Modeling the geological structure of Poland – approach, recent results and roadmap

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Baltimore, 31.10.2015
Modeling at the PGI – team and approach

**TEAM**
- **Geomodeling Lab:** 11-person team
  - Structure modeling
- **Computational Geology Lab:** 7-person team
  - Process modeling

**APPROACH**
- **pore & fracture scale**
  - Flow in shale gas formations and other fractured rocks
- **dune & dune field scale**
  - Sedimentary architecture & lateral permeability
- **sub-regional:** ~60/30 km
  - Transboundary geothermal energy
- **regional:** ~260/80 km
  - Legacy data-based 3D mapping in Lublin sedimentary basin
Transport phenomena in porous media

Porous flow

Effective permeability

Front migration

Porous convection

Two-phase flow

Fracture flow

Computational Geology Laboratory at PGI-NRI
Flow and transport in rough-walled propped fractures

CO₂ front propagation - Passive solute transport

Fracture wall roughness

Rough-walled propped fracture

Advection of chemical front

Proppant distribution

Computational Geology Laboratory at PGI-NRI
Flow and transport in rough-walled propped fractures

- Fracture wall roughness
- CO$_2$ front propagation - Passive solute transport
- Rough-walled propped fracture
- Advection of chemical front
- Proppant distribution

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Fracture wall roughness: synthetic models

isotropic vs anisotropic fracture wall roughness
Fracture contact area: synthetic models

contact area developing due to overburden pressure
Fracture flow channelling

propped fractures

rough-walled fractures

Computational Geology Laboratory at PGI-NRI
Modern depositional system – a key to understand facies distribution in geological formations

Even simple, cross-stratified aeolian reservoirs are associated with significant lateral permeability variations! We thus need to build quantitative 3D facies models that will facilitate the prediction of facies distribution within key geological formations.
From 3D GPR datasets to 3D facies model
2D and 3D GPR, shallow excavations, vibrocores & air-borne LIDAR helped to predict the distribution of cross-strata dip directions (map A) followed by trend analysis (map B).
From 3D GPR datasets to 3D facies model

If we only had a library of 3D GPR images of aeolian architecture... Such images could be directly used as 3D training images in stochastic facies simulations!
TransGeoTherm: supporting the development of shallow geothermal energy sources.

Polish–Saxon trans-boundary project

Project area: ca 1 000 km²
Let’s do the border part first!

5 146 borehole logs + 5 168 virtual boreholes + rock formations/layers grouped into 75 hydrogeological-geothermal (HGE) units.
Petrographic assignment of thermal conductivities (λ) of diverse rock types

Example of borehole log divided and coded into different HGK bodies

<table>
<thead>
<tr>
<th>HGK</th>
<th>Layer Description</th>
<th>λ_dry</th>
<th>λ_H2O_sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGE 5</td>
<td>silt</td>
<td>0.9 W/m K</td>
<td>1.8 W/m K</td>
</tr>
<tr>
<td>HGE 10</td>
<td>sand</td>
<td>0.4 W/m K</td>
<td>2.4 W/m K</td>
</tr>
<tr>
<td>HGE 21</td>
<td>sand, gravelly</td>
<td>0.4 W/m K</td>
<td>2.0 W/m K</td>
</tr>
<tr>
<td>HGE 21</td>
<td>shale, weathered</td>
<td>0.5 W/m K</td>
<td>1.7 W/m K</td>
</tr>
<tr>
<td>HGE 21</td>
<td>shale, dense</td>
<td>2.1 W/m K</td>
<td>2.1 W/m K</td>
</tr>
</tbody>
</table>

λ averaging in 3D grid

0–40 meters output from 3D grid

www.transgeotherm.eu
Results: how to calculate depth & number of boreholes for installation of a 12 kW heat pump

1. For a depth interval of 0-40 meters:
- 12 kW / 1.8 kW = 6.6
- x 40 m = 1800 ... 1900 W
- 1.8 ... 1.9 kW

2. For a depth interval of 0-130 meters:
- 12 kW / 6.5 kW = 1.8
- x 130 m = 6500 ... 6825 W
- 6.5 ... 6.8 kW

www.transgeotherm.eu
3D geological model of Lublin Basin

- Solid
- Seamless
- Multi-scale
- Lithofacies and property grid model
Borehole data input

- 224 deep wells (1200-5800m) selected for best depiction of geology
- Detailed review of stratigraphy and lithofacies in the wells to get best quality of data
- Additional 196 deep wells with verified stratigraphy.
- For Cenozoic some thousands of shallow wells are available with various level of accuracy and can be added to the model if needed.
Chronostratigraphy: PreCambrian – Quaternary
43 zones
Seismic interpretation: several thousands km of 2D surveys
144 faults interpreted (mostly reverse faults)
9 horizons interpreted
Lithofacies modelling
Chronostratigraphic grid of 250x250 m was populated with interpreted lithofacies.
Three steps of modelling: 
often diachronous lithostratygraphy → lithofacies → litology
Properties
The property modelling at selected formations in order to assess both shallow and deep regional groundwater systems. The large collection of core samples and wireline log data used to simulate stochastically reservoir properties.
Uncertainty
Subsurface modelling in the Lublin Basin requires an assessment and consistent quantification of various types of geological uncertainties both in input data and in the model.

Seismic picking uncertainty
The model is delivered to the end user through:

- standalone viewer GEO3D which is freely distributed with the model
- 3D web viewer, which will be launched at the end of 2015
Coastal stability

Gorzów block

Mid-Polish Trough

Resources, flow and geomechanics

Fore-Sudetic monocline

Carpathian Fore-deep

East-European Platform
Thank you very much for your attention