Developing an integrated resource risk assessment toolkit for Hot Sedimentary Aquifer projects

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INTRODUCTION

Geothermal energy has been identified as a **central technology** that could have the potential to **play a significant role** in the future **net zero energy provision of many countries.**

Hot Sedimentary Aquifers (HSAs) are hydrothermal systems found in sedimentary strata at **depths of 2-4km** and **temperatures from 20 to 80°C** (Fig.1). The hot water is typically used for **heating** and sometimes electricity generation (T>100°C).

However, there is still a considerable **amount of risk associated with geothermal exploration** (including HSAs) due to **subsurface uncertainty and paucity of data.**

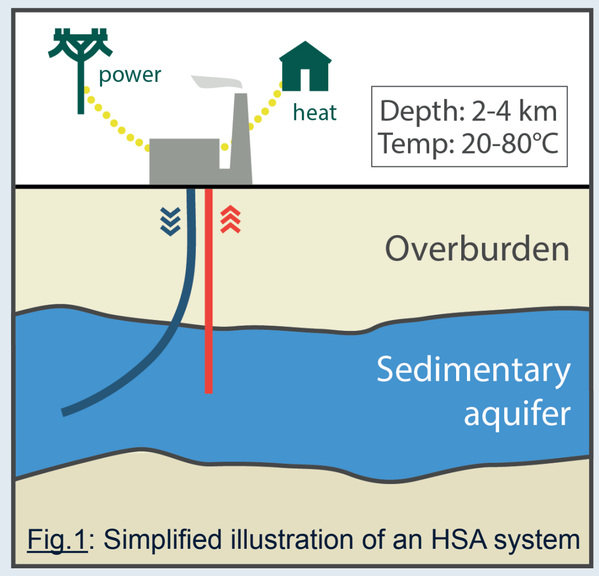

Fig.1: Simplified illustration of an HSA system

RESEARCH OBJECTIVES

Develop an integrative toolkit that will enable an effective risk assessment of hot sedimentary aquifer resources

- How much do geological factors contribute to project failure in HSAs? ✓
- What are the key geological and hydrogeological information gaps that must be addressed to diminish risks linked to geothermal projects?
- What can be done to learn the right things about the geology in advance of an investment decision?

RESULTS

- **461 boreholes** from **255** HSA **projects**
- **8 countries** investigated: UK, Netherlands, Denmark, Poland, Croatia, France, Germany, Australia
- More than 14000 values classified in **4 categories** (Fig.2)

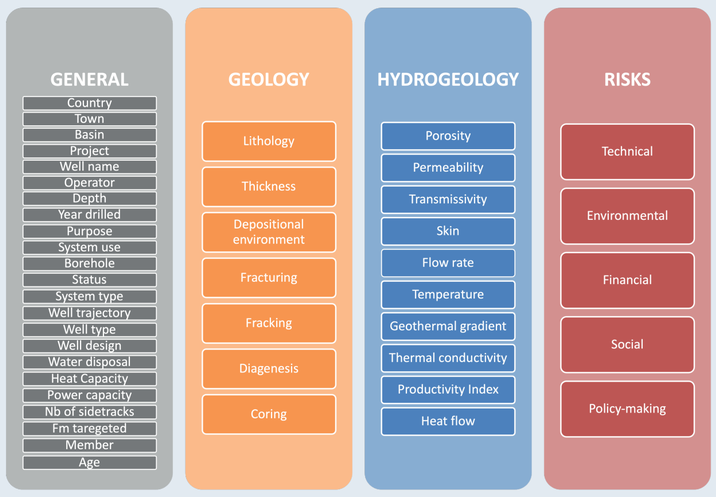

Fig.2: Listing of all parameters researched for each HSA project

- **66/255** projects have failed (26%)
- **37%** of the 65 unsuccessful projects have failed due to **geological or reservoir factors** (Fig.3), and **61%** of the failures happened in the **operational phase** of the project (Fig.4)

> *Failure: at least one of the risks occurs, cannot be mitigated, and leads to an abandonment of the project and/or a change in the purpose of the wells during the project lifetime.*

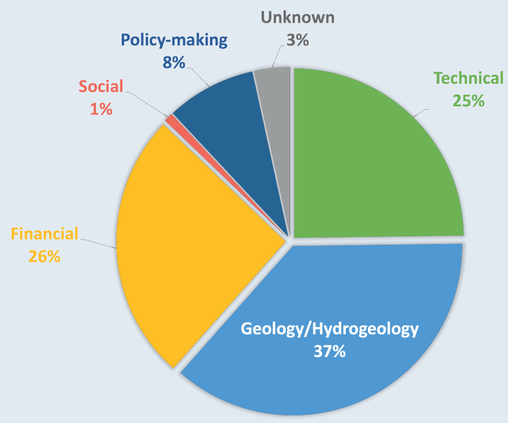

Fig.3: Reasons for failure for the 65 unsuccessful projects collected

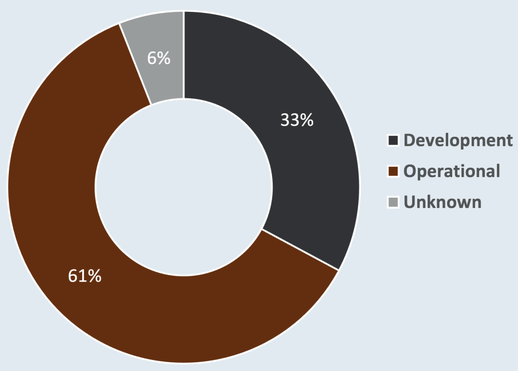

Fig.4: Project phase during which the projects failed

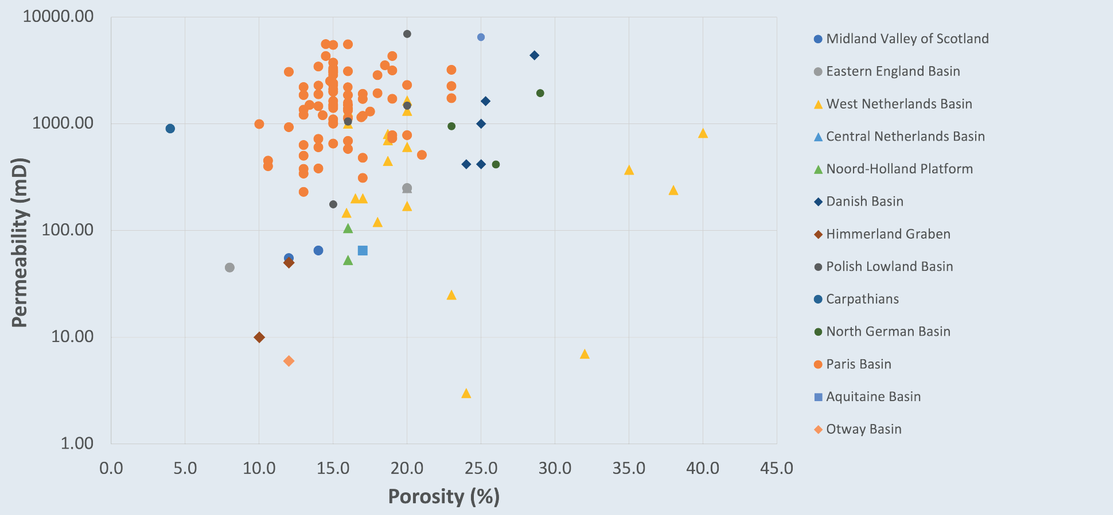

Fig.5: Porosity (%) versus permeability (mD) plot of data per basin

138 porosity and permeability measurements and **a lot of variability** in the number of values per basin (Fig.5)

2 projects with permeability and porosity values that provide **info on fractures/faults** in the vicinity of the well

12 thermal property values reported from **8 projects**, all targeting sandstone reservoirs

DISCUSSION AND FUTURE WORK

- **Geology/Hydrogeology** causes account for almost **40% of failed projects** but remarkably, related parameters are **not often reported by geothermal operators.**
- Reported **values** (including success rates and data availability) **vary considerably across countries and basins**; most probably driven by **regulatory regimes**, **technological evolutions** and **geological features** peculiar to each area.

- Provide **new thermal and petrophysical data**:
  - Chester Fm outcrops samples collected near Chester
  - Core samples from UK Geonergy Observatories (UKGEOS) Cheshire borehole array
  - Comparison of **near and far fault properties**
- In-depth analysis of the database using multivariate statistics and Machine Learning to **identify key parameters and gaps**

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