Utilization potentials of the low-enthalpy geothermal aquifer of the Bad Radkersburg – Hodoš pilot area – based on 3D modelling results of the TRANSENERGY project

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Introduction

The Bad Radkersburg – Hodoš area is one of the study areas of the project TRANSENERGY (http://transenergy-eu.geologie.ac.at/). The pilot area extends through the NE part of Slovenia, SE part of Austria and continues to the W part of Hungarian state territory (Fig. 1). In order to determine the potential effects of different production scenarios on the low-enthalpy geothermal aquifer in the Pre-Neogene basement of the Mura-Zala basin and to provide support for future utilization in this sensitive transboundary area, a numerical model of flow and heat transfer was established.

Settings

In the Bad Radkersburg – Hodoš pilot area the thickness of the Neogene sedimentary cover generally increases from SW to NE. The Pre-Neogene basement consists of Mesozoic carbonate rocks and Paleozoic metamorphic rocks. The main subvertical tectonic zone represents the continuation of the Raba Fault zone into the Radgona-Vas tectonic half - graben. In the tectonic zone the basement rocks are strongly fractured and fissured and represent the main aquifer in the investigated area.

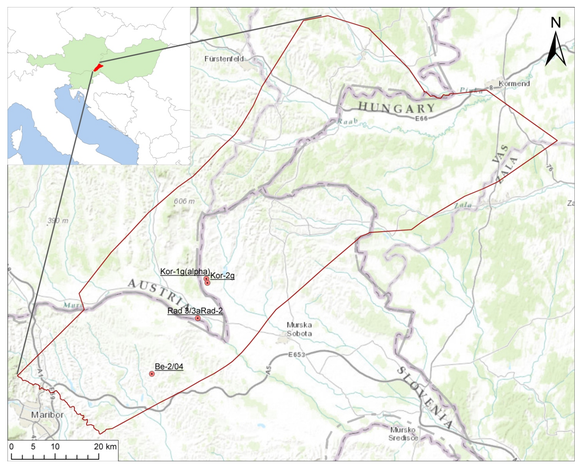

Fig. 1. Delineation of the pilot model area with the production wells (red dots).

Tab. 1. Summary of existing hydrothermal utilisation in Bad Radkersburg – Hodoš area

Location	Wells	Total yield	Outflow temperature	Use
Bad Radkersburg (AT)	2 wells	22 l/s	~78 °C	Balneological and Energy Use
Benedikt (SI)	1 well	5 l/s	72 °C	District heating
Korovci (SI)	1 well	~20 l/s	80 °C	Not in use yet

Geothermal model

The geothermal model is based on the 3D geological model which is founded on the supra-regional geological model of the TRANSENERGY project. The 3D hydraulic and geothermal model was set up with FEFLOW 6.0 modelling software (Fig.2). Delineation of the computational layers is based on geological horizons. Due to sparse borehole data only two geological layers were defined, namely the Neogene sediments and Pre-Neogene basement rocks.
First, a steady state hydraulic model was developed. Due to lack of measured data, the model parameters were defined in the calibration process. Next, a steady state thermal model was developed. Calibration of geothermal parameters was based on temperature measurements in boreholes Peč-1, Kor-1gα and Be-2 (Fig. 3).

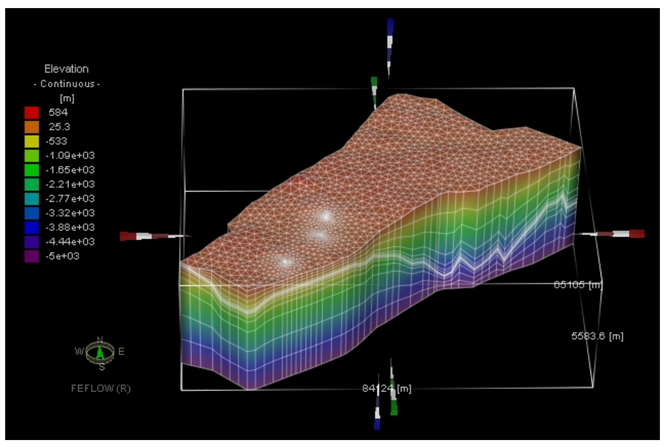

Fig. 2. Geometry of the pilot area model.

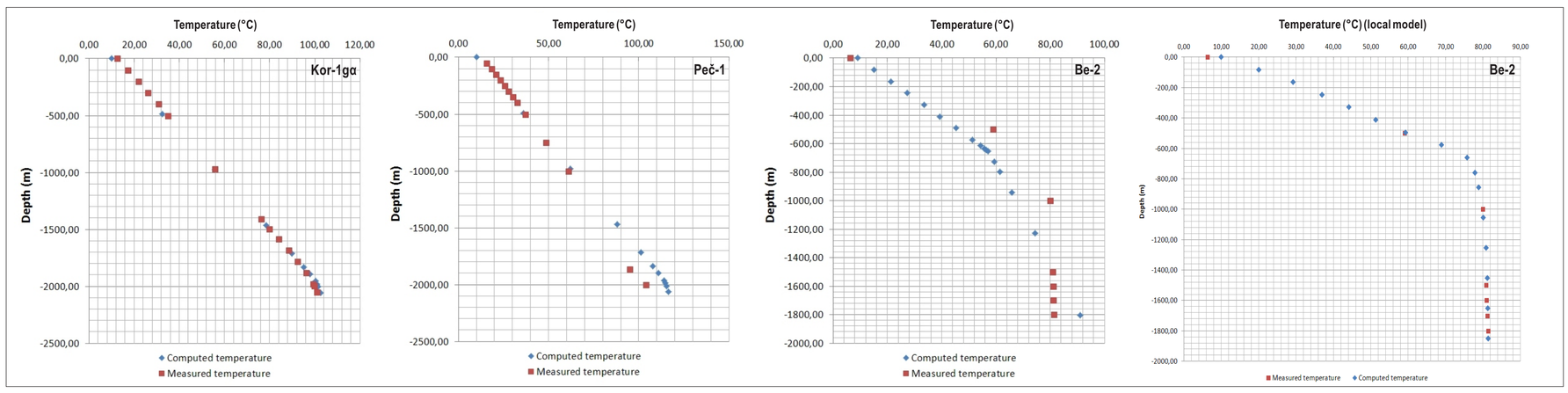

Fig. 3. Comparison of computed and measured temperatures in Kor-1gα, Peč-1 and Be-2 boreholes (left 3 for conductive heat transfer, right one for convection cell)

Assessment of the transboundary utilisation impacts

In order to estimate the impacts of the planned utilization in Korovci (SI) on the nearby spa resort in Bad Radkersburg (A) several scenarios were tested. To incorporate uncertainty, related to defined parameter values, ranges of parameters values were implemented. All production scenarios were simulated for 50 years period. First, 8 production scenarios without reinjection (Tab. 2) were performed and computed drawdowns were observed (Tab. 2 and Fig. 4).

In the next step, 5 scenarios using a geothermal doublet in Korovci (Tab. 3) were performed and potential cool-down effects of the reinjected water front were determined (Tab. 3 and Fig. 5). The temperature of reinjected water was set to 35 °C. The production (Kor-1gα) and reinjection (Kor-2g) points are 700 m apart.

Tab. 1. Production scenarios in Korovci (without reinjection) and computed drawdown after 50 years in production in Korovci for all scenarios.

Scenario	Hydraulic conductivity [m/s]	Aquifer thickness (m)	Specific storage	Rate [l/s]	Computed drawdown Kor-1ga [m]	Computed drawdown Kor-2g
1	1×10^{-6}	70	1×10^{-4}	20	14.5	5.0
2	1×10^{-6}	150	1×10^{-4}	20	14.5	5.0
3	1×10^{-6}	300	1×10^{-4}	20	13.5	4.7
4	1×10^{-6}	150	5×10^{-5}	20	14.5	5.0
5	1×10^{-6}	150	1×10^{-5}	20	14.5	5.0
6	1×10^{-7}	150	1×10^{-5}	20	15	5.2
7	1×10^{-5}	150	1×10^{-5}	20	11	4.5
8	1×10^{-6}	150	1×10^{-5}	40	30	9.3

Tab. 2. Reinjection scenarios in Korovci and temperature decrease in production borehole Kor-1gα

Scenario	Longitudinal / tranverse dispersity	Hydraulic conductivity [m/s]	Reinjection rate [l/s]	Temperature decrease [°C]	Simulation time [years]
1a	5 / 0.5	1×10^{-6}	20	0.3	1000
2a	50 / 5	1×10^{-6}	20	0.3	1000
3a	150 / 15	1×10^{-6}	20	0.6	1000
4a	150 / 15	1×10^{-5}	20	0.6	100
5a	150 / 15	1×10^{-5}	40	3.9	100

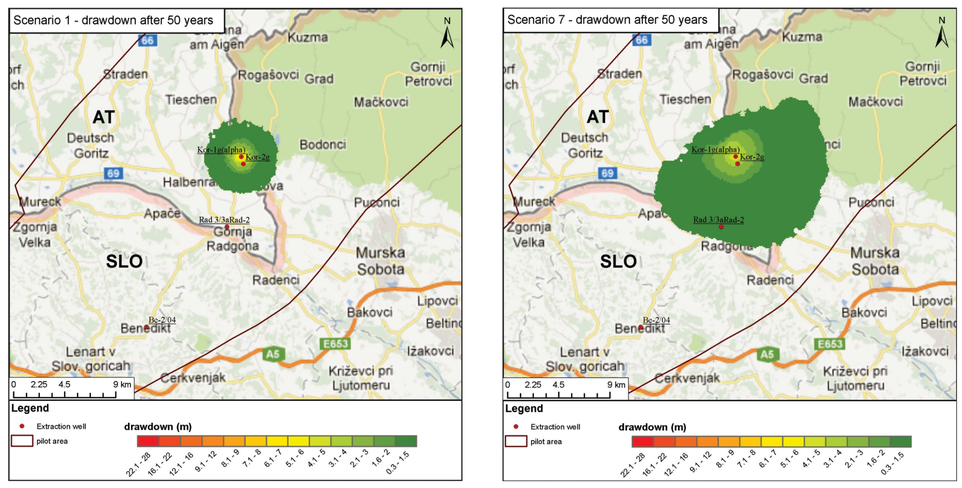

Fig. 4. Computed drawdown after 50 years of production in Korovci (without reinjection).

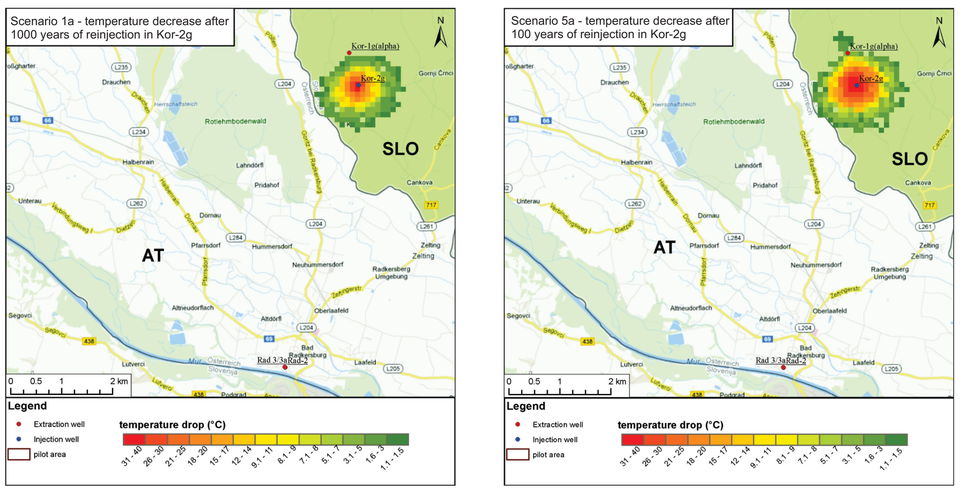

Fig. 5. Simulated temperature decrease and extent of the thermal front after reinjection in Korovci.

Future perspectives

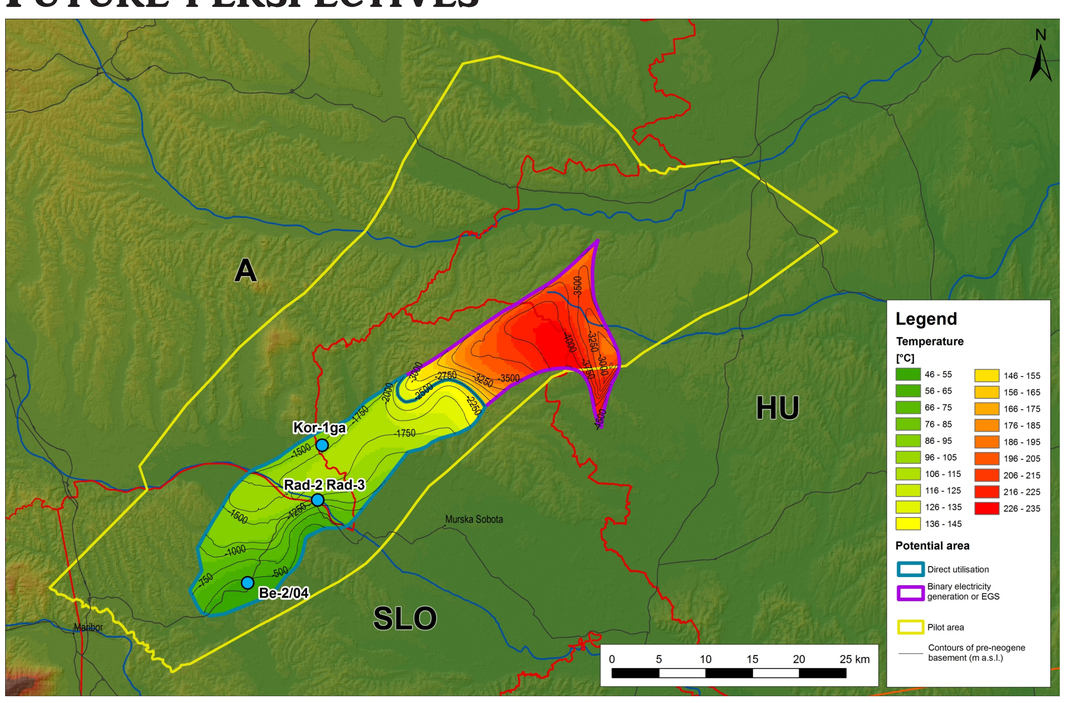

Fig. 6. Identification of the low enthalpy geothermal potential area within the pilot area Bad Radkersburg - Hodoš

Conclusion

The modelling of the Bad Radkersburg – Hodoš pilot area was focused on deep geothermal aquifers in the Pre-Neogene basement. The constructed models simulated a regional conductive heat transfer and a local convective positive geothermal anomaly in Benedikt. Simulations showed no impact between abstraction wells in Korovci and Benedikt. The simulated transboundary effects on Bad Radkersburg showed that when no reinjection was applied the hydraulic depression reached Bad Radkersburg only if very higher abstraction rates or preference flow paths were considered. Five reinjection scenarios imply that thermal breakthrough after 50 years is unlikely.
Since the transboundary character of the investigated geothermal aquifer will be an issue in the future, it is strongly recommended that the best available technologies for the utilisation are applied and that all existing and new developers use thermal water with application of geothermal doublets. Due to scaling potential and environmental concerns the heat recovery with use of doublets is also preferred.
In the eastern part of the pilot area the identified potential of temperatures >100°C in the depth below 2500 meters need to be further investigated (Fig. 6).

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