MALEG – Machine Learning for Enhancing Geothermal Energy

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Agenda

- Project & Partner
- Motivation
- The Idea
- Concept
- Implementation of Artificial Intelligence

Project & Partner

Karlsruhe Institute of Technology

Funded by:

GEOTHERMICA

Federal Ministry for Economic Affairs and Climate Action

Started in 2022 until 2025

Funding volume: 1 788000 €

Fraunhofer ISE

KIT Karlsruhe Institute of Technology

hF hydroFilt

Hydroisotop

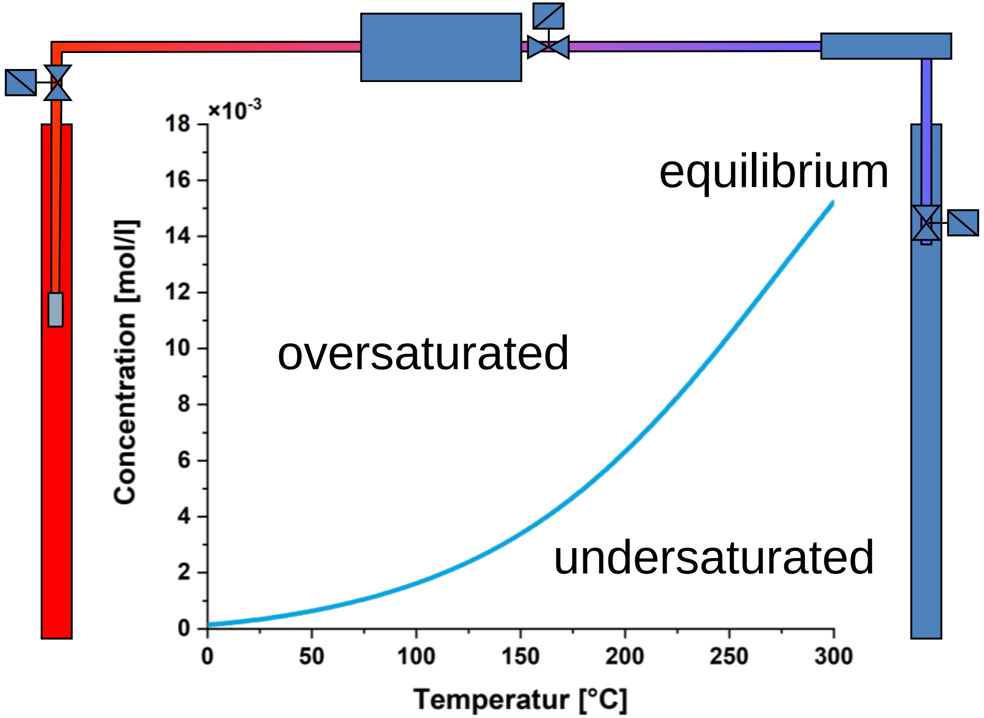
Geosaic GmbH

Transmark Renewables

Motivation - Scaling

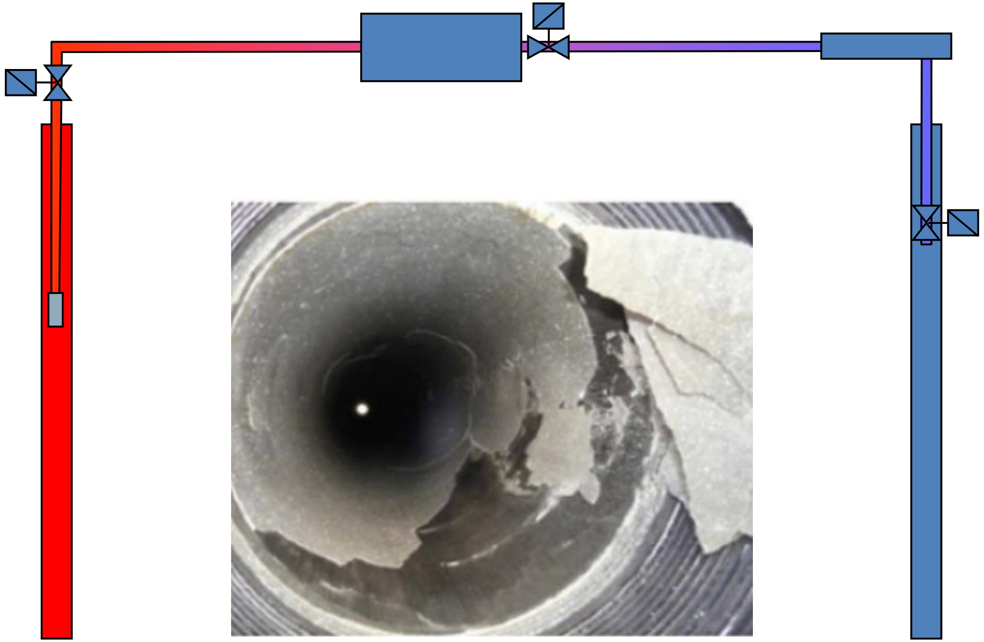
Solubility is dependant on:

1. pH
2. Pressure
3. Temperature
4. Salinity



Motivation – Degassing & Corrosion

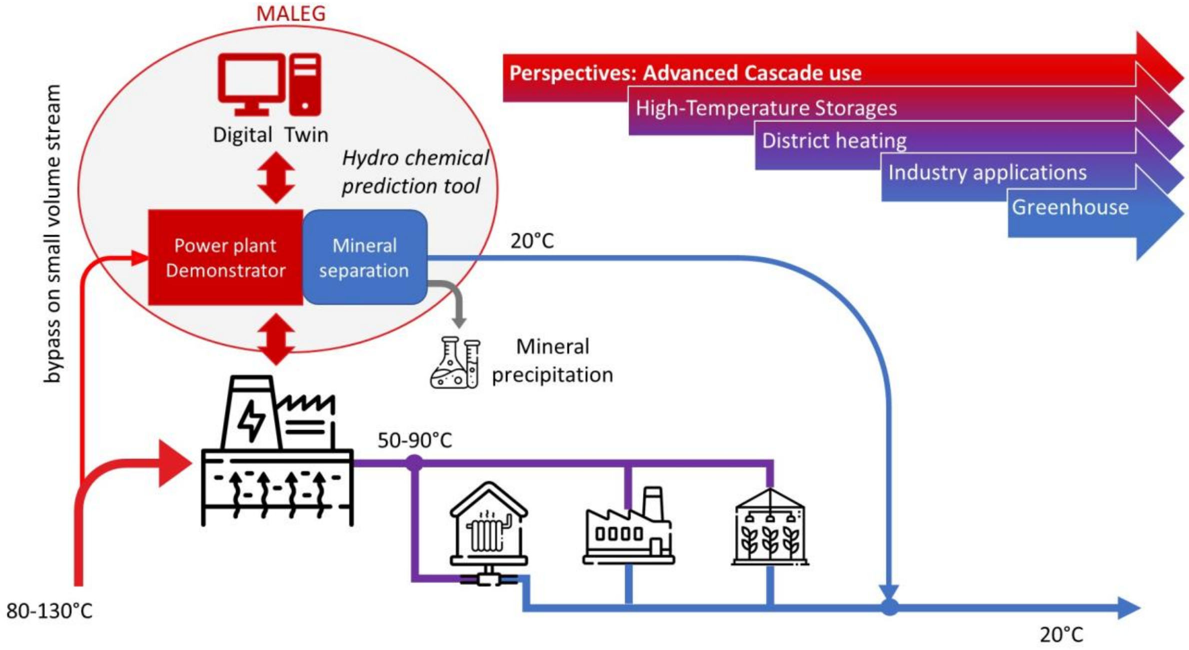
- Gas solubility mainly controlled by **pressure** and **temperature**
- Brine loses water column pressure as it rises through the production well
- Formation of a free gas phase leads to **carbonate scaling** and **corrosion** by CO_2 and H_2S



WANNER ET AL., 2017

The Idea

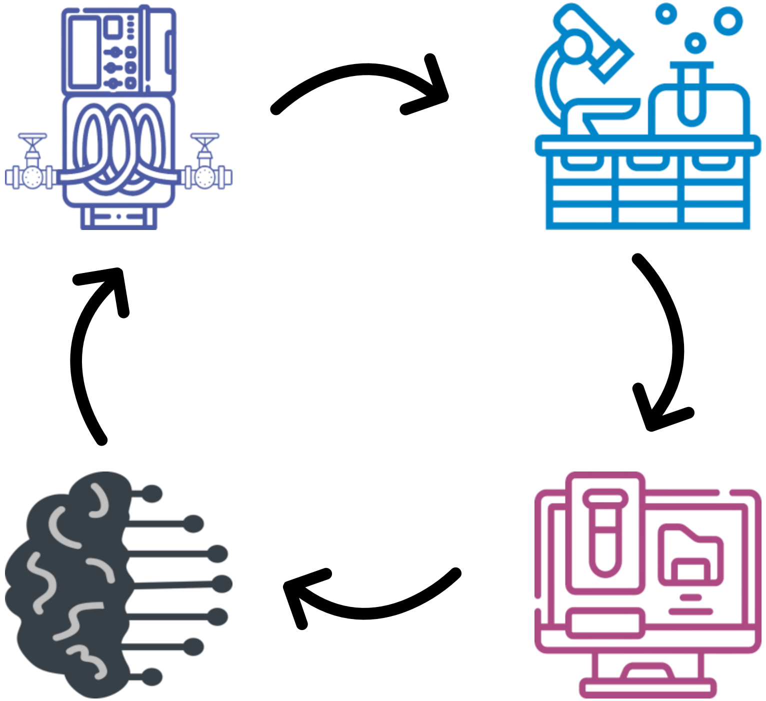
- Using AI to control the occurrence of scaling and degassing
- Control of possible mineral separation of valuable elements
- Increased ΔT for cascade use and heightened heat extraction efficiency



The Concept

Hardware-Twin

Hydrogeochemical sampling

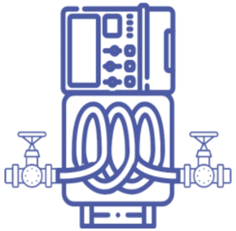


Digital-Twin

Database development

Hardware-Twin

- Demonstrator for continuous geochemical monitoring
  - Coupled directly to the power plant
  - Experimental adaptation of power plant parameters (e.g. temperature, pH, pressure)

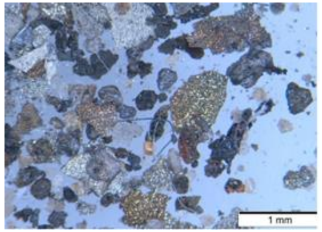


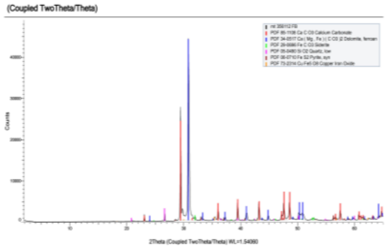
→ On-site degassing, scaling, and corrosion experiments

Intensive hydrogeochemical sampling

- Hydrogeochemical sampling campaign
  - Fluid analyses of the geothermal brine include major elements, trace elements, common isotopes and gas phase
  - Solid analyses of suspended particles and scaling via SEM, XRF, XRD….

→ Hydrogeochemical data for deterministic modelling

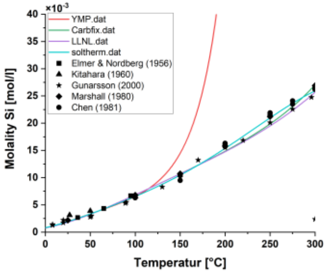




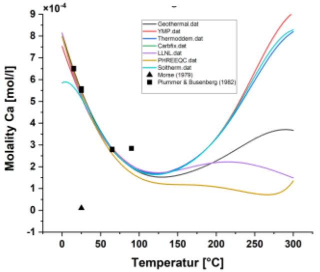
Thermodynamic databases

- Validation of thermodynamic data
  - For details refer to the poster of Michael Trumpp and his pitch in today's poster session
  - Compilation of a valid thermodynamic database

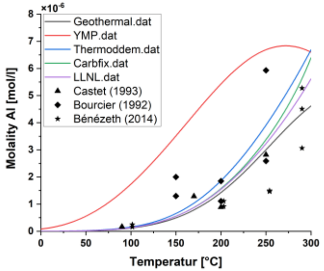
Am. Silica



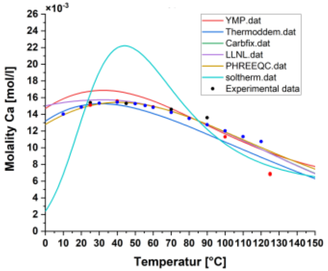
Aragonite



Boehmite



Gypsum



→ Improvement of deterministic calculations and models

Digital-Twin

Karlsruhe Institute of Technology

- Deterministic modelling
  - Deterministic adaptation of power plant parameters (temperature, pH, pressure)
  - Modelling of degassing, scaling, and corrosion potential

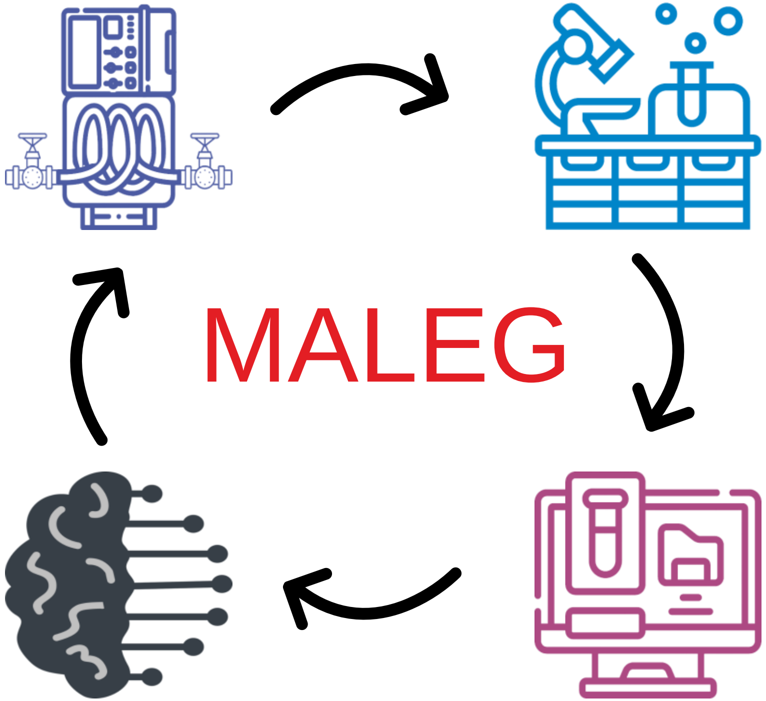
```
% For-loops of the several sensitivity analyses calculated via IPhreeqC
for bb = 1:bbb   % numbre of pressure sensitivity steps
for cc = 1:ccc   % number of steamloss/dilution sensitivity steps
for aa = 1:aaa   % number of pH sensitivity steps
    iphreeqc = actxserver('IPhreeqcCOM.Object');
    iphreeqc.LoadDatabase(['C:\Program Files\USGS\IPhreeqcCOM' ...
        ' 3.7.3-15968\database\llnl.dat']); % pathname to IPhreeqcCOM
    iphreeqc.ClearAccumulatedLines;
    iphreeqc.AccumulateLine ('SOLUTION 1');
    iphreeqc.AccumulateLine (['-units ' con]);
    iphreeqc.AccumulateLine (['-temperature ' (num2str(...
        struct.Temperature))]);
    iphreeqc.AccumulateLine (['-pH ' (num2str(struct.pH))]);
```

→ Establishment of a huge dataset to train the artificial intelligence

Implementation of artifical intelligence

Use results to train AI

Safe analytic cost



Compare hydro-geochemistry with AI model

Model hydrogeo-chemistry with live data feed

Summary

- We have a mobile tool for experiments to determine the most important parameters for scaling
- Identify key parameters in hydrogeochemical analyses using AI to reduce analytical costs
- Increase the productivity and efficiency of geothermal systems by controlling scaling and degassing processes with MALEG AI.

Thank you for your kind attention

Poster pitch today at 12:04 about the development of thermodynamic databases

References

- Christoph Wanner, Florian Eichinger, Thomas Jahrfeld, Larryn W. Diamond, Causes of abundant calcite scaling in geothermal wells in the Bavarian Molasse Basin, Southern Germany, Geothermics, Volume 70, 2017, Pages 324-338,ISSN 0375- 6505