Satellite measurements of deformation and the environmental impacts of Lithium mining in northern Chile

Lead supervisor: Dr John Elliott, University of Leeds

Co-supervisors: Dr Susanna Ebmeier, University of Leeds; Dr Ekbal Hussain, BGS.

Project Highlights:

- Interferometric Synthetic Aperture Radar (InSAR) time series to track deformation due to lithium extraction.
- Combine optical and radar imagery, to detect changes in surface water, groundwater levels, and changes in soil quality and vegetation cover in areas affected by mining.
- Integrate historical satellite data with machine learning and statistical models to create forecast maps of future environmental impacts based on mining expansion scenarios.

Overview:

Lithium mining is a critical for the global energy transition, particularly for the production of lithium-ion batteries essential for electric vehicles and renewable energy storage. Northern Chile is one of the world's primary sources of lithium, with the Salar de Atacama basin (Figure 1) accounting for a significant portion of global supply. However, the extraction of lithium from these rich salt flats poses serious environmental challenges, including water depletion, land subsidence, and soil degradation. Furthermore, there are concerns about the impact of mining-induced land deformation on surrounding ecosystems and communities.

Despite growing recognition of these environmental issues, comprehensive assessments of lithium mining's effects, particularly at a regional scale, remain limited. Satellite remote sensing offers a unique opportunity to quantify and monitor environmental changes caused by lithium mining activities. By utilizing state of the art analysis methods and the latest satellite data, this project aims to investigate the environmental impacts—particularly the land deformation and hydrological changes—caused by lithium extraction in Northern Chile.

The outcomes will contribute to the development of more sustainable mining practices, and will enhance the global understanding of how large-scale extraction of critical minerals can be managed in a way that minimizes harm to ecosystems and communities. With growing global demand for lithium, understanding its environmental costs is crucial.

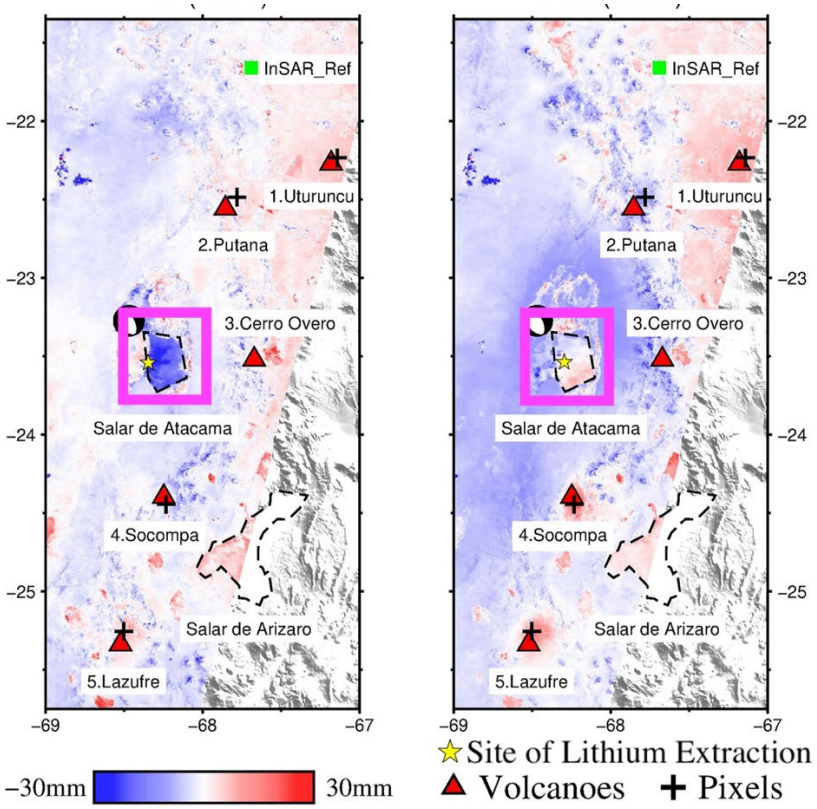

Figure 1. InSAR derived descending line-of-site displacements (left panel: 2018-2020; right panel 2020-2022) in the Atacama region of northern Chile showing deformation in the Salar de Atacama (magenta box). A major centre of Li extraction is indicated by the yellow star. Adapted from Liu et al., 2023. (https://doi.org/10.1029/2022GL102480)

Methodology:

We will make interferometric synthetic aperture radar (InSAR, Sentinel-1, CSK) measurements of deformation at sites of Lithium extraction in the Salar de Atacama in northern Chile. Mining in this area is associated with significant deformation (Figure 1) with a complex temporal patterns. We will also combine optical/IR measurements (e.g., Sentinel-2) with hyperspectral data (e.g., Hyperion) to detect changes in water table, vegetation and soil quality in zones of intense lithium mining. This combined analysis of diverse satellite imagery will allow us to analyse the developing impact of Lithium extraction. We will then use our satellite-derived indicators with machine learning methods to construct future scenarios for environmental impact based on ongoing and planned mining expansions.

Possible Timeline

Year 1: Initial analysis of InSAR data and development of approach for detecting environmental changes from optical/IR imagery

Year 2: Soil and vegetation impact studies, analysis of deformation time series in context of other markers of environmental change

Year 3: Environmental impact modelling and forecasting future deformation and hydrological changes.

Training and skills:

Training will be provided in analysis of satellite imagery, machine learning and cloud computing methods. The student will develop in-demand skills in processing and analysing SAR imagery.

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

Partners and collaboration (including CASE):

The successful applicant with have regular meetings with Dr Ekbal Hussain at the British Geological Survey online every 6 to 8 weeks and in person quarterly. We will work with a remote sensing specialist with experience in studying deformation in northern Chile at CGG who are potential CASE partners for this project.

Further reading:

Delgado, F., Shreve, T., Borgstrom, S., León-Ibáñez, P., & Poland, M. (2024). A global assessment of SAOCOM-1 L-band stripmap data for InSAR characterization of volcanic, tectonic, cryospheric, and anthropogenic deformation. *IEEE Transactions on Geoscience and Remote Sensing*.

Flores Fernández, C., & Alba, R. (2023). Water or mineral resource? Legal interpretations and hydrosocial configurations of lithium mining in Chile. *Frontiers in Water*, *5*, 1075139.

Liu, W., Agusdinata, D. B., & Myint, S. W. (2019). Spatiotemporal patterns of lithium mining and environmental degradation in the Atacama Salt Flat, Chile. *International Journal of Applied Earth Observation and Geoinformation*, *80*, 145-156.

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply.

For project details please email: j.elliott@leeds.ac.uk.