Exploring the Atacama Desert with TEM: Quebrada de los Tiburones and Salar Grande, Chile

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Introduction

- As a part of the CRC 1211 project, we employed geophysical techniques such as transient electromagnetic (TEM) and conductivity mapping (CMD) for subsurface imaging of various prospects across the Atacama desert in Chile in March-April 2023.
- Focusing on the Salar Grande and Quebrada Tiburón, inversion of TEM data will be carried out in order to contribute to a more profound knowledge of the area's subsurface characteristics.
- Results from conventional 1D inversion will be compared with a Bayesian/ probabilistic approach. A brief summary on its theory is presented below.

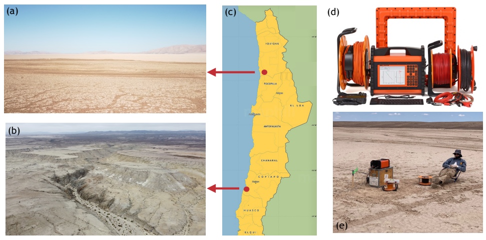
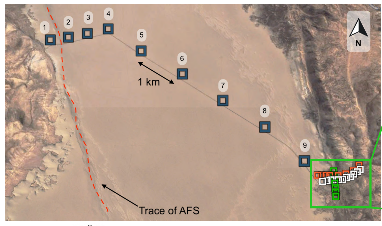


Figure 1. Dron view from (a) Salar Grande, Region of Tarapacá, Chile; (b) Quebrada Tiburón, Region of Atacama, Chile. (c) Map of the North of Chile. (d), (e) TEM device/setup in the field.

Salar Grande

Target: Salar Grande at Coastal Cordillera to provide the geometry of the halite + fine sediment deposits.

- First 1D models exhibit a clear contrast of resistive/conductive geometry, highly consistent with the geological literature (Fig. 2).
- Promising TEM data on which a clear and well- fitted geometry is detected.



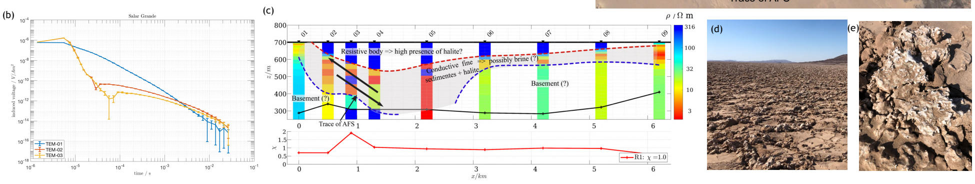


Figure 2. (a) TEM locations along the Salar Grande. (b) Transients from Stations 1, 2 and 3. (c) Occam 1D inversion of Salar Grande profile. (d), (e) Closer view on the terrain.

Alluvial fan

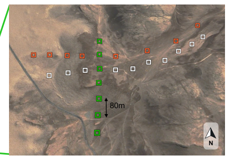


Figure 3. TEM locations in the alluvial fan.

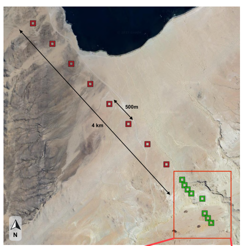
Target: Alluvial fan on the eastern side of the Salar Grande.

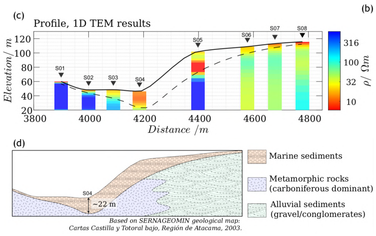
- 25 TEM stations (3 profiles) measured.
- Data not processed yet.

Marine Sediments

Target: Marine sediments in the Quebrada Tiburón. TEM was used to determine the thickness of these deposits.

- 8 stations in a long profile to the coast. Data not processed yet.
- 8 stations in a more dense profile along the Quebrada. First results reveal a shallow conductive top-surface layer interpreted as Neogene-Quaternary marine sediments.





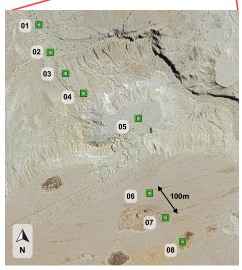


Figure 4. (a), (b) TEM locations. (c) Occam R1 1D inversion of transect NW-SE, of the stations in (b). (d) Geological interpretation sketch.

Bayesian Inversion

Bayes Theorem combines observed data with available prior information on the model to infer the posterior probability density function (PDF):

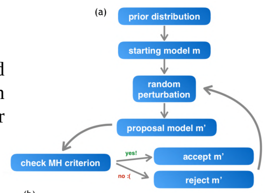
$$p(\mathbf{m} \mid \mathbf{d}_{obs}) \propto p(\mathbf{d}_{obs} \mid \mathbf{m}) p(\mathbf{m})$$

The McMC sampling method (Fig. 5) explores the full model space in a guided random walk, producing an ensemble of models from the prior, using a proposal function.

The Metropolis-Hastings acceptance Criterion is used to decide whether to replace the current model with the new proposed model:

$$\alpha(\mathbf{m}'|\mathbf{m}) = \min\left[1, \frac{p(\mathbf{m}')}{p(\mathbf{m})} \times \frac{p(\mathbf{d}|\mathbf{m}')}{p(\mathbf{d}|\mathbf{m})} \times \frac{q(\mathbf{m}|\mathbf{m}')}{q(\mathbf{m}'|\mathbf{m})} \times |\mathbf{J}|\right]$$

The algorithm produces an ensemble of models that converges to the posterior as the number of samples in the ensemble grows.



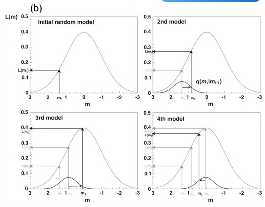


Figure 5. (a) Flowchart of the McMC scheme. (b) Implementation of the proposal function.

Conclusions & Outlook

- Successful multi-site geophysical survey.
- Preliminary TEM results are promising.

What is next?

- Full data evaluation at both sites with conventional 1D inversion techniques.
- Subsequently, 1D and quasi 2D bayesian inversion for selected site.

Acknowledgements & References

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