties of the subsurface in automated or semi-automated routines. Mapping aquifer structure and water quality metrics, for example, is a key motivation for modern groundwater availability surveys. Any attempt to do so requires consideration for the non-uniqueness of the relationship and compounding sources of uncertainty in data, models, and ultimately, interpretations. Here we present a Bayesian workflow to integrate borehole lithology and water quality observations with bulk resistivity models to generate posterior distributions of both lithology and salinity simultaneously. This approach is demonstrated with AEM data in Louisiana.

Defining the Hydrogeological Framework of the Mahomet using Airborne Electromagnetics and a Novel Sediment Interpretation Method

Day 2 · 12:20–12:40 · Oral presentation

K. Mwakanyamale [1], D. Keefer [1], J. Thomason [1], A. Stumpf [1]

[1] *University Of Illinois - Urbana-champaign*

Abstract

PROBLEM – In east-central Illinois, the Mahomet aquifer supplies approximately 220 Mgal/d of water to communities, agriculture, industry, and rural wells to a population of ~1 million people. Improving our understanding of the hydrological framework of the Mahomet aquifer, the distribution and complexity of the sediments within Mahomet aquifer, and the connectivity to adjacent shallow and deeper aquifers is one of the best ways to improve long-term planning of groundwater resources in east central Illinois.

SOLUTION - To address long-term, multiscale water planning, quantity, quality and management issues, we used advanced airborne geophysical mapping technologies to create improved geological models, geometry and character of Mahomet aquifer. Here we aim to investigate the overall hydrological framework of the Mahomet aquifer

APPROACH – Deployed high-density Helicopter-borne Time-domain Electromagnetic measurements (HTEM) to provide sound data with which Champaign County can formulate effective and sustainable strategies to protect groundwater resources and the economy of the county. A newly developed Material-Type Characterization (MTC) method was used for data interpretation to obtain high-resolution interpretations of geological material-type distributions and asses uncertainties associated with the interpretation of the material types.

Airborne EM Imaging for Coastal Aquifer Management in Muravera, Sardinia, Italy

Day 2 · 12:40–13:00 · Oral presentation

J. Moilanen [1], M.C. Porru [2], Y. Podmogov [3], C. Arras [2], E. Karshakov [1], G. Vignoli [2], S. Da Pelo [2], A. Moilanen [3]

[1] *V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences*

[2] *University of Cagliari*

[3] *Geotechnologies*

Abstract

An EQUATOR helicopter-borne AEM survey (~1,500 line-km, 200 m spacing) over the Muravera coastal plain

(Flumendosa delta, SE Sardinia) produced a quasi-3D resistivity volume that refines hydrostratigraphy and informs

groundwater management.

The AEM model maps discontinuous shallow conductive horizons (1–10 Ω·m) interpreted as lagoonal silts/clays or brackish

deposits, moderately resistive phreatic alluvium (10–50 Ω·m), and more resistive gravelly/coarse alluvial axes

(≈30–150 Ω·m).

Crucially, it delineates a laterally extensive deep conductive lagoonal clay unit (≈0.5–5 Ω·m) acting as an aquitard,

previously inferred only from sparse boreholes.

Resistivity patterns support a pathway-controlled salinization model,

with discontinuous conductive bodies and preferential-flow corridors (paleochannels, river mouths, foxi,

abstraction-driven upconing) rather than a uniform seawater wedge.

For management, AEM results

(1) delineate salinity-prone domains,

(2) identify transmissive coarse bodies that can propagate drawdown and salinity, and

(3) indicate areas where small head changes yield large salinity responses.

The survey prioritizes locations for targeted follow-up (TEM, ERT/IP, borehole logging, hydrochemistry, head-EC

monitoring) and recommends calibrated, uncertainty-aware integration with borehole and petrophysical data to support

vulnerability zoning, monitoring design, and abstraction scenarios.

Airborne Electromagnetics in Support of Critical-Mineral Resource Assessment: The Earth Mapping Resources Initiative

Day 2 · 15:00–15:20 · Oral presentation

P. Bedrosian [1], L. Ball [1], P. MacQueen [1], C. Gustafson [1], J. Crosbie [1]

[1] *United States Geological Survey*

Abstract

The Earth Mapping Resources Initiative (Earth MRI) is a partnership between the United States Geological Survey (USGS) and state geological surveys to modernize geological mapping for the United States and to identify areas prospective for undiscovered critical minerals. Components of the program, designed to support downstream mineral-resource assessments, include airborne geophysical surveying, topographic mapping, geologic mapping, and geochemical sampling. Initiated in 2019, the airborne geophysical survey campaign was expanded in 2022 to incorporate airborne electromagnetic (AEM) data collection. As of this writing, 10 AEM surveys have been flown or contracted under the Earth MRI totalling nearly 110,000 ln-kms of data (Fig. 1). Versioned releases of AEM data and models are being made public for each survey on ScienceBase, with the release of raw data and metadata followed at a later stage by processed data and one-dimensional (1D) inverse models. All data and models are being released in netCDF format following the recently developed Geophysical Survey (GS) data standard (James et al., 2022). Here we discuss several ways in which AEM data are being used to support mineral-resource investigations.

AEM for hydrogenic uranium exploration – EQUATOR case study

Day 2 · 15:20–15:40 · Oral presentation

E. Karshakov [1], I. Savinova [1], Y. Podmogov [2], J. Moilanen [1]

[1] *V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences*

[2] *Geotechnologies*

Abstract

This paper demonstrates the use of airborne geophysics with the EQUATOR electromagnetic system to map paleovalleys and detect buried high resistivity granite massifs beneath low resistivity Neogene–Quaternary cover in the Republic of Buryatia. EQUATOR combines frequency domain and time domain measurements, enabling detailed investigation of the shallow section and detection of conductive targets to ~400 m depth. A 2024 test survey at the Tetrakh deposit (Khiagda field) refined boundaries of lithological units, outlined radioactive granite bodies, and determined depths to the crystalline basement; paleovalleys act as natural traps for hydrogenic uranium mobilized by groundwater from weathered granitoids. An October 2025 survey at the Kupchinsky site produced resistivity maps and 1D inversions in time and frequency domains, reliably delineating the strong geoelectric contrast between low resistivity loose sediments and high resistivity granitoids. Interpreted maps identified paleovalley thalwegs and potentially uranium bearing paleovalleys, with a radioactive granite massif considered a likely uranium source. Comparison of EQUATOR profiles with a drilling line showed consistent mapping of the sediment–granite boundary. Drilling confirmed mineralization evidence (oxidative alteration, radioactivity halo, thin layers with increased uranium concentrations of 0.02%). The study concludes that EQUATOR AEM surveys significantly accelerate and improve hydrogenic uranium exploration.

Characterizing the geophysical response of a Carlin-style gold deposit using Helicopter NFEM-Magnetics at Hyland Project, Yukon

Day 2 · 15:40–16:00 · Oral presentation

J. Legault [1], D. Mackay [2]

[1] *Geotech Ltd.*

[2] *Banyan Gold Corp.*

Abstract

The Hyland Gold Project is interpreted as a sediment-hosted, structurally controlled, Carlin-style type, gold-silver deposit, situated in southeastern Yukon. Considering that Carlin-type gold deposits represent some of the largest hydrothermal gold deposits in the world, there are relatively few geophysical case studies available, and far fewer for Carlin-style deposits outside of Nevada. A ZTEM helicopter natural field EM and magnetic survey, consisting of 584 line-km, was flown over Hyland project in November, 2025. The survey results, assisted by 2D and 3D inversions, appear to map the known Hyland Main Zone deposit and Camp Zone as a local conductivity high associated with a known lineament, as well as other gold occurrences along the same conductive trend.

Heliborne and Drone Natural-Field Airborne EM: Differences, Advantages and Applications

Day 2 · 16:20–16:40 · Oral presentation

A. Prikhodko [1], A. Bagrianski [1], A. Sirohey [1], A. Carpenter [2]

[1] *Expert Geophysics Surveys Inc.*

[2] *Expert Geophysics Pty Ltd*

Abstract

This study compares heliborne and drone implementations of broadband natural-field airborne electromagnetic technology for subsurface resistivity imaging. The method passively measures natural electromagnetic-field variations over a wide frequency range, supporting investigation from near-surface to depths of 1–2 km or more, depending on geological conditions.

The heliborne system is optimized for regional surveys, providing efficient coverage of large and remote areas with stable acquisition conditions and strong depth capability. In contrast, the drone-based MobileMTd system provides higher spatial resolution due to lower flight altitude, slower survey speed, and shorter effective averaging lengths. Reduced motion noise can also support recovery of lower-frequency signals and, under favourable conditions, greater depth of investigation.

The platforms also differ operationally: heliborne surveys are suitable for remote regions with limited infrastructure, whereas drone surveys require closer logistical support but can be conducted during periods of stronger natural EM signal, including evening and nighttime.

Field examples from Western Australia demonstrate improved drone resolution, additional low-frequency content, and the ability to resolve compact, high-conductance targets. Together, the platforms enable a multi-scale exploration approach that improves structural characterization and reduces exploration risk.

By drone or helicopter – exceptional resolution from a compact and fully airborne TEM system

Day 2 · 16:40–17:00 · Oral presentation

N.S. Nyboe [1], E. Nielsen [1], P.L. Rasmussen [1]

[1] *SkyTEM Surveys ApS*

Abstract

This paper sums up the results of a continuous development effort at SkyTEM Surveys spanning a number of years, with the goal of achieving a compact airborne TEM instrument capable of filling the gap between large scale airborne electromagnetic surveys and ground-based resistivity measurements. The instrument was designed to achieve a total system weight small enough to allow it to be transported by a heavy lift drone, and the remarkable result is now known as the SkyTEM Diamond system. The system represents a mature airborne TEM solution specifically optimized for high-resolution near-surface investigations. Its combination of high bandwidth receiver design, fast transmitter behaviour, and effective primary field suppression enables the use of very early-time data, significantly enhancing sensitivity to shallow geological structures. The system has demonstrated robust performance across a wide range of survey types, including environmental, hydrogeological, and engineering applications, and has been successfully deployed in multiple operational settings using both helicopter and drone platforms. This operational flexibility does indeed allow the system to bridge the gap between large-scale airborne surveys and ground-based methods, serving as a powerful new option for detailed subsurface mapping.

Utilizing the SkyTEM Diamond system for point-source pollution investigations

Day 3 · 09:40–10:00 · Oral presentation

D.J. Okholm [1], T.M. Hansen [2], A. Edsen [3], I.D. Damgaard [1], F. Jørgensen [1]

[1] *Central Denmark Region / Aarhus University*

[2] *Aarhus University*

[3] *WSP*

Abstract

A comprehensive understanding of the often complex geological settings around a point-source polluted site is necessary for modelling the contamination transport and thereby providing a robust and reliable risk assessment.

The main objective of this study is to investigate how the SkyTEM Diamond system can be utilized for mapping point-source pollutions in comparison to established methods and to estimate the resolution and efficiency of the system evaluated against other geophysical methods.

The results from the investigated site demonstrate that the SkyTEM Diamond system bridges a gap between high-resolution ground-based surveys and large-sacle airborne mapping. The geophysical models provide the necessary spatial information to identify critical geological features that may constitue contamintant pathways.

Further, the SkyTEM Diamond system achieves better vertical resolution than the ground-based TEM systems. Simultaneously, the SkyTEM Diamond provides significantly higher efficiency than the other methods, including superior data coverage in difficult terrain.

Airborne mTEM Survey for Geotechnical Characterization Around the Kansanshi Mine, Zambia

Day 3 · 10:00–10:20 · Oral presentation

A. Prikhodko [1], A. Viezzoli [2], M. Ciaffarafà [2], R. Wilson [1]

[1] *Expert Geophysics Surveys Inc.*

[2] *EMergo s.r.l.*

Abstract

High-resolution characterization of near-surface geology is essential for geotechnical, hydrogeological, and mine-planning applications, yet many airborne electromagnetic systems are optimized for deeper mineral exploration and lack the early-time measurements required to resolve the upper few metres of the subsurface. This paper presents results from a helicopter-borne mTEM survey conducted over the Kansanshi Mine area, Zambia, covering 215 km^2 and 5,159 line-km. The survey was designed to map regolith thickness, bedrock topography, and shallow geological variations beneath thin cover.

The mTEM system combines a small transmitter-receiver geometry, 5 kHz base frequency, very early-time measurements, high spatial resolution, and robustness to industrial electromagnetic noise. Data processing included waveform characterization, geometrical corrections, coupling removal, altitude-time correction, and advanced inversion workflows. Results from a conventional conductivity inversion (GALEI) were compared with models produced using advanced processing and inversion in EEMstudio, including localized induced polarization (IP) modelling.

The advanced workflow reduced inversion misfit, improved imaging continuity, increased effective depth of investigation, and produced closer correspondence with known geology. The study demonstrates the effectiveness of airborne mTEM for detailed geotechnical characterization and near-surface geological mapping in active mining environments.

Airborne Electromagnetic Characterization of Shallow Permafrost in the Canadian Arctic for Infrastructure Challenges

Day 3 · 10:20–10:40 · Oral presentation

P. Chang Huang Arias [1], M.A. Couto Jr [1], L.J. Heagy [1], D.G. Froese [2], A. Alvarez [2], S.V. Kokelj [3]

[1] *Geophysical Inversion Facility, University of British Columbia*

[2] *Department of Earth and Atmospheric Sciences, University of Alberta*

[3] *NWT Geological Survey, Government of Northwest Territories, Yellowknife*

Abstract

Accelerating permafrost degradation across the Canadian Arctic poses increasing challenges for infrastructure stability, environmental monitoring, and northern communities. This project investigates the use of airborne frequency-domain electromagnetic (AEM) surveys to characterize shallow permafrost conditions along the Inuvik–Tuktoyaktuk Highway (ITH) corridor in the Northwest Territories, Canada. A total of 1,142 line-kilometres of AEM data were acquired and inverted to generate subsurface resistivity models. We present results from two areas along the ITH corridor that are experiencing infrastructure challenges associated with permafrost degradation driven by climate warming and highway construction effects. The resistivity models identify spatial variations associated with thawed and ice-rich permafrost, highlighting areas of concern and complex surface conditions. The results are evaluated using available ground-based observations, including borehole measurements, and supported by complementary remote sensing datasets. The resistivity models identify spatial variations associated with thawed and ice-rich permafrost, highlighting areas of concern and complex surface conditions. Overall, the study demonstrates the potential of AEM surveys as a rapid, large-scale, and cost-effective approach for permafrost characterization, supporting infrastructure monitoring and hazard assessment in remote Arctic regions.

Fast probabilistic inversion of airborne and ground-based EM data using GPU-accelerated rejection sampling

Day 3 · 11:20–11:40 · Oral presentation

T. Hansen [1], F.A. Falk [1], D.J. Okholm [1]

[1] *Aarhus University*

Abstract

We present integrate_module, an open-source Python package (MIT license) for fast, fully probabilistic inversion of airborne and ground-based electromagnetic (EM) data. Built on the extended rejection sampler with lookup tables, it integrates arbitrarily complex prior information (discrete lithology, non-Gaussian resistivity, groundwater table) with EM and borehole data, returning independent joint posterior samples of resistivity and lithology. Because the lookup table is built once and reused across all soundings, and the sampler is implemented in vectorised NumPy and GPU-accelerated JAX, survey-scale inversion is practical. 11,693 EM soundings invert in under 15 seconds on a GPU. Critically, the complete non-linear probabilistic workflow finishes faster (<1 hour) than a classical linearised deterministic inversion (~3.5 hours), while delivering full uncertainty quantification. A JSON query tool, with an optional large-language-model natural-language interface, lets non-specialists ask decision-relevant questions. For example, "the probability of ≥20 m of producible sand/gravel under ≤5 m overburden" answered directly from the posterior.

3D Modelling of Superparamagnetic Effect in Airborne Electromagnetics

Day 3 · 11:40–12:00 · Oral presentation

X. Ren [1], S. Wang [1], Z. Ke [1], C. Yin [1], Y. Liu [1], J. Macnae [2]

[1] *Jilin University*

[2] *RMIT University*

Abstract

Superparamagnetic (SPM) effects from ferromagnetic nanoparticles distort time-domain airborne EM (AEM) responses, often leading to misinterpretation. Existing studies are mostly 1D, ignoring the heterogeneous 3D nature of SPM carriers. This work develops a 3D AEM modeling framework by deriving a frequency-dependent magnetic permeability for SPM media and embedding it into Maxwell's equations. Using finite-element method on unstructured tetrahedral meshes, frequency-domain solutions are transformed to time domain. Numerical experiments on a half-space validate the algorithm with relative errors <2%. A 3D block model shows that SPM introduces a persistent secondary source near the upper surface of the anomaly, slowing late-time decay and enhancing amplitude with increasing susceptibility. This secondary source behaves differently from conventional smoke-ring diffusion, complicating interpretation. The framework enables accurate 3D simulation of SPM effects in AEM surveys.

A 3D finite volume approach for time-domain electromagnetic simulations with thin, highly conductive structures

Day 3 · 12:00–12:20 · Oral presentation

D. Cowan [1], L. Heagy [1], D. Oldenburg [1]

[1] *Univsersity of British Columbia*

Abstract

Inductive source time-domain electromagnetic (TDEM) methods are widely used to image ore-bearing mineralization, which often presents as thin, highly conductive bodies. Accurately simulating their inductive responses in geologically complex settings remains a numerical challenge. Here, we present a 3D hierarchical finite volume (HFV) formulation that accurately simulates the physics of thin conductors without undue computational cost. The formulation parameterizes the electrical properties of plate-like structures as conductances that live on mesh faces, and is implemented within the SimPEG framework. We validate the HFV code against plate-modelling software and show that it enables us to account for a background conductivity while using a fraction of the computational resources that would be required for standard 3D voxel approaches. We then demonstrate the simulation of airborne TDEM data where the geometry of the host and a conductive target are non-trivial, and the electrical properties of the target are inhomogeneous. By making such simulations tractable, the HFV formulation enables us to simulate geologically realistic scenarios involving thin conductive targets.

Modelling and inversion of deformable thin-sheet conductors for airborne time-domain electromagnetics

Day 3 · 12:20–12:40 · Oral presentation

A. Zamperoni [1]

[1] *Zamperoni Geophysics*

Abstract

Plate models are central to airborne electromagnetic (AEM) interpretation, but their flat, rigid geometry discards

information about a conductor's true shape into the residual. We present an extension of the conventional thin-plate

solution to deformable, sheet-like conductors, implemented in the Freeplate program, together with an inversion that

recovers conductor geometry directly. The forward problem is solved by two independently formulated methods, a fast

global-spectral solver and a geometry-native vertex stream-function solver on a triangulated mesh, whose agreement

gives a method-independent check on the curved physics; both reduce to the standard flat-plate response in the flat

limit. Because the mesh solver runs on an explicit triangulation, the same framework can drape a conductor over

topography or over an imported geological surface such as a fault or contact. The shape inversion parameterizes the

model by offsets at the surface's control points and lets the interpreter choose which points the data may move,

keeping an otherwise under-determined fit interpretable. We summarize the formulation, synthetic validation, and a

HELITEM field example over a complex curved conductor.

Resolution matrix based depth of investigation incorporating model constraints

Day 3 · 12:40–13:00 · Oral presentation

F. Hornung [1], A.V. Christiansen [1]

[1] *Aarhus University*

Abstract

The depth of investigation (DOI) is a key measure for assessing the reliability of geophysical inversion models. Conventional DOI estimates are commonly based on model sensitivities derived from the error-normalized Jacobian matrix. While this approach accounts for the final inversion model, system transfer function, and data uncertainty, it does not explicitly consider the influence of inversion regularization and model constraints.

This study extends a recently proposed DOI framework based on the model resolution matrix (MRM), which provides a posterior description of model resolution and inherently includes the effects of regularization. We introduce two DOI measures that explicitly incorporate lateral constraints within the MRM framework, enabling distinction between regions primarily resolved by local data and regions influenced by information propagated through neighboring models.

To further quantify parameter resolution, we introduce a resolution ratio that measures the degree to which individual parameters are independently resolved versus coupled through vertical and lateral constraints.

The methodology is demonstrated using a laterally constrained inversion of a SkyTEM survey from western Denmark. The proposed measures provide additional insight into the influence of lateral constraints and offer a valuable tool for interpreting constrained geophysical inversion models.

Integrated Airborne Electromagnetic and Magnetic Interpretation for Target Evaluation in a Sediment-Hosted Mineral System, Oman

Day 3 · 15:00–15:20 · Oral presentation

M. Sahin [1], S. Reford [1], D. Murray [1], M. Cihan [2], H. Al Balushi [2]

[1] *Xcalibur Smart Mapping*

[2] *Minerals Development Oman*

Abstract

This study presents an integrated interpretation of airborne time-domain electromagnetic (TDEM) and high-resolution magnetic data from a sediment-hosted mineral exploration project in Oman, locally constrained by limited ground gravity information. The objective was to evaluate conductivity anomalies, structural features and lithological variations in a mixed carbonate-siliciclastic basin setting affected by fold-related deformation, reactivated fault architecture and variable near-surface conductive cover.

The EM interpretation used apparent conductivity products, conductivity-depth imaging and Tau decay parameters to distinguish shallow conductive cover from more persistent bedrock-related conductive corridors. Magnetic interpretation, based on reduced-to-pole magnetic data and derivative products, provided structural constraints on fault trends, anticline-related fabrics and deeper lithological or basement-influenced contrasts. The most meaningful target zones are interpreted where conductivity persistence, Tau support, structural alignment, favourable sedimentary host conditions and independent geophysical evidence coincide.

Geological and Magnetic Constraints for Enhanced AEM-IP Inversion for Mineral Exploration

Day 3 · 15:20–15:40 · Oral presentation

S. Panepinto [1], J. Chen [1], F. Dauti [1], E. Kozlovskaya [2], G. Fiandaca [1]

[1] *University of Milan - La Statale*

[2] *University of Oulu - Mining School*

Abstract

This study presents a constrained inversion workflow for airborne electromagnetic data including induced polarization (AEM-IP), aimed at improving subsurface characterization in resistive and structurally complex environments. The approach integrates geological and magnetic information directly within an inversion framework, enhancing both model stability and geological consistency. The workflow combines standard AEM-IP inversion with structural constraints derived from geological mapping, combining lithological boundaries and dip information, and complementary magnetic constraints obtained through Source Parameter Imaging (SPI).

Within this framework, geological surfaces are used to guide lateral continuity and locally break inversion constraints across major structural boundaries, while magnetic-derived point-source solutions provide depth estimates and geometric control for magnetized bodies. This integrated strategy allows the inversion to better account for layered intrusion architectures and associated physical property contrasts. Application to the Akanvaara Cr–V–PGE intrusion demonstrates that the inclusion of geological and magnetic constraints leads to a more coherent model compared to unconstrained inversion.

Results show improved delineation of conductive and chargeable horizons, stronger agreement with geological features, and reduced ambiguity associated with induced polarization effects in resistive host rocks. The methodology demonstrates the value of multi-source constraints for enhancing AEM-IP imaging and interpretation in critical raw material exploration.

Investigating the former mining site of Abbaretz (France) with the new SkyTEM Diamond and tTEM systems

Day 3 · 15:40–16:00 · Oral presentation

A. Signora [1], B. Maurice [1], V. Guerin [2], N. Coppo [1], P. Reninger [1]

[1] *BRGM, French Geological Survey, DCGS/GTS*

[2] *BRGM, French Geological Survey, DRISS/RSSP*

Abstract

The Abbaretz area (Loire-Atlantique, France) hosted heavy industrial tin exploitation between 1952 and 1957. Nowadays, around 3.7 million m3 of mining residues are still present onsite within two dumps composed of rock tailings and mining processing waste. The presence of acid mining drainage (AMD) within the waste storage area resulted in its inclusion in a management and remediation project. Yet, uncertainty remains regarding the location of the contaminant flow paths within the schist bedrock, whose fractures control groundwater discharge in the area.

This study presents a geophysical investigation which aims to better identify the AMD seepage from the tailings to the surrounding areas. For this purpose, the new Airborne EM Diamond system and the ground tTEM system are employed.

After the comparison of the two systems, the first results from this study are presented, showing the airborne EM model to have a higher vertical resolution than the ground EM model. This improvement, combined with the wider and deeper airborne model coverage, may mark the beginning of a new season for airborne EM surveys in high-resolution and environmental studies.

A Novel Lightweight, Large Magnetic Moment UAV-Borne Transient Electromagnetic System and Its Field Tests

Day 3 · 16:20–16:40 · Oral presentation

X. Zhang [1,2], F. Teng [1,2], S. Li [1,2], X. Jiao [1,2], J. Lin [1,2]

[1] *College of Instrumentation and Electrical Engineering, Jilin University*

[2] *State Key Laboratory of Deep Earth Exploration and Imaging*

Abstract

To address the limitations of existing unmanned aerial vehicle (UAV)-borne transient electromagnetic (TEM) detection systems under constrained payload and power capacity, which make it difficult to achieve fine detection of both shallow and deep targets simultaneously, this paper proposes a novel UAV-borne TEM detection system with lightweight and large-magnetic-moment designs. Specifically, a half-sinusoidal multi-pulse-moment transmitter system is developed based on an H-bridge inverter and a gate-controlled series capacitor (GCSC) load matching technique, enabling flexible adjustment of multi-pulse current parameters and turn-off characteristics. Correspondingly, a lightweight receiving system with a large dynamic range and high sensitivity is designed. The overall system satisfies the weight constraints for UAV mounting and can acquire multi-depth geological information in a single flight without complex hardware configuration. Preliminary field flight experiments demonstrate that the system accurately identifies preset underground anomalous bodies, thereby comprehensively improving the efficiency and accuracy of UAV-borne TEM exploration.

Nonlinear model for the self-interference compensation in AEM

Day 3 · 16:40–17:00 · Oral presentation

E. Tretiakova [1], E. Karshakov [1]

[1] *V.A. Trapeznikov Institute Of Control Sciences Of Russian Academy Of Sciences*

Abstract

This study presents an analysis of existing methods for compensating for carrier interference in AEM data, culminating in the proposal of a new approach based on a polynomial expansion of the self-interference field based on the measured field of two dipoles. Carrier interference compensation algorithms using third-order polynomials were developed, demonstrating that the use of a third-order polynomial provides a compensation depth comparable to the sensitivity of the field sensors used. Experimental verification confirmed effective self-interference compensation using data obtained with a two-dipole configuration. The geometric limitations inherent in this method were identified, and an optimal regularization parameter was introduced and determined for estimating the coefficients of a cubic self-interference model, further enhancing the reliability and accuracy of the compensation process.

Drone-borne EM mapping using VLF radio signals

Day 3 · 17:00–17:20 · Oral presentation

N. Zorin [1], D. Epishkin [2], G. Muradyan [3]

[1] *Harbin Institute Of Technology*

[2] *Schmidt Institute of Physics of the Earth RAS*

[3] *Moscow State University*

Abstract

This study demonstrates the feasibility of high-precision total-field VLF-EM measurements using lightweight unmanned aerial vehicles. The proposed approach is based on calculating the Euclidean norm of the full complex magnetic field vector, making the measurements independent of sensor orientation. Variations in the primary field are compensated by normalizing the data with a synchronized reference signal recorded by a stationary base receiver. Measurement accuracy is further improved through pre-flight sensor calibration and spatial smoothing during data processing.

Test surveys show excellent reproducibility, with differences between repeated measurements of less than 0.5% of the signal amplitude. The resulting total-field VLF-EM anomalies show good agreement with those obtained from conventional ground-based inductive electromagnetic surveys.

YmerFlow: An open-source browser-based platform for AEM processing, forward modeling, and inversion

Day 4 · 09:00–09:40 · Oral presentation

E. Möller [1], B. Bloss [2]

[1] *Redhog.org*

[2] *Bloss Geo*

Abstract

YmerFlow is an open-source, browser-based platform that brings the full AEM workflow — signal processing, spatially constrained inversion, forward modeling, and interactive 3D visualization — into a single no-code environment. Built on SimPEG, emerald-processing-em, and libaarhusxyz, every result is fully reproducible without installing expensive proprietary software packages or writing a single line of code. We demonstrate YmerFlow on the publicly available LPNNRD2018 SkyTEM 304HR dual-moment dataset, applying two parallel workflows: inversion of the published processed data and a full pipeline from raw data through processing and inversion entirely within YmerFlow. Both workflows recover the principal hydrogeologic stratigraphy — thin conductive near-surface layers, a resistive aquifer package, and a conductive basement — consistent with the published model. The integrated AEM Model Simulator enables interactive synthetic modeling, survey design, and depth-of-investigation analysis in the same browser session.

Infrastructure-aware inversion for imaging a fault zone with semi-airborne electromagnetics

Day 4 · 09:20–09:40 · Oral presentation

M. Bayat [1,2], T. Günther [2], R. Rochlitz [1], M. Schiffler [3], S. Nazari [1], M. Ronczka [1]

[1] *LIAG Institute For Applied Geophysics*

[2] *Freiberg University of Mining and Technology*

[3] *Leibniz-Institute of Photonic Technology*

Abstract

Imaging subsurface conductivity structures with semi-airborne electromagnetic (SAEM) data can be challenging in areas containing man-made infrastructure. Conductive objects such as high-voltage power lines and buried pipelines act as secondary sources and produce electromagnetic responses that can interfere with geological signals, leading to misinterpretation. This study investigates the impact of such infrastructure on synthetic and field SAEM data as well as on electrical resistivity models final as inversion results. Two synthetic models were compared: one including the infrastructure and one without it. The findings were further validated using field SAEM data acquired in an area includes a high-voltage power line and underground gas pipelines. The results show that both types of infrastructure generate strong conductive anomalies that can mask or distort the true conductive structure of a fault zone. To address this problem, these man-made features were explicitly incorporated in the inversion domain with fixed electrical resistivity values. This constrained the inversion to account for their electromagnetic responses directly, preventing the inversion from introducing artificial conductive anomalies into the recovered electrical resistivity models.

Machine-learning prediction of rock quality designation from AEM and geotechnical data in a Himalayan railway tunnel

Day 4 · 09:40–10:00 · Oral presentation

C.W. Christensen [1], P. Rodrigues [1], F. Pacheco [1], A. Pfaffhuber [1], G. Skurdal [1], A. Gangwar [2]

[1] *EMerald Geomodelling AS*

[2] *Rail Vikas Nigam Limited*

Abstract

Airborne electromagnetics (AEM), when combined with sparse borehole logs and supervised machine learning, can produce spatially continuous engineering-geology models along linear infrastructure corridors. Existing workflows for volumetric lithological classification are insufficient for existing engineering parameters that are continuous scalars rather than discrete classes.

We extend an existing volumetric classification workflow to numerical regression and apply it to Rock Quality Designation (RQD) along a 40 km segment of the Rishikesh–Karanprayag railway in the Indian Himalaya. An ensemble of artificial neural network regressors is trained on RQD logs from 65 boreholes using inverted SkyTEM 312 resistivity and spatial and terrain-derived support variables. Key adaptations from the classification workflow included a larger ensemble, longer early-stopping patience, and kernel-density sample reweighting to counter the strong zero-bias in RQD. Modelling RQD specifically also required post-processing clipping to physical bounds and window-averaging to reconcile the differing vertical resolution of AEM and borehole data.

Five-fold grouped cross-validation gives a mean absolute error of 11.1 percentage points; high-RQD intervals are underpredicted but flagged by elevated uncertainty. A subset experiment shows that 40–50% of boreholes recover the principal RQD structures. This study demonstrates AEM's utility as a route optimisation and borehole planning tool, especially in early-phase projects.

Inverting for Features: A Hierarchical Latent Framework for Airborne Electromagnetic Inversion

Day 4 · 10:00–10:20 · Oral presentation

G. Schöning [1,2], J. Doherty [3,2]

[1] *Office of Groundwater Impact Assessment*

[2] *Flinders University, South Australia*

[3] *Watermark Numerical Computing*

Abstract

Airborne electromagnetic (AEM) inversion is ill-posed, so regularisation is unavoidable, and the form it takes determines what the inversion can find. That form is frequently selected on algorithmic grounds rather than driven by the data. Traditional regularised inversion imposes a spatial penalty on conductivity and so tends to obscure discrete, high-contrast features. We introduce Hierarchical Latent Inversion (HLI), which moves the regularisation off the conductivity field and into an uncorrelated latent space. The subsurface is parameterised with independent, identically distributed latent variables that an averaging operator maps to conductivity. The operator's correlation length is co-optimised rather than imposed and broadens with depth, while a sparsity penalty admits only as many features as the data require. On a synthetic faulted model HLI recovers sharp displacements that a laterally constrained inversion smears, and on a regional SkyTEM survey of the Condamine Alluvium in Southeastern Australia, it resolves aquifer boundaries that other inversions merge into a single recognisable feature. These interfaces are confirmed by wireline logs and stay coherent well below the standard depth of investigation. HLI is therefore best understood as a complementary interpretation tool, aimed not at estimating bulk electrical properties but at the discovery of subsurface features.

3D Total-Field Modelling and Inversion of Grounded-Wire Source TFEM Data with Induced Polarization Effects

Day 4 · 10:20–10:40 · Oral presentation

K. Qu [1], O. Terblanche [2], A. Viezzoli [3], J. Chen [1], G. Fiandaca [1]

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Abstract

We develop a 3D total-field finite-element framework for modelling and inversion of grounded-wire TFEM data with induced polarization effects. The forward problem is solved in the frequency domain on Octree meshes and transformed into time-domain off-time responses. Unlike conventional component data, TFEM is a scalar total-field response obtained by projecting the magnetic field onto the local geomagnetic-field direction, making the data dependent on both the 3D EM field and geomagnetic-field orientation. Synthetic modelling over conductive and chargeable targets shows that IP effects can significantly modify TFEM decay behaviour; ignoring them may bias subsequent interpretation. However, negative late-time total-field responses are not necessarily diagnostic of IP, because they may also arise from vector projection effects controlled by source-receiver geometry and receiver position. The inversion is implemented within the EEMverter strategy using decoupled Octree forward and structured inversion meshes linked by spatial interpolation. Synthetic inversion results reproduce the input TFEM data and recover both conductivity and IP information, demonstrating the potential of the proposed workflow for grounded-wire TFEM interpretation.

Recent follow-up geophysical surveys after airborne survey for Graphite exploration in Vikeid area, North Norway

Day 4 · 11:20–11:40 · Oral presentation

V.C. Baranwal [1], B.E. Larsen [1], F. Szitkar [1], G. Tasis [1], S. Wang [1], E.R. Norum [1], H. Gautneb [1], J.K. Solberg [1], M. Ganerød [1], M. Osinska [1], M. Bastani [2], E.D. Alofe [3], H. Hansen [4]

[1] *Geological Survey of Norway (NGU)*

[2] *Geological Survey of Sweden (SGU)*

[3] *Department of Earth Sciences, Uppsala University*

[4] *Arctic Graphite As, Sortland*

Abstract

Graphite is considered a critical raw material by the European Union and is an important mineral for the GREEN transition. Graphite mineralisations in Norway occurs in metamorphic rocks and is not easily visible at the surface due to erosion and overburden. Recent airborne geophysical surveys (helicopter EM and magnetic) with ground follow-up surveys and truthing were performed under the Minerals in North Norway (MINN) program during 2011–2015 in North Norway. Further geophysical follow-up surveys including drone magnetic, ERT, cross-hole ERT, controlled source radio magnetotellurics (CSRMT), surface time-domain EM (sTEM), borehole logging and oriented samples collection were performed near Vikeid, Vesterålen during field campaigns in 2024 and 2025 to understand graphite's distribution and relation between its magnetic and conductive properties.

The graphite zones are identified quite well by frequency-domain airborne EM and other electrical and EM surveys within the resolution limit of these geophysical methods. Petrophysical and paleomagnetic analyses of oriented and general samples from area showed that samples containing graphite have low magnetic susceptibility. Some of the host rock samples showed very high susceptibility and remanent magnetisation. However, a very strong remanent magnetisation is needed to justify strong negative magnetic anomalies observed in the field.

Ground IP Follow-Up Targeting for Mineral Exploration Using 3D AEM Modelling in Mountainous Terrain

Day 4 · 11:40–12:00 · Oral presentation

M. De Angelis [3], F. Dauti [1], L. Lo Schiavo [3], M. Moroni [2], G. Fiandaca [1]

[1] *The EEM Team for Hydro and eXploration - Univeristy Of Milan*

[2] *Univeristy Of Milan*

[3] *Freelancer*

Abstract

This study integrates airborne and ground geophysics to characterize a complex Ni-Cu-Fe sulphide mineralized body in the Ivrea-Verbano Zone (Italy). Airborne electromagnetic (AEM) data were used to guide targeted ground follow-up investigations. Exploration was driven by an advanced 3D electromagnetic inversion that models both conduction and polarization using an efficient primary-secondary field separation technique. This approach reduces computational demands and eliminates the need for ultra-dense meshing, allowing the 3D models to accurately and rapidly honor the rugged Alpine topography. The resulting models delineate near-surface conductive and chargeable domains consistent with coexisting massive and disseminated sulphides. A targeted ground follow-up campaign—using galvanic (DCIP) and inductive (TEM2Go, sTEM, MLEM) methods—successfully confirmed a deep chargeable core and a highly conductive deep structure. Direct comparison with airborne resistivity isovolumes (ρ < 30 Ω · m) demonstrates excellent multi-scale correlation, validating an efficient workflow in which ground IP follow-up is guided by AEM-IP 3D inversion results, thereby substantially reducing logistical complexity and exploration costs.

Wide-Azimuth Semi-Airborne Electromagnetic Method Using Total Magnetic Field Intensity for 360° Detection

Day 4 · 12:00–12:20 · Oral presentation

Y. Zhu [1], D. Li [1], Y. Wang [1,2]

[1] *Central South University*

[2] *Hunan Geosun High-tech Co., Ltd*

Abstract

This study proposes a wide-azimuth semi-airborne electromagnetic (WASAEM) method to address key limitations of conventional SAEM systems, including zero-value bands and angular sensitivity of single-component measurements. The method reconstructs horizontal and total magnetic field intensities from orthogonal components, enabling stable electromagnetic detection under arbitrary sensor attitudes. A high-power transmission system using pseudorandom multi-frequency signals is developed, supporting simultaneous transmission of 39 frequencies within the 4–9,600 Hz range. UAV-based two- or three-component magnetic sensors are employed for data acquisition. Numerical simulations indicate that horizontal magnetic field intensity is insensitive to azimuthal variations, while total magnetic field intensity remains stable under arbitrary attitude changes, effectively eliminating angular errors. Field experiments in a water-rich sedimentary area demonstrate high consistency of resistivity imaging across survey lines, with no significant systematic or flight-induced errors. The proposed WASAEM system extends azimuthal detection to 360°, improves measurement robustness, and enhances subsurface imaging reliability, providing an effective approach for geophysical exploration in complex environments.

Cultivating Open Data: Updates to the Geophysical Survey (GS) Data Standard and GSPy Software Tools

Day 4 · 12:20–12:40 · Oral presentation

S. James [1], B. Minsley [1], N.L. Foks [2], B. Hoogenboom [1], J. Crosbie [1]

[1] *U. S. Geological Survey*

[2] *Inalab Consulting, contracted to the U. S. Geological Survey*

Abstract

Geophysical data can adopt numerous formats depending on the choice of method, instrumentation, and system, or other aspects like institutional preferences and software compatibility. Moreover, survey details are required to fully understand the data yet are often documented separately and with no common practice. We developed the unifying framework of the Geophysical Survey (GS) data standard to provide an open, communal format and metadata convention that improves the transferability and usability of geophysical datasets. The GS standard has been developed with particular attention to airborne electromagnetic (AEM) datasets as they exemplify data/metadata complexity and have particular need for standardization. In version 2.0, the GS standard and companion Python package, GSPy, have been optimized for adaptability through a "Data Tree" motif. The Data Tree is composed of limited group types with a strict hierarchy: 1) a survey root group, 2) branch nodes, 3) data leaves, and 4) supplementary leaflets. Lastly, we developed a graphical user interface (GUI) application for GSPy to reduce barriers to adoption. The new Data Tree construct strikes a balance between strict standardization and flexibility, and with advancement of software tools the GS standard continues to be well-positioned as the communal format for geophysical datasets.

Driving Deep Mineral Exploration with Semi-Airborne EM Technologies: The DESMEX Project Suite

Extended-abstract poster · Stand 1

A. Steuer [1], M. Becken [2], T. Günther [3,6], P. Yogeshwar [5,3], M. Schiffler [4], R. Rochlitz [3], W. Mörbe [5,3], A. Thiede [2], P.O. Kotowski [2], S. Nazari [3]

[1] *Federal Institute for Geosciences and Natural Resources (BGR)*

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[4] *Leibniz-IPHT Jena*

[5] *University of Cologne*

[6] *TU Bergakademie Freiberg*

Abstract

The DESMEX project suite develops semi-airborne electromagnetic (SAEM) technologies to explore deep mineral deposits - down to about 1000 m - by combining powerful ground transmitters with highly sensitive airborne receivers. Across several project phases, the consortium has built advanced receiver systems (induction coils, SQUIDs, OPMs), created new processing and inversion methods, and tested the technology in Germany, Sweden, Namibia, and Spain.

The systems were also adapted for UAV platforms, enabling low-cost and flexible surveys in small or difficult terrain, though with shallower penetration depths than helicopter-towed systems.

DESMEX-REAL established a real-world laboratory in the Upper Harz Mountains, integrating geophysical surveys with extensive geological archives to build a 3D subsurface model.

The newest phase, DESMEX-MinD, expands the approach to mineral system analysis, integrating geophysical, geological, and geochemical data and applying AI-based interpretation to identify exploration targets in the Upper Harz and the Erzgebirge.

Overall, the DESMEX projects show that semi-airborne EM systems can image deep conductive structures beyond the reach of conventional airborne EM and that UAV-based systems provide a valuable, flexible option for detailed local investigations.

Three-dimensional inversion of QAMT airborne natural-source electromagnetic data

Extended-abstract poster · Stand 2

M. Schiffler [1], A. Thiede [2], R. Rochlitz [3], M. Schneider [4], M. Becken [2], R. Stolz [1,5]

[1] *Leibniz Institute of Photonic Technology*

[2] *University of Münster*

[3] *LIAG Institute for Applied Geophysics, Hanover*

[4] *Supracon AG, Jena*

[5] *Ilmenau University of Technology*

Abstract

Airborne natural source electromagnetics (EM) is a deep-sounding method like magnetotellurics, providing efficient and large-scale data acquisition even in rough or inaccessible terrains. exploiting natural EM field variations. Supracon's QAMT airborne instrument allows for the acquisition of three-dimensional magnetic field data in Earth-fixed coordinates at very high resolution. The airborne recorded data are processed to magnetic inter-site transfer functions referring to ground-based horizontal field recordings.

This procedure raises special requirements for modelling and inversion of these physical quantities. After data processing, we extract these quantities and feed them into the modelling toolbox custEM. Corresponding forward responses and Jacobians are calculated for the use with the inversion library pyGIMLi. CustEM is an open source, finite-element code designed for airborne applications and allowing for the implementation of complex topography.

We present inversion results of three case studies performed with the QAMT platform: One dataset acquired at Gobabis (Namibia) showing good agreement with the geological model, reaching depths of investigations of up to 2 km. Secondly, Supracon AG and DIAS Geophysical Ltd. carried out measurements at Hatchet Lake (Canada), with the capability of cross-validation and joint inversion with ZTEM data. Finally, we present a recent example from the Kuusamo Schist Belt in Finland.

A Cloud Platform for Joint Time-Frequency Electromagnetic Inversion and Multi-Method Airborne-Related EM Processing

Extended-abstract poster · Stand 3

Z. Huang [1,2], M. Zhang [1,2], Q. Wang [1,2], J. Lin [1,2]

[1] *Jilin University*

[2] *State Key Laboratory of Deep Earth Exploration and Imaging*

Abstract

Airborne-related electromagnetic (EM) methods are widely used in mineral exploration and geological investigation, yet their processing workflows often remain fragmented across desktop tools, limiting resource sharing, reproducibility, and integrated interpretation. This paper presents a browser-based cloud platform for multi-method airborne-related EM processing and joint time-frequency inversion. Built on a configuration-driven architecture and method registry, the platform supports data upload, asynchronous server-side computation, task and result management, and 2D/3D visualization through a unified web interface. GAFEM, GATEM, ATEM, and joint-inversion workflows share common front-end services, API endpoints, and task-dispatching infrastructure while retaining method-specific backend modules. The joint inversion combines TDEM time-channel and FDEM frequency-point data in a single objective function that constrains a shared log-resistivity model using per-datum noise weighting, a Huber robust penalty, Occam-style regularization, and Gauss-Newton optimization. A mine-backfill case study demonstrates the end-to-end workflow using measured FDEM responses and converted TDEM-like responses generated by a neural-network-based FDEM-to-TDEM conversion model. Because the TDEM-like responses were not independently acquired, the case is presented as a workflow demonstration rather than a full validation of inversion accuracy. The demonstration shows that the platform can organize heterogeneous EM datasets and execute, manage, and visualize single-domain and joint-inversion workflows within one browser environment.

CNN-GRU-Based One-Dimensional Inversion of Airborne Transient Electromagnetic Induction and Polarization Effects

Extended-abstract poster · Stand 4

H. Luan [1], N. Chang [1], Y. Ji [1], Q. Wu [1], X. Zhao [1], H. Liu [1], S. Qiu [1], Y. Yu [1]

[1] *Jilin University*

Abstract

Currently, data interpretation and inversion methods for Airborne Transient Electromagnetic Method (ATEM) primarily include traditional linear inversion methods, methods based on intelligent optimization algorithms, and machine learning-based electromagnetic data imaging methods. Traditional inversion algorithms use iterative procedures for data inversion calculations, which are relatively inefficient and struggle to handle complex subsurface electrical structures accurately and efficiently. ATEM inversion methods based on intelligent optimization algorithms are time-consuming, involve complex parameter tuning and exhibit poor stability, and are prone to getting stuck at local optima. Furthermore, their resolution remains inadequate for complex subsurface electrical structures.

Artificial neural networks hold great potential for addressing nonlinear and unstructured problems, making them particularly well-suited to the characteristics of ATEM inversion data. This paper combines Convolution Neural Networks with Gated Recurrent Units for one-dimensional inversion of ATEM data. This method can simultaneously obtain feature representations in both the temporal and spatial domains. During inversion, simply inputting preprocessed measured ATEM decay data into the trained neural network model allows for the direct and rapid determination of the corresponding subsurface electrical structure. This eliminates the need for iterative optimization, significantly improving the computational efficiency and stability of the inversion process.

FD Airborne System EM4H: A Tool for Efficient Regional-Scale Geological Mapping and Mineral Exploration

Extended-abstract poster · Stand 5

K. Antashchuk [1], E. Karshakov [2]

[1] *PJSC Polyus*

[2] *GeoTechnologies*

Abstract

The EM-4H frequency-domain airborne electromagnetic system is an efficient tool for regional geological mapping and mineral exploration, especially in remote and mountainous areas. Operating simultaneously at four frequencies (130, 520, 2080, and 8320 Hz), it provides informative data on near-surface geoelectrical structures and supports interpretation in both resistive and conductive geological environments.

Experience from surveys in Russia shows that EM-4H can be effectively used not only at the regional mapping stage but also for prospecting tasks, reducing the need for more expensive time-domain electromagnetic surveys in some cases. Integrated with magnetic and gamma-ray spectrometry data, EM-4H helps map fault zones, lithological boundaries, intrusive bodies, contact metamorphism, and alteration zones.

Regional surveys in the Magadan Region demonstrated its ability to identify prospective areas for polymetallic and gold mineralization. At a copper-porphyry prospect in the Russian Far East, EM-4H results were comparable to TDEM data in outlining major geoelectrical contrasts, intrusive-related structures, and conductive fault zones.

Although EM-4H has lower investigation depth than TDEM systems, its cost-effectiveness, rapid deployment, and sufficient resolution make it a valuable method for planning further ground-based, UAV, and detailed exploration surveys.

Comparison of Extended and Unscented Kalman Filter Algorithms for Geophysical Inversion

Extended-abstract poster · Stand 6

D. Khliustov [1], E. Karshakov [1]

[1] *Geotechnologies LLC*

Abstract

The abstract compares two algorithms for solving inverse problem of airborne electromagnetics - Extended Kalman Filter and Unscented Kalman Filter. It is shown that EKF may provide low residual, but biased solution in cases when UKF arrives to the correct model. The abstract compares UKF and EKF results in inverting data form Sardara, Italy. It is demonstrated that the depth of investigation, as measured by sensitivity of model parameters, is larger for UKF.

ReDoCO2: High-resolution mapping of lowland soils using drone-based geophysics

Extended-abstract poster · Stand 7

T.B. Rasmussen [1]

[1] *I•GIS A/S*

Abstract

The ReDoCO2 project presents an integrated workflow for high-resolution mapping of lowland soils and peatlands, aimed at supporting climate mitigation and rewetting initiatives. Accurate mapping of peat distribution, thickness, and hydrogeological conditions remains a key challenge due to limited accessibility and insufficient near-surface resolution in traditional methods.

The developed methodology combines drone-based geophysics, machine learning, and geological modelling into a unified framework. High-resolution subsurface data are acquired using drone-mounted transient electromagnetic (TEM) systems, complemented by airborne gamma measurements that delineate the lateral extent of peat. These datasets are integrated with limited ground-truth observations and processed through machine learning algorithms to optimise data acquisition and interpretation.

A pilot study from Oebakker, Denmark, demonstrates the capability of the workflow. The combined approach enables improved mapping of peat thickness and extent, identification of previously unmapped mineral in-islands, and the generation of spatial models of peat properties and subsurface conditions.

The results support scenario-based CO_2 emission modelling, illustrating the potential for significant emission reductions through rewetting. Overall, the workflow reduces reliance on extensive field investigations while improving data quality and decision support for peatland management.

Mobile MT surveys over epithermal gold deposits in central Azerbaijan

Extended-abstract poster · Stand 8

V. Kaminski [1], F. Huseynov [2], H. Hasanli [2]

[1] *Promiseland Exploration, Ltd*
[2] *Azergold, CJSC*

Abstract

The epithermal deposit under study is located in Dashkesan region of central Azerbaijan. It is an economically significant producing mine, known for its rich mineral resources, particularly gold and copper. The area has undergone extensive airborne EM surveying using Mobile MT technology and interpretation presented herein is predominantly based on results derived from 2.5D inversion of MMT data and 3D inversion of magnetic data. Some deposits can be clearly seen in resistive domain, while one is generally associated with a conductive zone, which leads to interpretation dependant not only on presence of ore, but also on levels of oxidization of ores, alongside with other significant differences in mineral composition of the targets.

Using advanced hybrid type UAV for semi-airborne TDEM: examples from South Africa and Russia

Extended-abstract poster · Stand 9

V. Kaminski [1], V. Hallbauer [1]

[1] *Promiseland Exploration, Ltd*

Abstract

In this study we are showing examples of semi-airborne UAV surveys with recent equipment upgrades, featuring modified TSIKL PDI-50 sensor, installed on a new hybrid “hornet” UAV carrier, capable of delivering over 1 hour of flight time in automated mode. TDEM surveys are powered by a 200 x 200 m ground loop. Interpretation of the in-loop and out-of-loop data is based on ASFI method (Advanced Floating S-plane Inversion), a fast and reliable method suitable for inversion of airborne (helicopter and UAV platforms) TDEM data, which also works in presence of airborne IP (AIP). The method is based on S-plane modelling and theoretical background is supported by two field examples from Russia and South Africa.

Trial-and-error approach for noise reduction in AEM data

Extended-abstract poster · Stand 10

P. Reninger [1]

[1] *BRGM, F-45060 Orléans, France*

Abstract

AEM is a tool integrated into many studies aiming at understanding the first few hundred meters of the subsurface for hydrogeological purposes, risk assessment or mineral resource exploitation.

However, most of the areas of interest are located in anthropized environments, resulting in significant noise in the measured data.

In order to reduce this noise, a processing methodology based on a trial-and-error approach was developed.

This includes a supervised stacking and an adaptive trapezoidal filtering.

The principle is to stack the data by testing different combinations in order to find those that lead to the least noisy data.

This methodology is now routinely applied to the acquired data.

The results obtained in highly anthropized areas demonstrate the ability of this type of approach to reduce noise by adapting to its variations over the area studied.

Cumulative Conductance Mapping for the Direct Transformation of TDEM Data into 1D Resistivity Models

Extended-abstract poster · Stand 11

O.I. Calderon Hernandez [1], L.V. Socco [1,2], E. Slob [2]

[1] *Politecnico Di Torino*

[2] *Delft University of Technology*

Abstract

Inversion of Time-Domain Electromagnetic (TDEM) data is an inherently non-unique problem. To address this, we present a fully data-driven method that directly transforms 1D TDEM data into layered resistivity models via cumulative conductance mapping. By defining a cumulative conductance model function of the diffusion time, and by transforming the TDEM data into a conductance by using the S-transformation, we establish a mapping function that allows the conversion of the transient data into a cumulative conductance model, that is then differentiated to recover a 1D resistivity model. To generalize this for unknown data without a priori constraints, a neural network is trained to predict this mapping. Furthermore, the predicted mapping function follows the true current density maxima, highlighting how the mapping function is related to the diffusion of the EM field. To evaluate the proposed methodology on field data, we used the Southern Thomson Orogen VTEM plus Airborne Electromagnetic dataset, published by Geoscience Australia. The survey's goal to characterize underlying geological structures makes it a good case study for assessing the robustness the methodology in a real-world scenario. Our results show that our method retrieves resistivity profiles that follow the same trend as the CDI profiles published in the repository.

Drone-based frequency domain EM sounding system MEMI: 6 years' experience for mineral exploration.

Extended-abstract poster · Stand 12

K. Antashchuk [1], A. Atakov [2], K. Kharchenko [3]

[1] *Chief Expert in Geophysics*

[2] *Karpinsky Russian Geological Institute*

[3] *ALPOM Ltd*

Abstract

The MEMI drone-based frequency-domain electromagnetic (EM) sounding system has been developed for mineral exploration and geological mapping over large and logistically challenging areas. During six years of field application, the system has been successfully used in remote regions of Russia, including the Far East, Transbaikalia, Altai and Yakutia, where mountainous terrain, limited infrastructure and difficult access strongly constrain conventional ground surveys. The lightweight UAV-towed receiver records three magnetic-field components in the 10 Hz–100 kHz range from a grounded electric dipole source, enabling efficient acquisition of geoelectrical data over areas from tens to hundreds of square kilometres. More than 1000 km^2 have been surveyed to date, demonstrating the capability of the technology to construct resistivity sections to depths of about 600–1000 m, map lateral variations in subsurface electrical properties and delineate prospective zones. A case study from a gold prospect shows that MEMI data can identify structural and lithological controls of mineralization, guide ground verification surveys and support exploration targeting. The experience confirms that UAV-based EM sounding is a productive intermediate-scale tool for mapping and prioritizing search areas in remote regions.

Generating Power Line Maps from High-Resolution Aerial Imagery for Automated Detection of Galvanic Coupling in TEM-Data

Extended-abstract poster · Stand 14

M. Michaelsen [2], T.H. Soeltoft [1], A.V. Christensen [1], J.J. Larsen [1], M.R. Asif [1]

[1] *Aarhus University*

[2] *Seequent*

Abstract

TEM data requires careful processing, which is typically performed manually by domain experts, making the process time-consuming and difficult to scale. While deep learning approaches exist for detecting capacitive coupling from individual soundings, they are not applicable to galvanic coupling, which cannot be identified from soundings alone. As such, no methods exist for detecting galvanic coupling in TEM data.

We propose an automatic processing workflow for detecting galvanic coupling caused by power lines (PLs) by producing PL maps using state-of-the-art deep learning methods, serving as a proxy for detecting affected TEM soundings. A connected graph-based PL representation is used to remove TEM data within a predefined unsafe distance.

The approach is validated against manually processed survey data. Using a 200 m safe distance, it captures most manually flagged gates while also removing additional soundings in most lines. The workflow is near instantaneous and reduces processing time while resulting in more aggressive data removal.

Overall, the proposed approach provides a scalable alternative to manual processing and reduces the need for trained experts during TEM processing. Although this work focuses on PLs, it can be extended to other types of infrastructure, further reducing processing time.

Adaptive AEM Inversion driven by Decay Characteristics and Improved Estimation of Background Resistivity

Extended-abstract poster · Stand 15

R. Paterson [1]

[1] *Intrepid Geophysics*

Abstract

We investigate a method run prior to inversion that will identify AEM survey line segments where cultural or non inductive interference is identified and classified. This information is then used to adapt/optimise the inversion method as it proceeds, estimate the reliability of the result and minimise the need for repetition. In particular we want to identify survey noise, powerline interference, induced polarisation (IP), super paramagnetic (SPM), pure induction effects or mixtures thereof.

In addition we propose a fast approximate method that estimates the background resistivity across the survey area for the purpose of adapting the starting model to the background geoelectrical domains and thereby improving the convergence speed and minimising residual halfspace remnants and improving line to line coherence in a 2.5D inversion

A New UAV-Based Semi-Airborne EM System for Shallow and Deep Investigations

Extended-abstract poster · Stand 16

G. Paleolog, A. Trusov, O. Kontarovich

[1] *AGP Consulting*

[2] *AGP Consulting*

[3] *AGP Consulting*

Abstract

In this paper, we present a new lightweight broadband UAV-based semi-airborne EM system and discuss the first results obtained with it. The receiver payload weighs only 4 kg and operates in the frequency range from 10 Hz to 100 kHz, making it suitable for both shallow high-resolution surveys and deeper resistivity imaging. Two case studies are presented: a shallow survey using relatively high frequencies and short offsets, and a deeper survey using lower frequencies, a long grounded transmitter, and large transmitter-receiver offsets. For the deep case, the SAEM inversion result is compared with the result of a conventional electrical resistivity tomography (ERT) survey.

A New Natural Field Airborne EM System: AGP-MT

Extended-abstract poster · Stand 17

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Abstract

AGP-MT is a new passive airborne electromagnetic system based on natural electromagnetic fields in the audio-frequency range. It continues the development of the AFMAG concept and modern natural-field systems such as ZTEM and MobileMT, while introducing a new receiver design, acquisition architecture, and processing workflow. The system records three airborne components of dB/dt using 1.5 m induction coils installed in a specially damped bird. A ground base station simultaneously records Ex, Ey, Hx, Hy, and Hz, providing MT-type reference data. Both airborne and base-station signals are acquired at 120 kHz over a frequency range of 40 Hz to 20,000 Hz.

Initial test surveys produced convincing results: AGP-MT anomalies correlate with known geological structures and complement AGP-TEM data acquired over the same area. The system shows strong potential for rapid geological mapping and mineral exploration, especially in difficult terrain and areas where passive airborne EM provides advantages over active-source methods.

Managing Geological Knowledge Derived from Airborne Electromagnetic Mapping: The LARCOS Framework for National 3D Geological Models

Extended-abstract poster · Stand 18

N. Jensen [1]

[1] *I-GIS*

Abstract

Airborne electromagnetic (AEM) surveys have transformed geological and hydrogeological mapping, but managing the resulting geological knowledge over time presents significant challenges. In Denmark, more than 25 years of groundwater mapping have produced hundreds of regional geological models, representing an investment of approximately 400 million EUR. Maintaining consistency and traceability across these models as new data and improved methodologies become available has become increasingly difficult.

To address this, the Large Scale Geo Model Management and Collaboration System (LARCOS) was developed. LARCOS provides a collaborative framework for updating, maintaining and quality-controlling large-scale 3D geological models. A key principle is the separation of geological interpretations — stored as attributed points linked to their source observations — from generated model surfaces, which are reproducible products derived from defined interpolation procedures. This enables model surfaces to be regenerated as new information becomes available without loss of prior interpretations.

LARCOS supports multi-user workflows through spatial check-out and check-in functionality, version control and integrated quality assurance. The system has been implemented within the Danish national hydrogeological modelling program, where more than 250 regional models are being consolidated into a common national framework. The approach demonstrates a pathway from project-based geological modelling towards continuously maintained geological knowledge infrastructures.

First application of the Anemone Python Package to Airborne Transient Electromagnetic Data

Extended-abstract poster · Stand 19

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[2] *EMerald Geomodelling*

Abstract

Anemone is a new open-source Python package for 1D forward modelling and inversion of airborne transient electromagnetic (TEM) data, designed to combine the speed of Geoscience Australia's code, the system realism of AarhusInv, and the ease of use of SimPEG. Built on PyTorch, it supports GPU-accelerated parallel computation.

The forward model accounts for five physical components: the dipole response (using recursive TE reflection coefficients and digital Hankel filters), transmitter loop geometry (via a geometric operator treating the loop as a series of electric dipoles), receiver filters applied in the frequency domain, the system waveform (convolved as a second-order time derivative), and gate windowing. Uniquely, Anemone combines the waveform and gating into a single matrix operation.

Anemone is validated on a real SkyTEM dataset from Kvong, Denmark, where a laterally constrained inversion produces resistivity sections broadly consistent with AarhusInv results.

On-Time System Response Modeling in 3D AEM–IP Inversion

Extended-abstract poster · Stand 20

J. Chen [1], J. Fridlund [2], L. Persson [2], M. Bastani [2], G. Fiandaca [1]

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Abstract

Time-domain airborne electromagnetic (AEM) data are affected by both subsurface electrical structure and the temporal response of the acquisition system. These system-response effects are most significant during on-time and early off-time gates, which also provide important constraints on shallow conductivity. In AEM data affected by induced polarization (IP), this creates a potential coupling problem: IP signatures are commonly expressed at intermediate-to-late times, but the corresponding sensitivity may remain concentrated in the shallow subsurface and depend on the recovered background conductivity. We present a 3D AEM-IP inversion workflow that incorporates system response directly in the time-domain forward modelling. The system response is treated as an effective waveform-convolution kernel. Its integrated form resembles an effective transmitter waveform, consistent with standard transient EM waveform-convolution formulations. The system-response-aware forward response is then used in 3D inversion with maximum phase angle IP parameterization. The method is applied to SkyTEM data from the Kiruna area, northern Sweden. The recovered model images 3D resistivity and chargeability phase structures, and the calculated responses reproduce both early-time system-response-affected gates and IP-related negative transients along a representative line. The workflow provides a practical basis for quantitative interpretation of AEM data in complex mineral exploration settings.

Joint inversion of inductive and galvanic data: improved resolution with 3D EM and 2D DCIP

Extended-abstract poster · Stand 21

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Abstract

Joint inversion of electrical and electromagnetic data can reduce the non-uniqueness of geophysical interpretation by exploiting the complementary sensitivities of galvanic and inductive measurements. However, conventional approaches often rely on one-dimensional EM modelling or neglect induced polarization effects, which can be limiting for polarizable targets with finite or laterally complex geometry. We present a joint inversion workflow that combines 3D EM modelling with 2D DCIP modelling using a common maximum phase angle reparameterization of the Cole-Cole model. Decoupled forward and model meshes allow inductive datasets with different footprints and galvanic DCIP data to be modelled with appropriate forward operators while updating a common 2D resistivity and IP model. The workflow is applied to AEM and ground DCIP data acquired over Fe-Ti-V oxide mineralization in southern Portugal. The results provide a single resistivity and IP model compatible with the mapped geological setting and demonstrate the applicability of 3D EM/2D DCIP joint inversion for IP-affected AEM datasets.

Array effects in TEM: misplacement of anomaly locations in 1D inversion

Extended-abstract poster · Stand 22

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Abstract

Laterally distributed conductive bodies and intervening resistive regions can cause anomalously enhanced transient electromagnetic responses over resistive regions. When interpreted with standard 1D inversion, these responses may cause conductive anomalies to be recovered at incorrect lateral positions relative to the true conductors. We refer to this family of inversion artefacts as array effects, where "array" refers to a subsurface arrangement of conductive and resistive features within the effective TEM response region. The underlying physical cause is the conductive–resistive alternation mechanism: spatially separated conductive regions, interleaved with resistive gaps or resistive cells, can jointly contribute to the measured TEM response, causing 1D inversion to misplace conductive anomalies into, or towards, intervening resistive regions. Using smoke-ring theory and 3D numerical modelling, we investigate how these effects arise and propose the Instantaneous Smoke Ring Footprint (InSR-Footprint) as a practical criterion for model design and effect identification.

3D Time-lapse AEM Inversion for Monitoring Salinity Dynamics at Bookpurnong

Extended-abstract poster · Stand 23

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Abstract

Time-lapse airborne electromagnetic (AEM) data can provide valuable constraints on salinity-related groundwater changes in managed floodplain systems. We present a 3D domain-decomposed time-lapse AEM inversion workflow implemented within the EEMverter platform and apply it to repeated SkyTEM surveys acquired over the Bookpurnong floodplain, South Australia, in 2015, 2022 and 2024. The workflow combines simultaneous time-lapse inversion with 3D EM forward and Jacobian computations. For each survey vintage, an independent 3D conductivity model is defined. The AEM coverage is tessellated into multiple local 3D forward domains, each represented by an Octree mesh and containing neighbouring soundings. These local forward meshes are linked by interpolation to the corresponding yearly model mesh, while temporal constraints couple the time-dependent models to focus compact, data-supported changes. Bookpurnong is characterised by saline floodplain aquifers, lower-salinity river recharge, meandering river geometry and strong lateral conductivity gradients. Preliminary results image spatially coherent conductivity changes concentrated near the Murray River corridor and selected floodplain zones, suggesting localised salinity redistribution controlled by river–aquifer exchange and preferential recharge pathways.

Saltwater-Freshwater interface: direct inversion of Airborne EM data in terms of hydraulic parameters

Extended-abstract poster · Stand 24

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Abstract

Airborne electromagnetics (AEM) is widely used to characterize seawater–groundwater interfaces by inverting AEM data in terms of electrical conductivity. Although effective, this approach does not explicitly account for the hydrogeological processes that control the position and geometry of the interface.

In this study, we use hydrogeological modelling to constrain the geophysical inversion, parameterizing the freshwater–saltwater interface in coastal aquifers in terms of hydrogeological properties and modelling the AEM response using a full 3D formulation. Specifically, flow beneath a strip island is described analytically as a function of: (1) island width; (2) freshwater and saltwater densities; (3) areal recharge; and (4) hydraulic conductivity. The corresponding AEM response is computed in 3D by assigning the freshwater and saltwater electrical conductivities. The AEM data are then inverted directly in 3D, using only hydraulic conductivity and the freshwater/saltwater electrical conductivities as inversion parameters.

Synthetic experiments and preliminary field tests provide promising results. We believe that constraining AEM inversion with hydrogeological modelling opens new perspectives for the direct characterization of hydraulic parameters and for the quantitative assessment of seawater–groundwater interactions in coastal aquifers, with applications to both seawater intrusion and submarine groundwater discharge.

Multi-scale imaging with complementary airborne electromagnetic methods: implications for regional groundwater studies

Extended-abstract poster · Stand 25

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Abstract

Airborne electromagnetic (AEM) methods have become an essential tool for regional groundwater investigations; however, different systems provide distinct trade-offs between near-surface resolution, depth of investigation (DOI), and sensitivity to subsurface structures. We compare three complementary AEM methods—VTEM-ET, VTEM-Max, and Z-axis Tipper Electromagnetic (ZTEM)—using co-located surveys acquired over the northern Tularosa Basin, New Mexico, as part of a pilot study supporting the design of a planned statewide AEM survey. VTEM-ET provides superior resolution within the upper ~100 m of the subsurface, whereas VTEM-Max nearly doubles the effective DOI (~400 m versus ~200 m) and better images deeper basin architecture, conductive structures, and faults. Although ZTEM achieves an even greater DOI, it primarily delineates large-scale lateral resistivity boundaries while exhibiting limited sensitivity to layered resistivity structures. These results demonstrate that the three methods provide complementary rather than competing information for groundwater characterization and support an integrated survey strategy.

AEM 2026

Short Abstract Collection

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Wukong Drone-Based Transient Electromagnetic System and Accelerated Inversion for Airborne Surveys

Short-abstract poster · Stand 26

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Abstract

Airborne transient electromagnetic (TEM) systems are widely used in geophysical exploration, and drone-based TEM (DTEM) platforms are increasingly adopted for high-resolution surveys in complex and difficult-to-access environments. This study presents a Wukong DTEM system with integrated acquisition and processing workflow designed for reliable high-density airborne TEM investigations. The Wukong system integrates small transmitter and receiver coils, current generator, and measurement electronics into a single drone-borne unit, ensuring stable system geometry and simplifying field deployment. The lightweight platform Wukong DTEM enables low-altitude, slow-speed flight and hovering operation to improve survey adaptability under challenging terrain conditions. To ensure data quality under drone motion and varying survey conditions, standard preprocessing corrections are applied prior to inversion, including background correction, altitude normalization, and terrain correction. These procedures mitigate environmental and operational effects and stabilize transient electromagnetic responses acquired during flight. Subsurface resistivity imaging is performed using one-dimensional laterally constrained inversion (LCI) to preserve lateral geological continuity along survey lines. Since Wukong DTEM can provide small electromagnetic footprints, vast amounts of data are collected, a GPU-accelerated parallel implementation of LCI is developed for efficient processing. The inversion time was less than five seconds for 100 soundings, enabling near real-time resistivity imaging during field acquisition. Thus, Wukong DTEM can support rapid interpretation and repeated monitoring applications. A polymetallic mineral prospecting case study is presented to demonstrate the practical applicability of Wukong DTEM system for moderate-depth mineral investigation.

Keywords: TEM; DRONE; LCI

Controlled-source Electromagnetic Signal Detection Using a Hybrid Deep Learning Model: Convolutional and Long Short-Term Memory Neural Networks

Short-abstract poster · Stand 27

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Abstract

Controlled-source electromagnetic (CSEM) method using a periodic transmitted signal source suppresses random noise by superimposing and averaging the recorded signal over multiple periods. However, it still faces great challenges in strong interference environments. Here we present a CSEM signal detection method based on a hybrid architecture of convolutional neural network (CNN) and long short-term memory neural network (LSTM). Our method improves the quality of the recorded signal by filtering out all the noise periods and retaining the useful signal periods. The core lies in combining the spatial feature extraction capability of CNN with the time series modeling capability of LSTM, which can deeply excavate the feature differences between noise and CSEM useful signal. Meanwhile, a classification model of signal and noise is constructed using a large-scale training dataset. This hybrid model exhibits superior performance compared to other deep learning models such as CNN or LSTM. Also, we propose a novel signal detection mechanism that not only maintains the periodicity of CSEM signal, but also greatly enhances processing efficiency. The results of synthetic and measured data demonstrate that our method can obtain useful signals from CSEM data containing different noise types and significantly improve the quality of sounding curves. In particular, our method is useful for CSEM signal detection in strong interference.

Keywords: ControlledSourceElectromagneticMethod; DeepLearning; SignalDenoising

Suppression of AEM Motion Noise Based on An Improved Dynamic Bandwidth VMD Method

Short-abstract poster · Stand 28

Presenting Author: Xiang Wang

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Abstract

The time-domain airborne electromagnetic (AEM) is widely used in geological mapping and mineral exploration. However, the acquired data often suffer from severe interference, particularly high-energy, low-frequency motion noise caused by bird swing and coil vibrations. This noise frequently overlaps with weak, exponentially decaying late-time signals that contain critical target information. The traditional Variational Mode Decomposition (VMD) is useful for non-stationary signals, yet it faces two major theoretical bottlenecks in AEM data processing. First, the filter with fixed bandwidths can trigger spectral leakage, as they cannot simultaneously accommodate broadband transients and narrowband noise. Second, the inter-band interference during the iterative optimization can cause a "center frequency pulling" bias. This steers mathematical convergence away from the true geological responses, ultimately hindering the effective separation of weak target signals from motion-induced noise. To address this, we present in this paper an improved Dynamic Bandwidth Variational Mode Decomposition (DB-VMD) algorithm based on a strategic three-part frequency partitioning framework. First, the zero-frequency DC component, representing the stable baseline response, is precisely extracted and retained as a valid signal. Second, the interference-dominated low-frequency band, primarily contaminated by the mechanical motion noise, is accurately targeted and stripped off through refined decomposition. Then, the high-frequency band of transient responses that contains high-fidelity geological information, is isolated through spectrum analysis. This partitioning process bypasses high-frequency components before the core iteration, can fundamentally prevent these components from exerting a "pulling effect" on the center frequencies of the targeted mid-low frequency modes. Subsequently, a dynamic bandwidth Gaussian prior model is introduced for the core band. By calculating the instantaneous frequency variance of the analytic signal in real-time, the penalty factor (α) is adaptively adjusted, namely broadening for wide-band abrupt signals and tightening for stable components. This can effectively attenuate the spectral leakage and maximize the suppression of mode mixing. The extensive processing experiments with simulated AEM data demonstrate the superiority of our approach. Under controlled tests with varying signal-to-noise ratios and complex interference backgrounds, the algorithm can not only pull the central frequencies, but also successfully overcome the persistent challenges of eradicating low-frequency motion noise and correct the center frequency deviation. Even when severely masked by strong non-stationary noise, the processed late-time EM decay curves remain smooth and natural, reconstructing the true secondary field of deep geological targets with high fidelity. This DB-VMD method can provide a robust, fully data-driven new tool for AEM data processing and quantitative interpretation in complex environments.

Keywords: AEM; DBVMD; motionnoise

3D Joint Inversion of Airborne Electromagnetic and Magnetic Data Based on Multi-scale Structural Similarity

Short-abstract poster · Stand 29

Presenting Author: Yu Gao

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Abstract

Airborne electromagnetic (AEM) and airborne magnetic (AirMag) methods are widely applied in geophysical exploration, offering complementary properties. While AEM provides high vertical resolution, AirMag offers better lateral resolution. The joint inversion of these methods mitigates inherent non-uniqueness and enhances overall spatial resolution. As modern airborne platforms typically acquire AEM and AirMag data synchronously, they are highly amenable to integrated interpretation via joint inversion frameworks. Structural coupling constraints in joint inversion rely on the fundamental assumption that different physical properties within the same geological region exhibit spatial correlation. Building upon this premise, we employ the Pearson correlation coefficient to quantify the cross-correlation between electrical and magnetic properties. By calculating the Pearson correlation for each subdomain and progressively enforcing this cross-parameter correlation during iterations, the structural similarity between the AEM and AirMag models is effectively constrained. However, the efficacy of this constraint is highly dependent on subdomain size, which is difficult to determine optimally in practice. To overcome this limitation, we develop a joint inversion algorithm based on multi-scale structural similarity constraints, thereby avoiding the inefficient trial-and-error of subdomain selection. A “pyramid” multi-scale model space is constructed to facilitate coarse-to-fine inversion using Gaussian kernel functions through successive convolutions and downsampling. Since the Gaussian function spreads the physical property information of each grid cell to its adjacent grid cells, the physical property information of the downsampled grids is still retained in the adjacent grid cells that have not been deleted. The gradient calculation of multi-scale joint constraints is similar to that of sub-domain Pearson constraints. At the fine scale, it is completely equivalent to the gradient of Pearson constraints. At the coarse scale, the inverse transformation of multi-scale transformation needs to be performed first, and then the gradient calculation of Pearson constraints is conducted. To address distinctions in sensitivity and station distribution, we employ an alternating iterative strategy, which utilizes Gaussian Newton (GN) for AEM inversion and nonlinear conjugate gradient (NLCG) for AirMag inversion, sharing structural information between iterations. To address data balancing and convergence issues, Tikhonov regularization factors are adaptively updated, large initially for stability, smaller later for data fitting. In addition, joint constraint weights are dynamically adjusted based on resolution evolution to better guide the inversion. Building upon this multi-scale framework, we propose a coarse-to-fine inversion strategy. The proposed joint inversion method effectively resolves the subdomain-size dependency in conventional Pearson-constrained inversions. It achieves faster convergence and stably reduces data misfit to low levels. Compared with separate inversions and existing joint inversion approaches, our algorithm can provide accurate delineation of anomalous body locations and geometries, significantly enhancing overall inversion resolution. Ultimately, the proposed multiscale joint inversion provides a robust and versatile framework capable of advancing the joint inversion and interpretation of multi-source geophysical data.

Keywords: JointInversion; Multiscale; PearsonCorrelation

Deep-Operator-Learning-Driven Rapid Targeting for Airborne EM Exploration

Short-abstract poster · Stand 30

Presenting Author: Fuying Yang

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Abstract

The airborne electromagnetic (AEM) method has become an important tool for large-scale subsurface exploration due to its high efficiency and low cost. Limited by early computing capabilities, traditional inversions were mostly based on one-dimensional (1D) models. However, with the increasing demand for exploration resolution, 1D methods are no longer sufficient to meet the needs of fine characterization of complex three-dimensional (3D) geological structures. Meanwhile, the large survey area and data volume in AEM exploration lead to significant resource consumed in 3D inversions. Traditional gradient based methods such as the Gauss Newton method can ensure high accuracy, but each iteration requires solving large systems of equations and repeated forward modeling and gradient calculations. This can severely limit their practicality in mineral exploration and engineering investigation. In recent years, the machine learning has provided a new technical path for accelerating 3D AEM inversions. However, the supervised learning-based inversion methods are highly dependent of the representativeness and completeness of training samples. When the distribution of training data does not match that of survey data, the generalization ability of the network will significantly decrease. On the other hand, the unsupervised learning-based methods struggle to embed the physical laws into neural network structures, leading to a lack of necessary physical constraints during AEM inversion and making it difficult to obtain reliability inversion results. To overcome these issues, we propose an AEM inversion method based on deep learning operators. This operator combines the advantages of Deep Operator Network (DeepONet) and Fourier Neural Operator (FNO), balances response mapping capability and stability of forward modeling results across different models, and thus provides an efficient forward modeling engine for AEM inversions. The data fitting term in the objective functional is constrained by L1 norm, while a total variation (TV) regularization is introduced to constrain model parameters. This can effectively preserve the interface characteristics of underground electrical structures and avoid excessive smoothing of the inversion results. To verify the effectiveness of the proposed method, we run test both on theoretical and field survey data. In the theoretical model testing, the traditional Gauss Newton inversions take about 5 hours, while the method proposed in this paper requires only 5 minutes. In the testing of field data from Graphite mines in Norway, the Gauss-Newton inversions take about 232 hours, while the method proposed in this paper requires only 24 minutes. Furthermore, using the model inverted by the method proposed in this paper as the initial model for Gauss-Newton inversions, the results show that the root-mean-square (RMS) of the data fitting error is highly consistent with those obtained directly using the Gauss-Newton method. This indicates that the method proposed in this paper not only achieves reliable inversion results but also improves computational efficiency.

Keywords: AirborneEM; 3Dinversion; DeepONet

Artificial Intelligence Based Airborne Electromagnetic Flight Altitude Reconstruction Technology

Short-abstract poster · Stand 31

Presenting Author: Siqi Wang

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Abstract

Airborne electromagnetic (AEM) methods, characterized by high operational efficiency and detection at high resolution, have been widely applied in mineral exploration, groundwater investigation, geological surveying, and environmental monitoring. The flight altitude is a first-order controlling parameter of AEM responses, any inaccuracies in altitude measurements can severely distort the acquired EM data. During the acquisition of field data, the factors such as topographic variations, surface vegetation cover, and the dynamic airborne platform often lead to missing or inaccurate records of flight altitudes. These can not only degrade the quality of AEM data but also reduce the reliability of subsequent subsurface interpretations. Currently, in one-dimensional AEM data inversions, the flight altitude is routinely treated as an inversion parameter. In some three-dimensional inversion approaches the altitude variations are also corrected to some extent, however, most existing methods rely on inaccurate or incomplete altitude measurements as initial inputs and perform only incremental corrections. When the altitude errors are large or the measurements are entirely missing, these approaches often fail to provide reliable results in AEM inversions. To address this limitation, in this study we propose a deep learning-based framework for flight altitude reconstruction from AEM data. The proposed method adopts a hybrid architecture combining a multi-scale convolutional neural network (CNN) and a transformer-based attention mechanism to extract temporal features. The convolutional kernels with different receptive fields are employed to capture both early-time and late-time responses. To enhance the modeling of long-range temporal dependencies, a multi-head self-attention mechanism is incorporated into the network. Based on a shared feature representation, two task-specific branches are constructed: a resistivity prediction branch and a flight altitude reconstruction branch. The predicted resistivity is further introduced as prior information to constrain the altitude reconstruction, thereby improving the physical consistency and stability. In addition, a gradient stopping strategy is applied to decouple the two tasks with the aim to prevent mutual interference during multi-task training. Compared with traditional inversion methods, the proposed approach can directly recover the true flight altitude without requiring an initial guess to the altitude. To validate the effectiveness of the proposed method, systematic experiments are conducted on multiple synthetic datasets, including: (1) randomly generated layered earth models to evaluate the model's inversion capability under complex subsurface conditions; and (2) datasets with randomly perturbed flight altitudes to simulate realistic altitude fluctuations and measurement errors. The results demonstrate that the proposed method can achieves high accuracy and robustness in both resistivity prediction and flight altitude reconstruction. We hope that our method will provide an efficient and robust tool for high-precision inversion and interpretation of AEM data.

Keywords: AirborneEM; flightaltituderecovery; CNNTransformer

Finite-element method Based on Unstructured Grids for 3D AEM B-field Inversions

Short-abstract poster · Stand 32

Presenting Author: Chengqian Huang

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Abstract

Compared with traditional airborne electromagnetic (AEM) dB/dt data, the magnetic field (B-field) decays more slowly and retains a higher signal amplitude at late times channels, thus showing significant potential for deep geological target detection. In recent years, superconducting AEM detection technology has been developed rapidly, and high-precision acquisition of AEM B-field data are relatively easy to obtain. However, the existing three-dimensional (3D) AEM inversion methods mainly focus on the interpretation of dB/dt data, while the 3D high-resolution inversion of B-field data remain insufficiently developed from either theory or methodology. To fully exploit the potential advantages of superconducting AEM systems in deep exploration, we develop a high-resolution 3D AEM inversion algorithm for B-field data. For 3D numerical simulations of superconducting AEM B-field, we begin with the double-curl equation satisfied by the electric field and establish the finite-element method for 3D AEM forward modeling based on the Galerkin method. To calculate AEM B-field responses for complex models with irregular anomalies and undulating terrain, we discretize the model space utilizing the unstructured tetrahedral grids. After obtaining the dB/dt responses, we compute the B-field responses via numerical integration, in which the late-time dB/dt responses are predicted using a data fitting approach by a power function. For 3D inversions of AEM B-field data, we construct an inversion objective function based on regularization theory and solve the inversion problem using the L-BFGS numerical optimization algorithm. To derive the sensitivity matrix for the B-field, we first compute the sensitivity matrix for dB/dt using the adjoint forward method and then transform it into the sensitivity matrix of B-field via a numerical integration. To validate the effectiveness of the proposed algorithm, we apply it first to 3D inversion of a synthetic model that contains a low-resistivity anomaly in the subsurface. The inversion results demonstrate that the data misfit achieved by 3D inversion of B-field data is substantially smaller than that for dB/dt data. Moreover, the B-field data inversion can better recover the location, shape, and electrical characteristics of the true model compared with those from dB/dt data inversion. Our numerical experiments indicate that, relative to the conventional dB/dt data inversion, the B-field data in AEM can better reconstruct the subsurface electrical conductivity model and shows promising applications for deep mineral resource exploration.

Keywords: SuperconductingairborneEM; threedimensional; Bfieldinversion

Airborne Electromagnetic Survey for the subsurface characterization of the Einstein Telescope Italian candidate area (Sardinia, Italy): Mapping Fractured Granite and Groundwater Systems

Short-abstract poster · Stand 33

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Abstract

The development of the Einstein Telescope (ET), a next-generation underground gravitational-wave observatory planned in Sardinia (Italy), requires an exceptional level of subsurface characterization to ensure long-term structural stability and extremely low environmental noise conditions. In this context, understanding the distribution of fractured zones and groundwater systems within the crystalline basement is of primary importance, as these factors directly influence excavation conditions, hydrogeological behavior, and potential sources of seismic and hydrological noise. This study presents the preliminary results of a large-scale Airborne Electromagnetic (AEM) survey aimed at supporting the geological and hydrogeological characterization of the ET candidate area. The objective is to reconstruct a high-resolution three-dimensional model of the subsurface down to approximately 500 m depth, with particular emphasis on identifying fracture networks and fluid-bearing zones within granitic formations. To achieve these objectives within such a complex and highly resistive geological environment, the SkyTEM system was employed, as it combines high near-surface resolution with a high transmitter moment, thereby ensuring both detailed shallow imaging and sufficient depth of investigation. The survey covers an area of approximately 450 km^2 corresponding to about 3000 line kms. Flight lines are designed with an average spacing of 170 m, providing a balance between coverage and resolution, and allowing the detection of lateral and vertical resistivity variations associated with structural discontinuities. AEM data are processed and inverted to produce 3D resistivity models of the subsurface. These models are interpreted in terms of geological and hydrogeological properties, where conductive anomalies are indicative of fractured or water-saturated zones, while resistive domains correspond to intact crystalline rock. Such information is critical for assessing excavation feasibility, identifying potential water inflows, and constraining zones that could impact the mechanical stability of underground infrastructures. To address uncertainty and enhance the robustness of interpretations, both deterministic and probabilistic inversion strategies are employed. Deterministic inversion provides a best-fit resistivity model constrained by available geological data, whereas probabilistic approaches estimate the likelihood of encountering significant fracturing within each subsurface volume element. This probabilistic framework is particularly relevant for ET, where risk mitigation and design optimization require quantitative assessment of subsurface variability. In addition, airborne magnetic data collected simultaneously contributed to the identification of structural lineaments and lithological contrasts, further refining the geological model. The integration of AEM, magnetic data, borehole information, and geological mapping enables a comprehensive multi-scale characterization of the site. The ultimate goal of this survey and the expected outcomes include (i) high-resolution 3D resistivity and chargeability models, (ii) probabilistic maps of fracture distribution within granitic rocks, and (iii) identification of zones of hydrogeological and geotechnical significance. These results will provide essential input for the design and optimization of the ET underground infrastructure, supporting decisions related to tunnel alignment, excavation strategy, and groundwater management.

Keywords: Fracturenetworkcharacterization; EinsteinTelescopeET; Probabilisticinversion

Airborne Electromagnetics at BGR: Present Status and Future Directions

Short-abstract poster · Stand 34

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Abstract

The Federal Institute for Geosciences and Natural Resources (BGR) owns and operates a Sikorsky S-76B helicopter D-HBGR, manufactured in 1986. The aircraft is registered as a non-commercial complex aircraft and serves as a scientific platform for governmental tasks as well as in-house and collaborative research projects. To support these operations, BGR maintains an approved Aircraft Maintenance Organization (AMO) and appoints the accountable manager, both of which are integrated within the Airborne Geophysics Group at BGR. The Group consists of seven scientists and technicians responsible for helicopter and sensor maintenance, project acquisition and management, field operations, data processing, interpretation, data administration, publication of results, and reporting. The applied standard airborne geophysical methods include helicopter electromagnetics (HEM), helicopter magnetics (HMG), helicopter radiometry (HRD), and, more recently, semi-airborne electromagnetics (SAEM). The current sensor fleet comprises two (one backup) active six-frequency electromagnetic systems (0.4–140 kHz; RESOLVE type, manufactured by Fugro Airborne Surveys, CA). Each system is mounted inside a 10 m long cigar-shaped fiberglass sensor platform (“bird”) suspended approximately 45 m below the helicopter. In addition to the EM system, the birds carry a total-field magnetometer, a GNSS receiver with solid state IMU, and a laser altimeter. A gamma-ray spectrometer (Radiation Solutions RSX-5) installed in the cabin measures the natural radioactivity of the ground for the characterization of near-surface soil conditions. For SAEM data acquisition, an outsourced bird has been equipped with an induction coil triple (Metronix, DE) measuring magnetic fields Bx, By, Bz, an analog-to-digital signal conditioning unit (ADU), and an INS/GNSS receiver for positioning of the bird. The battery-powered ICOIL system is entirely self-contained and mechanically suspended approximately 40-60 m below the helicopter. It measures the response to electromagnetic signals generated by grounded transmitting dipoles of several kilometres in length and currents of up to 50 A (GeoPak IPTX-2500 transmitter, GeoPak PS30HV power supply, GAP Geophysics, AU), enabling investigations of electrical properties of the ground down to depths of approximately 1000 m. Recent and ongoing HEM projects have focused on saltwater intrusion and submarine groundwater discharge along Northern German coastlines, the mapping of paleochannels in former East German open-pit mining regions, and the characterization of peat soils. Current SAEM applications target mineral exploration and deep groundwater investigations. Future developments aim at further modifications and expansion of BGR’s airborne geophysical infrastructure to enhance operational flexibility and scientific capabilities. The poster presents an overview of BGR’s airborne geophysical infrastructure, highlights and challenges from recent projects, and discusses future directions and applications of BGR’s airborne facilities.

Keywords: HEM; SAEM; groundwater

AEM Mapping of Saline Water for Management of Water Resources

Short-abstract poster · Stand 35

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Abstract

The Lower Platte South Natural Resources District (LPSNRD) in Nebraska, United States has systematically used Airborne Electromagnetic (AEM) mapping since 2007. The LPSNRD has collected ~8,000 line-km of data over 10 surveys. The purpose of these data were to inform the LPSNRD Board in managing water resources with the LPSNRD and for maintaining compliance with the State of Nebraska mandated water regulations and water management plans. A subregional groundwater model encompassing most of eastern Nebraska including the LPSNRD, Lower Platte North Natural Resources District, and the Papio-Missouri River Natural Resources District utilized the AEM data (~30,000 line-km) collected between 2007-2022. The improvements to the groundwater model were significant and provided an improved tool for evaluating groundwater in storage and stream flows. After the completion of the groundwater model the LPSNRD embarked on an updated District Groundwater Management Plan. Saline wetlands and waters have long been known within this part of Nebraska. Originally, the town of Lancaster was established in the area of salt-mining in 1856. In 1867, after the transcontinental railroad was connected to the area and the Capital of Nebraska was moved from Omaha, and the town was renamed in “Lincoln” honor of US President Abraham Lincoln. A part of the Groundwater Management Plan was to develop a guide to the depth of the saline water within the District. The AEM data coupled with mapped saline wetlands were used to build a map of the depth of the saline water. Investigation of the AEM data showed saline water moving up through the Cretaceous Dakota Group along interpreted fractures and high permeable zones. Many of the wetlands are significantly above the bulk of the saline water and these conduits are connections to the deeper saline water and the wetlands. Water quality data is not sufficient for the development of a total dissolved solids (TDS) map of the District. This would also be impacted by limitations on mixing models to develop resistivity versus TDS relationships due to the variability of the porosity and clay content of the Quaternary and Cretaceous Dakota Group. While the combinations of AEM models, limited sampling of the wetlands, and very limited well samples cannot provide an absolute TDS map, a more generalized approach was taken. The mapping approach was to take the shallowest depth of saline water and use that as a point. In this approach the details of the conduits are lost, but the map indicates areas of saline water. The Managers and Board Members of the LPSNRD can use this map as a guide to well permits and groundwater development. By knowing the depth of the saline waters these areas can be avoided, and inadvertent drilling releases of saline waters can be avoided.

Keywords: Saline; Water; Nebraska

Investigating the Quaternary sedimentary filling of glacial valleys using airborne electromagnetics, northern Pyrenees, France

Short-abstract poster · Stand 36

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Abstract

The last glaciation led to the carving of deep glacial valleys in mountain environments, which were then filled with post-glacial Quaternary sediments during the subsequent deglaciation. In the Alps, this type of deposit is well understood from studies of paleolakes and residual lakes based on data from deep boreholes as well as terrestrial and lacustrine geophysical surveys. In the French Pyrenees, deep glacial valleys were also incised down to the foothills, but their filling has been studied very little to date. The objective of this study is therefore to develop a sedimentological and chronological model of the sedimentary filling of the upper Garonne Valley, which was once submerged by a paleolake during the deglaciation. The downstream section of this ~15 km-long glacial valley is thought to consist of three glacial overdeepening basins, separated by two barriers, and its postglacial sedimentary fill (e.g., fluvial, deltaic, lacustrine, glaciolacustrine, fluvioglacial, and glacial deposits) is estimated reaching up to ~300 m based on gravimetric data. The study of the paleolake fill presented here is based on the interpretation of 800 kml of recently acquired airborne electromagnetic (AEM) measurements in the upper Garonne Valley and in other neighboring glacial valleys (i.e., Gave de Pau, Neste, and Ariège). These data, obtained using the SkyTEM 306HP system, enable the resistivity of subsurface geological formations to be imaged to a depth of up to 400 m. The interpretation of the subsurface geology based on this geophysical imagery has been correlated with the geological descriptions of industrial and scientific ground boreholes available in the valley. These data allow the interpretation of up to 250 m deep of post-glacial Quaternary sediments in the basins of the valley and imaging the filling of one of the barriers. The basal glaciolacustrine and lacustrine sediments are characterized by a low resistivity, contrasting sharply with the highly resistive substratum. The uppermost fluvial and deltaic sediments, in contrast, are characterized by more resistive values. The cross-sectional view of the valley based on these interpretations of the AEM data shows finer sediment in the downstream basins and coarser sediment in the upstream basin, located proximal to the glacial meltwater during deglaciation. This comprehensive dataset demonstrates the usefulness and limitations of the AEM method for geological mapping in glacial valleys, allowing the estimation of the volume and geometry of post-glacial Quaternary sediments filling the valley. Finally, this model of the filling of the upper Garonne Valley, constructed using an unprecedented AEM data coverage in the region, will serve as a reference model to study the filling of neighboring glacial valleys on the northern slope of the Pyrenees.

Keywords: Postglacialsediment; AEM; Pyrenees

Preliminary results of the UNDERCOVER semi-airborne EM survey at the Juomasuo deposit (Kuusamo Schist Belt, Finland)

Short-abstract poster · Stand 37

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Abstract

The Juomasuo mineral deposit hosts the largest known Au-Co-Cu-REE occurrence in the Kuusamo Schist Belt (KSB), a Paleoproterozoic orogenic belt in the Fennoscandian shield. However, the ore formation processes at Juomasuo and across the KSB remain poorly understood. Within the UNDERCOVER project, we aim to improve our understanding of the KSB mineral system. Following a multi-scale approach, multiple EM surveys operating at different scales were carried out across the KSB. While large-scale methods cover the entire belt, more local investigations focus on the Juomasuo deposit. Among those, semi-airborne electromagnetics operates at district scale (< $100 km^2$). The method combines an airborne receiver with powerful ground-based transmitters, thereby enabling efficient data acquisition while maintaining great penetration depths. We present first results from semi-airborne EM measurements at Juomasuo conducted in August 2025. The survey area covers the deposit as well as surrounding occurrences, encompassing a total of 25km2 with 250m line spacing. A good coverage of the Juomasuo deposit is ensured by six flights patches that overlap in the target area. Each flight patch corresponds to a horizontal electric dipole transmitter. Data were recorded using the QAMT airborne platform, providing high quality in the frequency range of 15–1000 Hz. Preliminary inversion results are in good agreement with bedrock geology. In this contribution, we focus on the processing stream and the 3D inversion models of the semi-airborne EM data. Ultimately, we aim at integrating the data and models with those from an independent airborne natural source EM survey acquired on a larger scale and an even more focused ground-based controlled source EM survey, both acquired within the UNDERCOVER project. This research has received funding from the European Union through the Horizon Europe project UNDERCOVER (Grant agreement No. 101177528).

Keywords: sAEM; electromagnetics; inversion

Fault Signatures in AEM Inversion: On Interpreting Structural Styles

Short-abstract poster · Stand 38

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Abstract

Although faults are often expressed geomorphologically in surface topography or as offset of geologic units, they can be difficult to identify and trace accurately; this challenge becomes even greater when attempting to delineate their continuity and geometry in the subsurface. Faults occur across all spatial scales and tectonic settings, spanning plate-boundary and intraplate regimes alike, and develop in both lithified and unconsolidated materials. In particular, the identification and characterization of faults within unconsolidated sediments is most challenging because they may exhibit diffuse expression and be covered by surficial deposits. Electrical and seismic tomography surveys have proven useful in mapping faults in unconsolidated materials but have specified limits on areal coverage and depth of investigation. Airborne electromagnetic (AEM) methods provide coarse spatial sampling resolution and can be correlated to regional structural and stratigraphic relationships using borehole and fine-resolution geophysical studies. AEM data, when calibrated to local geology and filtered for potential infrastructure interference, can provide high-resolution representations of subsurface resistivity variations, offering a powerful basis for geologic structural interpretation. This study presents a systematic approach for identifying fault-related structures directly from AEM inversions, emphasizing consistent interpretive criteria. Interpretation is grounded in the identification of diagnostic structural signatures within resistivity sections, lateral contrasts, stratigraphic offsets, and discontinuities in layer continuity systematically evaluated across flight lines for geometric consistency and structural coherence. Profile-based comparative analysis reveals resistivity patterns spatially coincident with dip-slip and strike-slip faulting, from which fault geometries are delineated and subsurface structural styles reconstructed. Careful identification between structurally controlled features and inversion artifacts remains essential; this is not a procedural footnote but a foundational interpretive obligation. Rigorous, profile-based interpretation of AEM data can yield meaningful constraints on fault architecture, though integration with auxiliary geophysical datasets remains necessary to fully resolve structural ambiguities. The framework developed herein for unconsolidated sediments nonetheless provides a reproducible and transferable methodology for structural interpretation across diverse geological settings wherever resistivity contrasts faithfully reflect tectonic architecture.

Keywords: FaultCharacterization; StructuralInterpretation; AirborneElectromagnetics

THE APPLICATION OF COMBINED AIRBORNE ELECTROMAGNETIC SURVEYS FOR ORE TARGETS IN THE RUSSIAN FAR EAST

Short-abstract poster · Stand 39

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Abstract

Practical results of using combined airborne electromagnetic (AEM) surveys in the time and frequency domains include the exploration of epithermal high-sulfide (HS) gold deposits in Kamchatka (2021) and copper-nickel mineralization in ultramafic rocks of the Kun-Manie complex in the Khabarovsk region (2023). In Kamchatka, epithermal HS deposits were targeted. These deposits exhibit specific geophysical signatures. Gold mineralization is associated with secondary quartzites, which are characterized by very high resistivity (especially in the quartz core) and the absence of magnetic and radioactive anomalies in the near-surface section. A profile fragment from a survey of the Maletoyvayam region is presented, clearly demonstrating the advantages of a combined AEM system. Geoelectric sections are shown. They were constructed by inversion of the time, frequency, and combined domain data. A one-dimensional inversion was performed using an iterated extended Kalman filter. High-resistivity zones correspond to exploration targets—quartz cores in secondary quartzites. It was also noted that high-resistivity anomalies correspond to minimal potassium concentrations, which is also typical of HS-type deposits. During exploration in the Khabarovsk Region, test surveys were initially conducted at known occurrences. The goal was to identify promising mineralization zones associated with sulfide-bearing Early Proterozoic mafic-ultramafic rocks of the Kun Manye type. Geoelectric sections correlate well with drilling data. Sulfide-saturated ore intervals exhibit significantly lower resistivity compared to high-resistivity ultramafic rocks. Ore-bearing gabbroids, in addition to high resistivity, are well mapped by sharply differentiated magnetic anomalies and minimal radioactivity values. Based on known deposits, promising areas were identified as those containing anomalously low resistivity within high-resistivity zones. Inversion results revealed subhorizontal conductive bodies. These are comparable to known deposits in the reference area in terms of thickness and resistivity. An ultramafic sample rich in sulfides was later discovered in one of the identified conductive zones. Conclusion Combined time-domain and frequency-domain AEM has proven to be a highly effective tool in ore exploration. It enables resistivity estimation over a wide range (0.1–20,000 Ohm m). In the presence of high-resistivity (Kamchatka) or conductive (Khabarovsk) targets, we can successfully use the same AEM system.

Keywords: AEM; FD; TD

Three-dimensional Gramian-Constrained Joint Inversion of Airborne Electromagnetic Data into Conductivity and Chargeability Models

Short-abstract poster · Stand 40

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Abstract

Airborne electromagnetic (AEM) systems are now known to have sensitivity to induced polarization (IP) effects, creating opportunities to recover both electrical conductivity and chargeability information from a single survey. These parameters often provide complementary indicators of lithology, alteration, and mineralization. However, they are commonly recovered through inversions and workflows that yield chargeability and conductivity models that fit the measured data but may exhibit substantially different spatial characteristics. Such discrepancies can complicate geological interpretation and reduce confidence in the inferred subsurface structure. In this work, we present a new methodology for jointly inverting airborne electromagnetic data into 3D conductivity and chargeability models using a Gramian coupling constraint. The objective is to recover conductivity and chargeability distributions that share common geological features while remaining consistent with the observed electromagnetic response. The proposed Gramian formulation promotes correlation between the recovered conductivity and chargeability models. The method is based on the premise that both parameters often respond to the same underlying geological controls, even when their amplitudes and physical significance differ. Rather than recovering two independent models that satisfy the data separately, the inversion seeks solutions in which conductivity and chargeability anomalies exhibit a common spatial framework. This direct coupling guides the inversion toward geologically consistent models, which reduces ambiguity arising from non-uniqueness. The proposed methodology is implemented within a rigorous three-dimensional inversion framework based on the Generalized Effective Medium Theory of Induced Polarization (GEMTIP). The proposed approach simultaneously recovers conductivity and chargeability in full 3D using the complete physics of electromagnetic induction and polarization. This distinction is particularly important in areas characterized by complex geology and strong lateral conductivity contrasts, where 1D approximations can introduce geometric distortions and inversion artifacts. By honoring the true geometry of the subsurface and the full electromagnetic physics, the inversion produces more reliable conductivity and chargeability models. It provides a more robust foundation for coupling through the Gramian constraint. To enable application to modern large-scale airborne surveys, the inversion employs a moving-sensitivity-domain strategy, in which sensitivities are computed and updated only within localized regions surrounding the active data subset. This approach significantly reduces memory and computational requirements while maintaining the accuracy required for high-resolution 3D recovery of conductivity and chargeability structures. The methodology is demonstrated using airborne electromagnetic data acquired over the Mpatasie Gold Belt in Ghana. Previous studies have shown that advanced 3D inversion of AEM and magnetic data can successfully delineate mineralized structures and alteration systems within this geologically complex environment. The Gramian-constrained joint inversion further enhances interpretation by producing conductivity and chargeability models that exhibit coherent structural relationships. These results demonstrate that Gramian coupling provides an effective framework for recovering more geologically meaningful conductivity and chargeability models from airborne electromagnetic data than simply fitting the data alone. The combination of structural coupling, full-physics 3D inversion, and scalable computational implementation represents an important step toward more reliable interpretation of airborne IP responses and improved targeting of mineralized systems in exploration environments.

Keywords: chargeability; inversion; joint

Resistivity-lithology relationships: A tool in geological modelling based on electromagnetic data

Short-abstract poster · Stand 41

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Abstract

Geological interpretations from electrical and electromagnetic data requires a well-founded understanding of the resistivity values associated with the various lithology or rock types. However, the resistivity-lithology relationships can be complicated due to influences by variations in soil and rock properties, mineral content, and pore-fluid conditions. Therefore, reliable information on these relationships is crucial for interpretation-based and stochastic geological modelling, as well as for stochastic inverse modelling involving geophysical data and resulting in ensembles of geological models. In a limited number of cases, the relationship between resistivity and various lithologies have been investigated in connection with local- or regional-scale studies, where resistivity values obtained from electrical and electromagnetic surveys are compiled together with local geological borehole logs. Only a few studies have addressed these relationships at larger spatial scales. In stochastic geological modelling, a common approach is to juxtapose the nearest geophysical sounding with a borehole lithological log, or alternatively to extract resistivity values from a 3D resistivity grid at the position of the lithological observations. In this study, we establish resistivity-lithology relationships at local, regional or national scale based on archived borehole wireline resistivity logs and borehole lithological descriptions, allowing resistivity measurements to be directly associated with specific and well-characterized lithological samples. The analysis is based on the Danish national geophysical database containing wireline resistivity log and the national geological and hydrological database containing the lithological sample descriptions. The methodology uses selectively curated wireline logging data to derive resistivity distributions for specific lithologies or geological formations. The application of quality-controlled, well-documented high-quality data, combined with filtering based on logging tool geometry, uncertainty-based weighting of both resistivity and lithological information, and a 3D declustering, ensure robust results that capture the intrinsic resistivity characteristics of lithologies. As an example of an application of the resistivity-lithology relationships, we demonstrate how the relationships are incorporated into the construction of geological and geophysical prior ensamples for a sampling-based probabilistic inversion framework; specifically an extended rejection sampler for TEM data that outputs both resistivity and lithological models together with associated uncertainty estimates. As part of the procedure, the geologist defines a set of lithological classes, each assigned an accompanying resistivity distribution. Local or regional subsets of the national-scale resistivity-lithology relationships, derived from survey-adjacent areas of similar depositional environments and geological histories are used to generate the geophysical prior ensample. The rigours and robust procedure established for compiling resistivity-lithology relationships is almost exclusively data-driven. Meaning that the relationships are optimal for use as prior information in analytical or probabilistic problems, e.g. when constructing a resistivity prior in combination with a geological prior. Such data-driven relationships are essential for obtaining reliable inversion results and robust posterior lithological distributions.

Keywords: datadriven; databases; properties

A Preliminary Multi-Attribute HELITEM Workflow for EM Response Classification and VMS-Oriented Target Screening

Short-abstract poster · Stand 42

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Abstract

Classifying HELITEM EM responses for VMS-oriented target screening is challenging when conductive targets occur within broad conductive backgrounds, formational conductors, cultural sources, or exhibit non-standard decay behaviour such as superparamagnetic (SPM) effects. This is particularly relevant in VMS terrains, where localized targets may occur within, or adjacent to, broader conductive geological units. We present a preliminary multi-attribute workflow for classifying HELITEM responses and supporting early-stage VMS-oriented target screening. The workflow is designed as an interpretation support tool rather than a replacement for expert geophysical judgement. The workflow detects local anomalies in the vertical dB/dt component (EMZ) by identifying peak responses along flight lines, emphasizing gate persistence and line-to-line continuity over absolute amplitude. This helps preserve internal responses that may otherwise be masked within high-amplitude conductive zones. Each detected segment is characterized by attributes including time-gate persistence, segment length, mid- to late-time response, and internal peak structure. Decay behaviour is analysed point by point within each segment to define the spatial extent of the dominant conductive response, identify internal subtargets, and separate conventional exponential decay from possible SPM-like signatures. Multiple Tau estimates across early-, mid-, and late-time windows are integrated into a segment-level ranking. EMX and magnetic/RMI attributes are also being integrated to improve the geometric and magnetic context of the classified responses. Initial testing across two HELITEM survey blocks, comprising over 3,000 classified segments, shows that several top-ranked segments are spatially consistent with known VMS-related areas. This provides a first indication of the workflow's discrimination potential, although further validation on additional known and blind test cases is ongoing. The expected output is a practical screening framework for distinguishing VMS-related conductive candidates, discrete conductors, broad conductive zones, cultural responses, and possible SPM-related signatures, supporting more systematic and reproducible EM interpretation in early-stage mineral exploration.

Keywords: HELITEM; VMS; CLASSIFICATION

Development of a New UAV-Towed Three-Component Receiver System for Semi-Airborne Electromagnetics

Short-abstract poster · Stand 43

Presenting Author: Philipp Kotowski

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Abstract

The capabilities and applications of UAVs to tow geophysical instruments, amongst others for magnetic or electromagnetic (EM) exploration, are continuously increasing. This development and advances of commercially available optimized system components allow to build new superior receiver systems to be attached to the UAVs. In this context, “superior” may refer to the sensitivity of the magnetometers, data logger capabilities, weight, aerodynamics and other performance-related characteristics. Here, we present an upgraded version of an EM bird containing a coil-magnetometer triple, two inertial measurement units (IMU), and a data logger, providing the practical advantages of this system to be operable by any kind of UAV worldwide which is able to carry the payload. The first key components of the new EM bird are three SHFT-03e magnetic-field sensors by Metronix geophysics. Compared with the predecessor, these sensors provide higher sensitivities at frequencies below 100 Hz for the price of a bigger size and tripled weight. The second component is the newest generation of data loggers by Metronix geophysics, the ADU 11, whose main board has a significantly more compact and lightweight design compared with the previous ADU 08 data logger. By shielding the data logger with mu-metal, we developed the first EM bird prototype with a distance of approximately 80 cm between data logger and coils, providing further optimization potential for an even more compact and lightweight version in the future. To measure the movement and orientation angles of the bird, we installed a U-200 IMU by IMAR and an Iphone 13 as a backup IMU providing generally robust recordings. First, we present static recordings to evaluate the best practical distance between the magnetometers and the data logger. These recordings are benchmarked against the established previous system based on SHFT-02e coils. We further analyze flight tests with the new bird in a natural environment with infrastructure noise as well as recording signals from a running CSEM transmitter to evaluate the noise characteristics over frequencies. The system was recently applied in the framework of the SeeKaquA project in Zambia, allowing us to show first recordings, results, and benchmarks against the predecessor system from a real-world environment. The experiences gathered during this survey help us to further optimize the system design in terms of both, system noise and also practical handling.

Keywords: Electromagnetics; SemiAirborneEM; UAV

The regional occurrence of closed basin brines in North America's Basin and Range Province: Transforming regional AEM survey results into mappable criteria for lithium assessments.

Short-abstract poster · Stand 44

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Abstract

Lithium is essential for the future of energy storage, electrification of the transportation sector, and numerous industrial processes. Closed-basin brine deposits are one of the largest potential lithium sources in North America. In hydrologically closed arid basins, evapoconcentration of surface water and shallow groundwater leads to the enrichment of numerous constituents, potentially including lithium under the right combination of geologic and climatic conditions. The Basin and Range Province is the most prospective region for lithium brines in the United States, along with hosting a variety of other critical mineral and precious/base metal systems. As part of the U.S. Geological Survey's Earth Mapping Resources Initiative (USGS Earth MRI), over 30,000 linear kilometers of regional-scale airborne electromagnetic (AEM) data have been collected across 121,000 square kilometers of the Basin and Range Province to improve our understanding of the three-dimensional geologic framework of this mineral-rich region. Groundwater brine can lead to uniquely high subsurface conductivity in basin sediments, allowing these deposits to be located and their lateral extent defined by AEM surveys in the depth ranges most economically accessible for exploration. The Earth MRI surveys used a 5-km line spacing in combination with basin-center tie lines through topographic watersheds containing playas; these supplemental tie lines play a key role in identifying smaller brine deposits as well as assessing the potential for subsurface groundwater flow between topographic watersheds. We use these regional data to systematically explore the closed basins of western and central Nevada for conductive features consistent with subsurface brine deposits. Watersheds are classified throughout the region by the presence and relative area of brine deposits. By using a strategic regional AEM survey design and synthesizing results at the watershed scale, this analysis helps bridge the gap between AEM data and mappable criteria at both the scale and spatial consistency relevant to mineral-resource assessments being conducted by the USGS. While not all brines contain elevated concentrations of lithium, the occurrence of brine is a diagnostic requirement. Our analysis provides a key mappable criteria for mineral-resource assessments that when combined with other criteria, such as the proximity to certain volcanic source deposits, can be used to assess the likelihood of economically significant lithium brine resources. This analysis also reveals new insights about the general characteristics of groundwater brine deposits of the Basin and Range that are relevant to mineral and water resources: 1) playa extent is not always a reliable indicator of brine extent, 2) subsurface brine distributions are commonly asymmetric relative to the surface playa and suggest structural controls on groundwater flow, and 3) not all closed basins have developed shallow brine fields.

Keywords: lithium; groundwater; minerals

Guiding the effective application of AEM surveys for United States military installation resource management through the development of an AEM suitability framework

Short-abstract poster · Stand 45

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Abstract

The U.S. Military manages nearly 100,000 square kilometers of land in the United States across hundreds of installations. In many instances, installation resource managers are tasked with managing groundwater supplies and mitigating contamination across installation boundaries, where the current understanding of local aquifers is often based on sparse subsurface data. Airborne electromagnetic (AEM) systems are powerful tools for gaining spatially extensive high-resolution information about geologic and hydrogeologic conditions, leading to valuable insights for researchers and resource managers. However, technical and logistical limitations do not make all problems or locations suitable for the AEM method. Installation resource managers do not have ready access to the knowledge base necessary to be aware of the potential utility of AEM data or to determine whether they should consider this technology for their site. As part of a grant through the Environmental Security Technology Certification Program, the U.S. Geological Survey and U.S. Army Corps of Engineers are partnering to facilitate the strategic and technically sound adoption of AEM surveys into water security planning for domestic military installations. Through the development of an AEM suitability framework, we aim to provide installation managers with clear, definable criteria for non-experts to initially evaluate whether the AEM method is a technically sound and cost effective approach for their location and resource management objectives prior to consulting with a geophysicist or methods expert. The suitability framework is currently focused on groundwater availability applications. The framework defines and ranks several metrics under three primary categories: (1) scale (area of interest, aquifer and groundwater depth, geologic complexity), (2) resolvability (conductivity contrasts, relative thickness of features of interest, AEM system sensitivity), and (3) environment (infrastructure and population intensity, cultural noise sources, ecological conflicts, site use conflicts, airspace restrictions, sensitivity to data collection). While some of these considerations are unique to military installations, many factors are common to typical hydrogeologic applications. The framework is applied to Edwards Air Force Base as well other selected bases in the southwestern United States as a demonstration of the application for water resource management.

Keywords: groundwater; feasibility; California

Country-scale AEM survey for sustainable water management

Short-abstract poster · Stand 46

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Abstract

Fresh groundwater has become an increasingly scarce resource worldwide. The salinisation process, climate change, urbanization and unsustainable resource management are the main drivers of this long-term groundwater crisis. Well planned, executed and managed projects are needed to address crucial water management challenges. A recent example is the FRESHEM-NL Project in The Netherlands, a result of a broad collaboration between provinces, water authorities, drinking water companies and led by Deltares and TNO institutes. With 26,000 line-km of data acquired by SkyTEM, this currently represents the largest groundwater Airborne Electro-Magnetic survey in Europe. Airborne EM aims to revealing remarkable insights into the aquifer system such as the identification of fresh, brackish, and saline groundwater, as well as the thickness and position of crucial protective clay layers. In this conductive environment, careful and detailed processing is essential to separate subsurface signals from the response of urban infrastructure. The work will show how Emergo handled the advanced processing of the high-resolution data collected adopting ad-hoc workflows to ensure the data will be modelled and interpreted to the highest level of accuracy. Flexibility, effective communication and expertise are the key points for the success of a such important groundbreaking project

Keywords: AEM; groundwater; processing

Inferring Platform Attitude from UAV Logs: Learning-Based Sensor Fusion Demonstrated on Semi-Airborne Electromagnetics

Short-abstract poster · Stand 47

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Abstract

This study explores the use of a feedforward neural network (FNN) for data-driven sensor fusion in UAV-based geophysical surveying. Our approach is developed and evaluated using aircraft telemetry data from a semi-airborne electromagnetic (SAEM) campaign in Northern Germany. The deployed measurement system consists of a battery-powered uncrewed aerial vehicle (UAV) with a maximum take-off weight of 25 kg carrying a semi-flexible carbon-fibre rod with a three-component induction coil mounted at its distal end. An inertial measurement unit (IMU) is also mounted on the rod to continuously record platform orientation, as reliable attitude information of the sensor platform is essential for SAEM data processing. However, for the selected survey campaign, incomplete and erroneous IMU recordings were encountered, rendering a conventional evaluation workflow infeasible for a substantial portion of the acquired data. To reconstruct missing attitude information, an FNN was set up and trained on an intact data set to infer the orientation of the sensor platform directly from UAV telemetry data. The network architecture comprises a single hidden layer and an output layer and was trained by minimizing the mean squared error between telemetry-based inputs and available IMU attitude estimates. Time series from ten survey flights were used for training and validation, while an additional independent flight served as a test data set. Training converged within minutes on a standard notebook computer, highlighting the computational efficiency and field applicability of the approach. Mean absolute errors of the inferred attitude information remained below 3° for all Euler angles within the independent test data set, with accuracies better than 1° achieved for selected components. To assess the practical impact on geophysical interpretation, magnetic transfer functions were determined for a selected ground-based electromagnetic transmitter based on measured and predicted platform attitudes. Transfer functions obtained from the two attitude data sets show a high degree of agreement. Furthermore, subsequent three-dimensional inversions yield closely matching subsurface conductivity models.So far, the results demonstrate that platform attitude can be reconstructed from UAV telemetry logs, opening a path toward a practical fallback solution in cases of sensor failure and, potentially, toward data-driven surrogates for sensor-fusion hardware. Our approach appears especially promising for multi-sensor UAV systems that routinely generate rich operational log data.

Keywords: MachineLearning; UAV; SemiAirborneElectromagnetics

Comparison of Deep Learning Architectures for Cross-Sensor Time Series Reconstruction

Short-abstract poster · Stand 48

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Abstract

The acquisition of geophysical data using unmanned aerial vehicles (UAVs) is becoming increasingly important for electromagnetic (EM) exploration, enabling high-resolution measurements in challenging terrains. Within geophysical UAV-based surveying reliable sensor orientation data is essential. Thus ensuring data integrity remains a critical challenge for drone-based platforms. Technical malfunctions, such as sensor errors or memory failures within the Inertial Measurement Unit (IMU), can result in incomplete time series. This significantly hinders or even prevents subsequent data processing and orientation corrections of the EM data. To address this, we evaluate the performance of various deep learning architectures in reconstructing faulty or missing telemetry time series. By modeling complex temporal dependencies between parameters such as acceleration, orientation angles, and angular rates, these networks can accurately impute missing data segments. Previous benchmarks demonstrated that Transformer architectures, utilizing multi-head self-attention mechanisms, significantly outperform conventional Feed-Forward Networks (FFN), particularly in predicting the two Euler angles roll and pitch angles. While the yaw angle presents challenges due to boundary context effects, residual analyses confirm the general suitability of these models for robust data imputation. Building upon these findings, the current research expands into advanced hybrid sequence modeling. We explore options for combining attention mechanisms with alternative architectures, alongside optimized FFN baselines, to improve both prediction accuracy and computational efficiency for long time series.

Keywords: DeepLearning; UAV; CrossSensor

Uncovering hidden minerals with a towed bird electromagnetic system

Short-abstract poster · Stand 49

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Abstract

The maximum depth of investigation of airborne electromagnetic systems can be limited by uncertainty in the transmitter-receiver geometry. This poster presents efforts to overcome this problem on a towed bird electromagnetic system. Data from the receiver coils can be presented as the time derivative dB/dt or in integrated form as the secondary magnetic field B, integrating when the transmitter current is off or constant so there is no primary field. The secondary magnetic field B can better characterise highly conductive features such as massive nickel and copper sulphide deposits. A true B-field system with accurate geometry can also be used to detect thick orebodies under conductive overburden approximately 3 times earlier than dB/dt methods, and potentially sqrt(3) deeper. The constant of integration is often fitted based on the assumption that the extrapolated magnetic field B decays to zero, but this can lead to subsurface models with erroneously low conductivity at depth; a result no better than a dB/dt system. To determine the secondary magnetic field B precisely, we must include data when the transmitter current is switching and subtract the primary field component, but this requires accurate knowledge of the bird-aircraft geometry. This poster discusses a new project to solve this problem.

Keywords: Bfield; TEMPEST; bird

The Material-Type Characterization Method: Addressing Interpretation Uncertainty in Inverted HTEM Data

Short-abstract poster · Stand 50

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Abstract

Interpreting geologic-material distributions from inverted helicopter time-domain electromagnetic (HTEM) resistivity data involves managing uncertainties at every stage: data collection, processing, inversion, and the translation of resistivity values to material types. We present the Material-Type Characterization (MTC) method, which explicitly targets interpretation-stage uncertainty and allows multiple geologically plausible models to be generated from a single inversion using a user-definable set of material-type proportions. The MTC method was developed for a Champaign County, Illinois, USA study area, where 3,145 km of HTEM data were collected along flight lines spaced approximately 650 m apart. The target is a Quaternary succession overlying a regional bedrock valley, whose basal sand and gravel deposits constitute the only regional aquifer in east-central Illinois. The data were collected to characterize the distribution and internal architecture of the basal aquifer, and to identify the locations of interconnection between the basal and overlying sand and gravel aquifers. The method follows four conceptual steps. First, resistivity patterns and the existing regional lithostratigraphic framework are combined to define an electro-lithic stratigraphic framework — a novel unit scheme that integrates electrical and lithologic information. A strictly electrical classification was insufficient because resistivity-to-material-type relationships are non-stationary across lithostratigraphic units; the electro-lithic framework resolves this by preserving known lithologic constraints while honoring the resistivity distribution. Second, resistivity-to-material-type relationships and their uncertainty distributions are characterized for each electro-lithic unit, using particle size analyses, core descriptions, water well driller logs, and geophysical wireline logs. Third, conceptual models of material-type proportions are defined for each unit, encoding existing knowledge about plausible sediment distributions. These conceptual models allow for the creation of multiple interpretations, that together represent the range of interpretations that are consistent with both available data and sedimentary knowledge. Fourth, material types are assigned to 3-D grid nodes based on electro-lithic unit, resistivity value, and the selected material-type proportion model. A key advantage of this modeling architecture is that different material-type proportion models produce distinct, geologically plausible interpretations from the same inversion. Applied to the Champaign County data, we generated three models, each with six different electro-lithic stratigraphic units: a Preferred model, a Low Sand Frequency model, and a High Sand Frequency model, representing a range of plausible aquifer geometries suitable for groundwater modeling scenarios. Future work is focused on two key areas. First, integration and anchoring of interpretations to existing borehole data is complicated by resistivity-to-material-type ambiguity, thin layering common in Quaternary sediments, and the volume-averaging inherent to HTEM measurements. The MTC currently uses borehole data to inform the development of material-type proportion models. Development of methods to use high-quality borehole data as interpretation anchors is a focus of current method evolution. Second, architectural realism in the sediment distribution is also a difficult characteristic to evaluate and address. Integration of indicator variography and transition probability metrics (e.g., Carle and Fogg, 1996, Mathematical Geology) is the target of method extensions to address improvements in sediment architecture.

Keywords: Modeling; Uncertainties; TEM

Integrating surface spectral and subsurface geophysical data for comprehensive resource characterisation of mining residues

Short-abstract poster · Stand 51

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Abstract

Mining waste deposits are increasingly recognised not as inert liabilities but as objects requiring integrated assessment of their valorisation potential, environmental impact, and geotechnical stability. Decision making thus requires information on the three dimensional composition of these deposits, which can be a significant challenge due to their heterogeneous structure and often poorly documented construction. Airborne hyperspectral imaging (HSI) provides high-resolution mineralogical information across exposed surfaces, while low-frequency airborne electromagnetics (AEM) can be used to estimate multi-parameter geophysical properties at depth. Both tools are valuable for characterising exposed and subsurface structures, but their combined use holds greater potential. However this integration remains challenging, owing to differences in resolution, coverage, and other data characteristics. In this contribution we combine AEM and HSI data, supplemented by LiDAR and ground validation, in a novel 3D modelling and machine learning framework that maximises the predictive capacity of these datasets. We then demonstrate the approach on sulfidic waste rocks associated with volcanic-hosted massive sulfide (VMS) deposits of the Iberian Pyrite Belt in southern Spain. These extraction remnants, long overlooked for their economic potential, have gained importance due to favourable metal prices and improved processing techniques. Our method parameterises variability within the rock-waste using an implicit neural representation (INR) that is trained to maximise the mutual information between (sub)surface geometry (implicit field) and our HSI and AEM measurements. Subsurface constraints were derived by inverting the time-domain AEM data (acquired with a SkyTEM312HP system) using an induced-polarisation–aware, layered-earth scheme based on the Maximum Phase Angle (MPA) Cole-Cole re-parameterisation. This inversion yielded three-dimensional volumes of resistivity and chargeability. Surface constraints were derived by extracting mineralogically and lithologically interpretable spectral features using endmember extraction and unmixing, resulting in endmember abundance maps across the rockwaste. These disparate data were then unified to constrain subsurface mineralogy by training the INR to predict both endmember abundance (using the surface constraints), resistivity and chargeability (using the inversion results for the subsurface). This assumes that lithology is the dominant control on the AEM signal, and thus that an optimal implicit representation of the subsurface geometry will correlate to both hyperspectral endmember abundance and the petrophysical properties. Once trained, this INR lets us identify lithological domains for the entire 3D rock-waste volume, which are then used to infer potential value (Cu content). These results could also be applied to identify potential environmental or stability issues. We validate our results against drill hole assays, achieving reasonable correlation with logged waste rock lithologies and copper and sulfur grades. To conclude, we suggest that non-invasive remote sensing methods can enable comprehensive and three-dimensional understanding of waste rock deposits, reducing the amount of expensive drilling needed to characterise them (although drilling data remains essential). Such three-dimensional material characterisation provides a shared basis for evaluating the valorisation potential of secondary raw materials, anticipating the environmental impact of reactive sulfidic waste, and informing on geotechnical stability for risk management and planning. In combination, these methods can thus support a more sustainable and informed approach to resource supply and management.

Keywords: AEM; hyperspectral; minewaste

Beyond Conductivity: Simultaneous Resistivity and Chargeability Recovery from Airborne Time-Domain EM Data

Short-abstract poster · Stand 52

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Abstract

Airborne time-domain electromagnetic surveys are widely used for mineral exploration because of their ability to detect conductive targets and map subsurface conductivity over large areas. Conventional processing assumes that the measured transient is governed solely by electromagnetic diffusion, producing conductivity or resistivity models for geological interpretation. However, many economically important mineral systems contain disseminated sulphides and other polarizable minerals that generate induced polarization (IP) effects. These responses are commonly treated as distortions of the electromagnetic transient despite containing valuable information about mineralization. Recent advances in inversion algorithms enable simultaneous modelling of conductive and polarization responses from the same airborne TDEM data. This study presents an advanced processing workflow that recovers both resistivity and airborne induced polarization (AIP) from helicopter-borne TDEM measurements. The methodology is demonstrated using the 15 Hz base-frequency TargetEM survey over the Chrome Mountain deposit within the Stillwater Complex, Montana, where geological mapping, drilling, and ground IP data provide an independent basis for validation. Following transmitter current turn-off, the transient response is initially dominated by diffusing eddy currents. In polarizable materials, including disseminated sulphides and alteration minerals, electrical charges accumulated at grain-fluid interfaces relax after current termination, generating secondary currents that modify the transient decay. Because the inductive response decays more rapidly than the polarization response, IP effects become increasingly significant during the late-time transient. Rather than suppressing these effects, the proposed workflow explicitly incorporates polarization into the inversion, enabling simultaneous estimation of resistivity and chargeability from the complete transient response. The study utilized helicopter-borne TargetEM data acquired over approximately 2.9 × 2.3 km covering known Ni-PGE-Cu-Co-Au mineralization. Following comprehensive noise attenuation and system calibration, the complete transient responses were inverted using the advanced AIP workflow implemented in EMStudio. The inversion simultaneously estimates resistivity and chargeability without geological constraints, producing resistivity, chargeability, model misfit and depth-of-investigation products. Model validation was performed through comparison with available geological mapping, known mineralized horizons and independently inverted ground IP data. The TargetEM data proved suitable for simultaneous resistivity and AIP inversion, producing stable models with low data misfits and an estimated depth of investigation of approximately 200–500 m. Chargeability anomalies correlate well with known sulphide mineralization and independently acquired ground IP results, while resistivity models delineate lithological contacts, intrusive architecture and structural boundaries. The complementary nature of these physical properties provides significantly improved geological interpretation compared with resistivity alone. Reliable airborne IP recovery depends on preservation of high-quality late-time transient measurements. Low receiver noise, stable transmitter performance, accurate timing, and long off-times are essential to resolve the relatively weak polarization response. Although the chargeability depth of investigation is generally shallower than that of resistivity, inversion remains inherently non-unique, and chargeability depth of investigation is generally shallower than that of resistivity and inversion remains inherently non-unique, integration with geological and ground geophysical information substantially improves interpretation reliability. The presented methodology demonstrates that existing helicopter TDEM datasets can be reprocessed to recover both resistivity and airborne chargeability from a single survey, significantly enhancing their value for regional exploration and targeting of polarizable mineral systems.

Keywords: Airborne; electromagnetics; inversion

A Multiscale Finite Element Method for Accelerating 3D Airborne Electromagnetic Inversion

Short-abstract poster · Stand 53

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Abstract

Airborne electromagnetic (AEM) methods have the advantages of high efficiency of data acquisition and high resolution, making them particularly suitable for mineral exploration, geological hazard prediction, and geological mapping. However, AEM exploration usually collect large amount of data, leading to high computational costs and memory demands that can severely restrict the practical use of three-dimensional (3D) inversions. In 3D AEM inversions, the most time-consuming process is the computation of forward responses and adjoint modeling for sensitivity matrices. To accelerate the computational speed of 3D AEM inversion, we propose a 3D AEM inversion method based on the multiscale finite-element method (MsFEM). The MsFEM employs two nested hexahedral meshes with different element sizes, with a fine-scale mesh to describe detailed variations of the subsurface conductivity, and a coarse-scale mesh to reduce the dimensionality of the forward and joint modeling equations. The method first constructs a large-scale linear equations system on the fine-scale meshes, and then builds an interpolation mapping operator between the fine- and coarse-scale meshes by solving local adjoint forward modeling equations within each coarse mesh. Using the interpolation operator, the forward modeling equations are projected onto the coarse-scale mesh, yielding solutions with accuracy comparable to those of fine-scale meshes but with significantly reduced cost. For 3D AEM inversions, the Jacobian matrix is computed using adjoint formulation in MsFEM. Once the forward responses and Jacobian matrix are obtained, the Gauss-Newton scheme is applied to perform 3D inversions. Since all computations are carried out on the coarse-scale mesh, both computational time and memory usage are largely reduced. To validate the effectiveness of the proposed MsFEM inversion method, we conduct numerical tests on both synthetic and field datasets. The synthetic model tests demonstrate that the MsFEM inversion achieves accuracy comparable to that of the traditional finite-element method. Furthermore, the inversions of an AEM field dataset from Norway show that our method can not only effectively recover electrical structures in the subsurface but can also improve the computational efficiency and reduces memory consumptions. These results indicate that the MsFEM have potentials for promoting the practical application of 3D AEM inversions.

Keywords: Airborneelectromagnetic; Inversion; MultiscalefiniteelementmethodThreedimensional