The Hochleiten-Pirawarth fields are located in the Vienna Basin, Austria, approximately 30 km to the northeast of Vienna. The comprehensive modelling and re-evaluation effort focused on sediments deposited in near-shore environments in the Middle to Late Miocene. The Vienna Basin formed a part of the Central Paratethys at this time. The deposition was defined by the transgressive-regressive cycles resulting in a mixed layer-cake to jigsaw-type reservoir architecture. The regional NE-SW oriented structural feature of the Steinberg Fault system and its multiple hanging wall splays generate the highly compartmentalized Hochleiten-Pirawarth fields.

The Hochleiten Field started production in 1977; 75 wells were drilled with production from 11 reservoirs. Cumulative production is 2.74 million tons of oil and 283 million Nm$^3$ of gas (Nov. 2018). The Pirawarth Field started production in 1958; 115 wells were drilled with production from 13 reservoirs. Cumulative production is 2.92 million tons of oil and 485 million Nm$^3$ of gas (Nov. 2018).

Due to the long life of both fields and differing views on their remaining potential, an integrated study was initiated at the end of 2015. The aim was to achieve a holistic view of both fields and to increase the chance of success of future wells.

To reduce geological uncertainty in the highly compartmentalized area, a field-scale depth processing was performed on a merged seismic dataset covering both fields. The established multi-layer velocity model greatly increased confidence in the structural picture. Based on this approach a comprehensive structural model was created for a large spatial area, vertically covering the Neogene reservoirs. For the geomodel a larger areal extent was also chosen to minimize possible boundary effects. To enhance overall quality a complete petrophysical re-evaluation of available log data for all Hochleiten and selected Pirawarth wells was carried out. The then-generated property model utilizes a net to gross approach that creates a net log using global porosity and Vshale cutoffs, while variogram analysis was carried out for each single reservoir horizon separately.
For future well planning efforts supported by the geomodel, the estimation of hydrocarbon volumes in place had a very high priority. To achieve robust results, different volume calculation methods were applied to determine the recoverable hydrocarbon volumes initially in place (STOIIP, GIIP): (1) A stochastic Monte-Carlo approach, (2) the static model, and (3) several applied reservoir engineering methods. The results of all volume calculations were reviewed and agreed by an interdisciplinary team.

The presented Hochleiten-Pirawarth geomodel is the first holistic modelling effort integrating both fields. Finalized in October 2018, the study yielded a realistic view of the complex reservoir geology, revised volumes and new ideas for future wells.

**References Cited**


Geological re-evaluation of the mature reservoirs of the Hochleiten-Pirawarth Fields (Vienna Basin)

Vienna, 26th of March 2019
Outline - why was this study carried out?

- Production of oil and gas since 1958.
- Currently 59 active wells in Hochleiten and 41 active wells in Pirawarth.
- Structurally complex field, documentation only by maps and cross sections until 2015.

The purpose of the presented study was to gain a holistic view of a mature field.
- New opportunities (infill wells, reperforation and exact volume estimations) to improve recovery and prolong the production.
The Hochleiten-Pirawarth Fields are located in the central Vienna Basin.

The main regional feature is the Steinberg Fault System
- Active through almost all evolution phases of the Vienna Basin
- Badenian to Pannonian sections display significant thickness differences on both sides of the fault system indicating syntectonic deposition

Extensional tectonic activity during Neogene separated the area into two main blocks:
- Footwall block (Mistelbach High)
- Hangingwall block – separation into several compartments
- Main reservoirs are located in the Sarmatian and Badenian

Both fields consist of highly compartmentalized, stacked reservoirs.
Seismic cross section
Seismic attribute study

HD frequency decomposition revealing Late Sarmatian infill of the Vienna Basin.
Depositional environment

Sarmatian
Stacked retrogradational parasequences plus more muddy coastal plain sediments with lesser channel deposits when compared to shallower sequences.

Badenian
Generally, sediment transport from NW combined with transgression/regression cycles (Kreutzer, 1986).
Reservoir sedimentology, example well Hochleiten

Core 3
- 1042-1045 m MD (in the 12.SH)
- Coastal plain sandstones
- Oil impregnated, fine- to medium-grained sandstone
- low angle cross-lamination
- Av. por. 26%, av. perm 1900 mD

- Oil impregnated, fine-grained sandstone
- small-scale cross-bedding
- bidirectional foreset laminae
Reservoir model (porosity)

- Effective porosity, conditioning to a net reservoir volume
- Cutoff values: PHIE > 15 % and Vsh < 47%
- Variogram settings adjusted for each horizon
Volume estimation Hochleiten-Pirawarth Fields

- High priority for future production estimations.
- Different volume calculation methods (G&G and RE) to achieve robust results.

- Outcome cross-checked by a simple deterministic calculation and reviewed by an interdisciplinary team.
- Plot of ranges (P10, P50, P90) against cumulative production of the reservoir.
- Display of the achieved production, estimation of the RF and assessment of future production potential.

Input data for G&G methods

- Petrophysics
  - Contacts
  - Gross reservoir thickness
  - Net to gross
  - Swi
  - Porosity

- Reservoir engineering
  - FVF
  -GOR
  - Contacts

- Petrel Static Model
  - Area vs. depth
  - Gross reservoir thickness
  - Region blocks
  - Each reservoir considered
  - Porosity property
  - NTG property
Volumes – example Hochleiten 12.SH

Top 12.SH Structure Map

Block 1a

Block 1b

Block 2

Block 3

Block 4

12.SH STOIIP \(10^3\text{m}^3\)
Exemplary production profile - Hochleiten

- Slow decline in oil production
- High water cut of 80-90%
- Almost complete shut-in from 1984 to 1989
- Relatively weak aquifer support
  - Pressure support by water injection starting 1990
- Best producer coming on stream in 1999
  - Additional production from Badenian Horizons
What is left to be done after 62 years of production?

- Target attic oil
- Target so far undrained horizons/compartments
- Perforate so far undrained layers
- Review potential in deeper horizons
The way forward

Drill an already planned infill well that is based on the holistic view of the Hochleiten-Pirawarth Fields.

Acquire data (NMR, image logs) that allow a thin-bed analysis with the aim to unlock so far hidden potential.

Simulate additional reservoirs and update the field development plans.

Evaluate the potential for further infill wells (producers and injectors) and the economic potential of enhanced oil recovery methods.

Evaluate and perforate so far untapped reservoirs in existing wells.

Update the model after the next well and establish organisational steps to enable continuity.
# QC, project managements view

<table>
<thead>
<tr>
<th>Activity</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Validation of data-base</td>
<td>Extensive data mining, benefits from previous work</td>
</tr>
<tr>
<td>Seismic, re-processing</td>
<td>Tailored to enhance resolution</td>
</tr>
<tr>
<td>Seismic, interpretation</td>
<td>Focus on the fault pattern</td>
</tr>
<tr>
<td>Attributes</td>
<td>Restricted use</td>
</tr>
<tr>
<td>Geology, re-correlation</td>
<td>Tops, seismic and production history in line</td>
</tr>
<tr>
<td>Geology, mapping</td>
<td>Strong effort. Next to the model, 23 reference maps established</td>
</tr>
<tr>
<td>Petrophysics, re-interpretation</td>
<td>Standardized approach that integrates new measurements</td>
</tr>
<tr>
<td>Sedimentology, facies from cores etc.</td>
<td>Reviewed and integrated</td>
</tr>
<tr>
<td>Reservoir diagenesis</td>
<td>Reviewed, more could be done</td>
</tr>
<tr>
<td>Structure model</td>
<td>Convincing structure model with improved layering</td>
</tr>
<tr>
<td>Property models (por, perm)</td>
<td>Various solutions established</td>
</tr>
<tr>
<td>Modeling algorithms</td>
<td>Results compared</td>
</tr>
<tr>
<td>Integration of applied RE</td>
<td>Strong effort, all reservoirs and all wells considered</td>
</tr>
<tr>
<td>Integration of simulation results</td>
<td>11. SH (main reservoir in HL) simulated; more is possible</td>
</tr>
<tr>
<td>Volume calculation</td>
<td>Strong effort, various methods applied and results aligned</td>
</tr>
<tr>
<td>Workflows, updateability</td>
<td>Established, model can be updated</td>
</tr>
<tr>
<td>Documentation, reporting</td>
<td>Strong effort, all topics covered</td>
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</tbody>
</table>

Quality range from unacceptable to fully satisfying: based on project definitions
The presented study was planned and carried out as an integrated project. The following persons contributed:

<table>
<thead>
<tr>
<th>Name</th>
<th>Contribution</th>
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</thead>
<tbody>
<tr>
<td>Baric, Nikola</td>
<td>Reservoir engineering</td>
</tr>
<tr>
<td>Finsterwalder, Rudolf</td>
<td>Concept, G&amp;G advice, QC and coaching</td>
</tr>
<tr>
<td>Haake, Martin</td>
<td>G&amp;G and modelling</td>
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<tr>
<td>Hendizadeh, Hadi</td>
<td>Reservoir engineering</td>
</tr>
<tr>
<td>Hujer, Wolfgang</td>
<td>Core analysis advice</td>
</tr>
<tr>
<td>Kuffner, Thomas</td>
<td>Core analysis</td>
</tr>
<tr>
<td>Leitner, Manfred</td>
<td>RE advice and coordination</td>
</tr>
<tr>
<td>Osivandi, Keyvan</td>
<td>G&amp;G and modelling</td>
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<tr>
<td>Schmidt, Dennis</td>
<td>Petrophysics</td>
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<tr>
<td>Schretter, Isabell</td>
<td>Volumes</td>
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<tr>
<td>Steckhan, Jan</td>
<td>Petrophysical advice</td>
</tr>
<tr>
<td>Volpini, Sebastian</td>
<td>Reservoir engineering</td>
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<tr>
<td>Zámolyi, Andras</td>
<td>G&amp;G, modelling and coordination</td>
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