Geochemical monitoring of the geothermal reservoirs using a high-temperature downhole sampler

Gunnar S. Kaldal[1], **Deirdre Clark**[1], Bjarni S. Gunnarsson[2], Iwona Galeczka[1], Ingólfur Ö. Þorbjörnsson[1], Steinþór Nielsen[1], and Ásgerður K. Sigurðardóttir[3]

[1] Iceland GeoSurvey (ÍSOR), [2] Verkís, [3] Landsvirkjun - Iceland

EGU 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Photos by Finnbogi Óskarsson
& Deirdre Clark

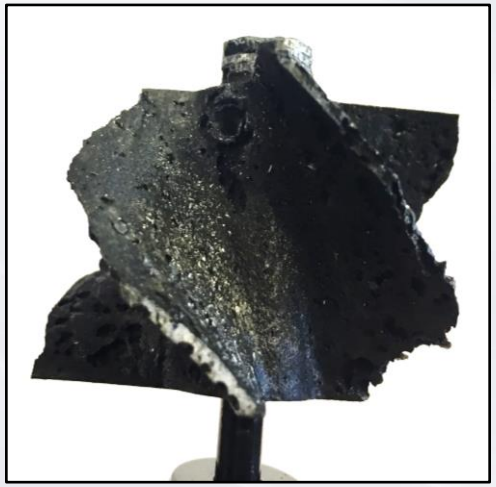
Why downhole sampling?

Examples of corrosion and scaling issues

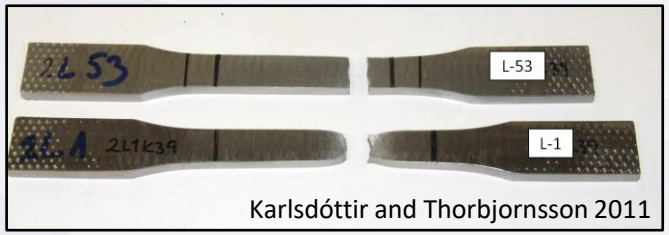
Clogged holes in liner from well in N-Iceland

Corroded liner due to mixing of fluids from two feed zones

ÍSOR's spinner tool damaged after logging a new well to 2350 m depth



Logging tool came black out of the well



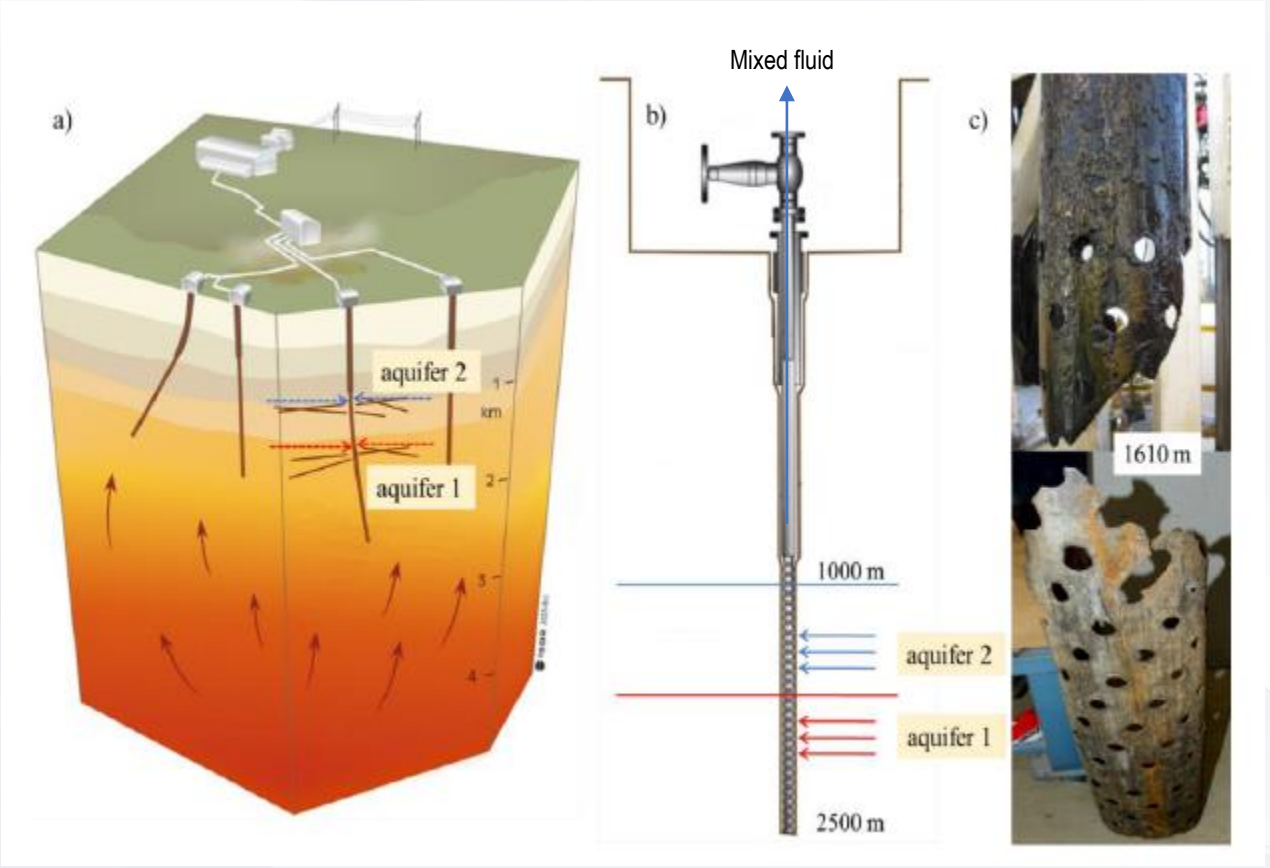
Karlsdóttir and Thorbjornsson 2011

Hydrogen attack leads to diminished material properties

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Why downhole sampling?

- ***Lack of knowledge about fluid-properties of distinct aquifers*** feeding a singular well in hot and super-hot geothermal fields leads to long term and high-cost geothermal utilization problems with surface and downhole installations (liner corrosion), and increased greenhouse gas emissions.
- ***Optimised casing design***, requires knowledge on fluid composition at depth and therefore an extension of the P-, T- range at which existing samplers are enabled to collect fluid samples.
- **High-temperature wells:** Temperatures are typically around 200-300°C
- **Ultra-high-temperature wells:** Temperatures can be much higher, 400-550°C



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Why design a new sampler?

Types of samplers:

- Positive displacement samplers
- Vacuum samplers
- **Flow-through samplers**
- Pumps
- U-tube

Flow through samplers from Thermochem and Kuster can sample fluids up to 350 °C

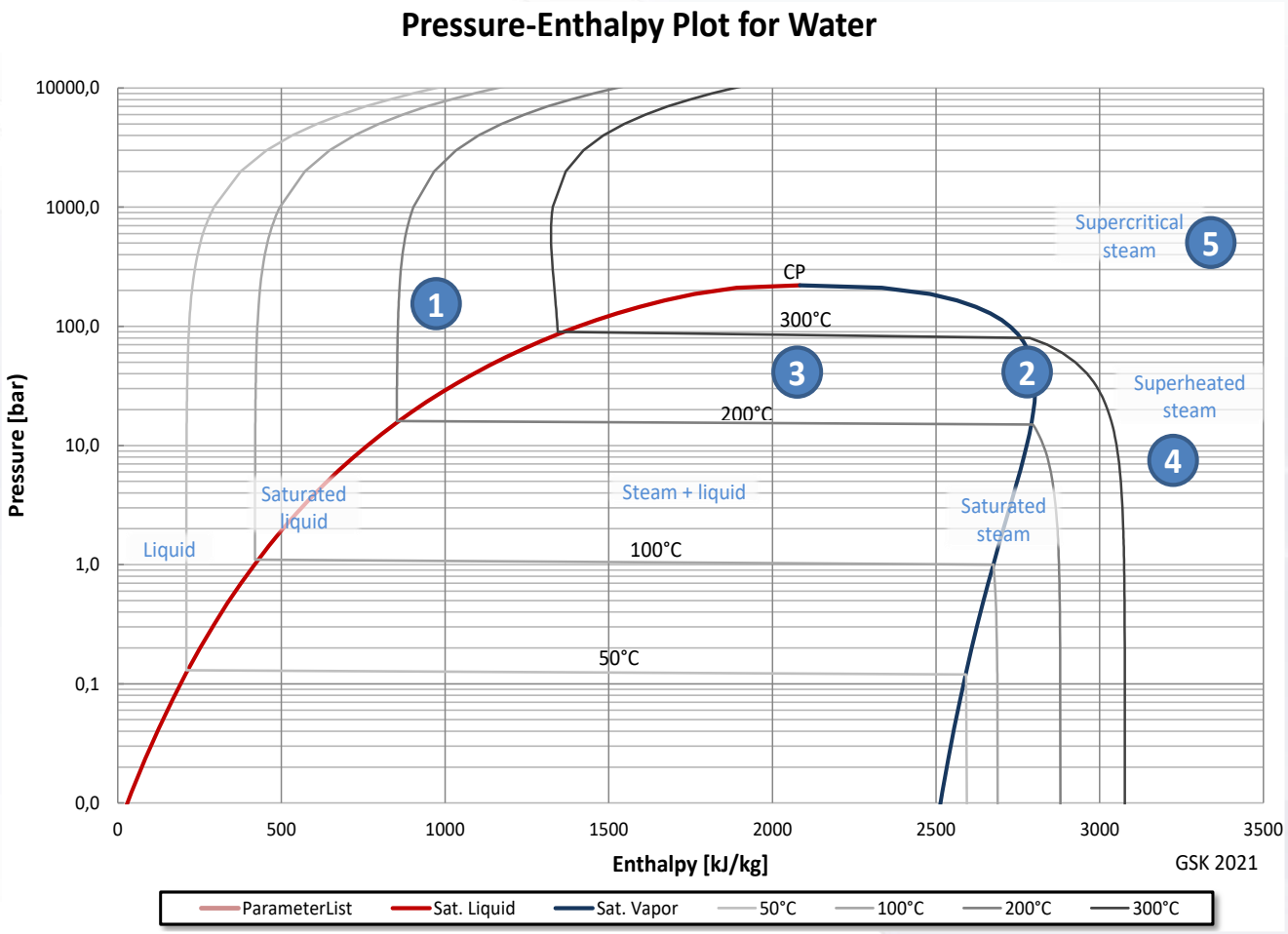
→ Great interest in sampling fluids at depth at that are greater than 350 °C

Kuster

Thermochem

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Sampling Scenarios in HT- to super-HT wells



1. Liquid (low-temperature or saturated liquid)
2. Steam (high-temperature saturated steam)
3. Two-phase (high-temperature above flashing zone)
4. Superheated (one phase steam at all depths within the well)
5. One-phase supercritical (one phase steam at all depths within the well)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Pressure of Contained Sample

Design basis and assumptions:

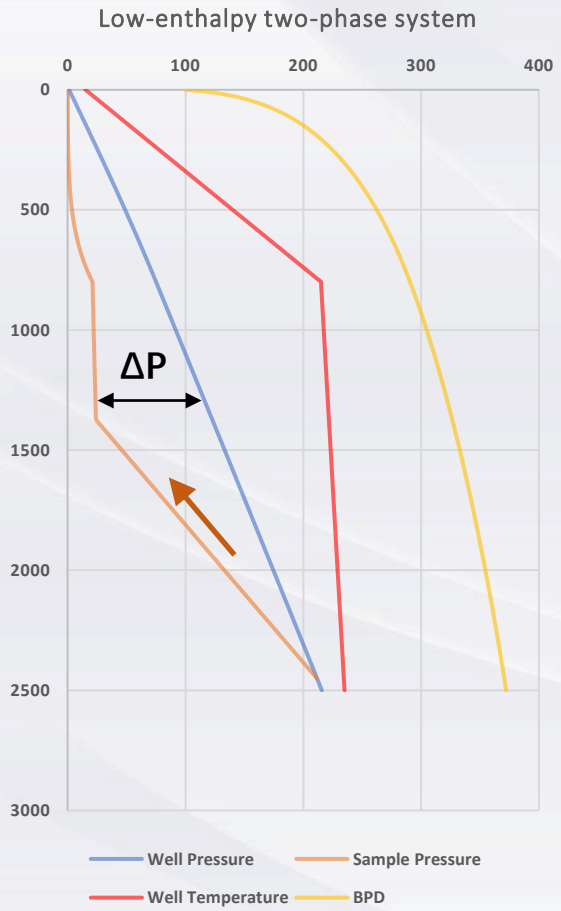
- Sample taken at a certain depth and sample pulled out of the well
- Pressure inside the sample bottle calculated on its way up the well
- Differential pressure is the difference in P_well and P_sample

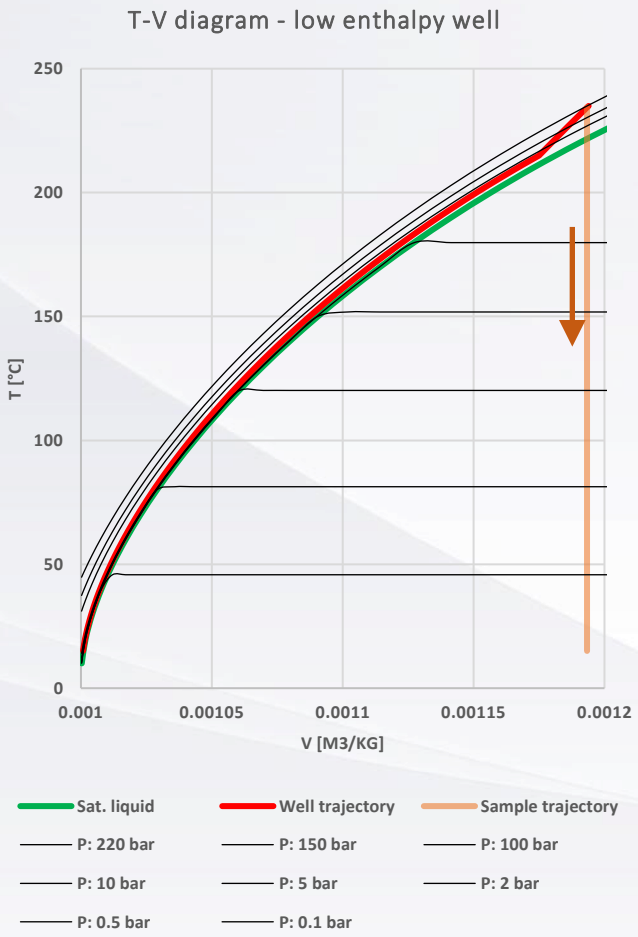
Assumption 1: No NCGs in the fluid – only water

- How does the presence of NCGs effect the pressure conditions?

Assumption 2: Thermal equilibrium between the sample and the well fluid at all depths

Assumption 3: The thermodynamic process inside the sample bottle when it is pulled out of the well is isochronic, i.e. happens at constant specific volume [m3/kg]





This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

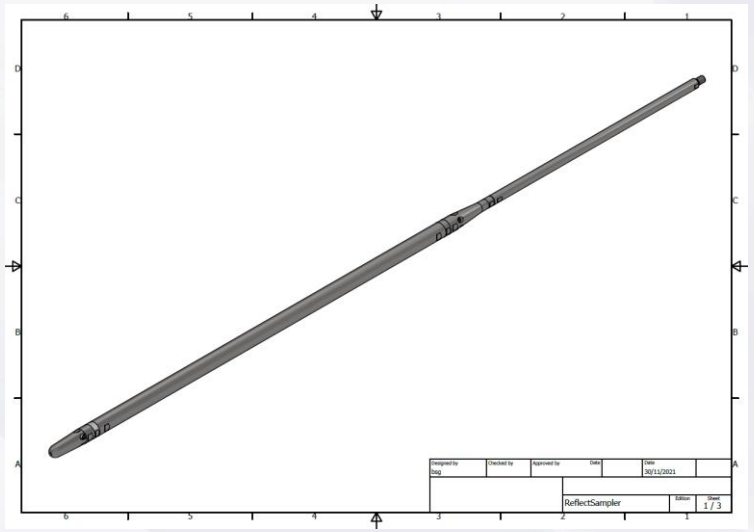
Current status – Design and Prototype Build

- ✔ Sampler design complete
- Sampling volume: >1 Liter
- Ranging temperature limits
  - 230°C – Viton o-ring seals
  - 300°C – Kalrez o-ring seals
  - Up to 500°C – metal-to-metal seals

Next Steps:

- Prototypes and materials
- Prototype built and ready for in situ testing

Assembled sampler



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626

Thank you for your attention!

www.reflect-h2020.eu

www.isor.is

gunnar.skulason.kaldal@isor.is, deirdre.clark@isor.is

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 850626