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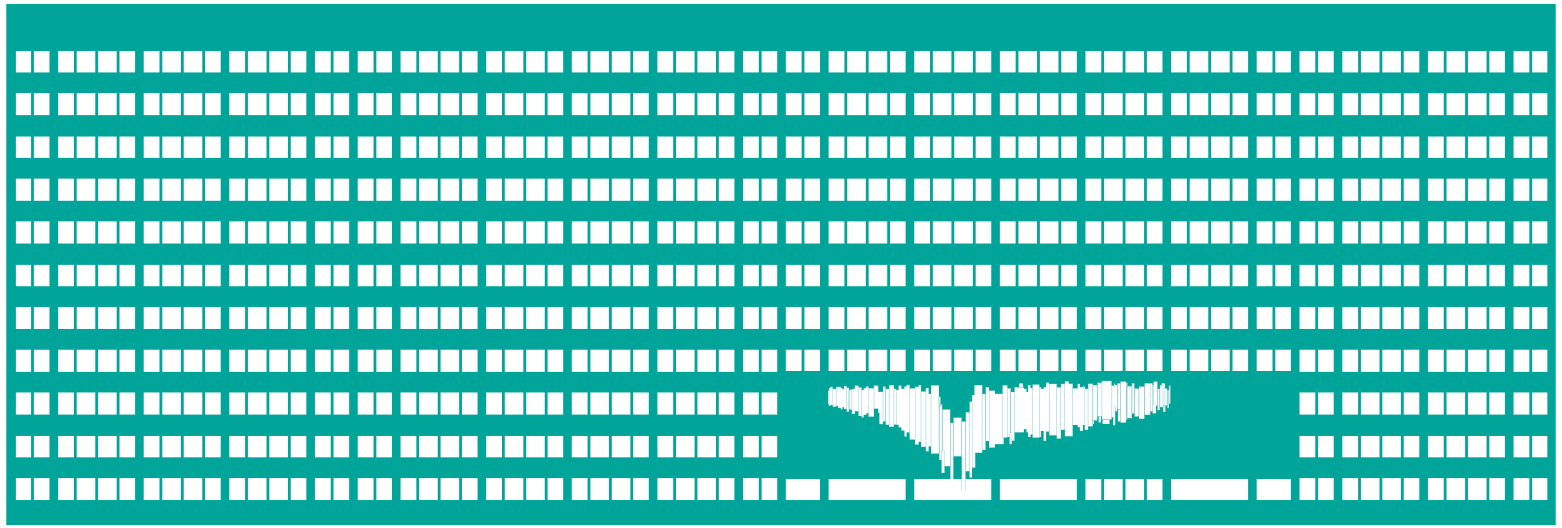

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Energy utilization of the rock massive - university research

Martin Klempa

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Introduction

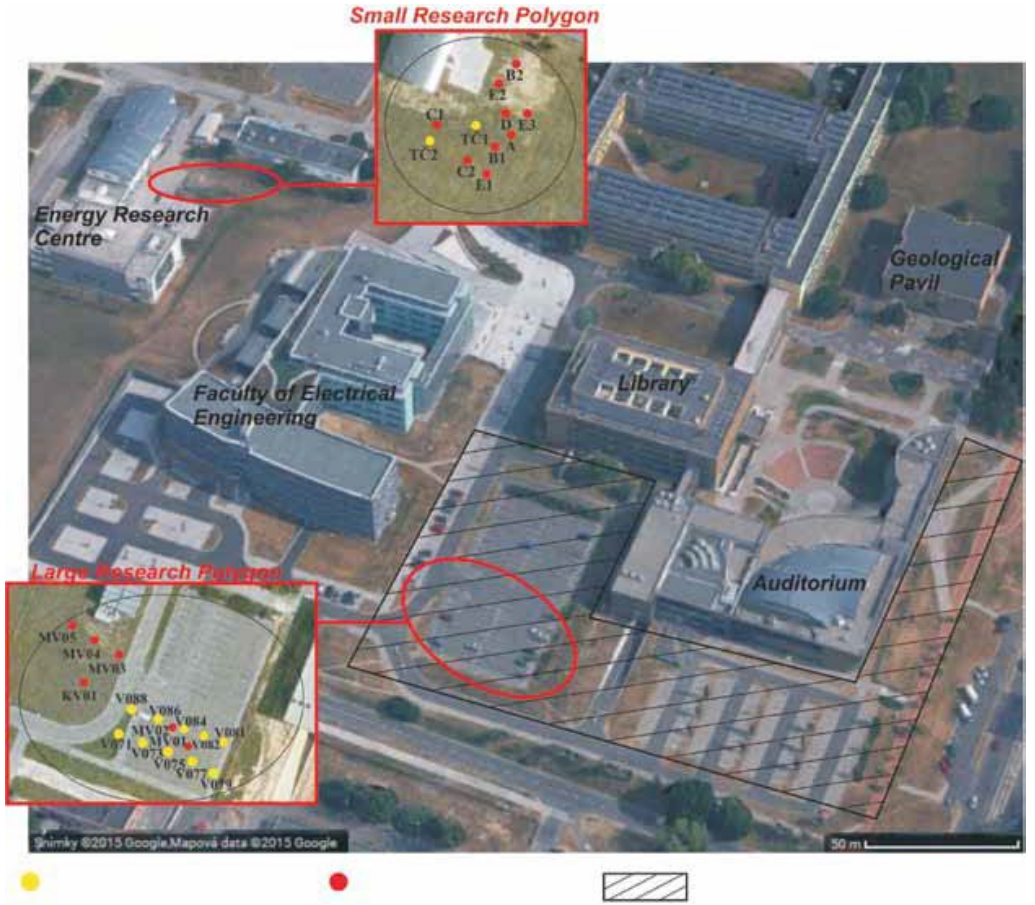
VŠB – Technical University of Ostrava has unique conditions for analysing temperature changes in the rock mass while borehole heat exchangers have been operational for a long time. The Auditory building is heated with a system of heat pumps (borehole heat exchangers). It is one of the largest such objects in the Czech Republic. The heat of the rock mass is provided by a system of technological boreholes. The research boreholes are used for monitoring temperature changes in the rock mass while using the Auditory's heating system. The system for monitoring boreholes within the area of technological borehole activity is called Large Research Polygon (LRP). Apart from LRP, the university also possesses another research polygon – Small Research Polygon (SRP) located at a distance from the LRP near the Energy Research Centre (ERC). All boreholes performed within both research fields are equipped with sensors monitoring the temperature changes while the Auditory building is being heated (thermal energy is recovered from the rock mass in winter) or cooled (thermal energy is transmitted to the rock mass in summer). The main objective of the research carried out in both research fields is checking the functionality and efficiency of the entire system. Certain aspects of thermal energy recuperation from the rock mass are described.

Evaluation of climate conditions on rock mass energy balance in the VŠB-TU Ostrava Research Polygons

Large Research Polygon

The system consists of 10 Swedish heat pumps IVT Greenline D70. The installed power was 700 kW. The entire system required 110 boreholes to be drilled to a depth of ca. 140 m each, giving the total of 15,400 m. The boreholes were performed under the parking lots near the Auditorium and close to the Library of the university campus

Interval [m]	Rock type	Stratigraphy
0.00–14.00	yellow clay	Quaternary
14.00–16.00	sand	Quaternary
16.00–25.00	grey clay	Quaternary
25.00–28.00	gravel with sand	Quaternary
28.00–105.00	green clay	Miocene
105.00–106.00	grey siltstone	Carboniferous
106.00–140.00	sage-green siltstone	Carboniferous



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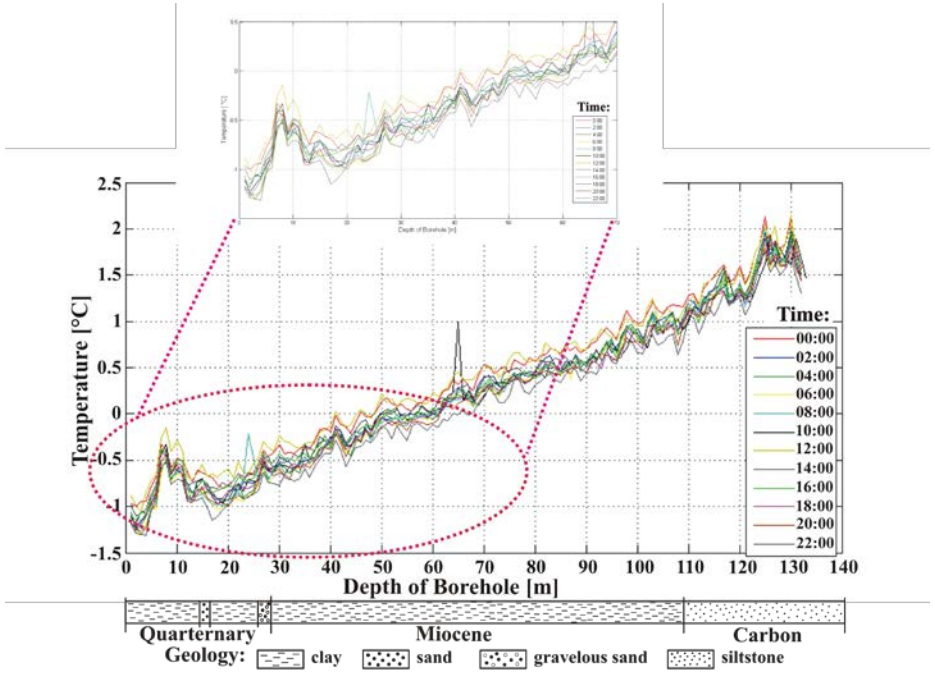
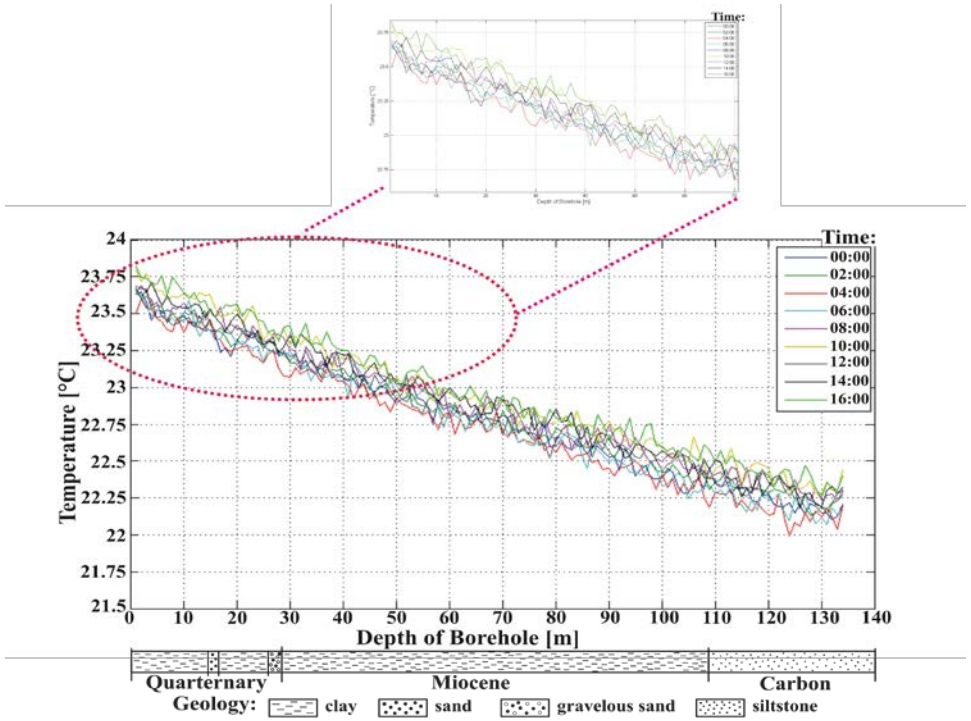
Evaluation of climate conditions on rock mass energy balance in the VŠB-TU Ostrava Research Polygons



Data record of the temperature changes after the optical cable installation for measurement of the temperature changes in the rock massif with respect to the depth and phase (during heat offtake).



Data record of temperature changes fifth day after start of rock massif charging.

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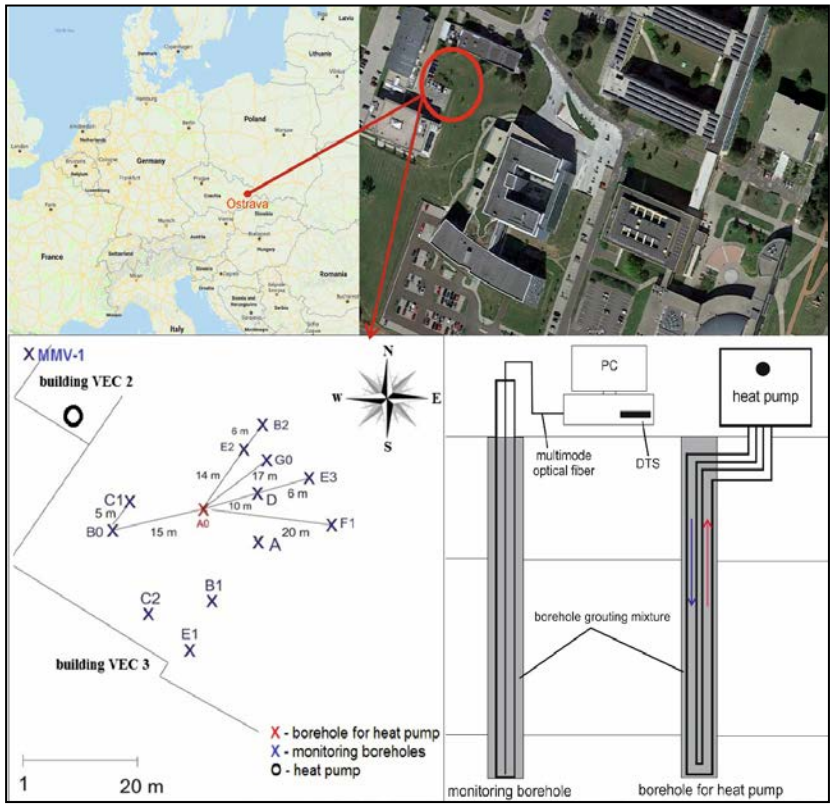
Characteristic of research infrastructure - The Small Research Polygon



	Depth [m]	Type of Rock	λ_{LAB} (W.m^{-1}.K^{-1})	C_V (kJ.m^{-3}.K^{-1})	α (m^2.s^{-1})	λ_{TRT} (W.m^{-1}.K^{-1})
Quarternary	0 – 2.5	Anthropogenic backfill	1.31 – 2.43	2.1 – 2.3	7.56.10^{-7}	2.4
	2.5 – 6	Claystone				
	6 – 7	Sandstone				
	7 – 8	Clayey sandstone				
	8 – 16	Claystone				
Miocene.	16 – 22	Sandstone	1.88	-		
	22 – 29	Sandy claystone				
	29 – 113	Claystone				
Carboniferous	113 – 126	Siltstone	Siltstone: 1.85 Sandstone: 2.59	Siltstone: 1.71 Sandstone: 1.91	-	
	126 – 128	Silty sandstone				
	128 – 130	Siltstone				
	130 – 131	Silty sandstone				
	131 – 137	Siltstone				
	137 – 141	Silty sandstone				
	141 – 160	Siltstone				

Month	October	November	December	January	February	March
Temperature	6 °C	2 °C	5 °C	-3,5 °C	1 °C	6 °C

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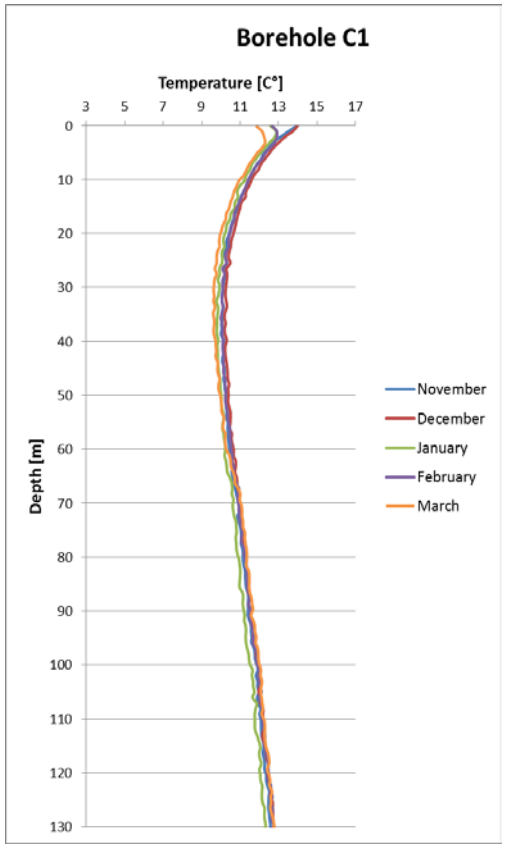
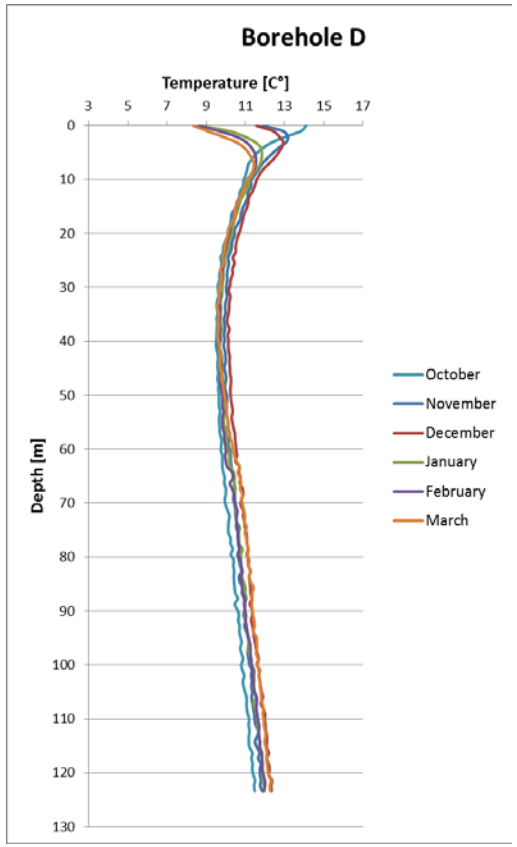
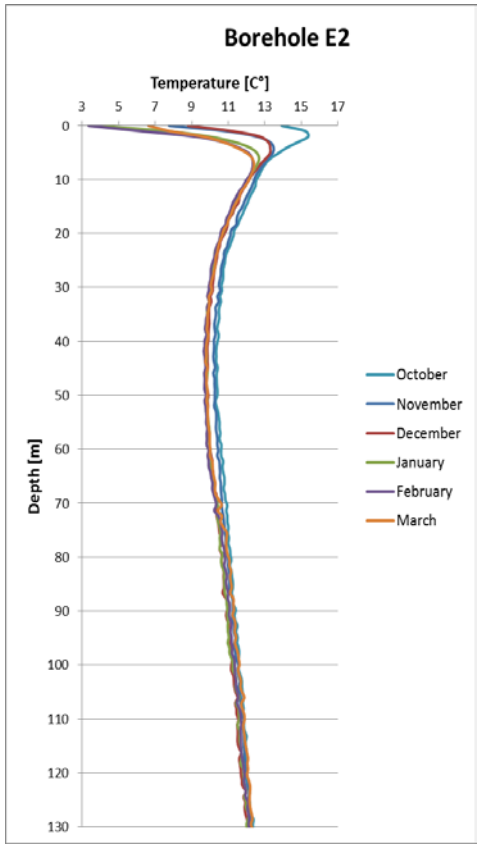
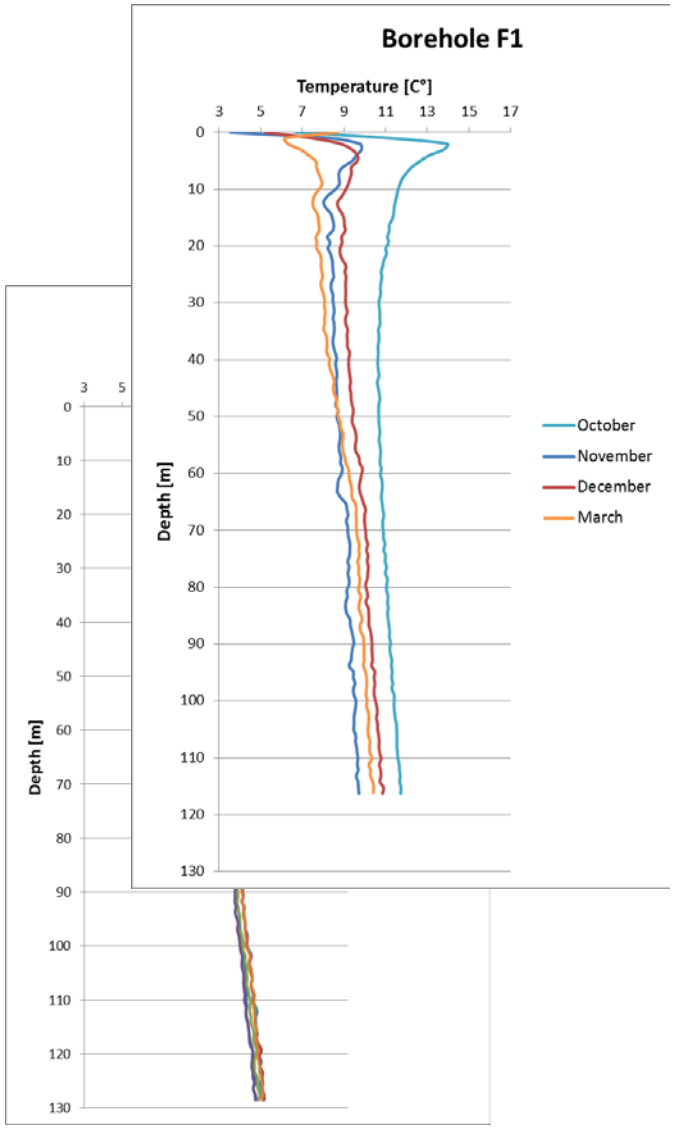
Results- The Small Research Polygon









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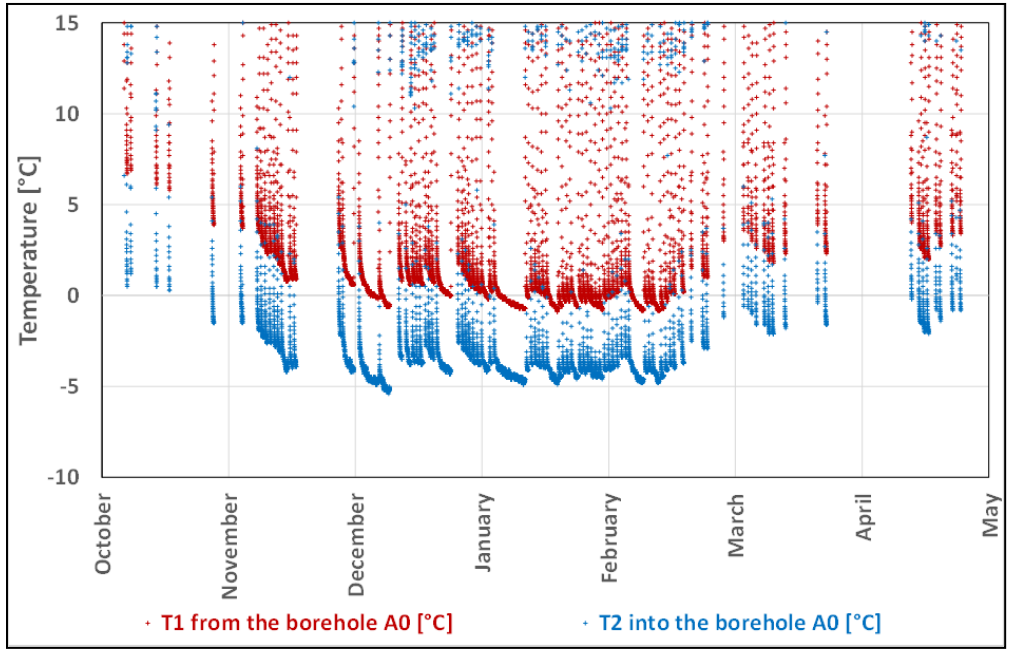
Characteristic of research infrastructure - The Small Research Polygon

During the heating season (September – May), 16499.7 kWh of heat was produced while total energy consumption for heating 6068.6 kWh of which 6006.0 occurred while heat pumps were heating. The difference of these values expresses the consumption of heat pumps at standby mode. Seasonal heating factor related to the total consumption of electricity is 2.72. Total physical withdrawal from the operational borehole A0 was 11096.3 kWh, while effectively used was 10493.7 kWh.



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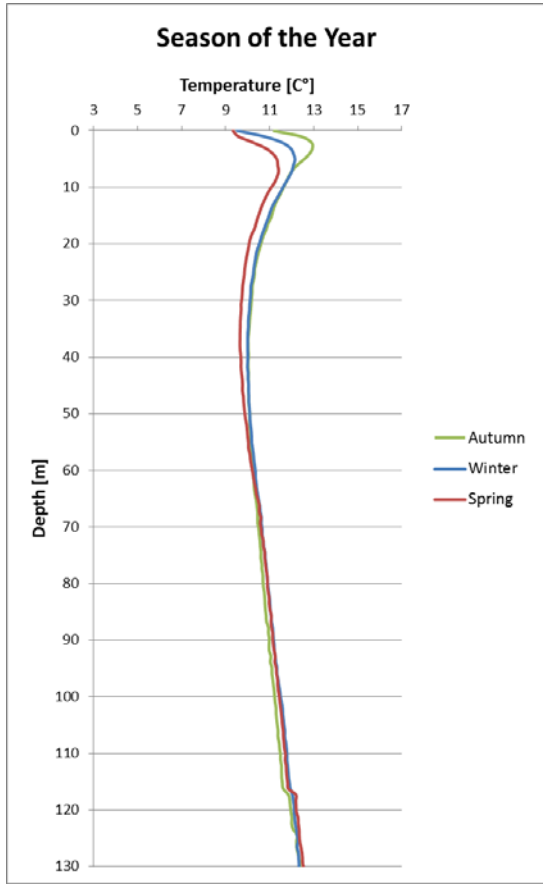
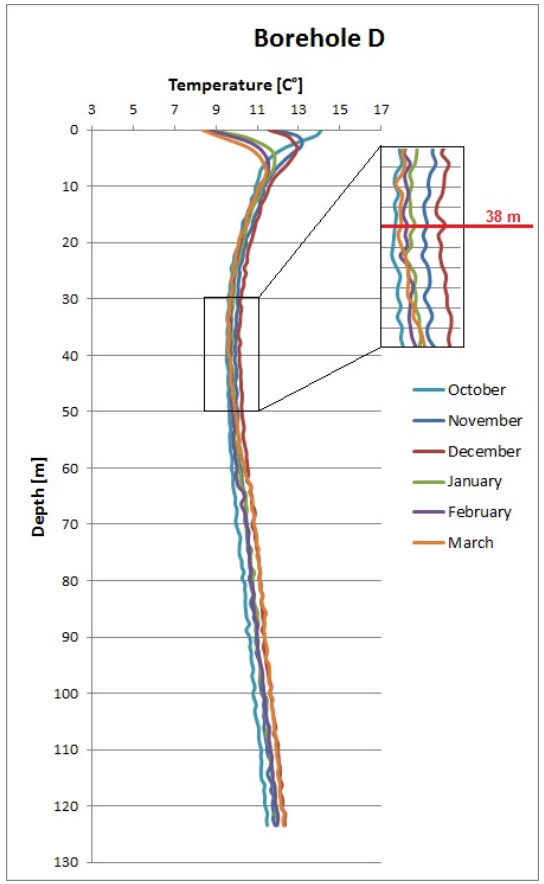
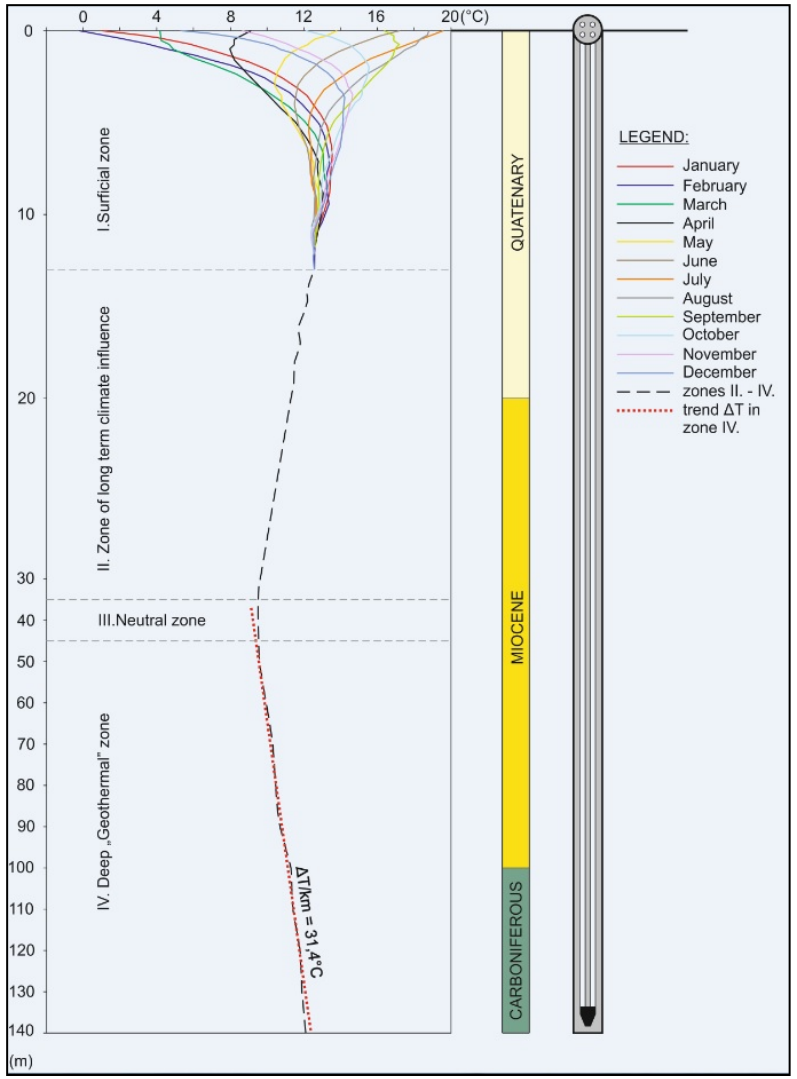
Analysis of the ground temperature field







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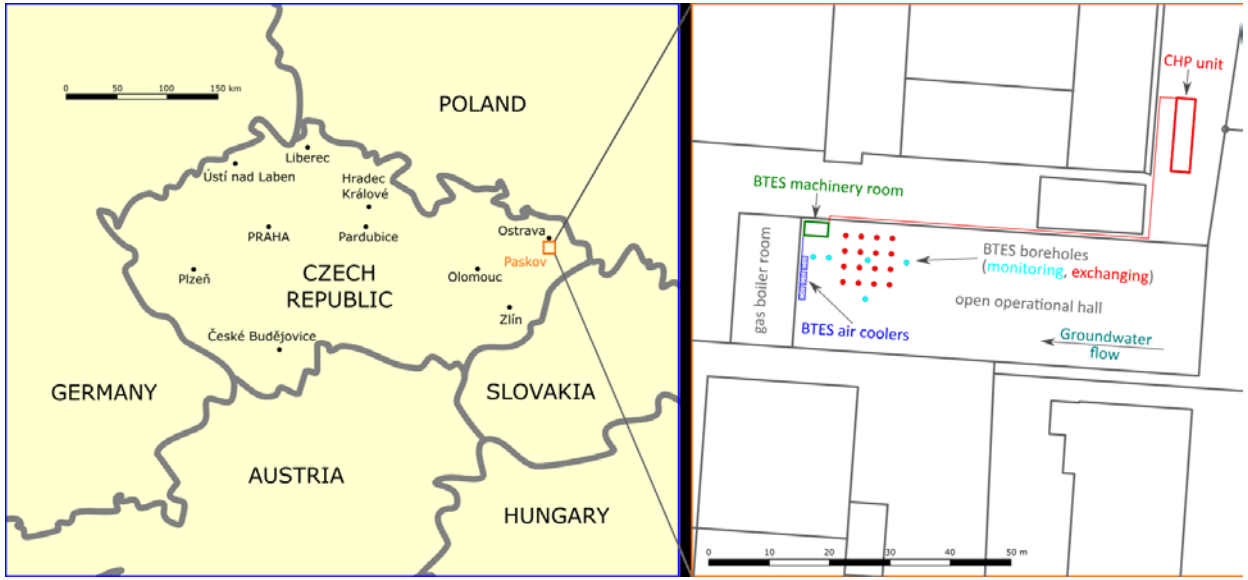
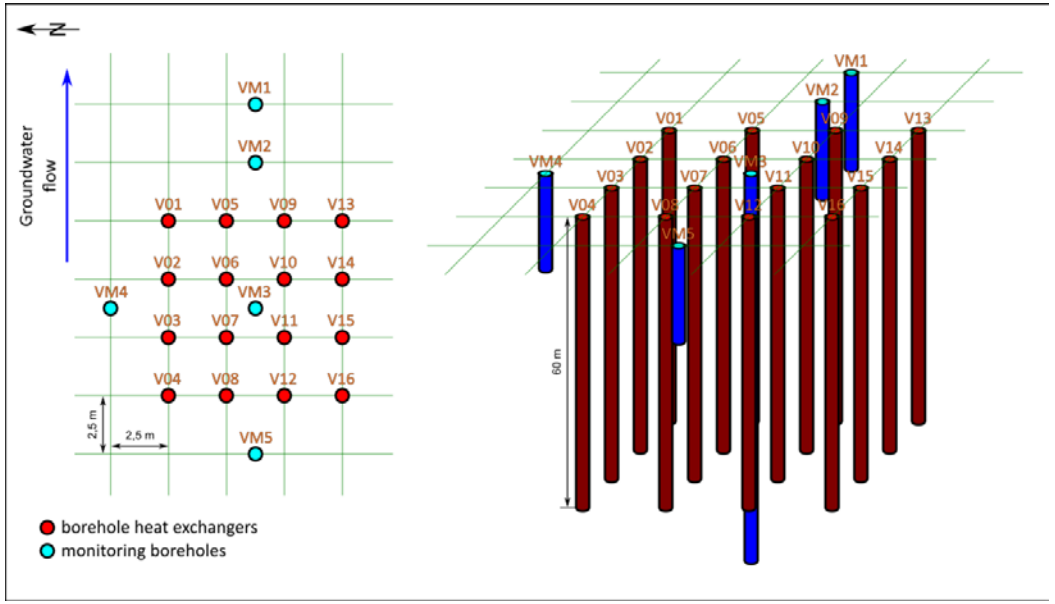
High-temperature BTES Paskov description





The storage is located in the area of an open operational hall next to the previously existing gas boiler room and consists of 21 boreholes, the 16 of which are BHEs (charging/discharging, V01 – V16) and 5 of which are monitoring (VM1 – VM5)

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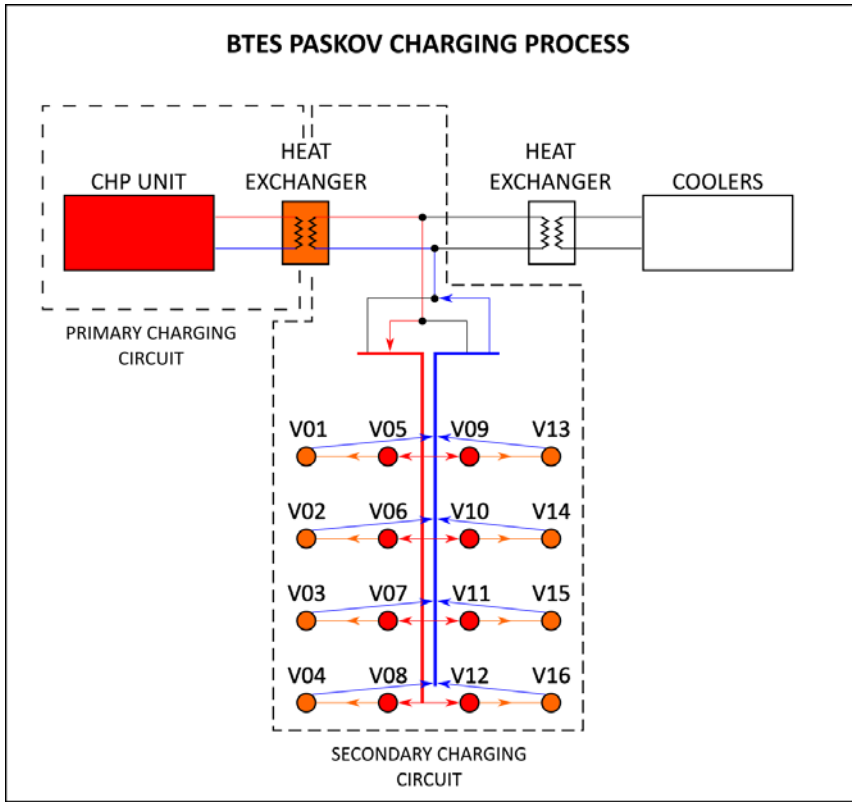
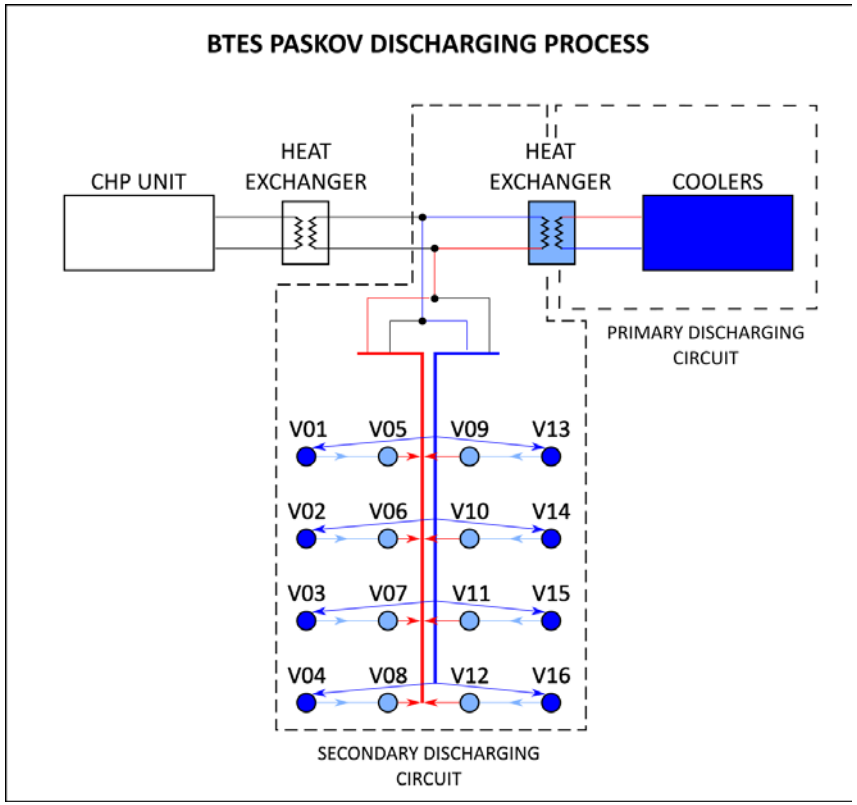
High-temperature BTES Paskov description

no.	stratigraphy	rock	depth range [m]		initial temperature (measured) [°C]
1.	Quaternary	made-ground	0.00	4.00	10.50
2.		water-bearing gravel	4.00	9.00	12.50
3.	Carpathian nappes	claystone	9.00	57.00	12.50
4.		sandy claystone	57.00	64.00	21.50
5.		claystone	64.00	80.00	12.50





The BHEs with 60 m of depth each are organized into a square (4 x 4) with 2.5 m long spacing between them. Every two BHEs are connected creating a loop, so the BTES has 8 loops. The deepest monitoring VM3 borehole, which is 80 m deep, is located in the centre of the storage. Four shallower monitoring boreholes with 15 m of depth each are located as follows: VM5 against the groundwater flow before the BTES, VM1 and VM2 with the groundwater flow behind the BTES, and VM4 is located next to the storage.

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