TA ČR project TK05020137 "Development of the play-fairway system for the low-temperature geothermal system exploration in sedimentary basins; with application to the Vienna Basin"

End-of-the-year-2023 progress report

Planned Aim

Aim of the project is to develop the play-fairway-map construction technique for low-temperature geothermal systems in sedimentary basins in the GIS environment. The goal is to parameterize the exploration by the system of factors characterizing the geothermal system, its efficiency and its engineering geology characteristics, such as production index for specific power producing technology, reinjection index, environmental impact index and cost index for specific technology; to subsequently normalize those factors and, finally, combine them in such a way that the color-coded play fairway map indicates areas of the basin with the best potential for the geothermal system commercialization, fair potential, poor potential and areas lacking data allowing their evaluation.

Planned Schedule

The project schedule is set for 2 years. Stage 1 of the project (March 2023 – March 2024) is focused on the development of the database, which contains structural geology, lithological, thermal and geochemical data. The development includes a map visualization of the aforementioned data. The data are planned to be collected from about 400 hydrocarbon exploration/production wells located in the Czech portion of the Vienna Basin. Stage 2 of the project (March 2024 – March 2025) is focused on the (a) parameterization of the factors controlling the existence of low-temperature geothermal systems in the study area and risks associated with their successful commercialization, and (b) development of the Arc GIS-based play fairway map.

Results developed by the end of the year 2023

The research team composed of the Technical University Ostrava (TUO) group and Moravské Naftové Doly (MND) group spent the time interval of March – December 2023 on:
1) the reflection seismic interpretation of top surfaces of four stratigraphies that include all main producing reservoirs (Lower Badenian, Middle Badenian, Upper Badenian and Sarmatian stratigraphies);
2) the Arc GIS visualization of the aforementioned four top surfaces (**Figs. 1**-**4**);
3) the well data collection from the MND archive (**Figs. 5**-**8**); and
4) the first pass at Petrel and Arc GIS visualizations of well data, such as temperature (**Figs. 9**-**11**).

All four aforementioned top surfaces of Lower Badenian, Middle Badenian, Upper Badenian and Sarmatian strata were interpreted from the reflection seismic imagery, using programs Kingdom Suite and Petrel, together with fault patterns that deform them. Interpreted surfaces were subsequently imported into the Arc GIS and processed. Processed depth contour maps were made using a 20 m- contour interval (**Figs. 1a, 2a, 3a, 4a**). Faults were represented as elongated polygons.

The polygon width represents fault heave, being proportional to both the fault throw and fault slip. On top of faults interpreted from the reflection seismic imagery, additional faults were interpreted from indicative contour patterns in Arc GIS. Throw of top surfaces of blocks juxtaposed over a fault provided the indication of the fault dip, which was marked in the map by triangular teeth.

Maps also contain a layer providing the location of hydrocarbon fields producing from reservoir horizons occurring in the respective stratigraphy (**Figs. 1b, 2b, 3b, 4b**). Additional layer contains locations of all hydrocarbon exploration and production wells in the study area (**Figs. 1c, 2c, 3c, 4c**).

Fig. 1. a) Depth contour map of the top surface of Lower Badenian strata with isolines labeled. The contour interval is 20 m.

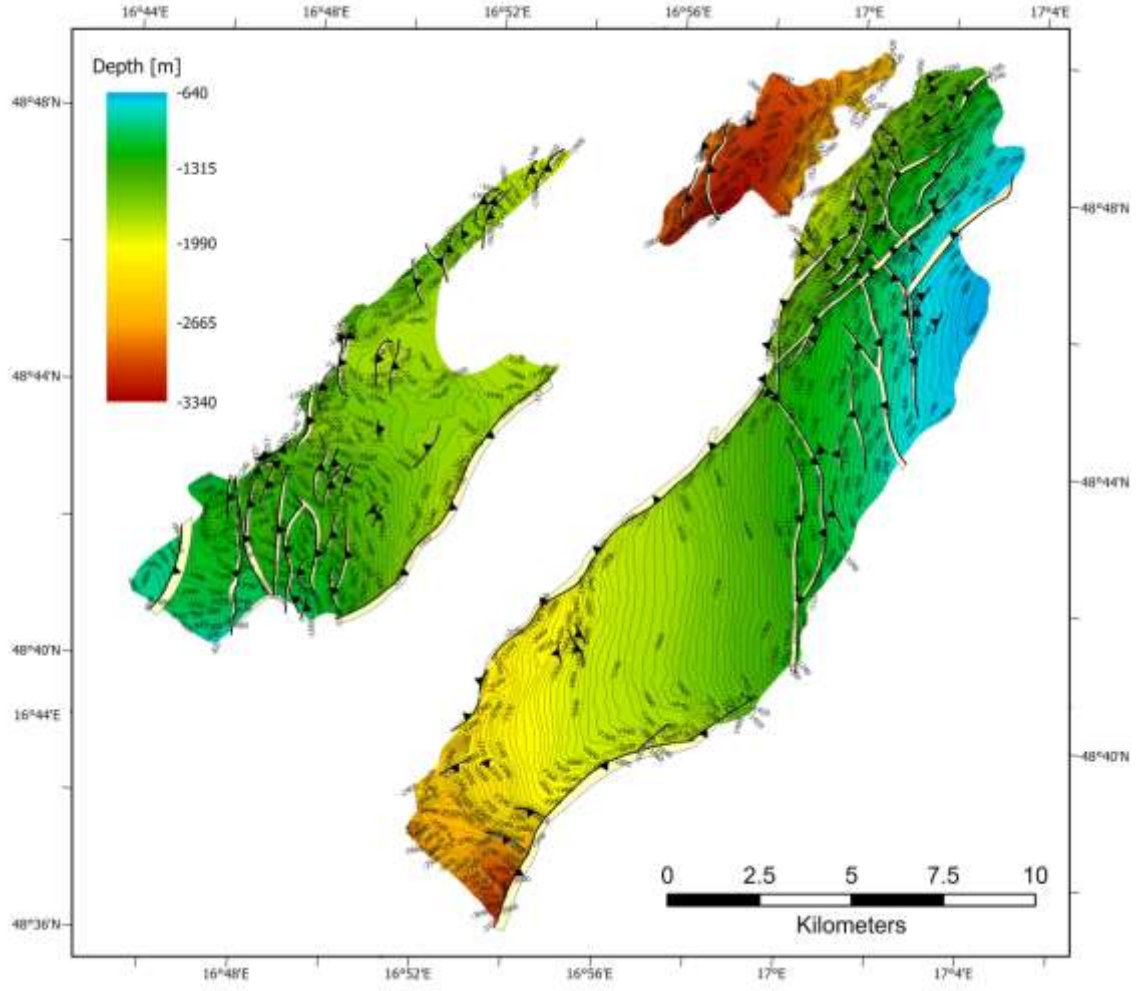


Fig. 1. b) Depth contour map of the top surface of Lower Badenian strata with location and names of existing hydrocarbon fields producing from this stratigraphy.

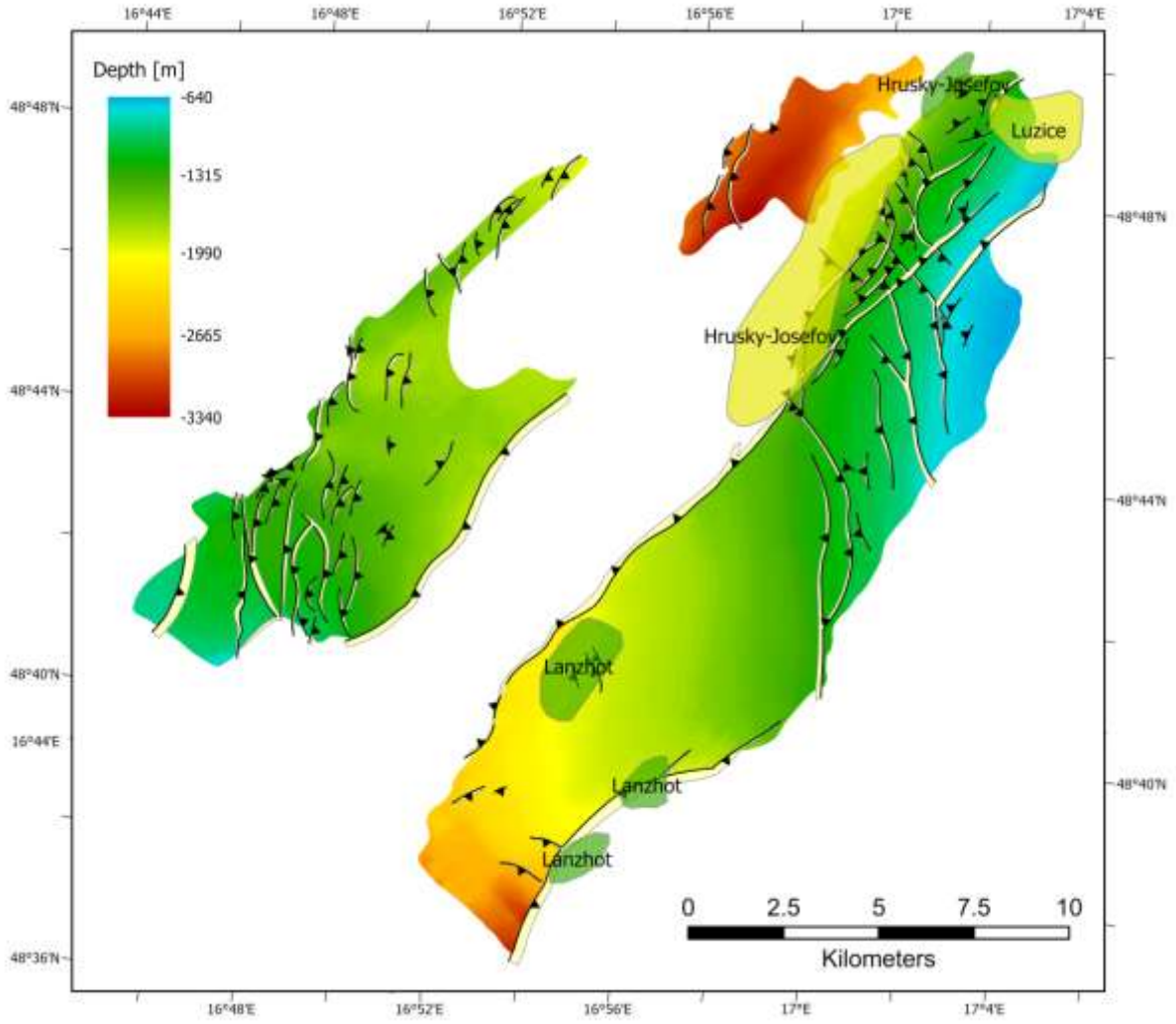


Fig. 1. c) Depth contour map of the top surface of Lower Badenian strata with location of all hydrocarbon exploration and production wells in the basin.

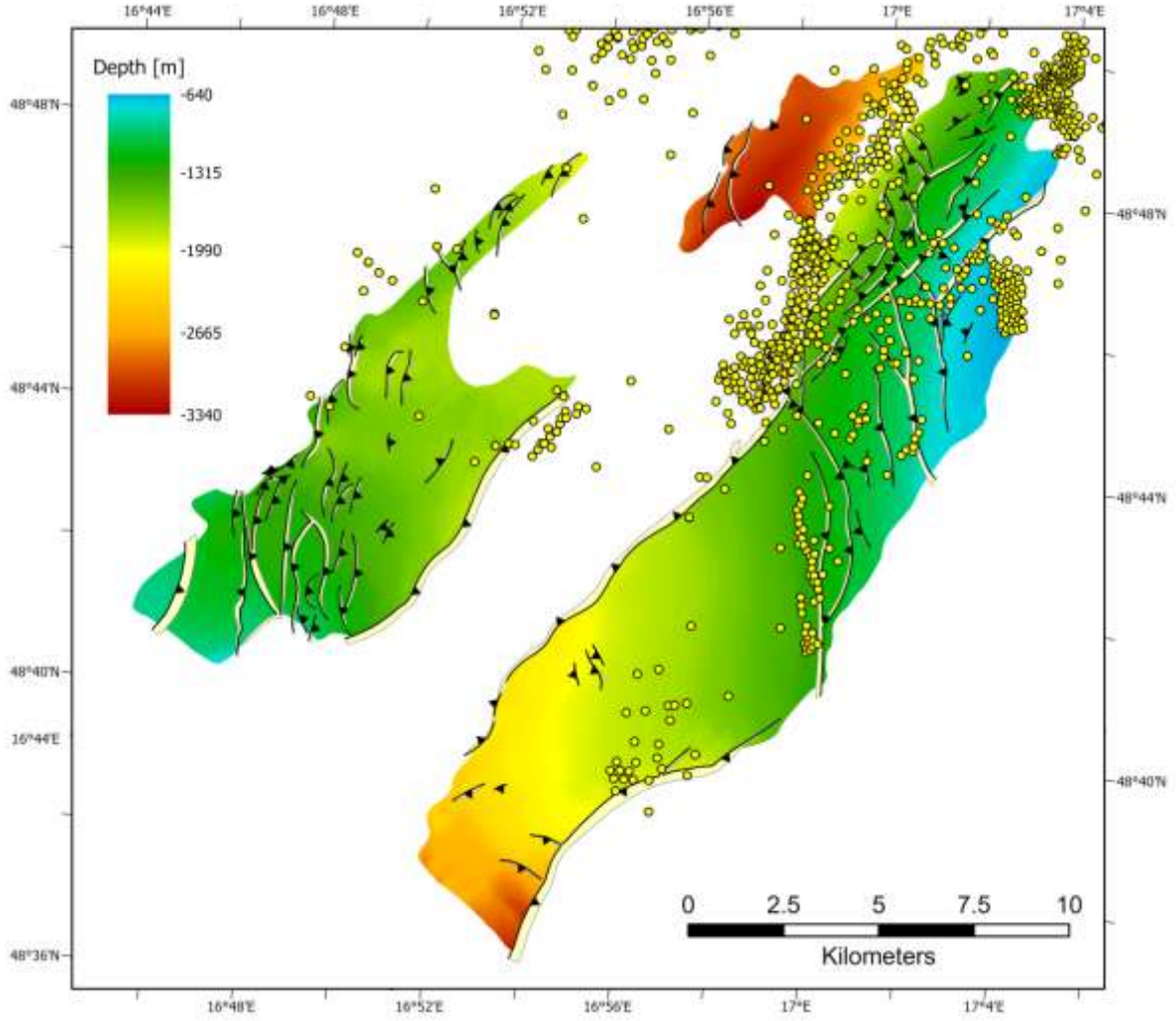


Fig. 2. a) Depth contour map of the top surface of Middle Badenian strata with isolines labeled. The contour interval is 20 m.

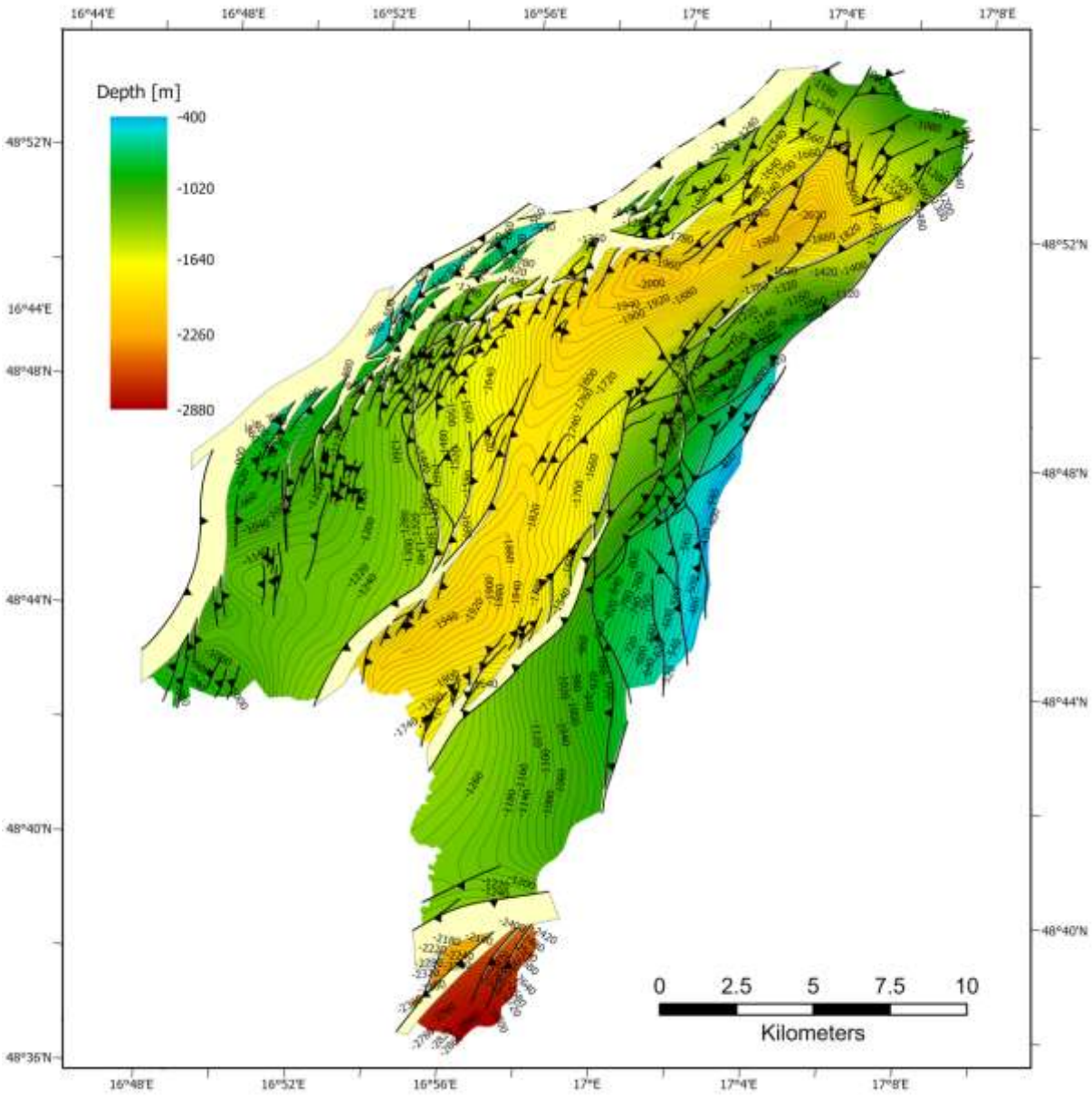


Fig. 2. b) Depth contour map of the top surface of Middle Badenian strata with location and names of existing hydrocarbon fields producing from this stratigraphy.

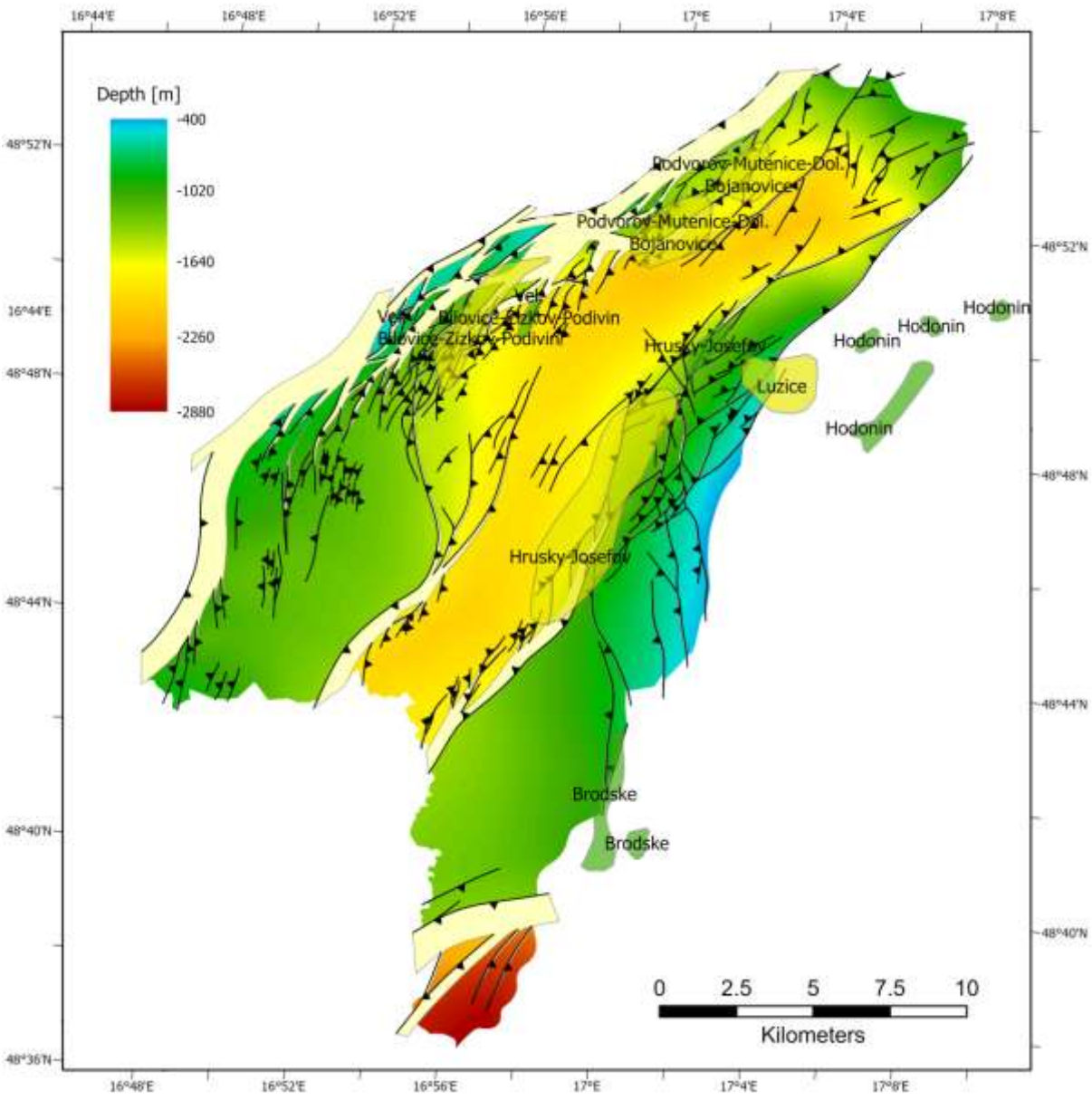


Fig. 2. c) Depth contour map of the top surface of Middle Badenian strata with location of all hydrocarbon exploration and production wells in the basin.

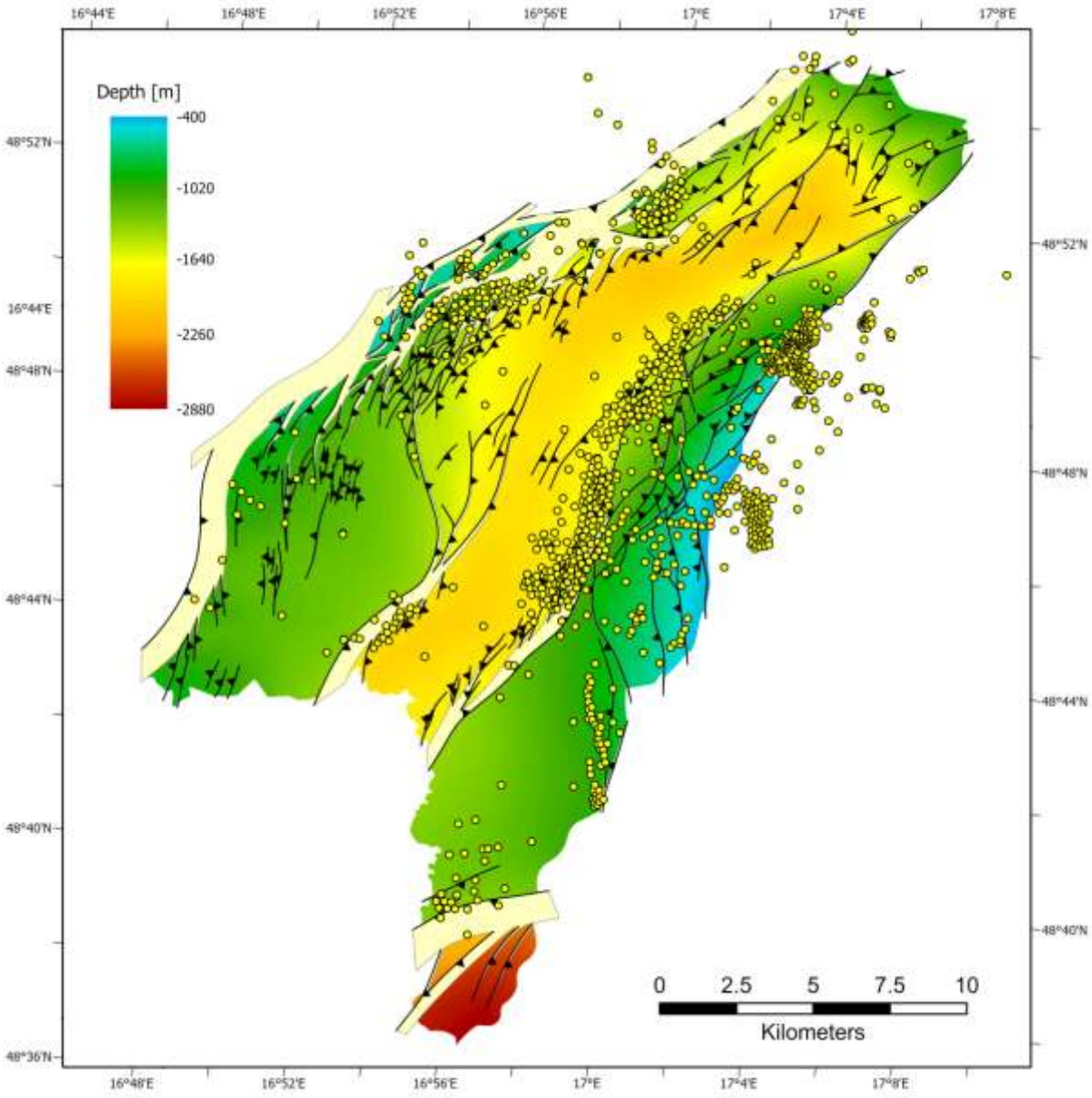


Fig. 3. a) Depth contour map of the top surface of Upper Badenian strata with isolines labeled. The contour interval is 20 m.

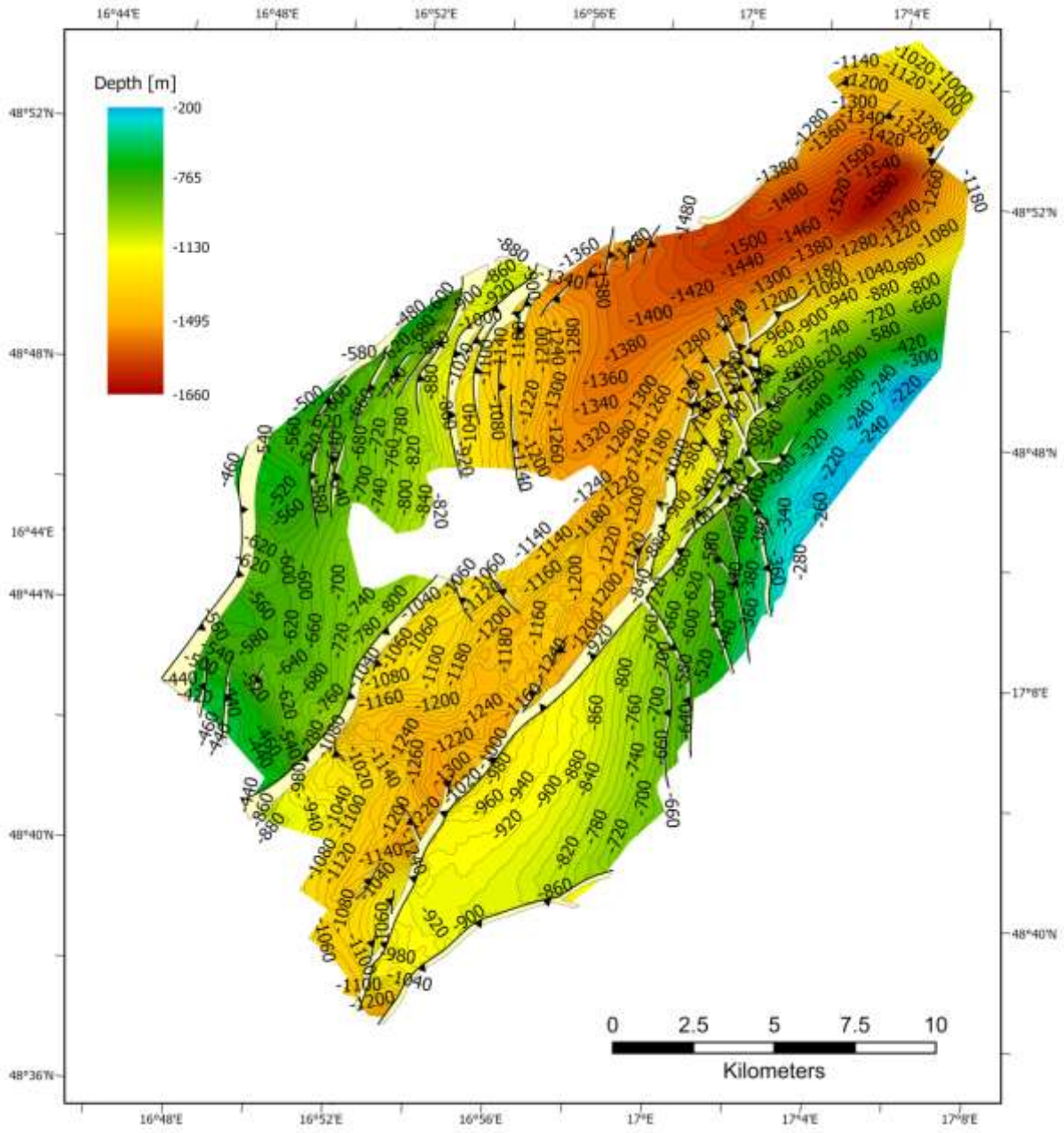


Fig. 3. b) Depth contour map of the top surface of Upper Badenian strata with location and names of existing hydrocarbon fields producing from this stratigraphy.

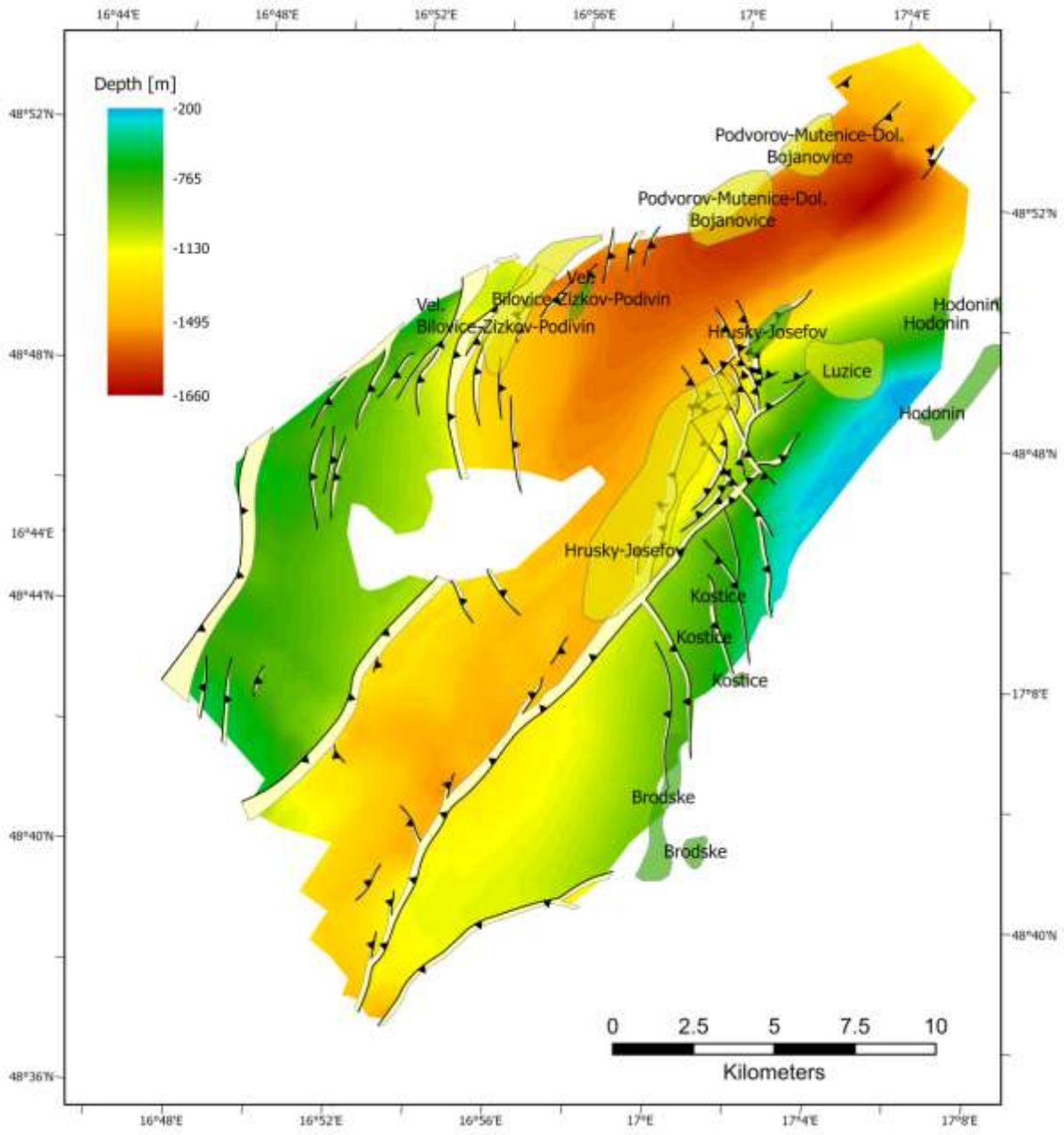


Fig. 3. c) Depth contour map of the top surface of Upper Badenian strata with location of all hydrocarbon exploration and production wells in the basin.

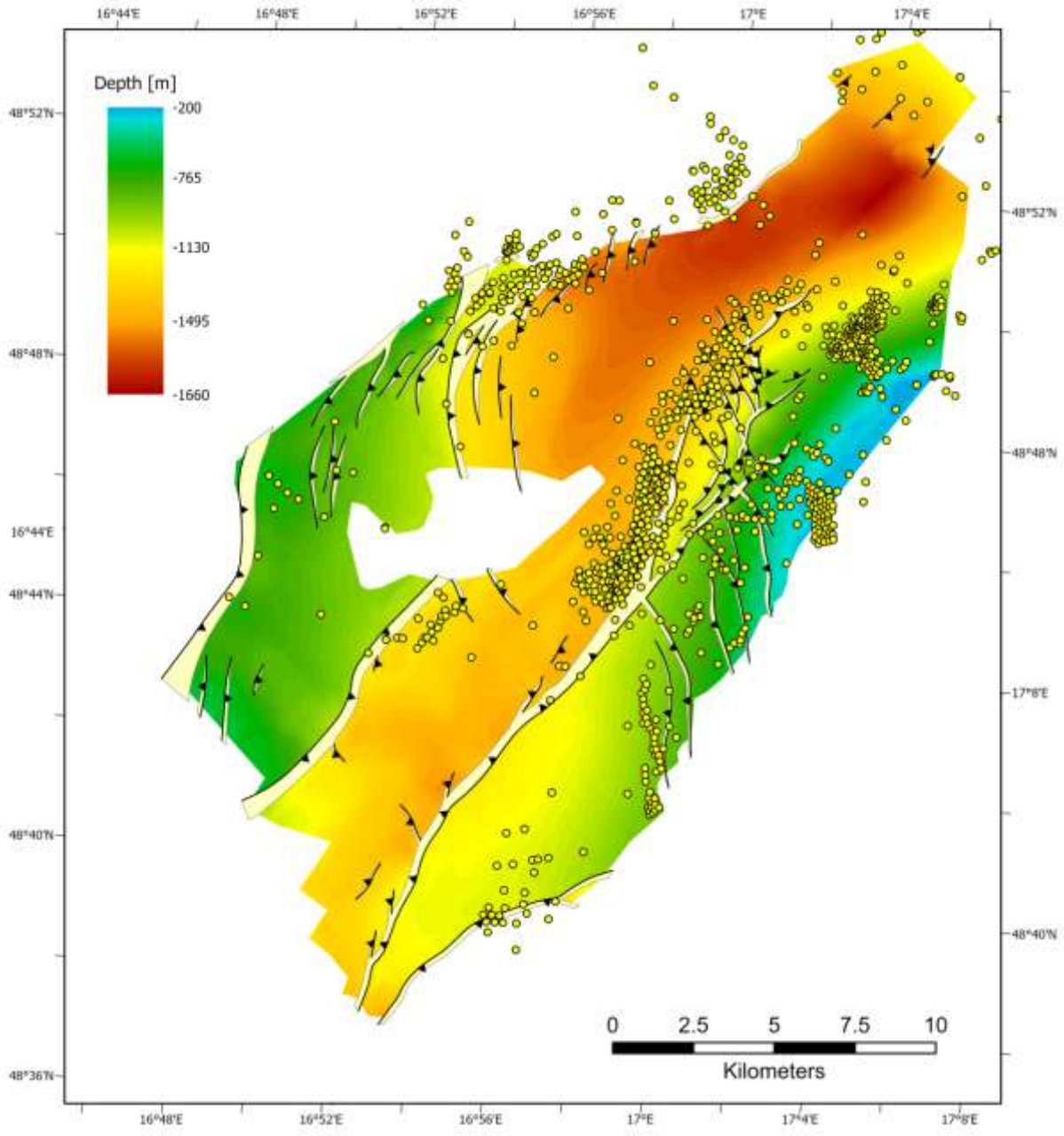


Fig. 4. a) Depth contour map of the top surface of Sarmatian strata with isolines labeled. The contour interval is 20 m.

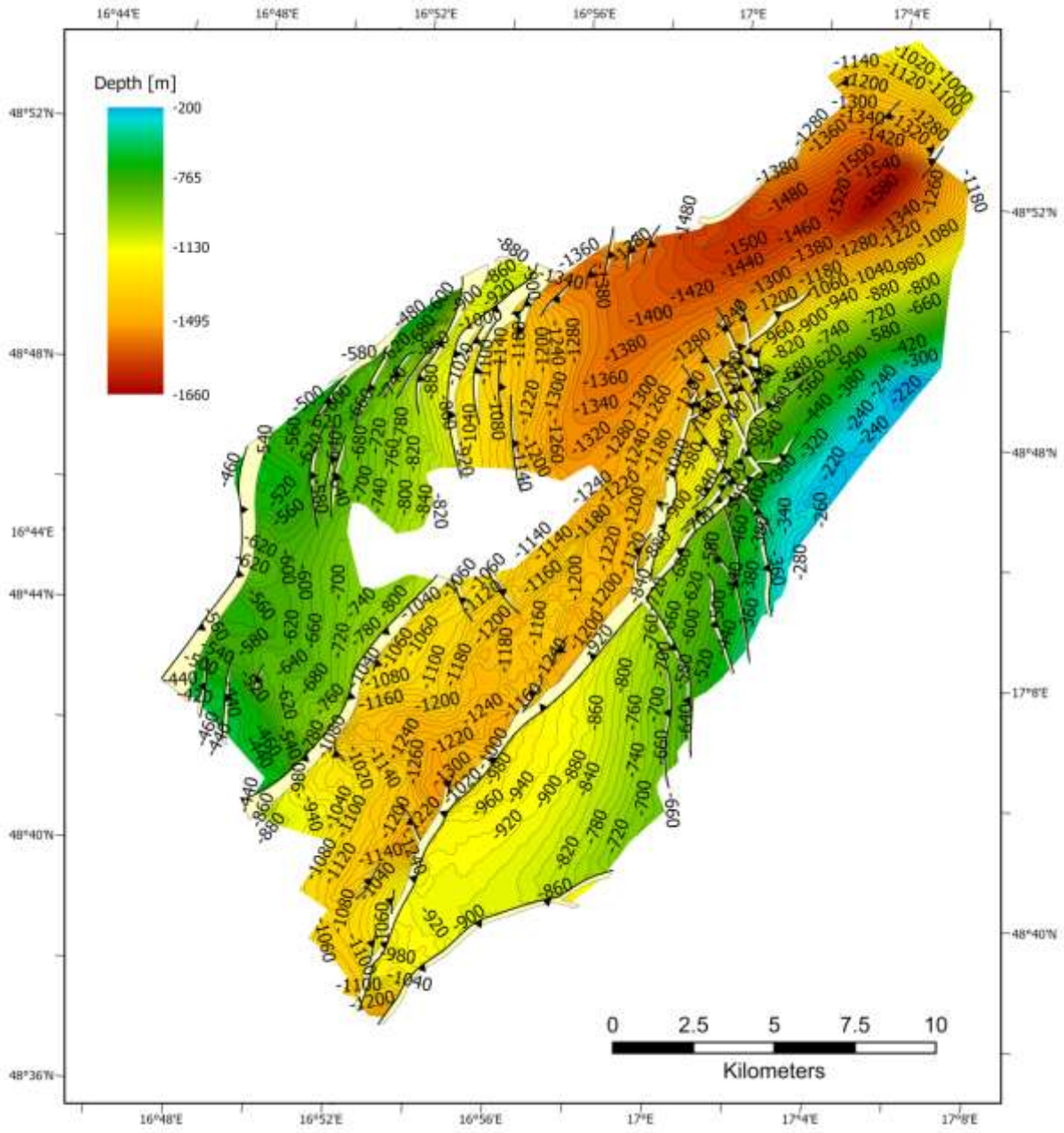


Fig. 4. b) Depth contour map of the top surface of Sarmatian strata with location and names of existing hydrocarbon fields producing from this stratigraphy.

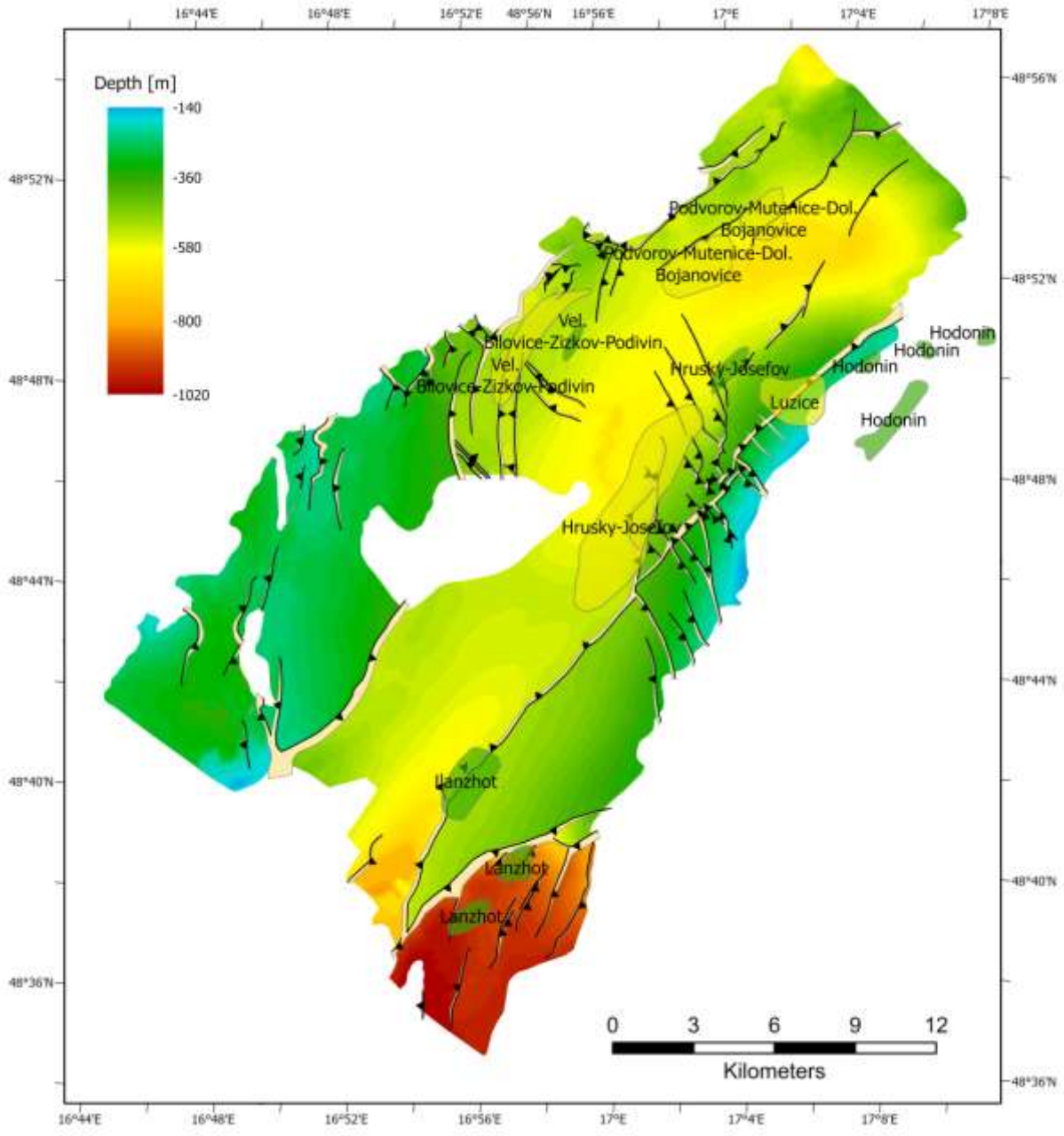
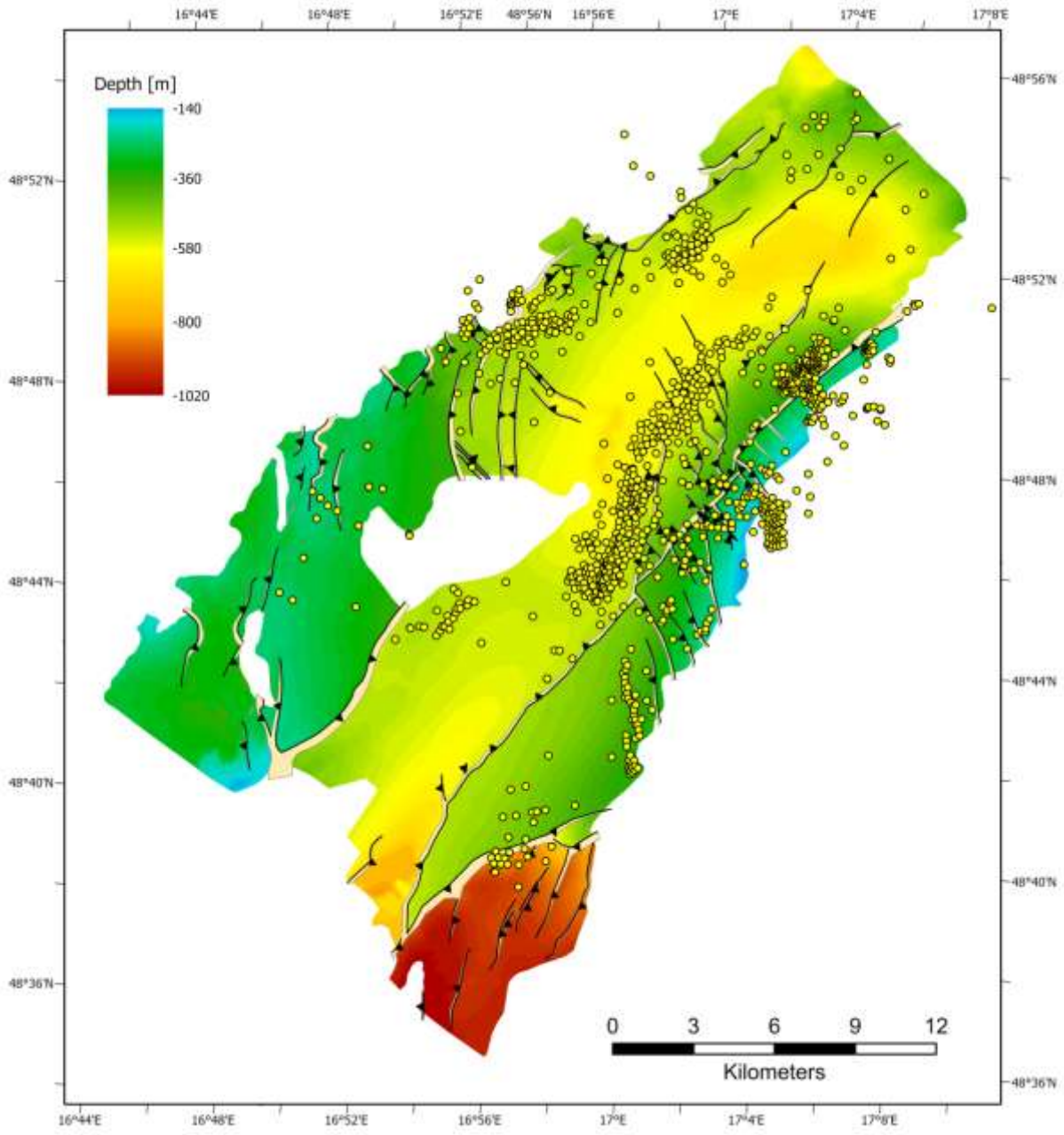


Fig. 4. c) Depth contour map of the top surface of Sarmatian strata with location of all hydrocarbon exploration and production wells in the basin.



Well data were collected from both MND electronic archive and individual well reports. The first cycle of data gathering went through the stratigraphic span of exploration and production wells. Subsequently, in the second cycle, representative wells characterizing various local well clusters were identified (**Figs. 5**-**8**) and their structural geology, lithological, thermal and geochemical data collected using Excel spreadsheets. Spreadsheets with data were imported into the Arc GIS attribute table. Their quality control is planned to be finished by March 2024, when they will be ready for the parameterization process.

Figs. 9-**11** show the first pass at temperature distribution map development in the study area.

Fig. 5. Depth contour map of the top surface of Lower Badenian strata with location of wells that provided structural geology, lithological, thermal and geochemical data for the Arc GIS database. Data contain the information on the oil density and water content. They also contain information on the water inflow rate, mineralization, density and temperature.

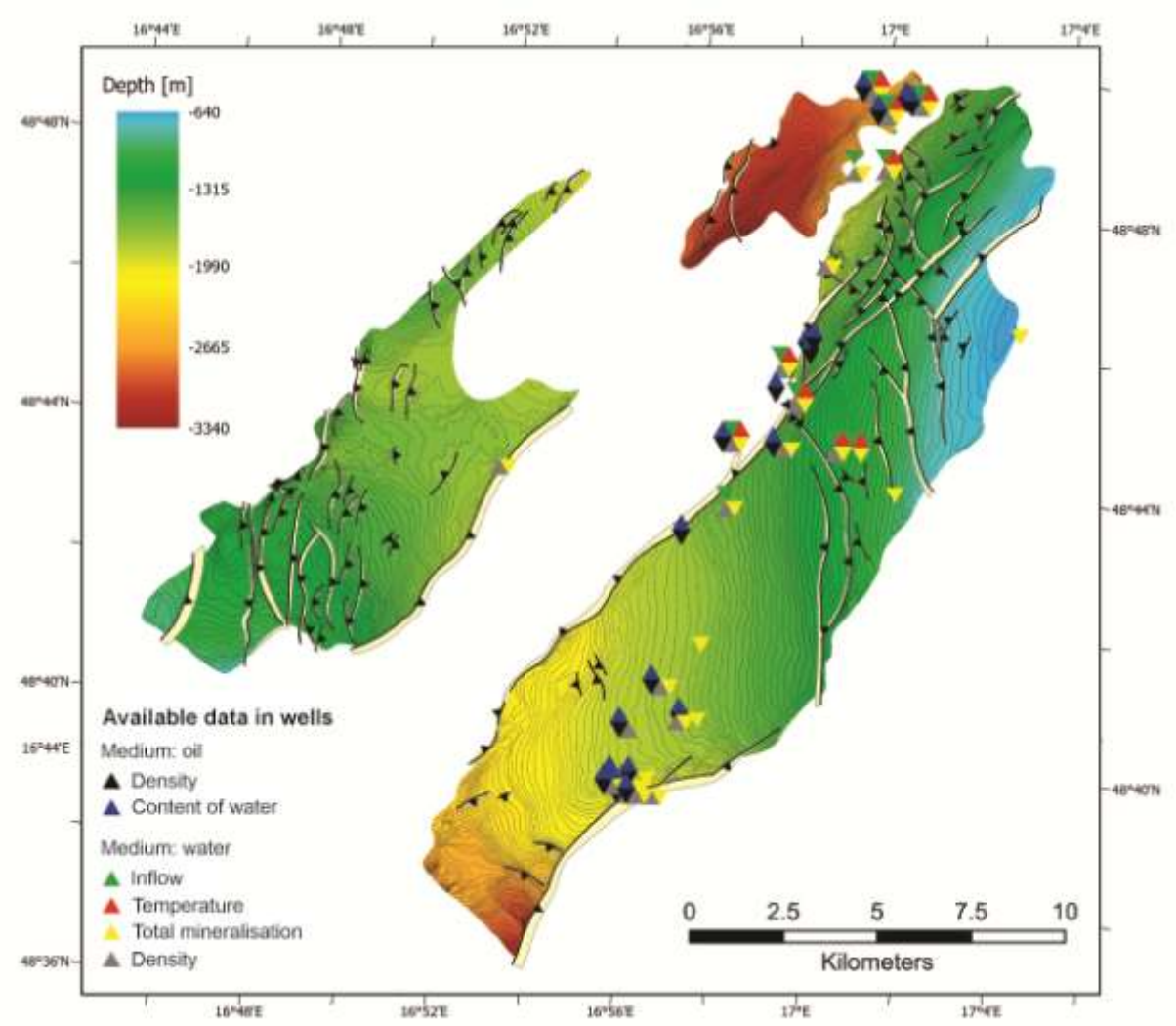


Fig. 6. Depth contour map of the top surface of Middle Badenian strata with location of wells that provided structural geology, lithological, thermal and geochemical data for the Arc GIS database. Data contain the information on the oil density and water content. They also contain information on the water inflow rate, mineralization, density and temperature.

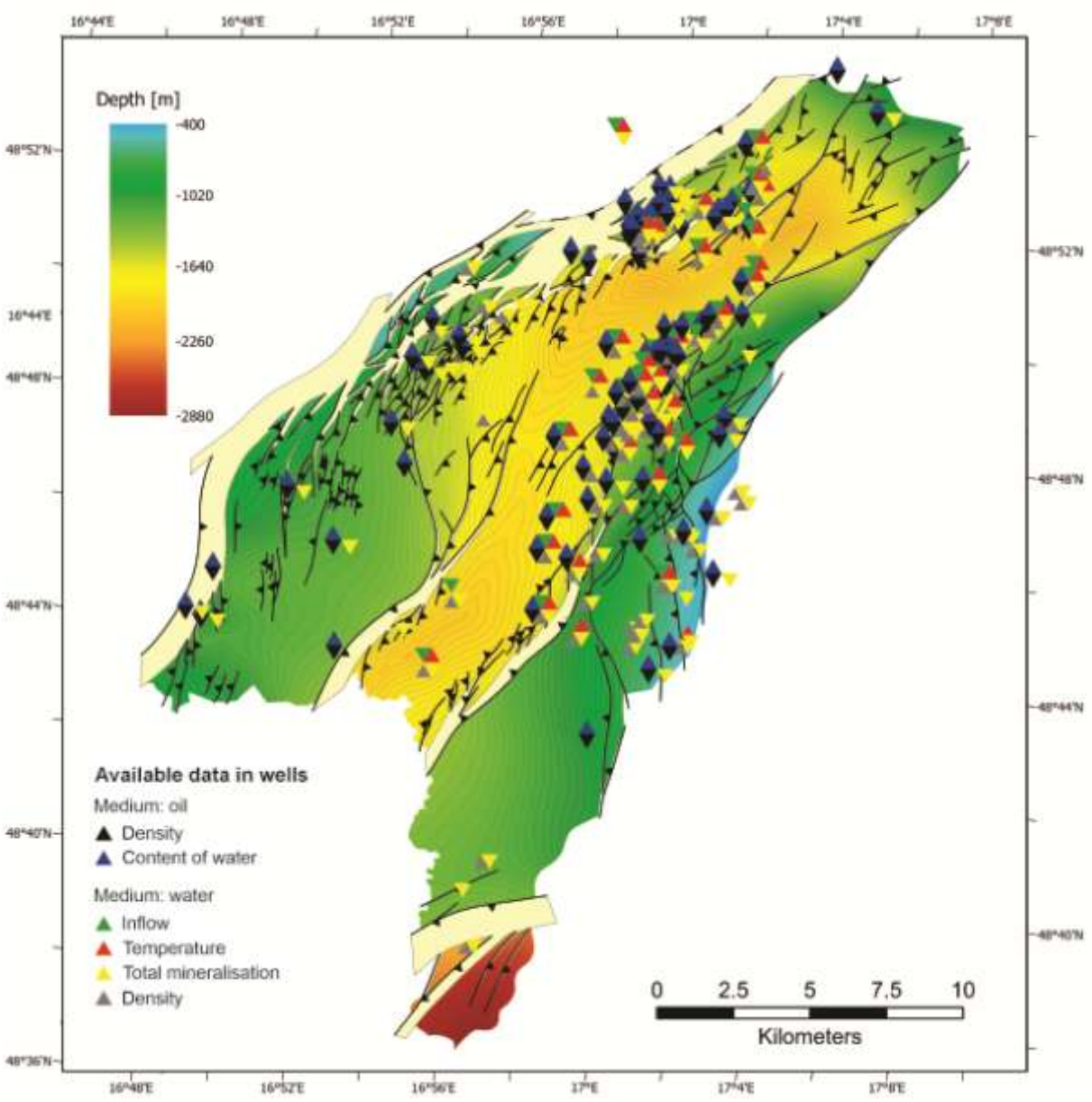


Fig. 7. Depth contour map of the top surface of Upper Badenian strata with location of wells that provided structural geology, lithological, thermal and geochemical data for the Arc GIS database. Data contain the information on the oil density and water content. They also contain information on the water inflow rate, mineralization, density and temperature.

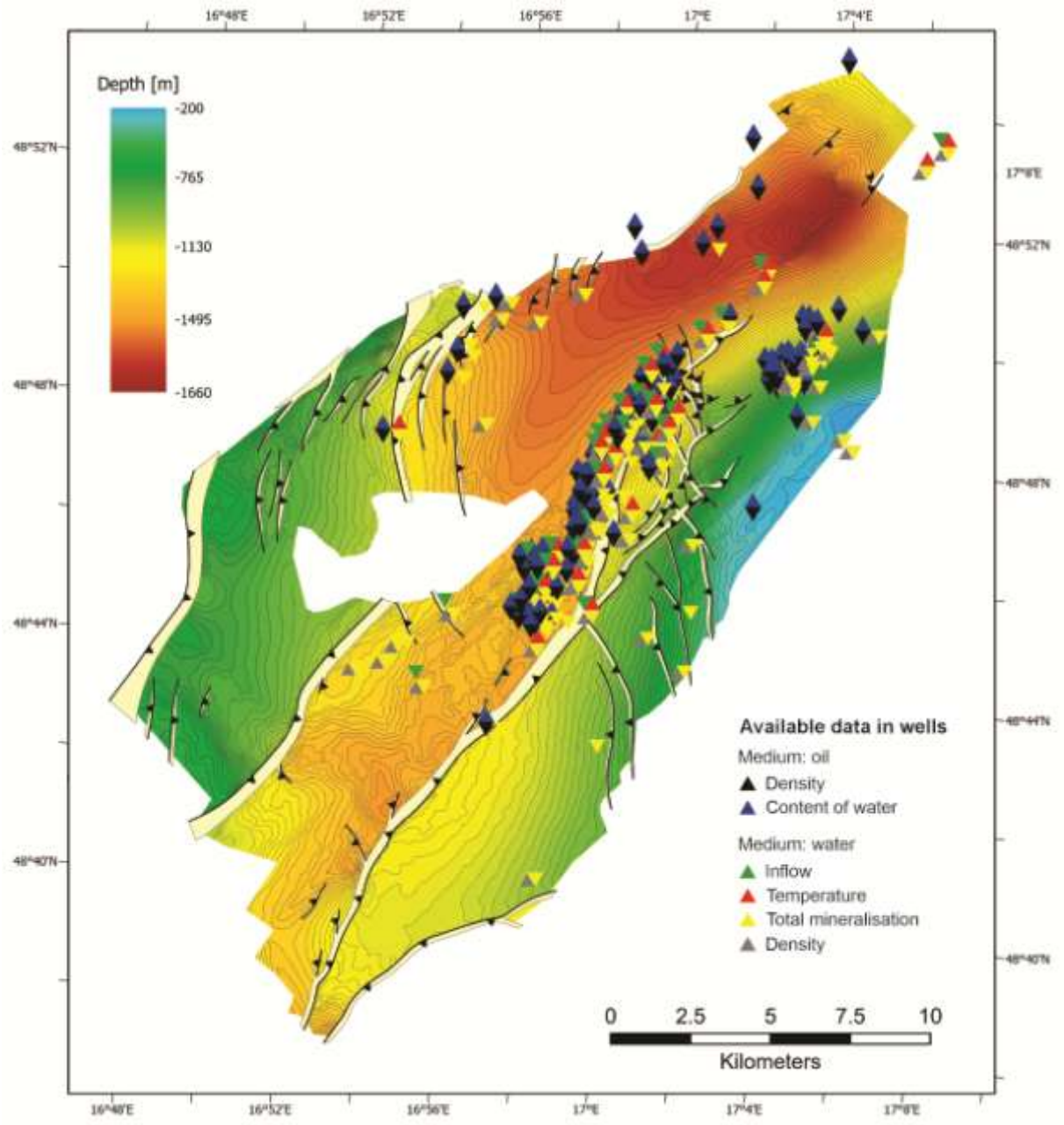


Fig. 8. Depth contour map of the top surface of Sarmatian strata with location of wells that provided structural geology, lithological, thermal and geochemical data for the Arc GIS database. Data contain the information on the oil density and water content. They also contain information on the water inflow rate, mineralization, density and temperature.

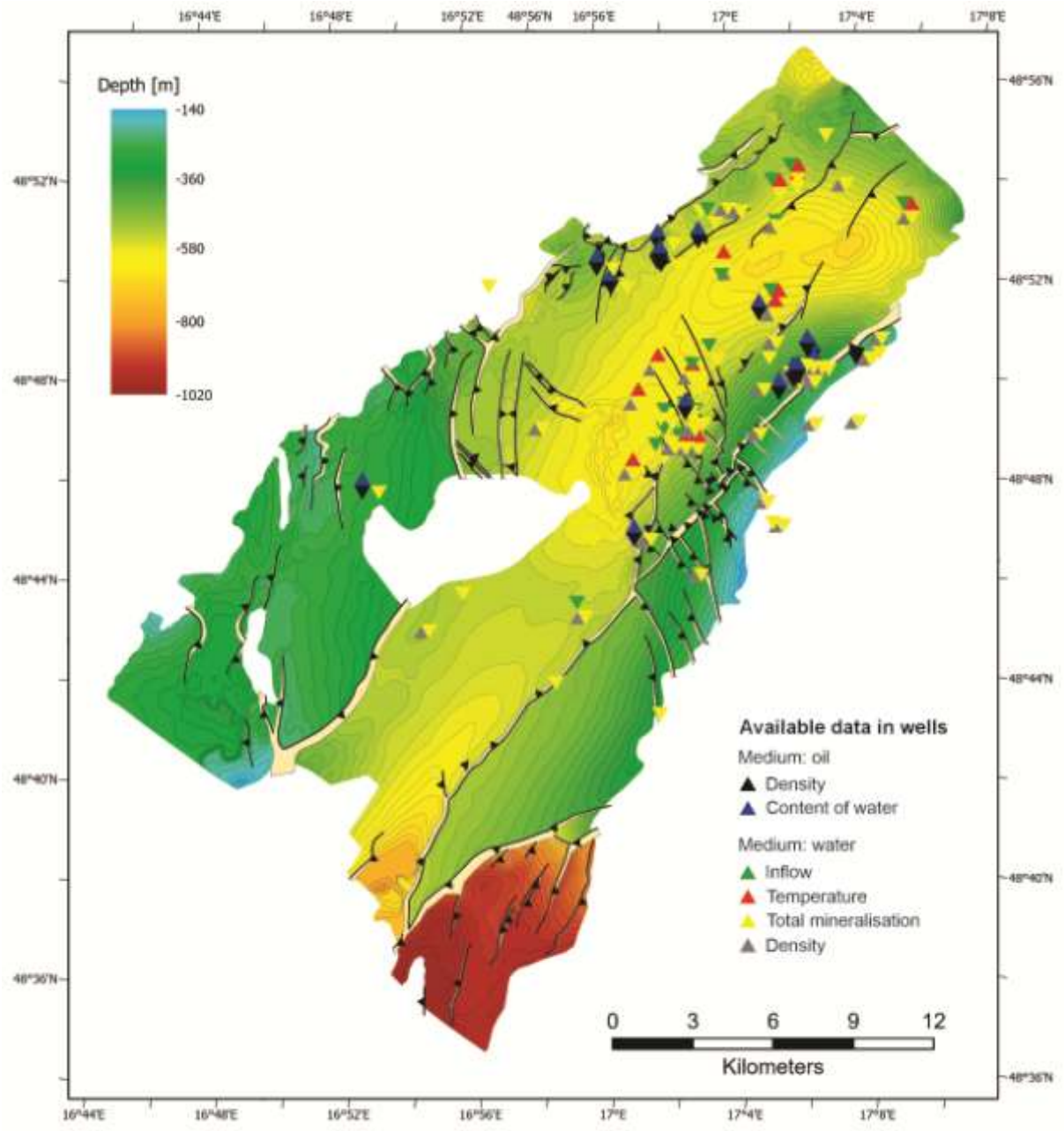


Fig. 9. Temperature distribution at a depth of 500 m in the study area. Points with values represent the data grid used for contouring.

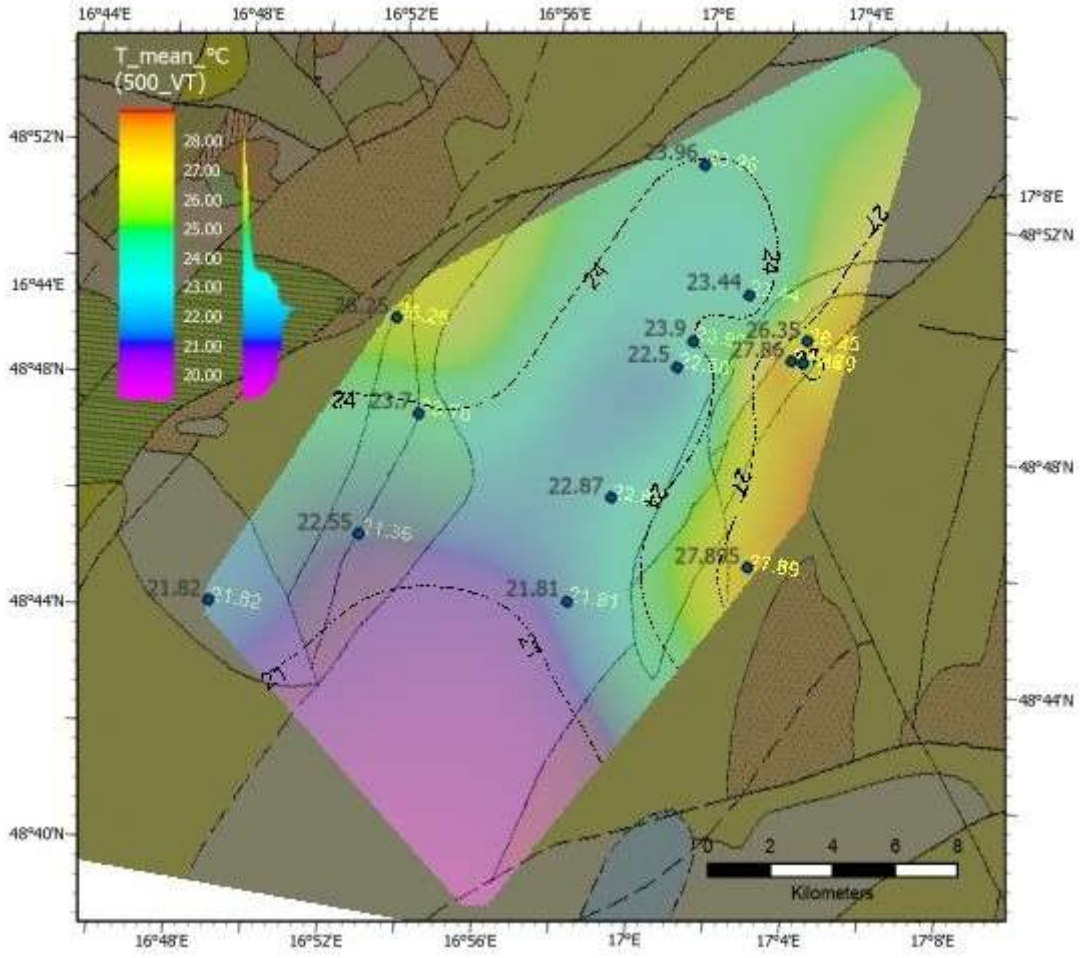


Fig. 10. Temperature distribution at a depth of 1, 000 m in the study area. Points with values represent the data grid used for contouring.

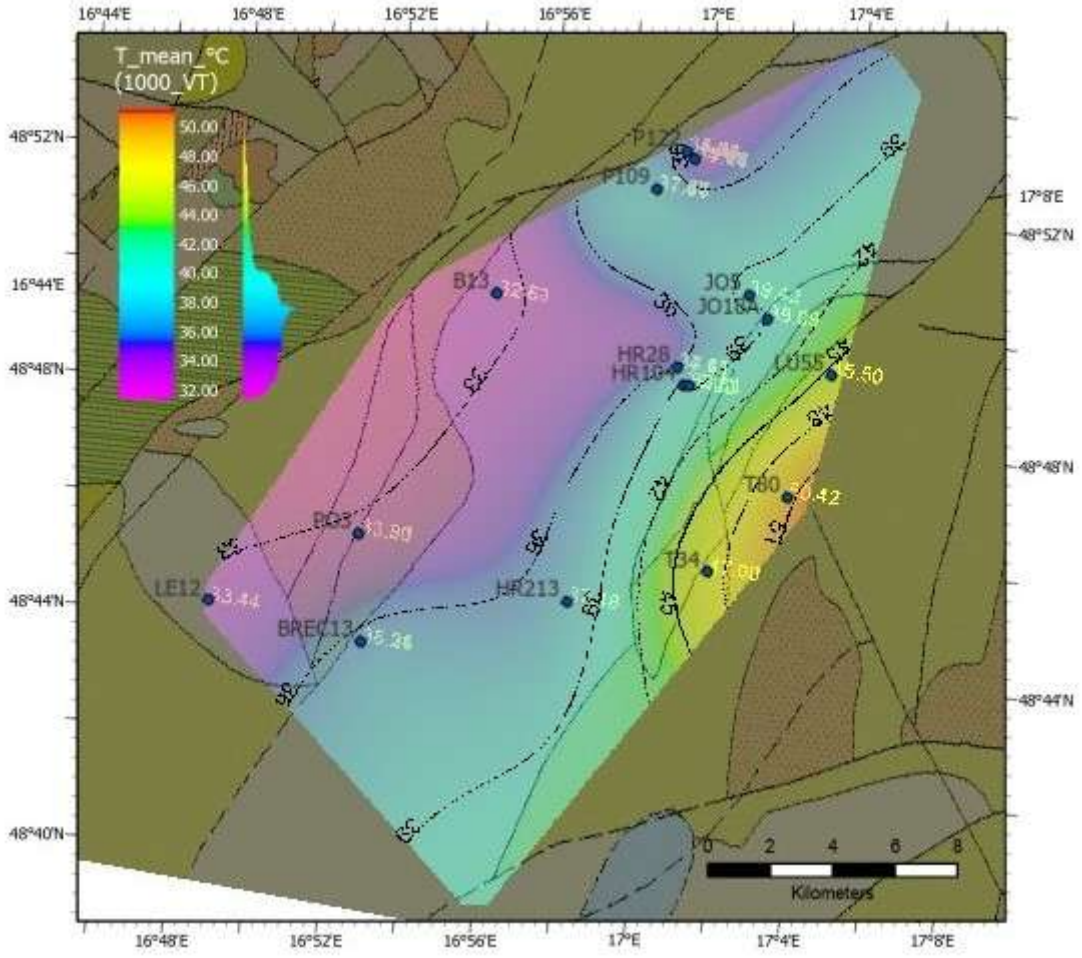


Fig. 11. Temperature distribution at a depth of 1, 500 m in the study area. Points with values represent the data grid used for contouring.