

Extraction of Critical Raw Materials from Geothermal Precipitates from Reykjanes, Iceland

Lea Krohn¹ (✉ lkrohn@ethz.ch), Maren Brehme¹, Simona Regenspurg²

1 ETH Zürich, Department of Earth and Planetary Sciences
2 GFZ Helmholtz Centre for Geosciences



Abstract

LinkedIn

Actively seeking a PhD position, please connect!



1 Introduction

We aim to assess a new combination of energy and critical raw material (CRM) extraction in the geothermal industry: **the valorization of otherwise discarded geothermal precipitate (scale) by leaching of CRMs**. CRMs are metals/minerals characterized by a high supply risk and economic importance for the EU [1]. Scale formation upon pressure and temperature drops during fluid ascent in the power plant (Fig. 1) removes CRMs from the brine [2]. In Reykjanes, scale is enriched in the CRMs As, Bi, Co, Ga, Mn, Sb, V and W, as well as other elements of economic importance [2].

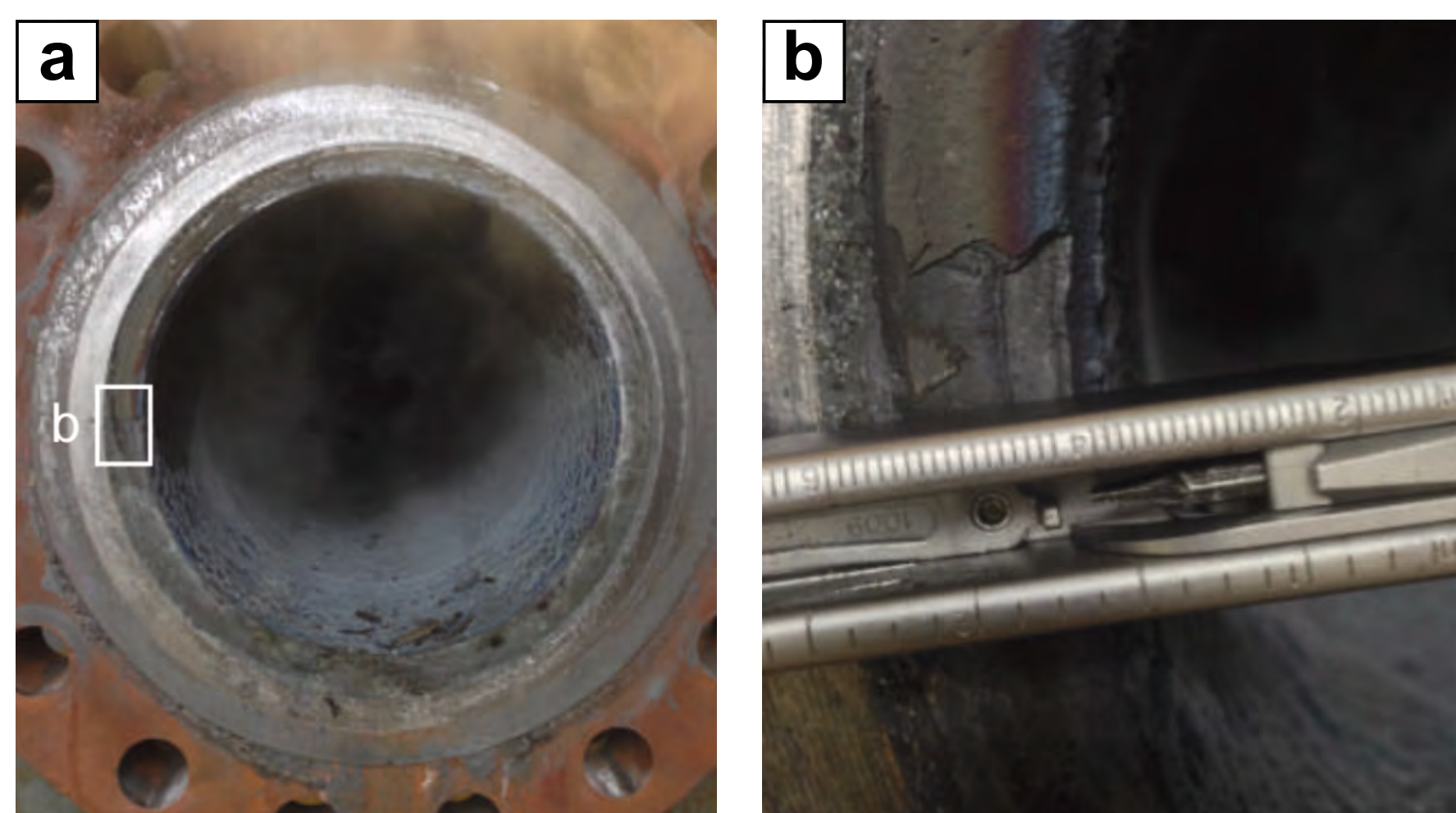


Figure 1 - Blue Cu-(Fe)-sulfide scale in surface high-pressure well in Reykjanes. From [2].

3 Preliminary Results & Discussion

Reykjanes scale exhibits a main mineralogy of Zn-Cu, Cu-Fe and Pb sulfides (light phases in Fig. 3b) along with Mn-Fe silicate (dark phase in Fig. 3b). A relative scarcity of sulfides after leaching experiments (Fig. 3c/d) indicates that CRM-bearing minerals have been dissolved.

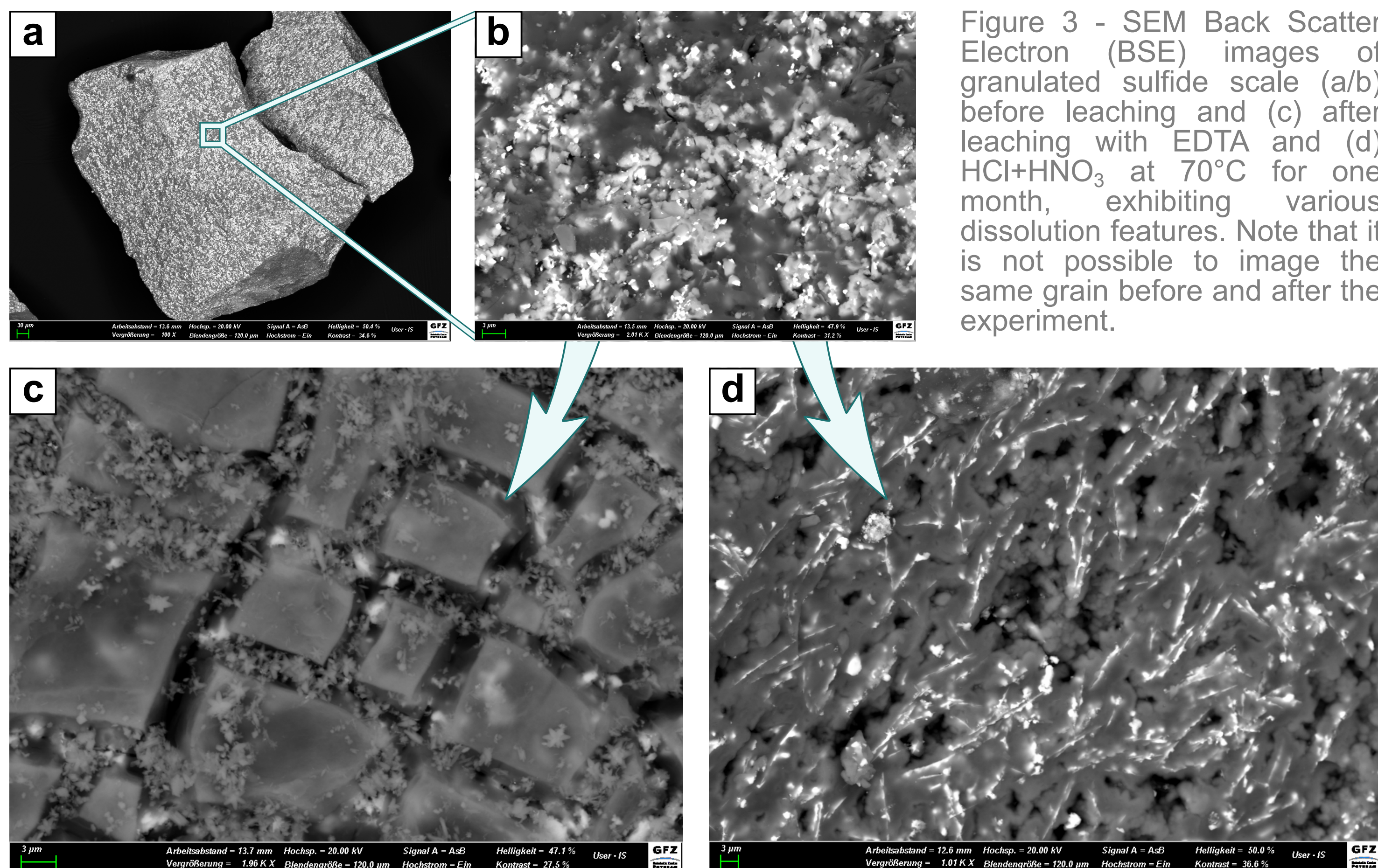


Figure 3 - SEM Back Scatter Electron (BSE) images of granulated sulfide scale (a/b) before leaching and (c) after leaching with EDTA and (d) HCl+HNO₃ at 70°C for one month, exhibiting various dissolution features. Note that it is not possible to image the same grain before and after the experiment.

Magnitude comparison of critical major element enrichments in leachates (Fig. 4) suggests favorable conditions for CRM release include:

- (1) higher temperature (70°C),
- (2) longer batch time (1 week - 1 month) and
- (3) complexing (EDTA) or acidic leachant properties (HCl+HNO₃).

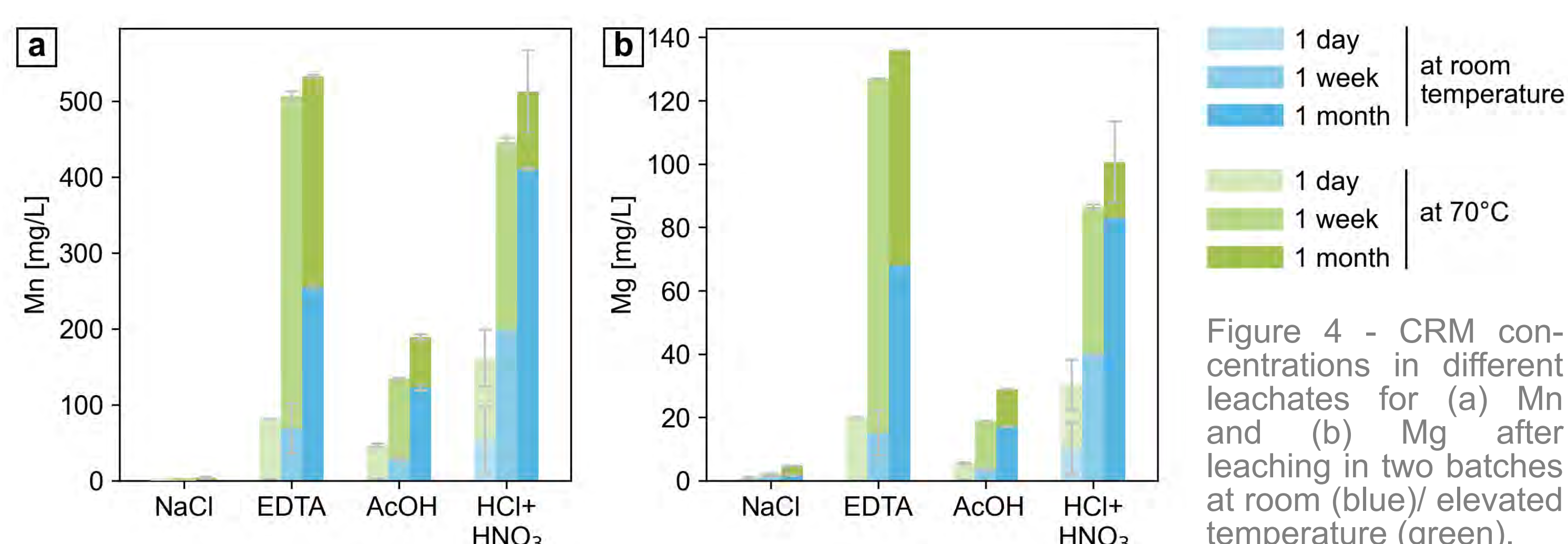


Figure 4 - CRM concentrations in different leachates for (a) Mn and (b) Mg after leaching in two batches at room (blue)/ elevated temperature (green).

2 Methods

Batch leaching experiments were conducted in an orbital shaker (Fig. 2) according to Table 1. Leachates were subjected to immediate in-situ measurements (S²⁻, ORP, O₂, pH, conductivity), IC and ICP-OES/MS, (un)leached scale to pXRF, XRD, SEM and ICP-OES/MS.

Figure 2 - Scale granulate with leachant and in orbital shaker.

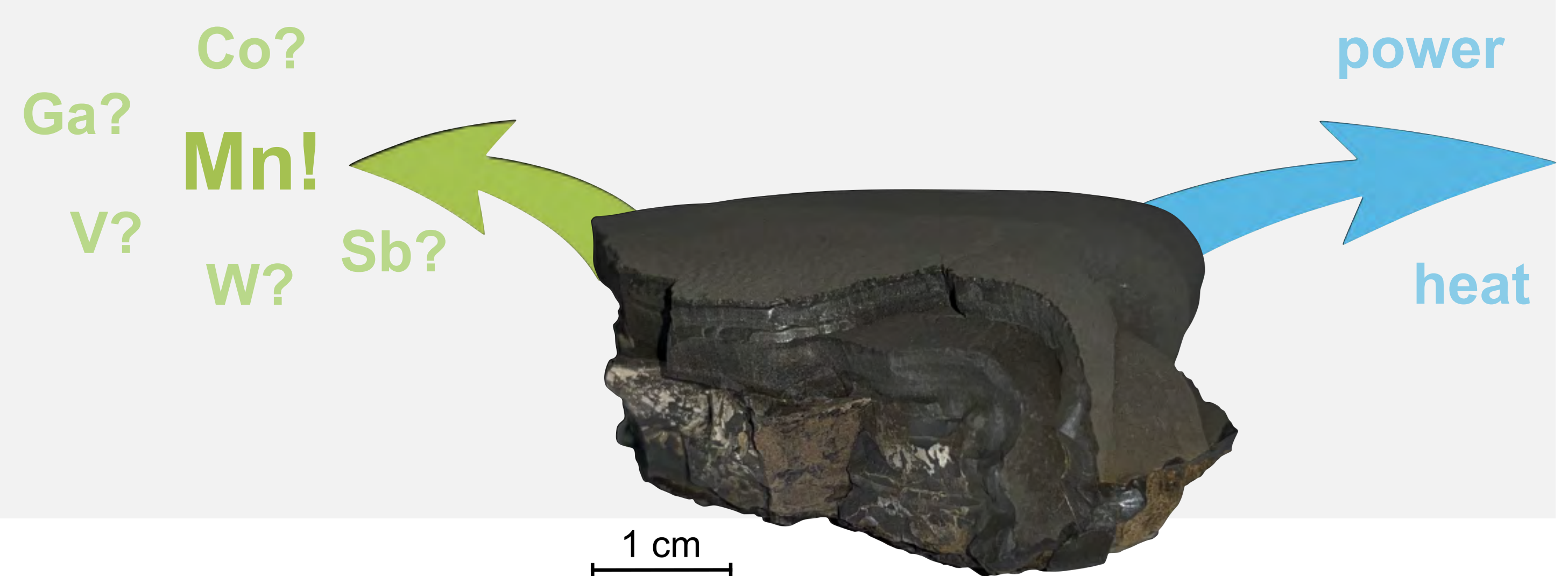


Table 1 - Variables in scale leaching tests.

preparation	pestled to 250-500 µm particle size using agate mortar
liquid/solid ratio	40 mL of leachant on 1 g of scale granulate
leachants	0.6M NaCl, 0.1M EDTA, 0.1M AcOH, 0.1M HCl + 0.03M HNO ₃ [3]
hydraulic conditions	batch
solid-leachant contact	agitated leaching vessel, not under pressure
temperature	room temperature and 70°C
duration	4 weeks batch time
sampling	after 1 day, 1 week and 1 month

4 Conclusion & Outlook

- (1) Successful dissolution of CRM-bearing sulfide phases in geothermal precipitates is achieved by leaching.
 - ⇒ next: quantification of mobilized fraction of CRM enrichment and leaching rates
- (2) One week batch time with EDTA / HCl+HNO₃ at elevated temperature is the most effective and feasible combination of experimental variables.
 - ⇒ next: detailed identification of physicochemical controls on, and mechanisms of, leaching
- (3) Scale formation and disposal rates need to be estimated before evaluating the total extractable amount of CRMs and the practical potential for valorization.
 - ⇒ next: **first assessment of whether geothermal scales constitute a CRM resource**



References & Acknowledgements

- [1] M. Grohol and C. Veeh, "Study on the Critical Raw Materials for the EU 2023," DG GROW, European Commission, 2023. Available: <https://doi.org/10.2873/725585>.
- [2] H. L. Grant, M. D. Hannington, V. Hardardóttir, S. H. Fuchs and D. Schumann, "Trace metal distributions in sulfide scales of the seawater-dominated Reykjanes geothermal system: Constraints on sub-seafloor hydrothermal mineralizing processes and metal fluxes," *Ore Geology Reviews*, vol. 116, 2020.
- [3] A. Kilpatrick, C. Rochelle, J. Rushton, A. Lacinska, D. Fúzeri, S. Chenery, A. Marriot, E. Hamilton, M. Watts, I. Mountney and S. Kemp, "CHPM2030 Deliverable D2.2 - Report on metal content mobilization using mild leaching," The Horizon Europe CHPM2030 project, 2017.



Funded by the European Union via the CRM-geothermal project (ID 101058163). 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.



Mobility Scheme Research Exchange



Thank you to Lioba Virchow, Robby Hoffmann, Jasper Lüdicke, Fiorenza Deon, Jörg Zotzmann, Katrin Kieling, Jessica Stammeier, Sabine Tonn, Kristin Günther and Ilona Schäpan for their support.