PROCEEDINGS, 50th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 10-12, 2025
SGP-TR-229

Closer Look at Some Key Characteristics of Fluids in the Low Temperature Geothermal System of the Vienna Basin – Czech Part

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Keywords: Vienna Basin, middle Badenian, temperature fluid flow, inflow, total dissolved solids.

ABSTRACT

Hydrocarbon exploration in the Czech part of Vienna Basin resulted in a number of boreholes drilled. There is a number of hydrocarbon fields hosted by four stratigraphies: lower, middle and upper Badenian, and Sarmatian, each further divided into reservoir horizons. This study utilized the data from boreholes to explore the geothermal potential of the area in general, and the potential of several key spots in particular. Our dataset contains data from several horizons from each of the key stratigraphies: 4 from lower Badenian, 6 from middle Badenian, 8 from upper Badenian and 10 from Sarmatian. Lower Badenian data are scarce, showing the highest amount of inflow and highest temperatures in the southernmost part of the study area, SSW from Lanžhot village. The temperature flow rate index (TFR) in these spots reaches values of 0.75 and 0.5. The Total dissolved solids (TDS) content in fluids ranges from 11,500 to 20,290 ppm. Middle Badenian dataset is the regionally most extensive in the study area. The highest inflow values were measured in the Central Moravian Depression and in a cluster of wells between villages Moravská Nová Ves and Prušánky. Most of them are on the fringe of a localized temperature hot-spot and have the highest TFR with values of 0.75 to 0.5. TDS have lower levels, ranging 10,600 to 13,000 ppm. Higher fluid inflow rates in the upper Badenian dataset are around Moravská Nová Ves village and, then, trending southwest from it. These wells are located mostly on a tailing edge or a high-temperature zone, and are the only ones with TFR values 0.5 or 0.75. The TDS content varies from spot to spot. Places with the highest amount of inflow reach just the intermediate values, and never exceed 11,500 ppm. The Sarmatian dataset is limited, with generally lower temperatures and containing only a few wells with higher inflow values. The highest inflow was measured close to Dolní Bojanovice village. Its TFR is the only one to reach 0.75. The TDS content of all wells with higher amount of inflowing fluids tends to be among the lower, but mostly populated range of 7,800-9,800 ppm.

1. INTRODUCTION

The Vienna Basin is located at the contact of Austria, Slovakia and Czechia, elongated in the NE-SW direction. It contains a large number of fault blocks belonging to the Bohemian Massif, and Western Carpathian and Eastern Alpine orogens. Its sedimentary fill was deposited during early to late Miocene, Pliocene and Quaternary. The basin evolved in several different developmental stages, including the piggy-back basin, pull-apart basin, wide rift of a back-arc region and basin inversion stages. It is one of the most studied sedimentary basins in Europe, as indicated by the dedicated literature (e.g., Fodor, 1995; Decker, 1996; Andrejeva Grigorovič et al., 2001; Kováč et al., 2004; Strauss et al., 2006; Hölzel et al., 2010; Harzhauser et al., 2020). The companion article by Rybár et al. in this volume provides a more detailed overview of the geological background and tectonic development of the Vienna Basin.

The Vienna Basin is considered to be the largest oil and gas province in onshore Europe, based on the amount of hosted oil and gas fields. Its fields are located in both its Miocene sedimentary fill and underneath its fill (Krejčí et al., 1996). Its hydrocarbon potential has been extensively explored, which led to a good understanding of tectonic development and geometry of the Vienna Basin (e.g., Hamilton et al., 2000; Pícha et al., 2006). A large number of boreholes had been drilled and a lot of seismic imagery acquired. The work of Krejčí et al. (1996) mentions about 260 deep boreholes that had been drilled in Czech Republic, with 130 in the Ždánice field to the North of Vienna Basin, while the total of all wells in the Czech portion reaches roughly 4,000.

Nappes of the West Carpathian orogen buried Jurassic and Paleogene source rocks of the lower-plate to a hydrocarbon generation depth during the Alpine orogeny. Their burial was further increased due to the subsequent deposition of Miocene-Pliocene sediments of the basin fill. The main phase of the oil and gas generation took place after this phase of deposition (Krejčí et al., 1996). Individual hydrocarbon pools are stacked vertically, which invites the assumption that vertical migration along faults dominates (Ladwein, 1988).

Our work, exploring the geothermal potential of the Czech part of Vienna Basin, is focused mostly on the low-temperature geothermal fluid flow systems hosted by lower Badenian-Sarmatian stratigraphies, which are regional stratigraphic stages that are equivalent to lower Langhian (l. Badenian), upper Langhian (m. Badenian), lower Serravallian (u. Badenian) and upper Serravallian (Sarmatian) (Harzhauser et al., 2020).

Currently there is more than 90 hydrocarbon volumes hosted by the Vienna Basin, including gas, oil and gas/oil types. The Czech part contains 30 of them. They include (going from South to North) Lanžhot, Brodské, Břeclav, Kostice, Hrušky-Josefov, Týnec-Cunín, Lednice-Valtice, Hodonín, Lužice, Velké Bílovice-Žižkov-Podivín, Podvorov-Mutěnice-Dolní Bojanovice, and other unnamed ones (Fig. 1). Each hydrocarbon field contains a number of producing reservoirs, located in lower Badenian to Sarmatian strata. 4 fields contain a producing reservoir in lower Badenian strata, 7 fields contain 9 different middle Badenian reservoirs, 9 fields have 10 producing reservoirs of upper Badenian age and 7 fields contain 9 different Sarmatian reservoirs (Tab. 1).

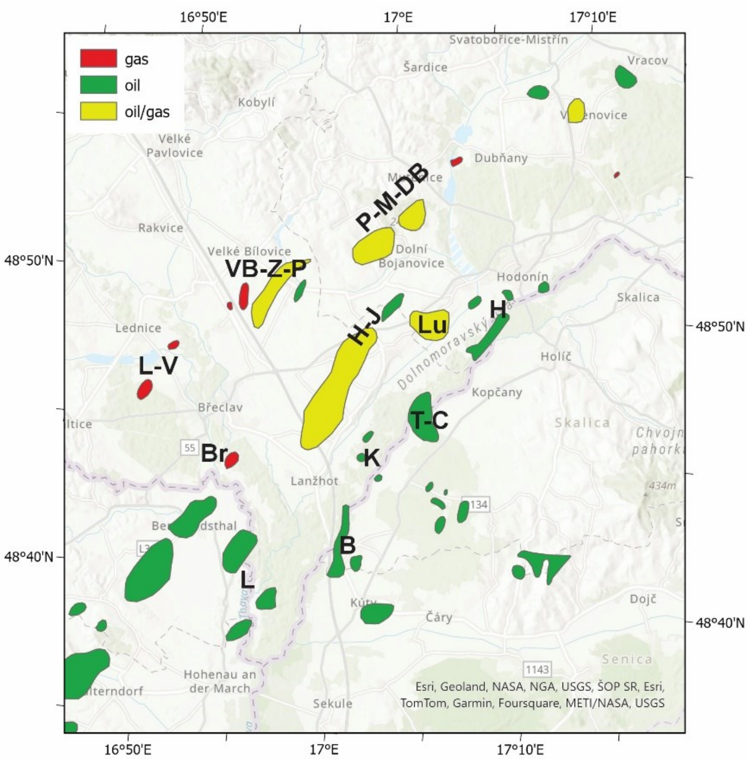

Figure 1: Hydrocarbon fields in the Czech part of Vienna Basin. B – Brodské, Br – Břeclav, H – Hodonín, H-J – Hrušky-Josefov, K – Kostice, L – Lanžhot, L-V – Lednice-Valtice, Lu – Lužice, P-M-DB – Podvorov-Mutěnice-Dolní Bojanovice, T-C – Týnec-Cunín, VB-Z-P –Velké Bílovice-Žižkov-Podivín.

The depositional environments of Vienna Basin are quite well-studied. Facies and sequence stratigraphy represent more problematic and discussed issues. As far as it could be determined, the depositional systems and sequence stratigraphy of our study area is as follows. The lower Badenian producing reservoirs are located in shelf, shallow marine, shallow marine & offshore and deltaic depositional environments with TST sequences. Middle Badenian reservoirs are deposited mostly in shelf to shallow marine depositional environments, with the rare deltaic, lagoonal and patch reef environments. Their sequence stratigraphy position is interpreted to be that of LST and TST sequences, with HST being present only in the Lednice-Valtice field (which is deposited in the environment of a shallow marine patch reef). Upper Badenian reservoirs are similar, having been deposited in shelf & shallow marine environments, sometimes combined with deltaic and rare lagoonal ones, and in the position of LST-TST sequences. Sarmatian reservoirs have depositional environments including combinations of shallow marine, deltaic and lagoonal, and meandering river environments. There are located in TST-HST and early TST (tentative LST) sequences (Kyselák, pers. comm.; Baráth et al., 2003; Kováč et al., 2004; Strauss et al., 2006; Harzhauser et al., 2020).

Table 1: Location of producing reservoirs of specific ages in individual hydrocarbons fields (see Fig. 1 for abbreviations).

Ages of producing reservoirs	**Hydrocarbon field**
lower Badenian	H, H-J, L, Lu
middle Badenian	B, H, H-J, L-V, Lu, P-M-DB, VB-Z-P
upper Badenian	Br, B, H, H-J, K, L-V, Lu, P-M-DB, VB-Z-P
Sarmatian	Br, H, H-J, L, Lu, P-M-DB, VB-Z-P

The topography-driven fluid migration from the recharge area to discharge area is accommodated by 44 siliciclastic and carbonate aquifers present in the aforementioned four stratigraphies. A different geochemical character of their fluids indicates that they are sealed from each other without any distinct communication. As indicated by reflection seismic imagery and well logs, they are divided by sealing intraformational shale horizons. The lower Badenian strata host 18 aquifers, middle Badenian strata 4, upper Badenian 9 and Sarmatian 14.

Our project focuses on exploring the geothermal potential of the Czech part of Vienna Basin and determination of the “sweet spots”, i.e. the areas that are the most interesting ones from the geothermal point of view. It utilizes well data, specifically various measured and analytical data on oil and water. This paper focuses mostly on the water and its various parameters, together with calculated indexes describing the geothermal fluid flow system.

2. METHODS

We collected a diverse information and various data we needed for calculations. Some data included reflection seismic imagery and well logs. Other data included the fluid inflow rate, fluid temperature, oil/water ratio, oil and water densities, and the basic geochemical composition of the geothermal fluid, to name the most important ones. Our main data source was the well database archived by the Moravské Naftové Doly, a.s., operating in the Czech part of the basin. It included physical and geochemical analyses of fluids, including age determination of the penetrated and tested stratigraphies.

The data represented a fairly long time span of drilling. As a result, they did not have the same format or were existent in every well. The geochemical composition of water was present most often. It included the amount of Total dissolved solids (TDS) in the fluid, including contents or various key anions and cations, all measured in mg/l. Water densities, which we needed to recalculate the mg/l into part-per-million units, were present less often. The information on the amount of inflowing water was the least occurring information.

The water temperature at wellhead was not present at all. The temperature of fluids at depth, although sometimes measured, was apparently at least partly corrupted in the original database, meaning that we could not collect the temperature data from there at all. In order to fill this gap, we used a database of ambient temperatures of the environment at different depths, which we then used for filling the temperature at a depth of every available inflow measurement in.

All available and acquired data have been visualized as point data using the ArcGIS software. We then created contour maps for individual stratigraphic horizons, if they had a sufficient amount of data-points to constrain a meaningful map.

On top of analytical/measured parameters, we have calculated the Temperature flow rate index (TFR), represented by the fluid inflow rate in m^3/hour divided by the fluid temperature in °C (Soldo and Alimonti, 2015).

3. KEY FLUID PARAMETERS IN THE STUDY AREA

Our dataset focuses on water analyses in different wells and depths, and contains data (varying in quantity) from several horizons from each of the four key stratigraphies: 4 from lower Badenian, 6 from middle Badenian, 8 from upper Badenian and 10 from Sarmatian.

Geologically speaking, sediments of these stratigraphic ages were deposited at a time when Vienna Basin started opening as a pull-apart basin (lower Badenian), reached its main pull-apart stage (middle Badenian), when the pull-apart system transformed into a wide rift of a back-arc (upper Badenian), and when it was a well-developed wide rift (Sarmatian, Fig. 2) (sensu Nemčok et al., 2025).

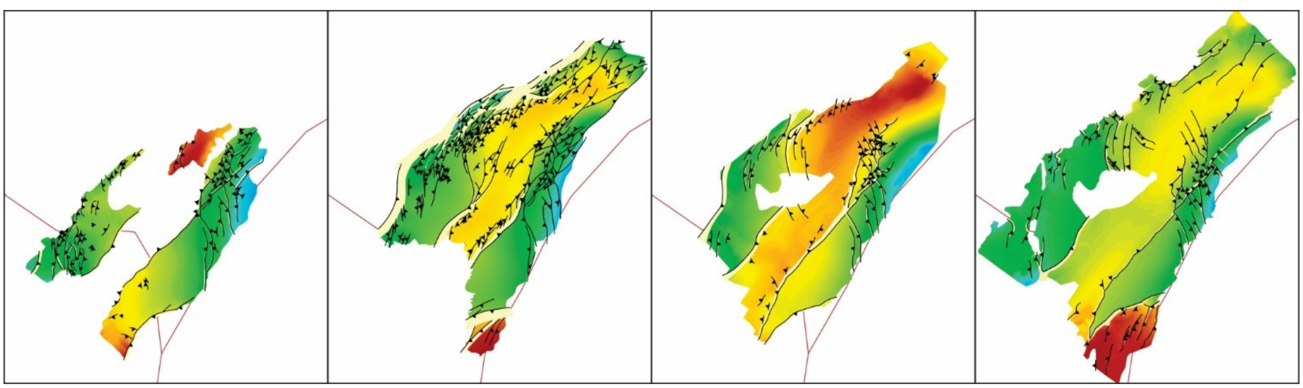

Figure 2: Depth-to-top-surface contour maps of lower, middle and upper Badenian and Sarmatian (from left to right). Thin red line represents the state boundary.

3.1 Lower Badenian

Our lower Badenian fluid data are very limited and constrained to the close vicinity of the Czech state boundary with both Austria and Slovakia. The general temperatures in this area at depth have higher values of 70-77 °C in the southernmost part of the area, where we have a looser cluster of three data-points about halfway between towns of Lanžhot (CZ) and Hohenau an der March (A). Out of the available data, the apparent highest inflow in this area is present in the aforementioned area south from Lanžhot village, reaching almost 14.5 m^3/h. The Temperature flow rate index (TFR) is highest in the spot of the highest inflow rate, with the second highest area representing a well in the area of Lanžhot village with inflow rate 5.6 m^3/h. These two areas reach the TFR of 0.75 and 0.5, respectively.

We have a slightly less limited amount of data points with the Total dissolved solids content (TDS), and they cover a slightly larger area (Fig. 3, left compared to right). TDS reaches 21,000 ppm. However, we only have inflow rate measurements from the SE part of the TDS contour map, where TDS reaches only 17,700 ppm. The well with the highest inflow rate also has the highest TDS from all the wells with measured inflow rate in this stratigraphy. The second highest inflow rate datum, located in the area of Lanžhot village, has a lower TDS of 10,538 ppm (Fig. 3).

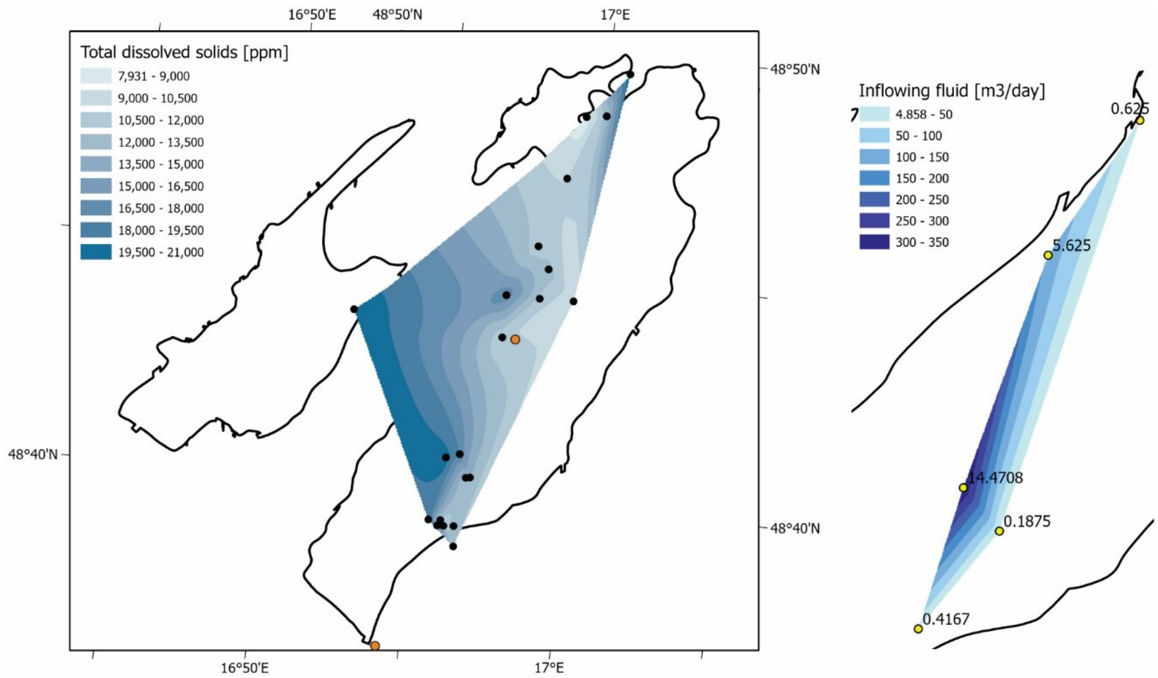

Figure 3: Lower Badenian strata. Left – Data coverage and contour map of TDS in lower Badenian fluids. Black line represents the extent of lower Badenian strata in the area. Orange dots represent Lanžhot and Hohenau an der March settlements. Right – Data points showing the rate of inflowing fluids in m^3/h. Contour map shows the inflowing volume per day.

3.2 Middle Badenian

Fluid data of the middle Badenian stratigraphic sequence are more extensive and cover the most of the study area, including a portion of the Central Moravian Depression. Our highest fluid inflow values were measured in several places located in the Central Moravian Depression and a cluster of wells between villages Moravská Nová Ves and Prušánky. This is also an area determined by us as the discharge zone for the fluids (see Rybár et al. in this volume). The higher inflow rates located in the center to mid North of the study area range from 4.88 to 11.04 m^3/h, and most of them are on the fringe of a localized temperature hot-spot at this stratigraphic level. These fluids have usually higher temperature than their surroundings. The aforementioned maxima correlate with: 1) the highest TFR with values of 0.75 to 0.5, and 2) moderate to higher levels of TDS (range of 10,600-14,600 ppm; Fig. 4). The discharge region has higher temperatures and higher amounts of TDS, but this tends to be more readily visible in visualizations made for specific horizons rather than when considering the stratigraphy as a whole, with all its horizon values combined together.

Generally speaking, the TDS of middle Badenian fluids range from approximately 3,400 to 18,000 ppm, with most samples reaching 11,000-14,600 ppm. A few spots have higher TDS values of more than 15,000 ppm, and one notable peak in the eastern part of study area reaches almost 86,500 ppm. This peak is caused by an usually high content of Potassium and Chlorine in the fluid, reaching 39,123 ppm and 19,536 ppm, respectively.

In terms of middle Badenian horizons, there are two horizons with a sufficient amount of data: Žižkov Fm. and Jakubov Fm. (Vass, 2002), one of them also known as the Láb horizon of Hrušky Fm. (in sense of Špička, 1966). The coverage of the third studied horizon, Basal horizon, is very limited with only 6 data-points.

The highest fluid inflow rate (11.04 m^3/h) and TFR (0.5) in the Basal horizon corresponds to a well approximately half-way between villages Moravská Nová Ves and Prušánky. It has a higher TDS content, reaching 14,160 ppm.

The reservoir horizon in the Žižkov Fm. correlates with the middle Badenian strata horizon in general, and in particular in the area located at the margin of the Central Moravian Depression. It contains several data points with more substantial inflow rates, which were mentioned in the section on middle Badenian strata. These wells are located around the village Prušánky and further SW from it. Their rates of inflowing fluids reach 4.14, 4.39, 4.88 and 9.82 m^3/h, with TFR of 0.75-0.5 and TDS comparable to those listed in the section above. The southern maximum of inflowing fluid rates in the Central Moravian Depression is not present in this horizon, and the northernmost maximum is much less pronounced, although present. TDS in this horizon range mostly from 8,000 to 15,000 ppm, with several spots with higher TDS, located at NW and SW margins of the Central Moravian Depression (the maximum TDS content is 19,164 ppm, located in the SW corner of the data coverage).

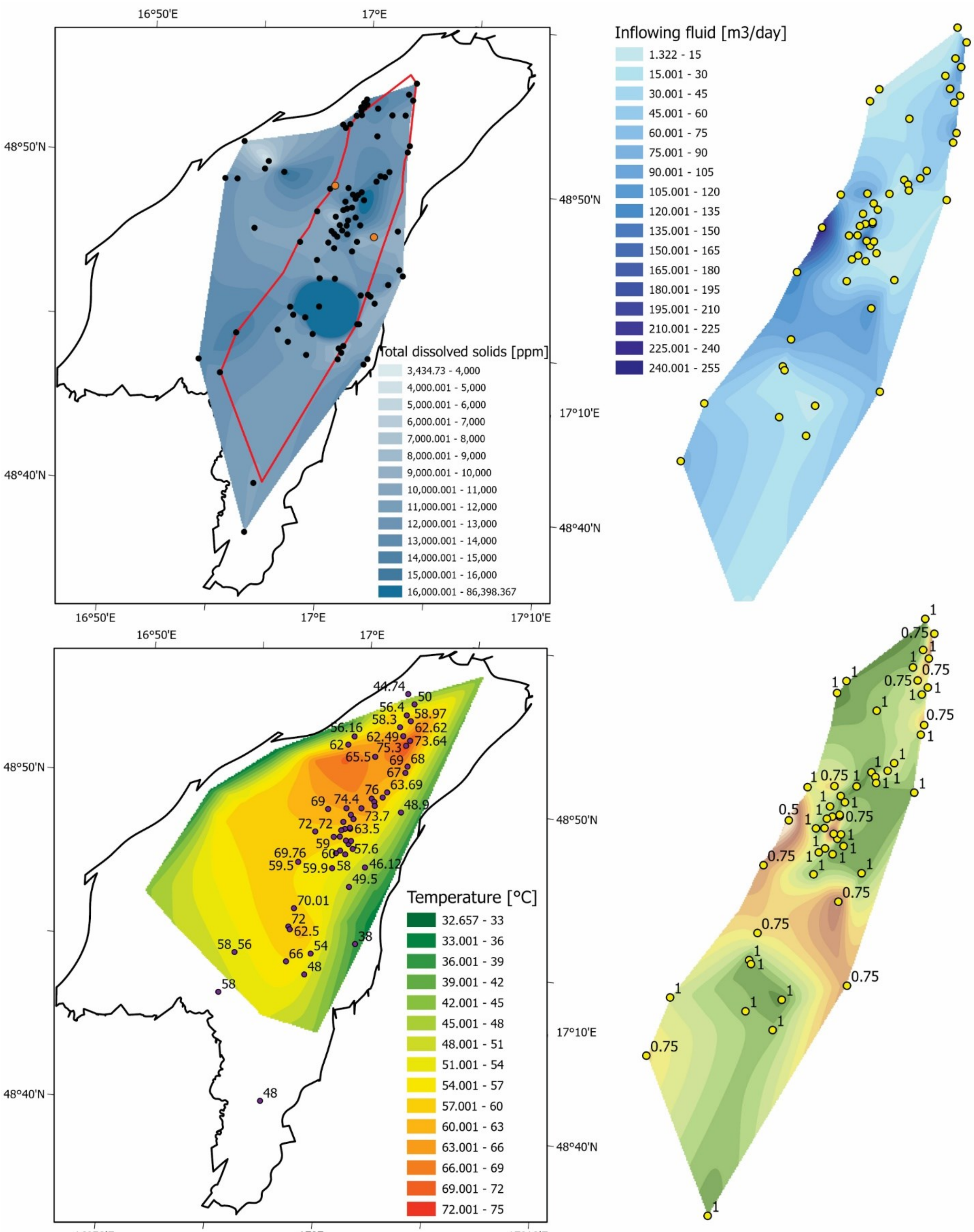

Figure 4: Middle Badenian strata. Upper left – Data coverage and TDS contour map. Red line shows the location of the figures in upper and lower right. Orange dots represent Prušánky and Moravská Nová Ves villages. Upper right – Contour map of inflowing fluid rate. Lower left – Thermal contour map at middle Badenian surface, compared to temperatures of fluids at their individual depths (labelled). Lower right – Temperature flow rate index contour map with values (labelled).

The higher rates of inflowing waters measured in the southernmost (3.4 m^3/h) and northernmost (4.79 m^3/h) parts of the Central Moravian Depression in the section above (see Fig. 4) are sourced predominantly from the Jakubov Fm. (Fig. 5). However, the highest amount of inflowing fluid in this horizon was slightly higher than that, reaching 5.01 m^3/h. It was measured at the Hodonín-Gbely Horst bordering the Central Moravian Depression from the east, in a well located east of Prušánky village. This inflowing water has a temperature of approximately 63.5 °C, which gives a TFR of 0.75, same as those in the two other spots of interest. This spot is also located in the fluid discharge area. Fluids of the northernmost spot have lower TDS (9,500 ppm) than the other two spots of higher inflow rate (14,500 ppm for the mid North spot and 12,500 ppm in the southernmost spot).

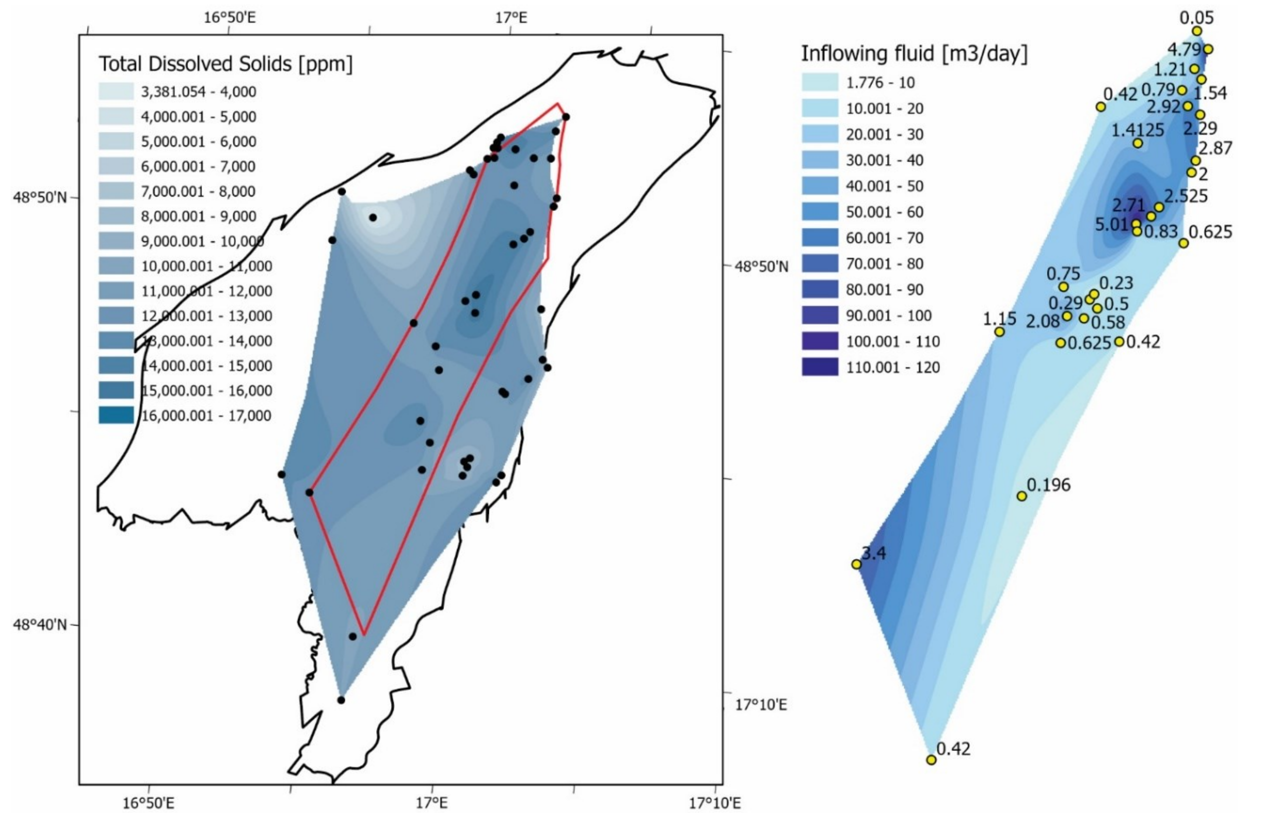

Figure 5: Jakubov Fm. horizon. Left – Data coverage and TDS contour map. Red line shows location of the figure in the right. Right – Data coverage and contour map of fluid inflow rate (labels show rate in m^3/h).

3.3 Upper Badenian

The Upper Badenian fluid dataset shows inflow maxima located mostly along the western margin of the data coverage, located in a line of three occurrences trending southwest from the village Moravská Nová Ves. They are located along a tailing edge of an increased temperature zone, where the fluid temperature ranges from 58 to 64 °C, and is probably becoming progressively hotter further north. Slightly raised amounts of hot inflowing waters were also noted in the southernmost and northernmost reaches of the coverage, both located in the Central Moravian Depression, with temperatures exceeding 63 °C.

The well with the highest amount of inflowing waters (7.66 m^3/h) is located closest to the Moravská Nová Ves village. It has a slightly lower temperature of 52 °C, which resulted in the TFR of 0.5. Other areas have usually the lower TFR values of 1 due to their lower inflow rates or higher fluid temperatures. The only wells that reach an index number 0.75 are the two other wells with the highest inflow rate.

TDS of fluids in these strata range from 5,600 to 13,600 ppm. Most of the measurements come from wells located along the edge of the Hodonín-Gbely Horst, which is formed by a rather complex fault architecture. This might have influenced the varying values of TDS present here, and may have worked as a barrier directing most of the fluids into the three spots with highest inflow rates in these strata. The fluids of these three areas have an average TDS content in comparison with neighbor wells. The northernmost well reaches 10,900 ppm, the second one further SW 11,400 ppm and the third one 9,100 ppm (Fig. 6).

Horizon-wise, the well with the highest fluid inflow receives fluids from horizon 7. Other than that, despite the fact that upper Badenian fluid data come from 8 horizons present in this stratigraphy, which is one with the most diverse reservoir architecture, none of the horizons have enough data-points or contain data that would be of interest to show separately. By far, the most data-rich horizon is horizon 5, characterized by 15 data-points. However, the data are spaced more-or-less linearly in the NE-SW direction, which does not allow for comprehensive visualization. Fluid inflow rates of these wells seldom exceed 1 m^3/h, the highest inflow rate of 2.83 m^3/h being the one furthest NE in close vicinity to village Dolní Bojanovice.

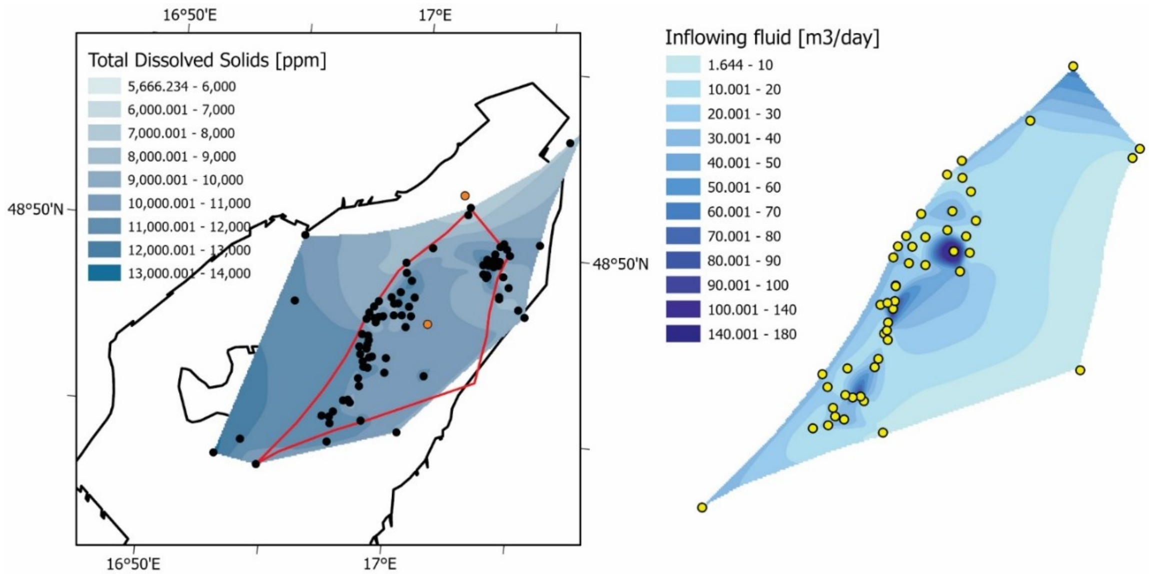

Figure 6: Upper Badenian strata. Left – Data coverage and contour map of TDS. Red line shows a location of the figure in the right. Orange dots represent Moravská Nová Ves and Dolní Bojanovice villages (South and North, respectively). Right – Data coverage and contour map of the fluid inflow rate.

3.4 Sarmatian

The Sarmatian dataset is slightly limited, covering an area located further north than those of upper and lower Badenian. It spatially correlates with the northern portion of the middle Badenian dataset. Fluid temperatures encountered in Sarmatian strata range from 27.86 to 55.8 °C.

This stratigraphic interval is characterized only by few wells with the fluid inflow rate exceeding 1 m^3/h. The most pronounced inflow of 5.97 m^3/h is the one close to Dolní Bojanovice village, measured in well JO12 (Fig. 7). Its TFR significantly exceeds the other ones in this stratigraphy. It is the only one with TFR reaching 0.75. However, this is caused by its temperature only reaching 50.7 °C. The second highest measured inflow rate is located in the NE corner of the data coverage.

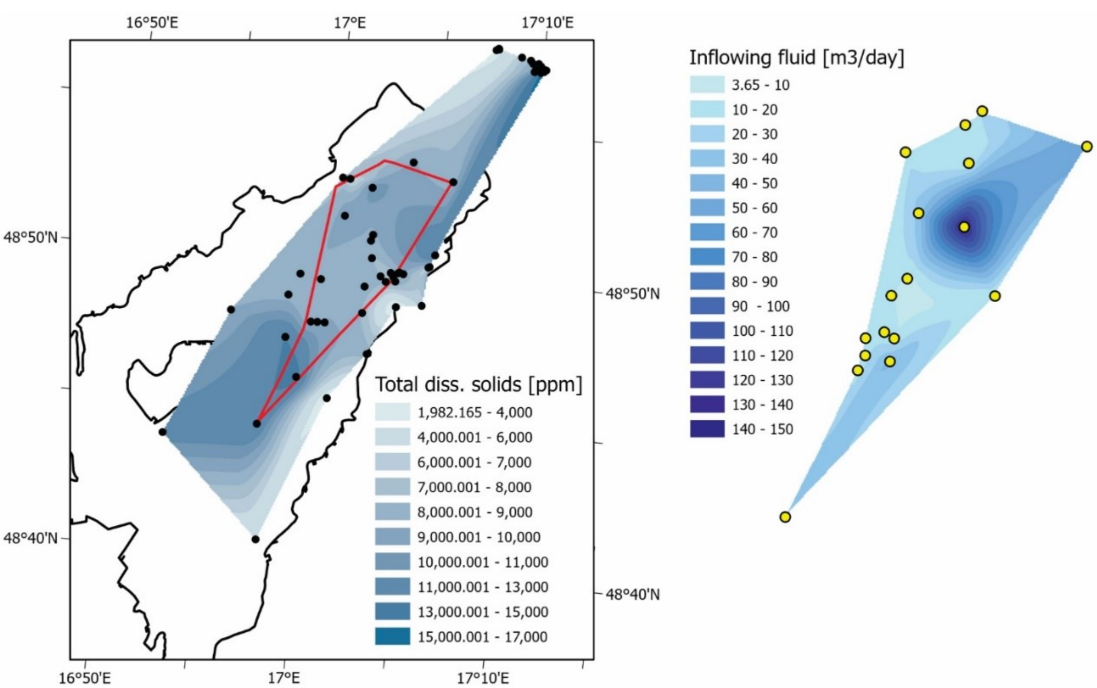

Figure 7: Sarmatian strata. Left – Data coverage and contour map of TDS. Red line shows location of the figure in the right. Right – Data coverage and contour map of the fluid inflow rate.

The TDS dataset is larger than that of Sarmatian inflowing fluids. It covers a larger area, even extending beyond the extent of the Sarmatian depth-to-top-surface contour map from Fig. 2. It ranges from 6,500 ppm to 14,167 ppm in most of the area. The most typical values range between 7,800 and 9,800 ppm. The spot with highest inflow rate correlates with the TDS content of 8,657 ppm. Some of the marginal areas contain anomalous TDS values. Several close-clustered wells at the northern edge of the data coverage and a few wells at the eastern margin of the coverage only reach 2,000-3,500 ppm. There is also a cluster of four wells located in the north-eastern part of the coverage, with unusually high TDS values exceeding 15,400 ppm (Fig. 7).

The data coverage on individual Sarmatian horizons (combined horizons 12-14) are poorer than that on the Sarmatian strata. It contains 10 points, which show that all of the higher amounts of inflow rate mentioned previously come solely from horizons 12-14, with the exception of the highest inflow rate of 5.97 m^3/h in one well. This well only receives a half of its inflowing fluid amount from horizons 12-14.

4. CONCLUSIONS

One of the main factors controlling the suitability of a geothermal system for generation of electricity from water utilizing an ORC plant is the minimum temperature of input water for the plant. This temperature varies depending on the requirements of individual ORC plants, but generally, 77 °C is one of the lowest thresholds. Seeing as the temperatures in our area do not reach or exceed this temperature, it is clear that the area will not be suitable for a direct generation of electricity from water. However, it may have some potential for the direct heating.

In this sense, the most interesting locations are those with the highest temperatures of fluids combined with the highest amount of inflowing fluids. Most of the highest rates of inflowing fluids in the study area are apparently located at or close-by to the fault-controlled western flank of the Hodonín-Gbely Horst, where the discharge area of fluids is located (see paper by Rybár et al. in this volume). The discharge area also represents the hottest area, so any future exploration efforts will likely be focused there. The fluids in discharge area are warmer than those in the recharge area and in the connecting basin. They also contain the higher amount of dissolved solids. This may be a disadvantage for further water processing, as the dissolved minerals may cause cementation in the production system. This may be mitigated by (1) migrating fluids at higher pressures, (2) chemical treatment or (3) choosing a location with lower amounts of TDS.

ACKNOWLEDGEMENTS

This research was funded by the Technology Agency of the Czech Republic (Technologická agentura ČR) under the TK – program for the Support of Applied Research, Experimental Development and Innovation THÉTA, subprogram 2, PID: TK05020137. Special thanks belong to MND, a.s., Czech Republic, for allowing us access to their digital data repositories.

REFERENCES

Andrejeva Grigorovič, S., Kováč, M., Halásová, E., and Hudáčková, N.: Litho and Biostratigraphy of the Lower and Middle Miocene sediments of the Vienna basin (NE part) on the basis of calcareous nannoplankton and foraminifers, Scripta Fac. Sci. Nat. Univ. Masaryk. Brun., 30, (2001), 27-40.

Baráth, I., Hlavatý, I., Kováč, M., and Hudáčková, N.: Depositional Systems of the Northern Vienna Basin, Slovak Geological Magazine, 9, 4, (2003), 237-239.

Decker, K.: Miocene tectonics at the Alpine-Carpathian junction and the evolution of the Vienna basin, Mitt. Ges. Geol. Bergbaustud. Österr., 41, (1996), 33-44.

Fodor, L.: From transpression to transtension: Oligocene-Miocene structural evolution of the Vienna basin and the East Alpine-Western Carpathian junction, Tectonophysics, 242, (1995), 151-182.

Hamilton, W., Wagner, L., and Wessely, G.: Oil and Gas in Austria, Mitteilungen der Österreichischen Geologischen Gesellschaft, 92 (2000), 235-262.

Harzhauser, M., Kranner, M., Mandic, O., Strauss, P., Siedl, W., and Piller, W.E.: Miocene lithostratigraphy of the northern and central Vienna Basin (Austria), Austrian Journal of Earth Sciences, 113, 2, (2020), 169-200.

Hölzel, M., Decker, K., Zámolyi, A., Strauss, P., and Wagreich, M.: Lower Miocene structural evolution of the central Vienna Basin (Austria), Marine and Petroleum Geology, 27, (2010), 666-681.

Kováč, M., Baráth, I., Harzhauser, M., Hlavatý, I., and Hudáčková, N.: Miocene depositional systems and sequence stratigraphy of the Vienna Basin, Cour. Forch.-Inst. Senckenberg, 246, (2004), 187-212.

Krejčí, O., Franců, J., Poelchau, H.S., Müller, P., and Stráník, Z.: Tectonic evolution and oil and gas generation at the border of the North European Platform with the West Carpathians (Czech Republic), in: Wessely, G., and Liebl, W. (eds), Oil and gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe, EAGE Special Publication, 5, (1996), 177-186.

Ladwein, H.W.: Organic Geochemistry of Vienna Basin: Model for Hydrocarbon Generation in Overthrust Belts, AAPG Bulletin, 72, 5, (1988), 586-599.

Nemčok, M., Doré, A.G., Doran, H., and Henk, A.: Strike-slip terrains and transform margins: structural architecture, thermal regimes and petroleum systems, Cambridge University Press, Cambridge (2024), 733pp.

Picha, F.J., Stráník, Z., and Krejčí, O.: Geology and Hydrocarbon Resources of the Outer Western Carpathians and Their Foreland, Czech Republic, in: Golonka, J., and Picha, F.J. (eds), The Carpathians and their foreland: Geology and hydrocarbon resources, AAPG Memoir, 84, (2006), 49-175.

Soldo, E., and Alimonti, C.: From an Oilfield to a Geothermal One: Use of a Selection Matrix to Choose Between Two Extraction Technologies, Proceedings, World Geothermal Congress, Melbourne, Australia (2015).

Strauss, P., Harzhauser, M., Hinsch, R., and Wagreich, M.: Sequence stratigraphy in a classic pull-apart basin (Neogene, Vienna Basin). A 3D seismic based integrated approach, Geologica Carpathica, 57, 3, (2006), 185-197.

Špička, V.: Paleogeografie a tektogeneze Vídeňské pánve a příspěvek k její naftové geologické problematice, Rozpr. Čs. Akad. Věd, R. mat. přír. věd, 76, 12, (1966), 3-118.

Vass, D.: Litostratigrafia Západných Karpát: neogén a budínsky paleogén, Litostratigrafia, Śtátny geologický ústav Dionýza Štúra, Bratislava (2002), 202pp.