GFZ Helmholtz Centre POTSDAM

Universität Potsdam

EGU23-8226

Hydrogeochemical impacts of pumped hydropower storage in open-pit lignite mines

Tobias Schnepper[1,2], Michael Kühn[1,2], Thomas Kempka[1,2]

[1] GFZ German Research Centre for Geosciences, Fluid Systems Modelling, Potsdam, Germany

[2] University of Potsdam, Institute of Geosciences, Potsdam, Germany

ATLANTIS

European Commission

Research Fund for Coal & Steel

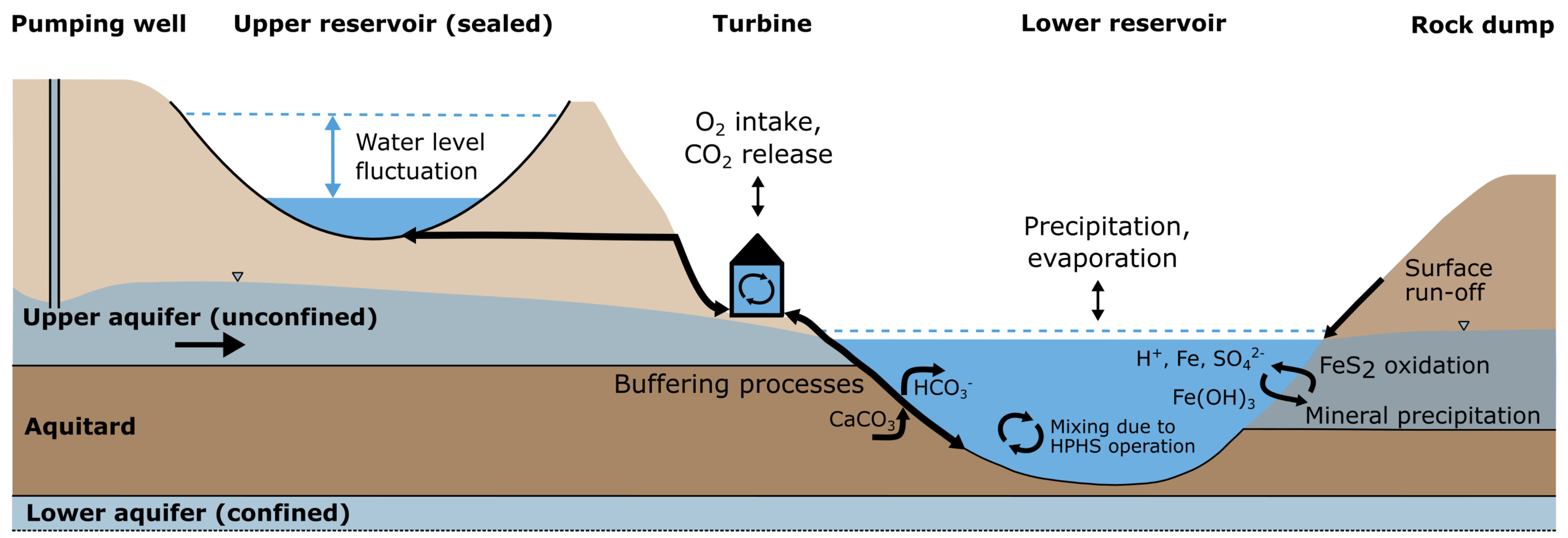
This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

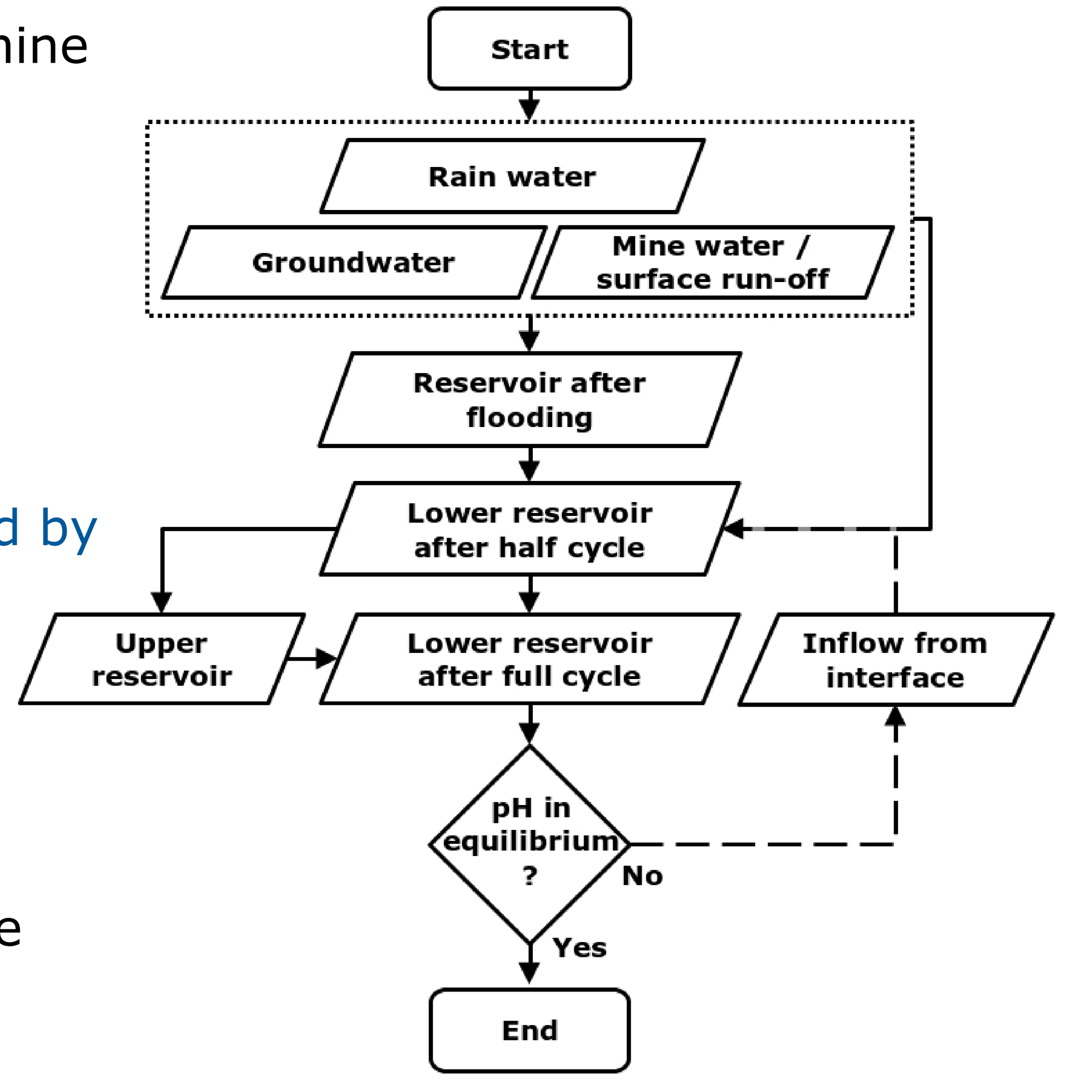
Motivation | Quantifying environmental impacts of hydropower storage in former coal mines

- Pumped hydropower storage (PHS) impacts on hydrochemistry in pit lake not yet addressed
- Sulphate and pH determine water quality in reservoir and adjacent aquifers
- Uncertainties resulting from dump material heterogeneities require comprehensive sensitivity studies



Methods | Modelling framework developed to enable for comprehensive sensitivity study

- Mixing of different waters determines initial mine flooding and subsequent PHS operation:
  - Rain water, surface run-off, groundwater, dump water, water in upper and lower reservoirs
  - PHS cycles enhance pyrite oxidation at reservoir-dump interface
- Reaction path modelling framework developed by means of PHREEQPY [1] to simulate hydrochemical reservoir development
- Extensive literature data sets used to evaluate any relevant PHS scenario
- Identification of chemical key parameters by large-scale sensitivity study considering entire PHS lifetime



Conclusions | Key hydrochemical parameters identified by reaction path simulations

- Comprehensive sensitivity study with ~50 million simulation runs undertaken to quantify hydrochemical impacts of PHS
- Mineral and oxygen availabilities as well as mixing ratios governing factors for final pit lake compositions
- Sulphate and iron concentrations depend on buffer system, pyrite content and mineral precipitation kinetics
- Prediction of hydrochemical pit lake stabilisation is a prerequisite for PHS project realisation
- Knowledge of water balances, present buffer systems and oxygen availability crucial for site-specific assessments

Acknowledgements

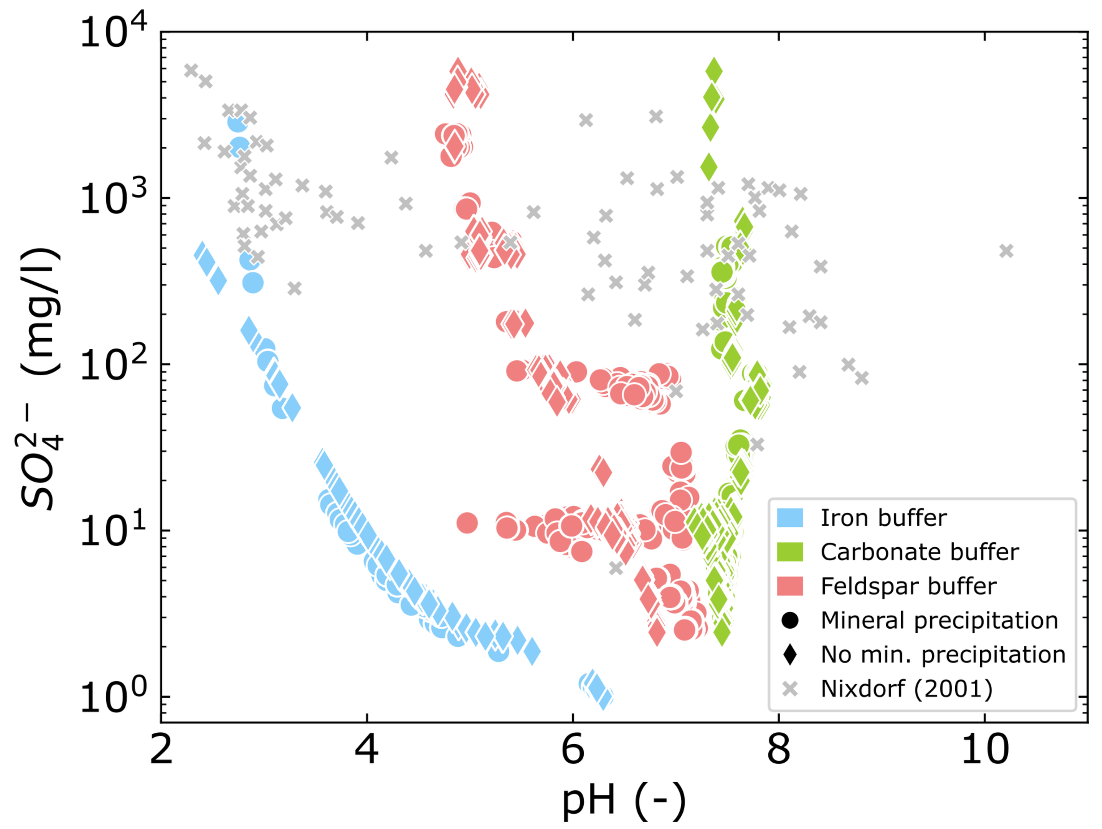
This publication is part of the ATLANTIS project that has received funding from the Research Fund for Coal and Steel under grant agreement no. 101034022.

https://masto.ai/@atlantis www.atlantis-project.eu EGU23 abstract

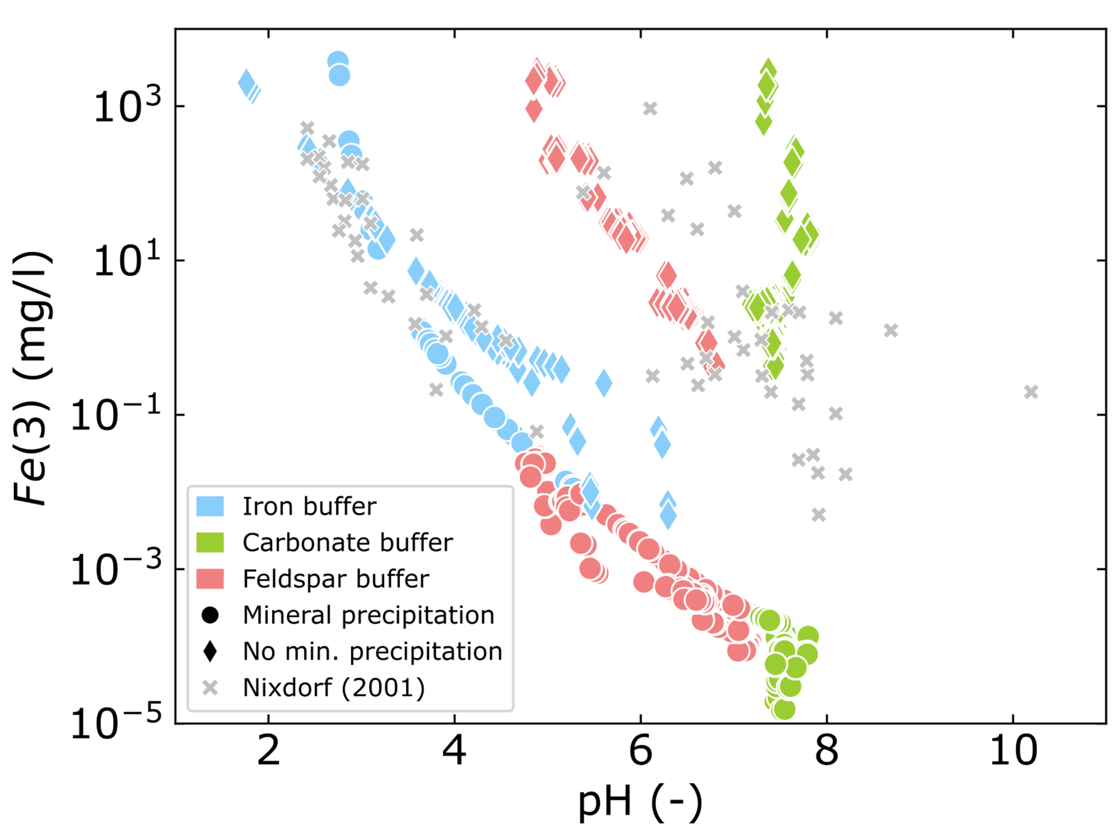
References

[1] Müller, M. et al. (2011): MODFLOW and More 2011: Integrated Hydrologic Modeling, 632-636.
[2] Nixdorf, B. et al. (2001): Umweltbundesamt Texte 35-01, Umweltbundesamt, Berlin.
[3] Krassakis, P. et al. (2023): Sensors 23, 593, DOI: 10.3390/s23020593

Results | Buffer system, precipitation kinetics, pyrite contents and mixing ratios govern sulphate and iron concentrations as well as pH

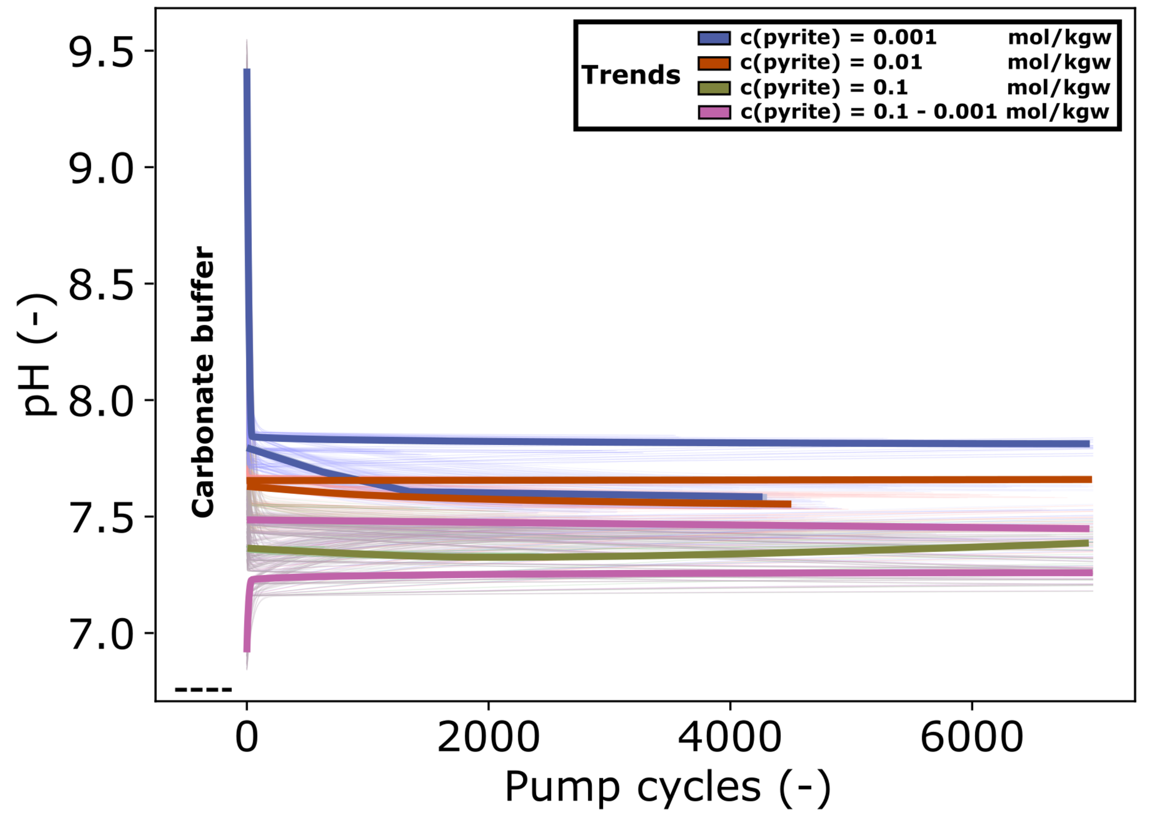


Sulphate concentrations governed by gypsum kinetics, buffer system and pyrite contents



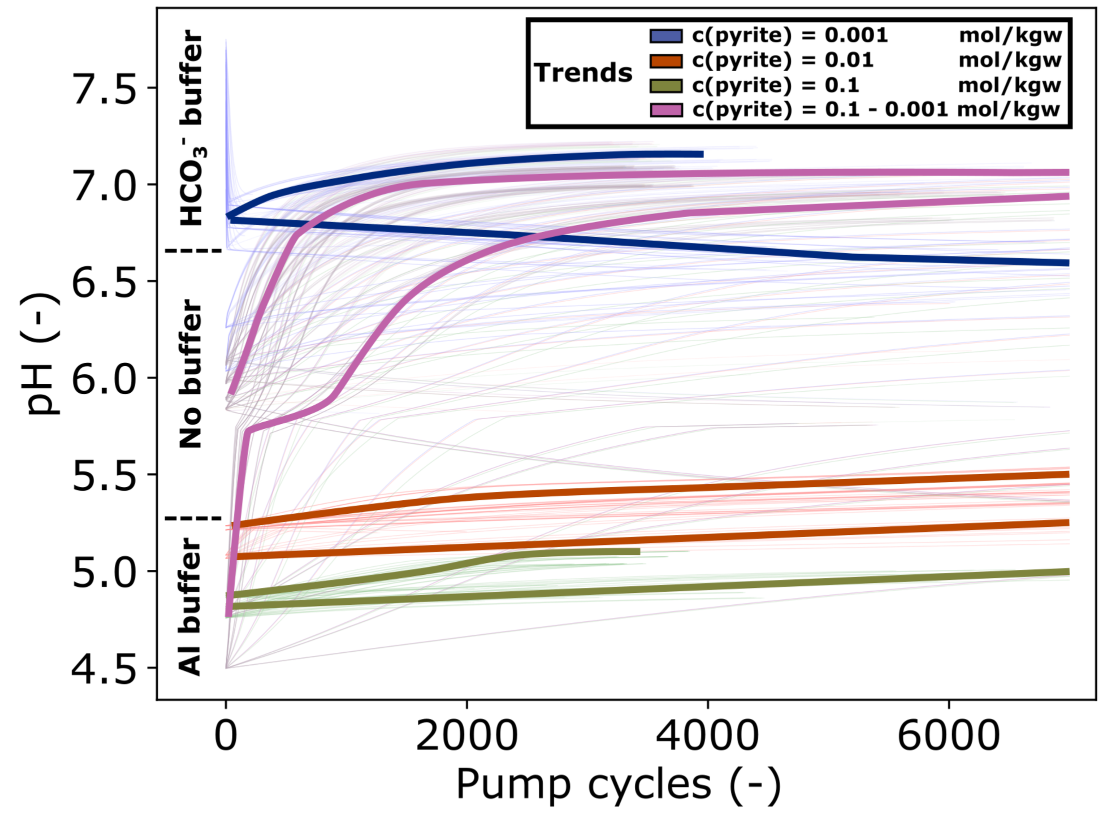
Iron concentrations governed by iron mineral kinetics, buffer system and pyrite contents

Carbonates



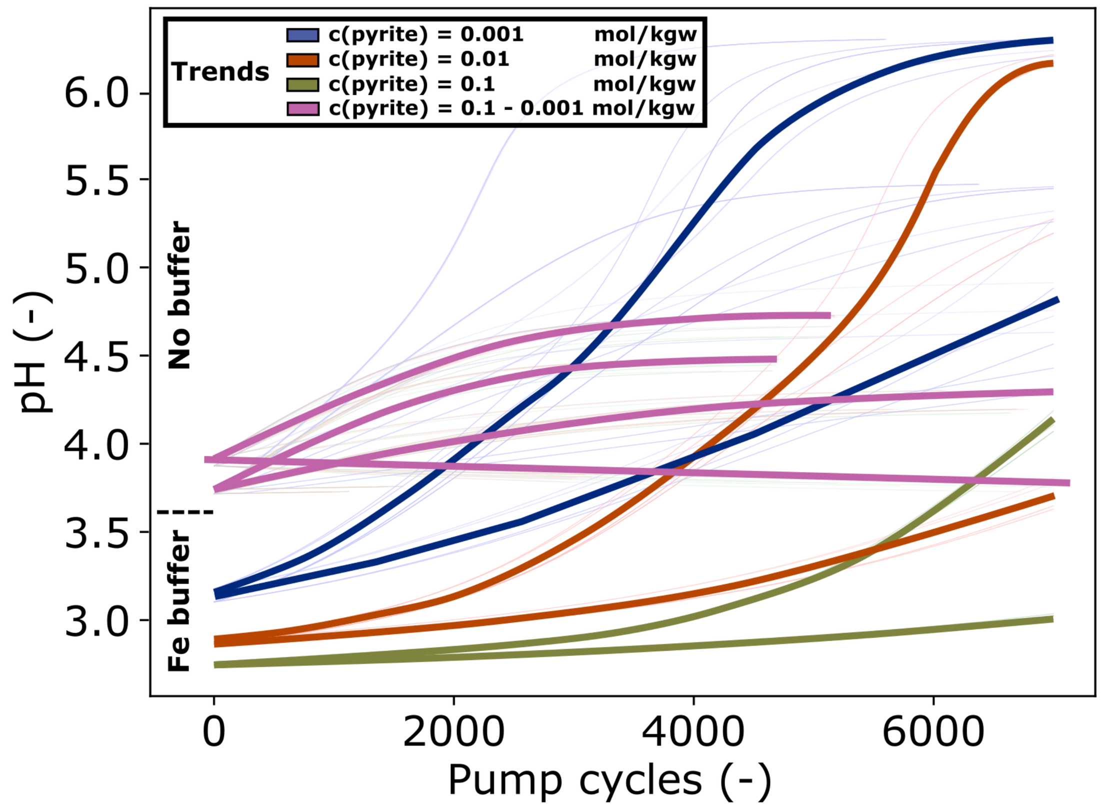
Carbonates provide sufficient buffer capacity, mixing and pyrite contents subordinate

Feldspars



Initial pH governed by pyrite content and mixing during flooding, final composition determined by buffer

Iron minerals



Initial pH governed by pyrite content, final composition determined by mixing during PHS