Design and Operation of a Fluid Metal Extraction (FluMex) Miniplant for Lithium Removal from Geothermal Brines by Adsorption

The CRM-geothermal project aims to develop effective, economically feasible and scalable technologies for the extraction of critical raw materials (CRMs) from geothermal brines without interfering with the heat extraction process. A range of extraction methods have been tested on a laboratory scale.

To bridge the gap between the laboratory and the industrial application, the adsorption method has been studied for lithium recovery in a miniplant using geothermal brine.

Challenges in the Extraction of Lithium from Geothermal Brines

The scaling up of the lithium extraction process from laboratory to pilot scale implies to overcome some challenges related to the operating conditions on site. For instance, the control of fluid with high flow rates of up to 100L/s at different salinities with lithium concentrations varying from 40 – 200 mg/L, and achieving sufficient contact time even with slow sorption kinetics.

How Does the FluMEx Miniplant Operate?

The FluMEx miniplant has been designed and constructed by the Helmholtz Centre for Geosciences (GFZ). It consists of four adsorption columns, and three different modes for operation: Adsorption, desorption and regeneration. In the adsorption, the brine feeds the system using a gear pump, which can generate a pressure of up to 16 bar, and pass through a pre-conditioned column containing $CaCO_3$ to adjust the pH in the neutral range so that Fe(II) could be removed from brine by precipitation. The outlet of this column, will be the new feed to the fixed-bed column that is filled with the adsorbent. In our study we tested the ion sieve extraction that was developed within the CRM project and that is based on granular MnO_2 oxides bound on chitosan. A maximum temperature of 100 °C and 10 bar are allowed in the whole system while operating. For desorption, a solution of HCl 0.5 M is pumped through the adsorbent filled column using a peristaltic pump (max. P = 1 bar) at room temperature. At the outlet of each column samples can be collected. After this step, adsorbent regeneration takes place. This last step includes the flushing of the column with NaOH 0.1 M and distilled water at pH 9-11 until achieving a pH in the effluent 4 > pH > 8.

Figure 1: FluMEx Miniplant with four different columns for adsorber materials.

In case the temperature of the brine needs to be increased, one column is conditioned to be heated up using a heating jacket and a heating bath. The feed brine will pass through the heating bath (opened to atmosphere) and after reaching the desired temperature, it enters into the column with the heating jacket. Temperature sensors are installed throughout this section of the system for safety measures, as well as a safety valve in case of overpressure.

Funded by the European Union

Design and Operation of a Fluid Metal Extraction (FluMex) Miniplant for Lithium Removal from Geothermal Brines by Adsorption

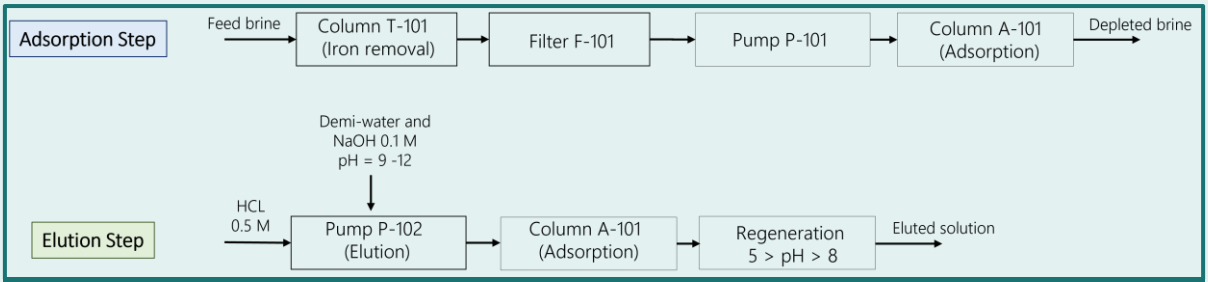

Figure 2: Flow scheme of fluid passing through the FluMEx Miniplant.

In the heating bath, the brine flows through a helix tubing able to rise the temperature up to 100 °C, however to avoid evaporation, overheating is limited while in operation. The pressure relief valve acts when inlet and outlet valves are blocked/closed and the heating system is still active.

What can we measure with the miniplant?

The miniplant works employing the adsorption method. This is a well-known DLE technique that offers benefits such as reduction in water consumption, less residuals and contaminants, high selectivity and more efficiency for lithium recovery. Each column is able to operate in continuous mode and deliver in real time variations in values of pH, temperature, pressure gradients, conductivity and oxygen. The pH value at each column is continuously measured and monitored. Samples can be taken at the column outlet based on the operator needs at certain time intervals. The samples are analyzed in the laboratory later using ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry) to obtain lithium and other elemental concentrations. With these values and the recorded sampling time, we can generate a breakthrough curve for the adsorbed metal.

The breakthrough curves are a graphical '*radiography*' of what happened inside the column during operation. It allows to estimate the lithium amount adsorbed per cycle, the column efficiency, the achieved residence time, assess the sorption kinetic behavior, shape and steepness of the curve, influences of variations in the flow, and diffusion rate. The evaluation of these and other parameters helps to understand the underlying physics of the process for further optimization.

Figure 3: Equilibrating of manganese oxide on chitosan in water before application in the FluMEx Miniplant.

Funded by the European Union

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

Design and Operation of a Fluid Metal Extraction (FluMex) Miniplant for Lithium Removal from Geothermal Brines by Adsorption

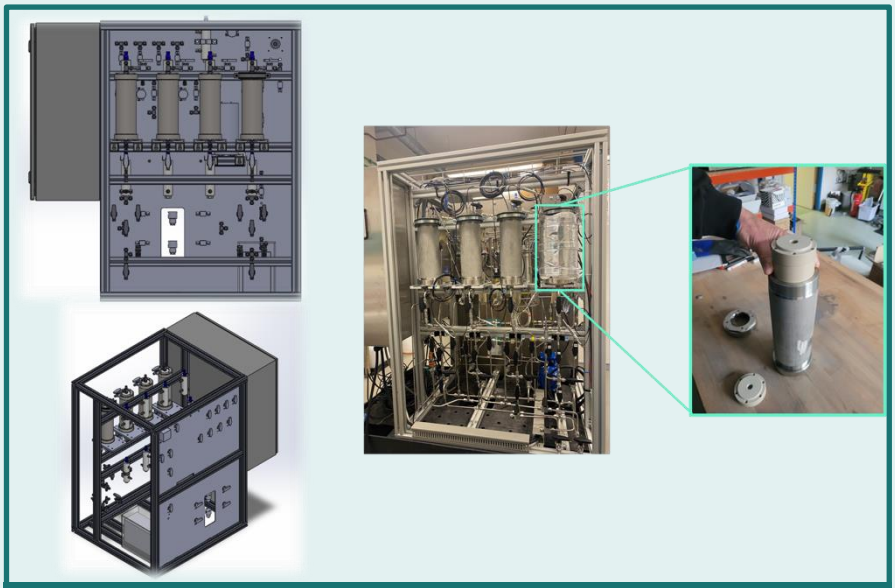

Figure 4: Design (left) and photo (middle) of the FluMEx Miniplant. Right: Enlargement of a column.

First field experiment with the Miniplant in Cornwall

In June 2026, the GFZ tested the FluMEx Miniplant together with partners from Cornish Lithium in United Downs (Cornwall, UK) to demonstrate extraction of lithium in the field at a geothermal well.

The geothermal well was drilled into granitic rocks and lithium-rich brine can be pumped from the well to test the extraction technologies under realistic flowing conditions.

The goal of the experiment was to test different parameters such as flow and temperature to observe how the adsorbent material would perform. The device allows to measure pH before and after the adsorption column and to vary the experimental conditions. During the following days, adsorption, desorption, and regeneration tests and intense sampling was performed. In addition to pH, also the redox value, the electric conductivity and oxygen content were monitored. On site analysis included quick tests for Fe(II), silica, lithium, and sulphide.

More information:
https://crm-geothermal.eu/2026/06/30/successful-field-demonstration-of-lithium-and-helium-extraction-technologies-in-cornwall/

Contact point:
Karen Silgado – GFZ -silgado@gfz.de

Funded by the European Union