BATCircle

Pyrometallurgical research highlights at Aalto University

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”Aalto Metallurgy”

Metallurgy

- Research group of 15 – 25 members
- Processing of metals from low grade and complex primary and secondary resources. Experimental & CFD
- In 2020, total 30 peer-reviewed papers
- In BATCircle:
  Improved Co and Ni recovery in primary production
  - Dr. ***Anna Dańczak***, PhD student ***Ronja Ruismäki*** + 2 MSc students

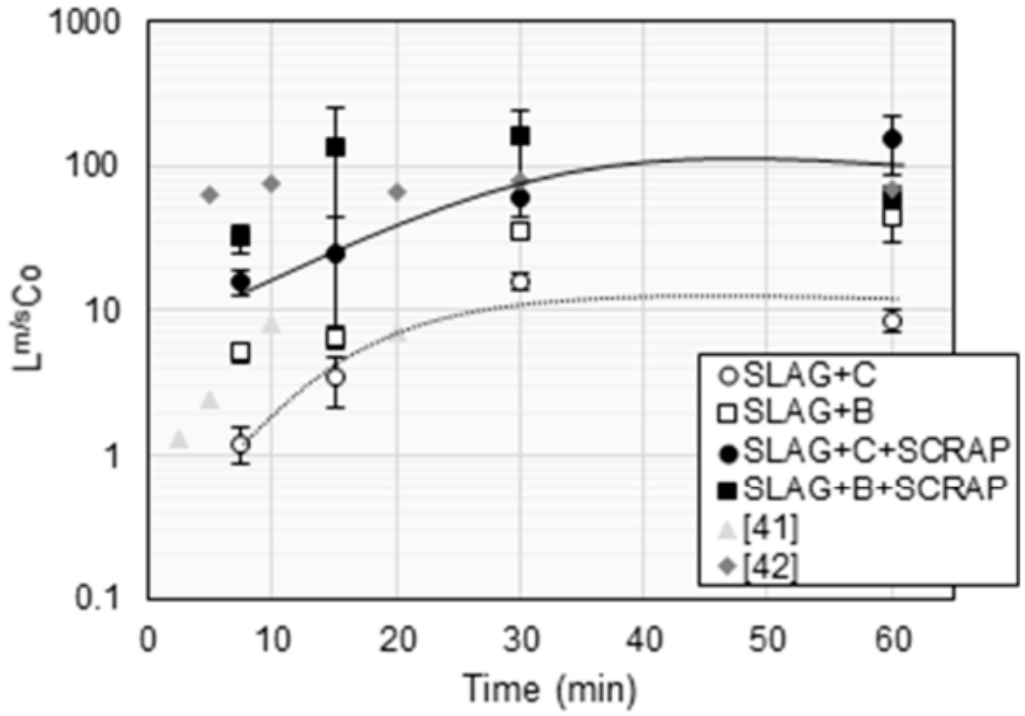
Avarmaa, K., Järvenpää, M., Klemettinen, L., Marjakoski, M., Taskinen, P., Lindberg, D. & **Jokilaakso, A.** (2020). ***Battery scrap and biochar utilization for improved metal recoveries in nickel slag cleaning conditions***. Batteries, 6, 58; doi:10.3390/batteries6040058

Ruismäki, R., Rinne, T., Dańczak, A., Taskinen, P., Serna Guerrero, R. & Jokilaakso, A. (2020) ***Integrating Flotation and Pyrometallurgy for Recovering Graphite and Valuable Metals from Battery Scrap***. Metals 2020, 10(5), 680; https://doi.org/10.3390/met10050680.

Ruismäki, R., Dańczak, A., Klemettinen, L., Taskinen, P., Lindberg, D. & Jokilaakso, A. (2020) ***Integrated battery scrap recycling and nickel slag cleaning with methane reduction.*** Minerals 2020, 10(5), 435; https://doi.org/10.3390/min10050435.

Highlights – Co and Ni recovery in primary production in Ni slag cleaning conditions

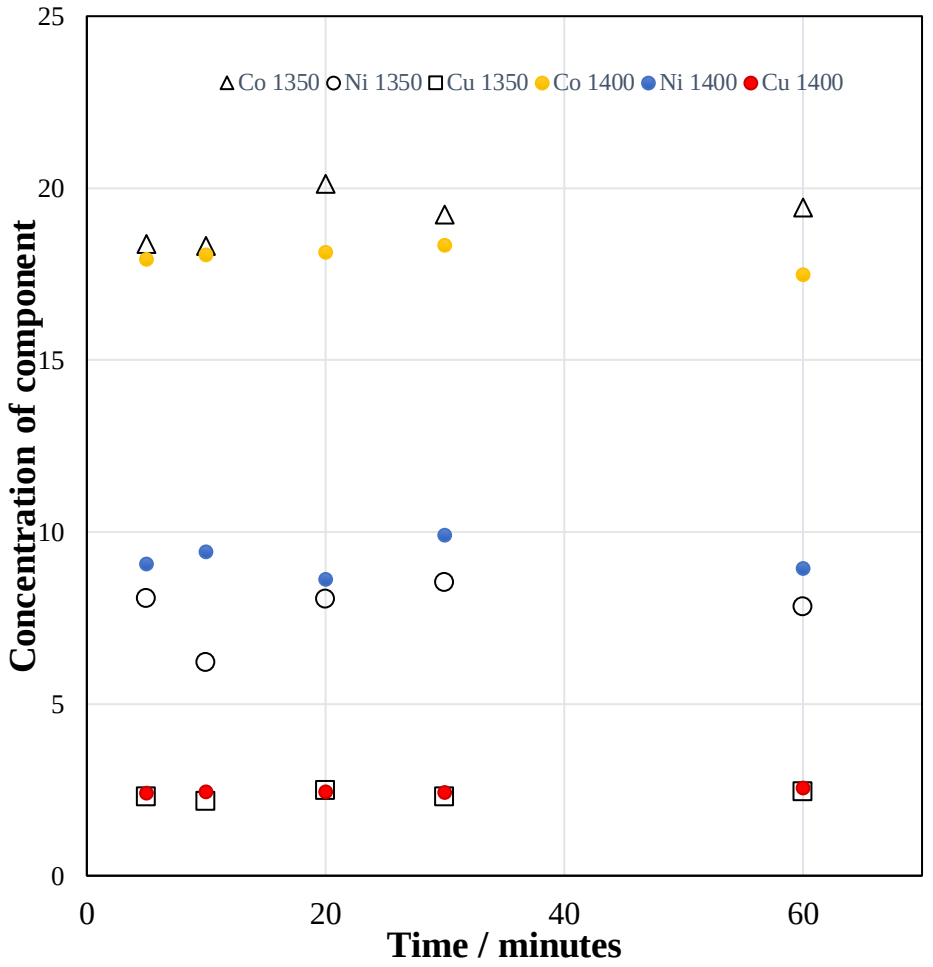
- Co-rich battery scrap can
  - improve the recoveries,
  - process kinetics, and
  - settling and separation of matte and slag.
- Additionally, use of alternative reductants: Biochar and methane would be suitable reductants



Matte-slag distribution coefficients of cobalt as a function on reduction time at 1400 ◦C. Trend lines were drawn for coke-containing reduction experiments: SLAG + C as dotted black line (· · ·) and SLAG + C + SCRAP as solid black line (−).

Highlights – Integrated battery scrap recycling and nickel slag cleaning

- A proof-of-concept for integrating froth flotation and high-temperature pyrometallurgical process for recovering valuable metals from lithium-ion batteries was investigated for the first time.
  - ➢ Froth flotation can be introduced as a mechanical pre-treatment for pyrometallurgical battery recycling.
  - ➢ Additionally, graphite in the flotation fraction can be utilized to replace coke at least partially in the nickel slag cleaning process.



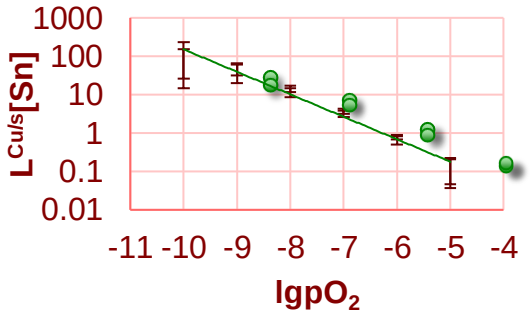
Metallurgical thermodynamics and modelling

- Research group of ca. 10 members
- Focus mainly on experimental phase equilibria and thermodynamic modeling of slags, mattes, alloys, molten salts, and aqueous systems in metallurgical processes
- In BATCircle:
  - Dr **Katri Avarmaa**, Dr **Min-Kyu Paek**, 2 PhD students
  - **Improved Co and Ni recovery in primary production**, focus on thermodynamic modeling and equilibrium chemistry

Prof Daniel Lindberg

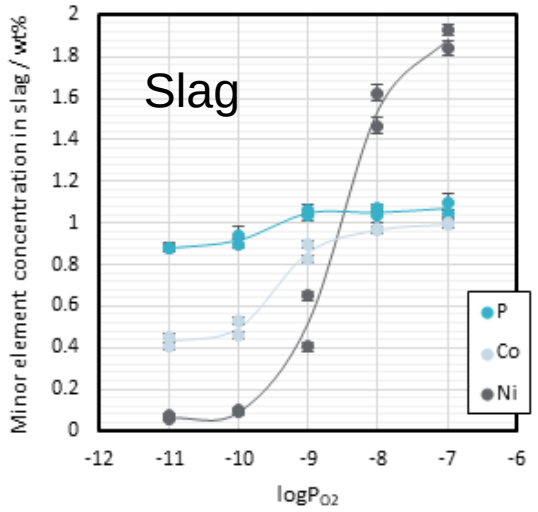
Distribution of Ni, Co, Precious, and Platinum Group Metals in Copper Making Process

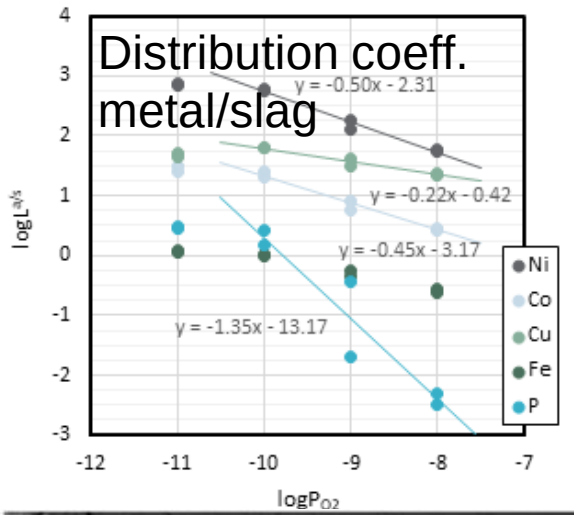
Sukhomlinov, D., Klemettinen, L., Avarmaa, K., (...), Taskinen, P., Jokilaakso, A..2019 in Metallurgical and Materials Transactions B: Process Metallurgy and Materials Processing Science
50(4), pp. 1752-1765

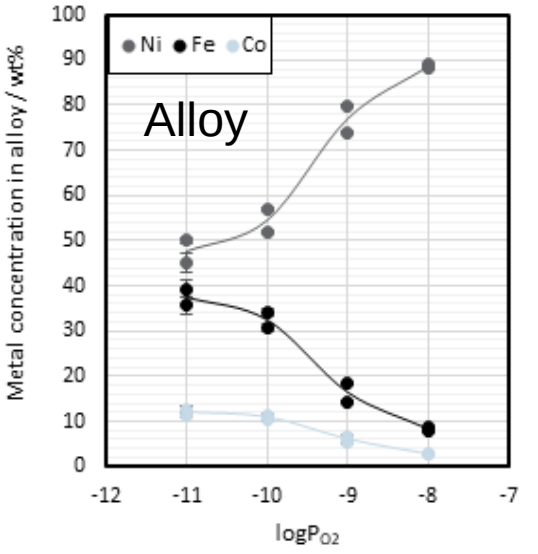


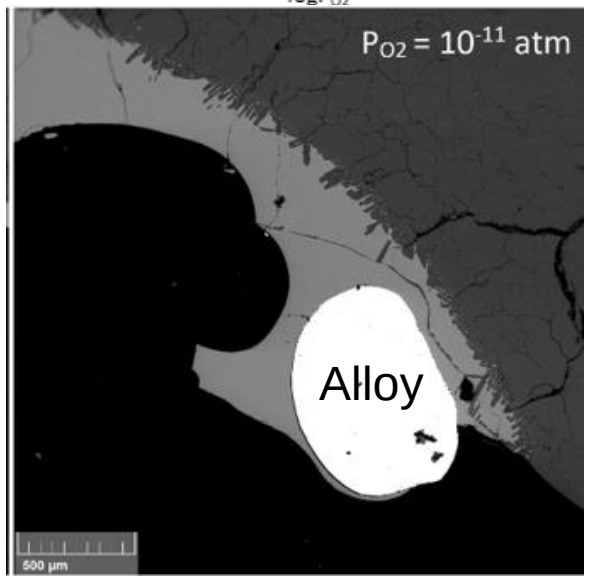
Highlights – Co and Ni recovery in primary production in Ni slag cleaning conditions

- Metal distribution between slag and liquid nickel-rich alloy determined at 1400 °C at varying $P(O_2)$
- Distribution coefficients alloy/slag were in the order Ni > Cu > Co > P
  - Significant vaporization of Cu occured
- Thermodynamic properties of metals determined for more accurate process simulations in future









Thank you!

- Dr. ***Anna Dańczak***
- PhD student ***Ronja Ruismäki***
- PhD student ***Lassi Klemettinen***
- Dr. ***Min-Kyu Paek***
- Dr ***Katri Avarmaa***

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Photo: Valeria Azovskaya / Aalto Materials Platform