

8. Databases of Storage Capacities

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In this work we present selected geological structures that might be suitable for CO₂ storage. The geological structures (their boundaries) are available in the georeferenced form are presented in Table 8.1-8.5.

Although we are fully aware that we have not exhausted all the options which varied and complicated geological structure of the Slovak territory provides, we have selected a particular set of objects. In the case that development in the sphere of global warming causes the need to implement concrete actions in this issue, the Slovak Republic has prepared structures that could serve in the initial stage of the pilot project. For comparison, the average price of pilot projects currently being implemented in Europe vary between 80-120 M €. We have to note that these projects deal with the 'impact study' where the storage volume is not significant (<100 kt). Besides the classical "hydrodynamic approach" to CO₂ storage (extracted hydrocarbon deposits and regional aquifers), we developed the technology of mineral carbonatization. Advantage of this approach rests in the fact that some structures have a capacity allowing to

move smoothly from the pilot (scale-up) stage to the industrial stage. Exceptions are objects of mineral carbonatization, which in terms of practical use "lag" behind depleted hydrocarbon deposits and regional aquifers in terms of their lesser scientific elaboration.

Within the database the objects were placed where it would be potentially possible (from the current point of view) to store carbon dioxide. The database is provided in the table form, where primary division refers to extracted hydrocarbon deposits and regional aquifers. Similarly, we lined up ultramafic rocks, with relevant properties. For the last group it should be noted that although our aim was to test all the essential bodies, in most cases only one technological sample represents one site. It is obvious that our assessment will certainly be vitiated due to the "random error", an unavoidable issue at this stage of research. Some sites with several samplings suggest that this factor has to be accounted for. The mineral sequestration is still only at the stage of laboratory research and thus we expect that in the near term, this gap will gradually fill up.

Tab. 8.1 Depleted hydrocarbon deposits

Num.	Name of storage site	Lithological - tectonic characteristic	Horizon	Depth of cap (m)	Collector thickness (m)	Number of boreholes
1.	Ptrukša (Ptr)					
		East Slovakian Basin, Lower Sarmatian, strongly faulted brachysyncline	3. Lower Sarmatian, fault block IX b. , Ptr. 21, 28, 29, 34	Ptr. 28-1,451, 29-1,503, 34-1,456.5	Ptr. 28-16.5, 29-5, 34-4	4
			4. Lower Sarmatian, fault block V.a. , Ptr. 2, 5, 16, 22, 58	Ptr. 2-1,800, 16-1,794, 58-1,815	Ptr. 2-13, 16-17, 58-4	5
			4. Lower Sarmatian, fault block IXb. , Ptr. 18, 21, 24, 28, 33, 34, 35, 36, 37, 43	Ptr. 21-1,476, 28-1,483, 33-1,499.5, 37-1,463	Ptr.21 - 5.5, 28 - 16, 33 - 8.5, 37 - 11	10
			4 a. Lower Sarmatian, fault block IX b. , Ptr. 24, 35, 37	Ptr. 24-1,521, 35-1,514, 37-1,508	Ptr. 24-24, 35-17, 37-28	3
			5. Lower Sarmatian, fault block VII b. , Ptr. 7, 26, 55	Ptr. 7-1,784, 26-1,771, 55-1,771	Ptr. 7-18, 26-70, 55-4	3
			6. Lower Sarmatian, fault block IX b. , Ptr. 4, 18, 21, 24, 28, 35, 36, 37, 43	Ptr. 18-1,730, 24-1,734, 35-1,737, 36-1,722, 37-1 733, 43-1,758	Ptr. 18-12, 24-11, 35-5, 36-5, 37-18, 43-4	9
2.	Stretava (Str)	East Slovakian Basin, Lower Sarmatian, brachyanticline, direction NNW/SSE, faulted by Močarany Topľa system faults	1. Lower Sarmatian, fault block VII. , Str. 1, 3, 10, 11	Str. 1-1,146, 3-1,145	Str. 1-13, 3-9	4
			2. Lower Sarmatian, fault block VII. , Str. 1, 3, 11	Str. 1-1,170, 3-1,169, 11-1,194	Str. 1-8, 3-6, 11-2	3
			3. Lower Sarmatian, fault block VII. , Str. 1, 3, 11	Str. 1-1,210, 3-1,206,	Str. 1-4, 3-5	3
			3 b Lower Sarmatian, fault block VI-VII. , Str. 1, 3, 11, 18, 48, 51	Str. 3-1302.5, 18-1,263, 48-1,246	Str. 3-10.5, 18-8.5, 48-6	6
			4. Lower Sarmatian, fault block IV. , Str. 4, 13	Str. 4-1,282, 13-1,297	Str. 4-5.5, 13-5	2
			8. Lower Sarmatian, fault block II a. , Str. 4, 12, 14, 15, 17, 35, 36, 38, 48	Str. 38-1,784.5, 48-1,850, 48-1,884	Str. 38-8.5, 48-22.5, 48-11	9

Num.	Name of storage site	Lithological - tectonic characteristic	Horizon	Depth of cap (m)	Collector thickness (m)	Number of boreholes
			8. Lower Sarmatian, Block III b, Str. 40, 46	Str. 40-1,885, 46-1,935	Str. 40-10, 46-82	2
			5. Lower Sarmatian, VI, Str. 27, 29	Str. 27-1,589, 29-1,657	Str. 27-29, 29-6	2
3.	Bánovce nad Ondavou	East Slovakian Basin Badenian, Bánovce structure, faulted	9. Badenian, fault block XV, Bánovce 35	1,837	9	1
4.	Trhovište - Pozdišovce (Trh)	East Slovakian Basin, Badenian, brachyanticline structure, strongly faulted	16.Badenian, fault block VII, Trh 12, 16, 19, 32, 33, 41, Po-2, 10	Trh 12-1,214, 16-1,233	Trh 12-63.5, 16-21	8
			18. Badenian, block VII, Trh 12, 16, 21, 32, 33, 41, Po 2, 10	Trh 12-353, 16-1295, 41-1,332.5	Trh 12-2, 16-43, 41-8.5	8
			20. Badenian, fault block VII, Trh 12, 16, 21, 29, 32, 33, 41, Po 2, 10	Trh 12-1,411, 12-1,397.5, 41-1,419	Trh 12-33.5, 12-7, 41-29	9
			20.Badenian, fault block XI, Trh 31, 44, 46, 48	Trh 31-1,409, 31-1,388, 44-1,395, 46-1,402	Trh 31-89, 31-5, 44-7, 46-22	4
			22. Badenian, fault block VI.b, Trh 26	Trh 26-1,512.5	Trh 26-45	1
5.	Senné (Sen)	East Slovakian Basin, Sarmatian, elevation situated on the high fault zones of Močarany-Topľa fault belt	5.a Sarmatian, fault block I., Sen 18	Sen 18-1,594	Sen 18-6	1
			5.a Sarmatian, fault block II., Sen 3, 10	Sen 3-1,670, Sen 10-1,634	Sen 3-2, Sen 10-18	2
			6.Sarmatian, fault block III.a, Sen 4, 8, 21	Sen 4-1,769, Sen 8-1,775.5, Sen 21-1,725.5	Sen 4-6, Sen 8-18.5, Sen 21-3	3
			7. Sarmatian, fault block II.a, Sen 1, 5, 27, 36	Sen 1-1,739, Sen 5-1,759.5	Sen 1- 26, Sen 5-22.5	4
			7. Sarmatian, block IV, Sen 7, 31, 35	Sen 35-1,854	Sen 35-6	3
			7. a Sarmatian, block IV, Sen 7, 31, 35	Sen 7-1,905, Sen 35-1,795	Sen 7-30, Sen 35-11	3
			8. Sarmatian block I.b., Sen 13, 25, 34	Sen 13-1,916, Sen 25-1,871	Sen 13-5.5, Sen 25-31	3

Num.	Name of storage site	Porosity (%)	Permeability (mD)	Temperature (°C)	Pressure (MPa)	Total dissolved solids	Overburden (type, thickness, deformation)	Capacity (kt)	Capacity type	Trap type
		18.4	n/a	110	29.5	very high	clay, tuffite	361	effective	structural - stratigraphic
		14	n/a	95	22.5	very high	clay, tuffite	84	effective	structural - stratigraphic
3.	Bánovce nad Ondavou	22	n/a	94.8	19.5	high	clay, tuffite	62	effective	structural
4.	Trhovište - Pozdišovce (Trh)	23	n/a	76.5	12.1	high	clayey deposit	474	effective	structural - stratigraphic
		19	n/a	80	13	high	clayey deposit	357	effective	structural - stratigraphic
		20	n/a	84	13.7	high	clayey deposit	142	effective	structural - stratigraphic
		18	n/a	83	13.9	high	clayey deposit	178	effective	structural - stratigraphic
		21.3	n/a	89	18.8	high	clayey deposit	296	effective	structural - stratigraphic
5.	Senné (Sen)	15.9	n/a	90	19.2	very high	clayey deposit	186	effective	structural - stratigraphic
		15.4	n/a	93.5	20	very high	intact, sandy micaceous stratified clay	185	effective	structural - stratigraphic
		14.81	n/a	100	21.6	very high	clay, claystone	135	effective	structural - stratigraphic
		13.8	n/a	99	23.8	very high	clay, claystone	354	effective	structural - stratigraphic
		22.3	n/a	103	24.9	very high	clay, claystone	4,982	effective	structural - stratigraphic
		17.3	n/a	103	23.7	very high	clay, claystone	391	effective	structural - stratigraphic
		26	n/a	102	27.8	very high	clay, claystone	143	effective	structural - stratigraphic

Num.	Name of storage site	Lithological - tectonic characteristic	Horizon	Depth of cap (m)	Collector thickness (m)	Number of boreholes
			8. Sarmatian, fault block II.b., Sen 6, 12, 16	Sen 6-1,990, Sen 12-1,986, Sen 16-1,959	Sen 6-8.5, Sen 12-9, Sen 16-5	3
			8. Sarmatian, fault block III.a, Sen 4, 8, 21, 38	Sen 8 – 1,986,5, Sen 21-1,976, Sen 38-1,916	Sen 8-41.5, Sen 21-3.5, Sen 38-135	4
			Badenian fault block I b, Sen 5, 12, 16	Sen 5-2,000, Sen 16-2,056	Sen 5-34, Sen 16-2	3
6.	Studienka (Stu)	Vienna Basin, Studienka elevation - a part of Láb-Lakšár. Nová Ves elevation belt	1. Sarmatian, Stu 83, 84, 88, 98	Stu 83-531, 84-536,5	Stu 83-6, 84-3,5	4
			Higher Bolivino - Bulimina horizon Late Badenian Stu 1, 6, 36, 39	965	157.5	4
			Bolivino - Bulimina horizon, Late Badenian, Stu 39	1,195	2.5	1
7.	Závod	Vienna Basin, Závod structure; brachyanticline, (Štefanov - Šaštín - Závod elevation belt)	Middle Badenian, 1-6 Láb sand	1,257	95	43
8.	Závod - South (Záv)	Vienna Basin, the north slope of Leváre gash	1. Late Badenian, Záv 80	1,372	4	1
9.	Závod Mesozoicum	Vienna Basin. Lower Golier nappe; brachyanticline	Mesozoic II., central object, Záv. 73, 76, 85, 89, 90	Záv 73-4,123, 76-4,175, 89 – 4,359	Záv 73-109, 76-65, 89-31	5
			Mesozoicum III., Záv 77	4,347	33	1
			Mesozoicum IV., Záv 79	4,365	155	1
			Mesozoicum V., Záv. 74, 78	Záv 74-4,390, 74-4,370, 78-4,053	Záv 73-30, 74-10, 78-19	2
10.	Gbely	Vienna Basin; elevation near Hodonin - Gbely fault	Staré pole	240	50	>100
			Nové pole	150	30	>100
11.	Jakubov (Jak)	Vienna Basin, depression zone	Jakubov-starý, 8.Pannonian, Jak 5, 6, 7	Jak 5-592, 6-605.5, 7-597	Jak 5-10, 6-1.5, 7-5	3
			Jakubov-starý, 2 Sarmatian, upper and lower object B, Jak 14, 39	Jak 14-716, 39-728	Jak 14-5.5, 39-2	2
			Jakubov-starý, Late Badenian, Jak 14	1,064	2	1

Num.	Name of storage site	Lithological - tectonic characteristic	Horizon	Depth of cap (m)	Collector thickness (m)	Number of boreholes
			Jakubov North, Middle Badenian, Jak 41, 43, 45	Jak 41-1,596, 43-1,540.5, 45-1,566	Jak 41-5, 43-6, 45-17.5	3
11.	Jakubov - South	Vienna Basin depression zone, Láb elevation belt, brachyanticline	Late Badenian "b" sand, Jak 20, 21, 23, 27, 28, 30, 31	Jak 20-1,257, Jak 21-1,215.5, Jak 23-1,260, Jak 27-1,243.5, Jak 28-1,267, Jak 31-1,246	Jak 20-5.5, Jak 21-28, Jak 23-6, Jak 27-3.5, Jak 28-1.5, Jak 31-23.5	7
12.	Láb	Vienna Basin, Láb elevation	Láb horizon + Lower Badenian, East; Láb North - East + West	1,383	66	22
13.	Vysoká pri Morave (Vys)	Vienna Basin, brachyanticline elevation	2. Sarmatian, Vys 9, 21, 23, 24, 30, 31	680	20	6
			Late Badenian E, Vys 1, 2, 5, 8, 10, 14, 15, 18, 21, 22, 23, 25, 26, 27	1,300	80	14
14.	Jakubov - Dúbrava (Dub)	Vienna Basin, Láb elevation	2. Middle Badenian, Dub 6, 8, 10, 11, 13, 14, 15, 19, 23, 24, 25, 26, 27, 28, 29, 30, 45, 46	1,538	113	18
15.	Ivanka - Golianovo	Danube Basin, Komjatice Depression	Sarmatian	1,750	60	10
16.	Križovany nad Dudváhom - natural CO₂ deposit, planned underground gas storage site	Danube Basin, Blatné Depression, brachyanticline	Middle Badenian	960-1,060	45	?
17.	Horná Krupá	Danube Basin, Blatné Depression, brachyanticline, conglomerate	Eggenburgian	800	60	?
			Karpatian	600	110	?
18.	Trakovice	Danube Basin, Blatné Depression, brachyanticline, conglomerate, sandstone	Early Badenian, Middle Badenian	810	260	?
19.	Cífer	Danube Basin, Blatné Depression, brachyanticline, sandy conglomerate	Palaeogene, Karpatian, Middle Badenian,	1,500	200	?
20.	Báhoň	Danube Basin, Blatné Depression, brachyanticline, conglomerate	Middle Badenian	1,100	250	?
22.	Lipany	Inner Carpathian Palaeogene, intraformation breccia	Late Cretaceous, Jurassic	2,000	300	6

Tab. 8.2 Local and regional aquifers

No.	Name of the locality	Polygon defining a cap of storage site (JTSK)		Lithological-tectonic characteristic	Horizon	Depth of cap (m)	Collector thickness (m)	Number of boreholes	Porosity (%)	Permeability (mD)	Temperature (°C)
		X	Y								
1	Zlatá Baňa	-249 245	-1 221 700	Slanské vrchy Mts.							
		-257 294	-1 221 201	Rhyolite and its pyroclastics in the Teriakovce Fm.	Early Karpatian	1,000-2,000	10-500	20	5		
		-256 006	-1 211 715								
		-245 522	-1 210 078	Rhyolite and its pyroclastics in the Teriakovce Fm.	Late Karpatian	700-1,200	10-300	20	5		
		-243 741	-1 216 579								
2	Zboj	-170 960	-1 209 263	Dukla Flysch		1,000 (?)	10-200	0	6		50
		-175 267	-1 206 583	Exo- and endocontact of interpreted andesite intrusion	Zboj Fm., Ľupkov Fm., clay, sandstone						
		-170 549	-1 202 917	Volcanic gas saturating upper part of the intrusive body							
		-166 994	-1 204 648	Contact between Ľupkov and Zboj Fms.							
3	Lipany	-282 642	-1 188 215	Šarišská vrchovina Highlands	Intraformational breccia	1,700-2,200	150-750	6	5		
		-281 246	-1 188 467	Base of Subtatric Group							
		-278 680	-1 189 313	Inner Carpathians Palaeogene							
		-277 436	-1 189 578								
		-274 764	-1 190 689								
		-275 214	-1 194 473								
		-277 119	-1 193 706								
		-277 727	-1 192 647								
4	Plavnica	-283 813	-1 189 393								
		-293 755	-1 179 802	Šarišská vrchovina Highlands	Intraformational breccia lower	1,700		2	5		
		-292 716	-1 179 011	Base of Subtatric Group	Intraformational breccia upper	2,306			5		
		-295 454	-1 177 994	Inner Carpathians Palaeogene							
5	Marcelová	-297 771	-1 177 992								
		-488 773	-1 330 272	Komárno marginal fault block	clayey limestone, calcareous shale, sandstone	1,035	162	1			50
		-483 459	-1 325 457	Carbonate - Early Triassic		1,405	354				
		-484 959	-1 324 179	Pelső Unit							
		-490 160	-1 327 293								

Tab. 8.3 Mineral carbonatization A

Locality	Type of rock	Sample labelling	Content of mineral components in weight % containing appropriate chemical components for CO ₂ sequestration	Potential for CO ₂ reaction expressed by content of Mg and Ca oxides in weight %	Quantity of rock with entirely amorphoused minerals per tonne for its fixation to the:	
					magnesite	hydromagnesite
Hodkovce	serpentine	HO-1	serpentine mineral 77.8 olivine + pyroxene 12.6	MgO = 36.06	2.54	3.174
				CaO = 0		
	serpentine	HO-2	serpentine mineral 80.3 olivine + pyroxene 9.9	MgO = 36.73	2.493	3.116
				CaO = 0		
Rudník	serpentine	RU-1	serpentine mineral 67.6 olivine + pyroxene 19.0	MgO = 34.75	2.635	3.294
				CaO = 0		
	serpentine	RU- 2	serpentine mineral 76.6 olivine + pyroxene 12.5	MgO = 36.47	2.511	3.138
				CaO = 0		
Jasov	serpentine	JA-1	serpentine mineral 78.5 olivine + pyroxene 9.7	MgO = 36.23	2.527	3.159
				CaO = 0		
Dobšiná	serpentine	S-1	serpentine mineral 88.7 olivine + pyroxene 0	MgO = 36.09	2.538	3.171
				CaO = 0		
Komárovce	serpentine	KO-1/2	serpentine mineral 65.7 olivine + pyroxene 25.2	MgO = 39.72	2.305	2.881
				CaO = 0		
	serpentine	KO-1/11	serpentine mineral 87.0 olivine + pyroxene 3.6	MgO = 38.64	2.37	2.962
				CaO = 0		
	serpentine	KO-1/16	serpentine mineral 70.4 olivine + pyroxene 19.8	MgO = 39.73	2.305	2.881
				CaO = 0		
Breznička	serpentine	BR-1	serpentine mineral 85.9 olivine + pyroxene 3.5	MgO = 36.90	2.482	3.102
				CaO = 0		
Miglinec	serpentine	MI-1	serpentine mineral 86.6 olivine + pyroxene 3.2	MgO = 35.80	2.558	3.197
				CaO = 0		

Tab. 8.4 Mineral carbonatization B

Locality	Type of rock	Geological material represented by the sample labelled	Equation of reactivity of mechanically and thermally activated rocks with CO ₂ ($y = k \cdot \text{Ln}(x) + q$)	Character of the new carbonate product after 6 hours of carbonation	Mineral composition of the newly created product after 6 hours of carbonation	
					hydromagnesite	amorphous phase
Hodkovce	serpentine	HO-1	$y = 4.0184 \cdot \text{Ln}(x) + 18.4420$	hydromagnesite		7,8
	serpentine	HO-2	$y = 5.8460 \cdot \text{Ln}(x) + 16.8350$	hydromagnesite	90	10
Rudník	serpentine	RU – 1	$y = 5.1263 \cdot \text{Ln}(x) + 21.9540$	hydromagnesite	82	18
	serpentine	RU - 2	$y = 0.5388 \cdot \text{Ln}(x) + 21.4010$	hydromagnesite	91.6	8.4
Jasov	serpentine	JA - 1	$y = 1.9931 \cdot \text{Ln}(x) + 13.2130$	hydromagnesite	66.7	33.3
Dobšiná	serpentine	S - 1	$y = 2.9346 \cdot \text{Ln}(x) + 26.8460$	hydromagnesite	90.3	9.7
Komárovice	serpentine	KO – 1/2	$y = 0.8591 \cdot \text{Ln}(x) + 19.9790$	hydromagnesite	90.3	9.7
	serpentine	KO – 1/11	-	-	-	-
	serpentine	KO – 1/16	$y = 1.9059 \cdot \text{Ln}(x) + 16.1040$	hydromagnesite	78.1	21.9
Breznička	serpentine	BR – 1	$y = 1.8597 \cdot \text{Ln}(x) + 10.2020$	hydromagnesite	72.5	17.5
Miglinc	serpentine	MI – 1	$y = 0.9813 \cdot \text{Ln}(x) + 16.6950$	hydromagnesite	89.2	10.8

Explanation:

CaO - the entire contents of input samples is bound to CaCO₃, it means zero content is "free" for the reaction of CaO with CO₂

y - increment in mass yield of the newly established carbonate product in weight % in relation to the material inlet of the sample;

k - coefficient

x - duration of action of carbon dioxide in hours;

q - increment in mass yield of the newly established carbonate product in weight % After one hour carbonatization;

LN - natural logarithm