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GO-Forward: Geothermal Exploration and Optimisation through FORWARD Modelling and Resource Development

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INTRODUCTION

To achieve the EU's goals of a net-zero greenhouse gas economy by 2050, geothermal energy is expected to play a substantially larger role in Europe's future energy supply system.

While geothermal resources are well established in some regions, wide-scale deployment across Europe requires considerable exploration due to the scarcity of available subsurface information.

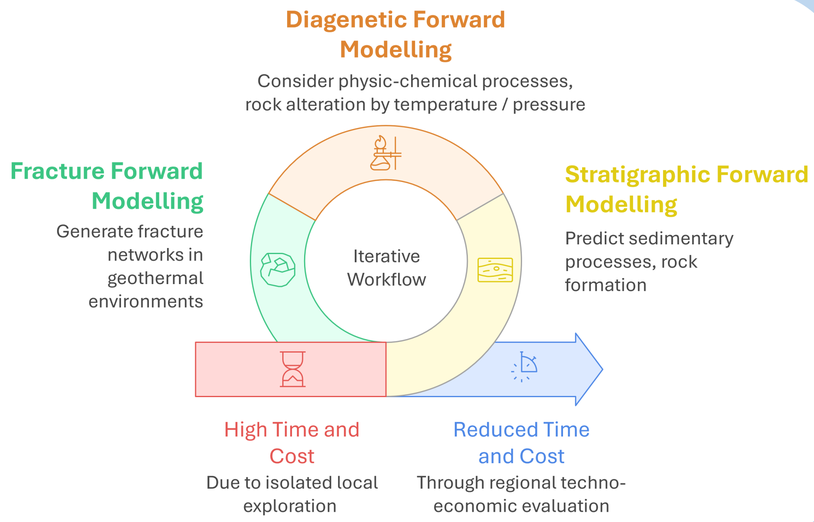
The acquisition of reliable data by active seismic surveying or by exploratory drilling is expensive and time consuming, which results in high initial investment costs and significant uncertainty risks.

MOTIVATION

Existing geothermal exploration workflows to create maps and 3D reservoir properties are commonly based on geostatistical extrapolation techniques of exploration data (interpretation).

One promising approach to predict reservoir properties is the analysis of the regional geological history of the reservoir rocks to simulate their development based on the geological processes leading to their formation and further evolution.

This use of regional, calibrated models enables a transfer of information from "data-rich" regions to "data-poor" regions.



MODELLING APPROACH

By utilizing and integrating stratigraphic, diagenetic, and fracture forward modelling techniques, the GO-Forward project aims to develop accurate reservoir models even in regions with limited direct subsurface information, due to the consideration of additional geological knowledge and context (Figure 1).

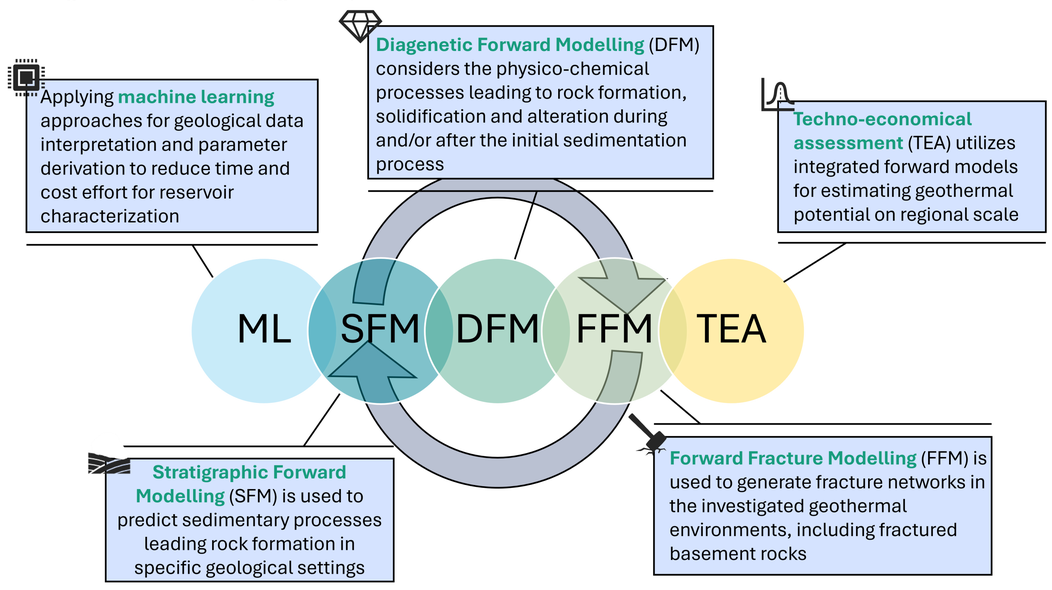


Figure 1. Schematic representation of the integrated forward modeling approach

MACHINE LEARNING AS AUTOMATED DATA DERIVATION TOOL

Process-based models rely on high-quality input data, which are often sparse in geothermal settings. To address this limitation, GO-Forward employs a suite of machine learning (ML) techniques, including neural networks, support vector machines, and random forest algorithms, to automatically extract petrophysical, lithological, and structural parameters from existing datasets (Figure 2).

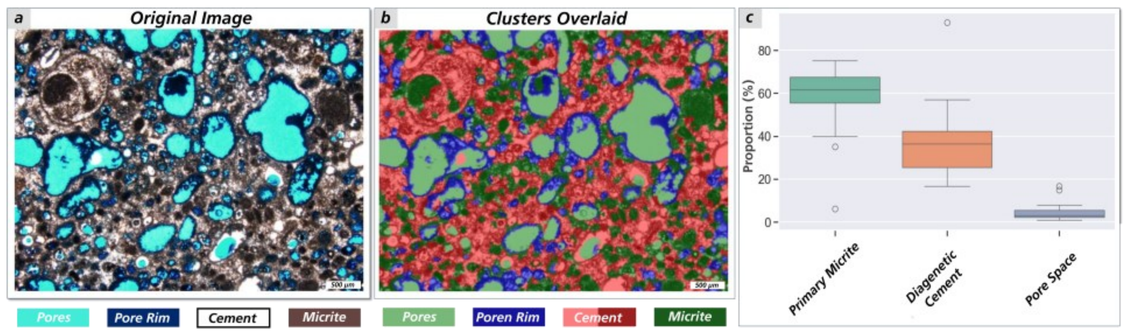


Figure 2. a) Original thin-section image. b) Automatized extraction of geological and reservoir parameters with ML for model parameterization. c) Proportion of each extracted parameter

Several ML approaches are tested and further developed to derive calibration data from diverse data sources, including among others: seismic data, well data (logs/cores/BHI) and surface/outcrop data (UAV photogrammetry, LIDAR) data.

APPLICATION

The methodological approach will be applied in three broad types of geological environments that represent the largest part of potential European geothermal sites (Figure 3): (1) clastic sedimentary systems with sandstone reservoirs, (2) fractured carbonate rocks (Figure 4, Figure 5), and (3) crystalline basement rock with existing fractures and EGS potential.

The developed iterative modelling workflow will be validated in regions with abundant subsurface data necessary for calibration of the integrated forward models. Once the model workflow has been calibrated and validated, it will be applied in areas with promising potential but much less available information and data.

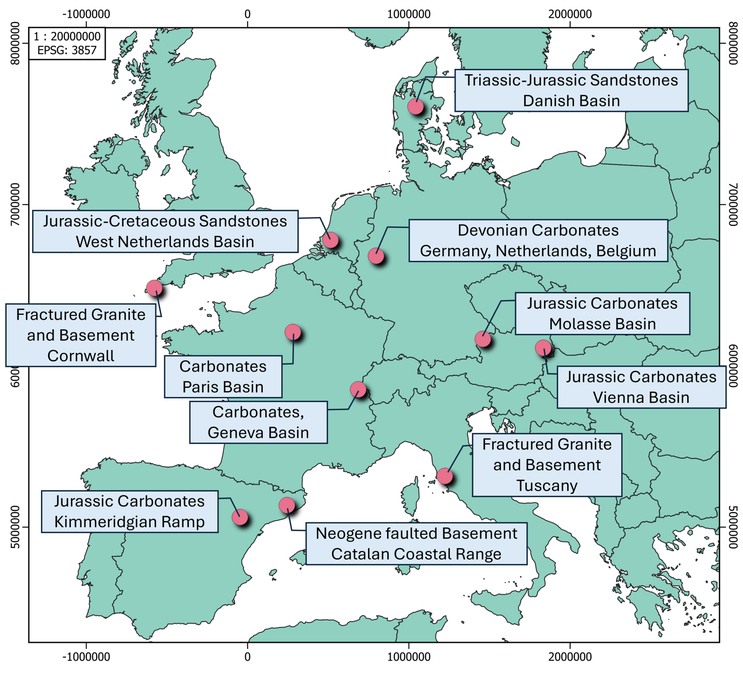


Figure 3. Overview of study regions. Those comprise potential reservoir types: siliciclastic sediments, carbonates, and crystalline formations

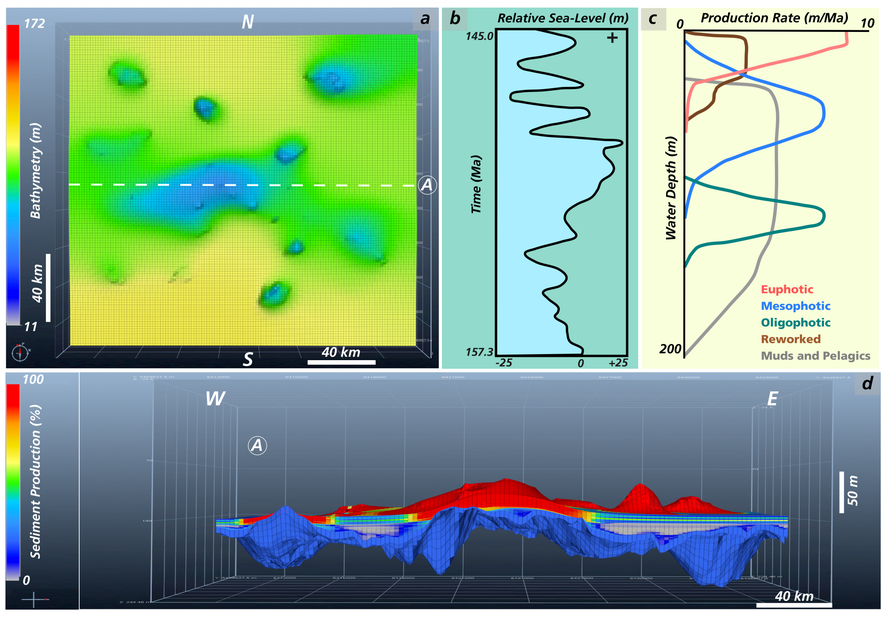


Figure 4. SFM Input Parameter a) Initial Bathymetry base Kimmeridgian. b) Sea level curve during modelling interval. c) Production versus depth for all sediment classes. d) Modelling results indicating production of microbial-spongue bioherms

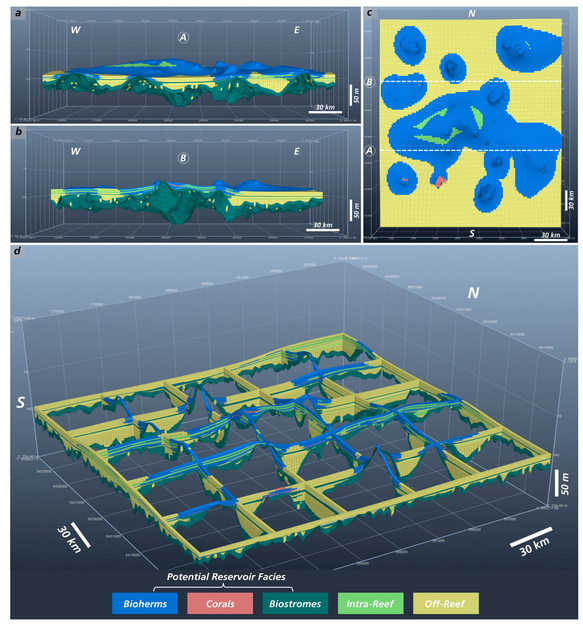


Figure 5. a) and b) cross sections (A,B) of the facies model. c) Map view at final modelling time step of 240 Ma. d) Reservoir grid of the study area

OUTLOOK

GO-Forward replaces geostatistical extrapolation with calibrated forward models (SFM, DFM and FFM), enhanced by machine learning (ML). The developed methodology enables regional models insights to be transfered from data-rich basins to data-poor basins, enhancing the rollout of geothermal energy in Europe. This innovative approach not only promises to reduce exploration costs and risks but also aims to increase the exploratory success rate by providing a comprehensive understanding of subsurface characteristics.

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Related works at the WGC 2026:

Salmon, L., P. Deb, S. Maerz, and G. Winterleitner, 2025. Process-Based Stratigraphic Forward Modelling for Carbonate Reservoir Characterization: Application to Geothermal Reservoirs in Eclépens.

Salmon, L., P. Deb, and M. Welch, 2025. Advancing Geothermal Reservoir Characterization through Process-Based Fracture Forward Modelling: A Case Study from the Cretaceous Formation in the Eclépens Region of the Swiss Molasse Basin.

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