



Ahoj sousede. Hallo Nachbar.
Interreg V A / 2014 – 2020



Europäische Union. Europäischer
Fonds für regionale Entwicklung.
Evropská unie. Evropský fond pro
regionální rozvoj.

Mathematical Modelling of the RESIBIL Project

3D geological model – methodology (sources, method, results)

Skácelová Z., Mlčoch B.

Workshop Prague, March 4, 2019



Creating of the 3D geological model:

Depth of surface level of individual geological layers:

- Geology – individual strata (e.g. crystalline basement, Carboniferous, Permian, Cretaceous, volcanic rocks)
- Engineering geology (Cenozoic – Quaternary)
- Hydrogeology – aquifers and aquitards (e.g. Cretaceous: A - Cenomanian, B - Lower Turonian, C - Middle and Upper Turonian),

Source of data:

- Geological maps
- Boreholes database
- Geophysics (electrical and electromagnetic sounding, seismic)

Definition of **faults** (simplified tectonic view)

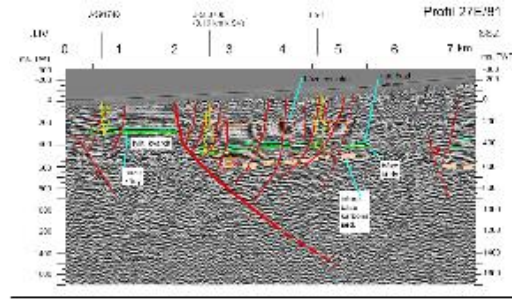
Determining the **range** of layer (strata)

3D modelling in CGS:

Database:

Boreholes

Geophysics



Depth of selected interfaces

Conversion to altitude

+

Outcrops of individual geological units (altitude of relief)

Input file to modelling

3D model of surface of individual geological units – basement, aquifers

Geological maps:

Map of scale 1 : 50 000 or 1 : 25 000



Microsoft Access Application – **input** – data from CGS borehole database (.mdb format)

GDO
Připojená databáze: C:\Documents and Settings\bedrich.mlcoch\dokumenty\Krystalinikum\2011\krystalinikum_2011\Zapad.mdb

KLIC_GDO: 47467
 Původní název: LE-127
 Druh objektu: vrt svislý
 Hloubka: 988,7
 Provádějící org.: Geindustria, n.p. Praha
 Rok obj.: 1978
 Archivní číslo: GF KT002123
 Zastížené strat: R.C

ZLM25: 02-323
 GK25: M-33-52-A-b

Najít okolní
 Přehledka
 Zadat rozhraní
 Definice zobrazení stropu

Hloubka rozhraní: [] [] přepočteno [] Zkontrolováno []

OD	DO STRATIGRAFIE	POPIS	DOPLNĚNÍ
287,10	289,20	K2C	prachovec [siltovec, aleurolit] šedá prokřemenělý zuhelnatělé zbytky rostli
289,20	291,60	K2C	pískovec šedá střednozrný zuhelnatělé zbytky rostlin
291,60	292,10	K2C	prachovec [siltovec, aleurolit] šedá zuhelnatělé zbytky rostlin přítomnost
292,10	292,80	K2C	pískovec šedá jemnozrný
292,80	294,20	K2C	pískovec šedá hrubozrný přechod konglomerát
294,20	294,50	K2C	konglomerát šedá
294,50	295,70	RC	křemenný porfyr zelená šedá silně kaolinizovaný
295,70	304,00	RC	křeme
304,00	318,10	RC	křeme
318,10	319,90	RC	křeme
319,90	324,30	RC	křeme
324,30	385,20	RC	křeme
385,20	388,80	RC	křeme
388,80	398,80	RC	křeme
398,80	404,90	RC	křeme
404,90	421,00	RC	křeme
421,00	423,00	RC	křeme
423,00	440,50	RC	křeme
440,50	465,30	RC	křeme
465,30	469,00	RC	křeme
469,00	470,80	RC	křeme
470,80	482,00	RC	křeme

Záznam: 106 z 139

Rozhraní
 KLIC_GDO: 47467
 Zkontrolováno

Vrstva: Český masiv · krystalinikum a prevariské
 Výška [hloubka]: 294,50
 Výškový systém: po vyrovnání
 Typ vrstvy: Strop
 Pořadí vrstvy: 1

Oblast: sasko-durynská oblast (saxothuringikum)
 Region: krušnohorský pluton
 Jednotka: teplický ryolit
 Souvrství: []

Hornina: ryolit
 Přívrástek: []
 Přívrástek min: []
 Zmitost: []

Poznámka: []

Záznam: 1 z 1 (Filtr)



Microsoft Access Application – **output** – data in Excel table .xls

Klic GDO	Vrt nazev	x	y	z	Rozhrani	Typ rozhrani	Hloubka rozhrani ve vrtu	Z rozhrani	Mapa ZM 25	Horni na	Přivlastek	Přivlastek mineralogický	Zrnitost	Oblast	Region	Jednotka	S	Vr	S	Poznámka	Klíč GEO	Hloubka vrtu	Autor	Datum
100965	L-10	-883730,8	-1006280,4	485,74	CMK	S	32	453,74	11-123	SVR				F	F2	F2B						33,3	Mlčoch	15.11.2011
101144	PJ-1	-886380	-1006650	510	CMK	S	7	503	11-123	SVR	KVR	GRN		F	F2	F2C						50	Mlčoch	15.11.2011
110655	JD686	-851059,7	-1002297,3	495,6	CMK	S	43,8	451,8	11-212	120		BTT	3	F	F3	NEJ							Mlčoch	15.11.2011
112452	OD 543	-851609,3	-1002450,8	508,6	CMK	S	26	482,6	11-212	120		BTT		F	F3	NEJ				nepřesni popsany profil,		66	Mlčoch	15.11.2011
114927	M-135	-857136,43	-1008824,43	408,32	CMK	S	10	398,32	11-213	120		BTT		F	F3	NEJ				37,90 - 46,80			Mlčoch	15.11.2011
122630	JE36	-853987,5	-1010626,8	390	CMK	S	40,6	349,4	11-214	120		B+A	3	F	F3	NEJ				porfyrický			Mlčoch	15.11.2011
125839	36H	-864602,2	-1012599,86	410,46	CMK	S	214	196,46	11-231	PRR		B+M		F	F2	F2B						252	Mlčoch	15.11.2011
110	TP 5	-774912,5	-974610,3	229,57	TR	S	182,8	46,77	02-322	porfyr		DVJ		F	F2	F2A				okatá		76,45	Mlčoch	11.10.2010
101	VR 24	-782817,38	-973696,73	324,5	TR	S	46,8	277,7	02-321	porfyr		DVJ		F	F2	F2A						164,59	Mlčoch	11.10.2010
55641	TH-33	-776803	-972036,4	311,3	TR	S	47,5	263,8	02-321	315				F		TR				47.50-51.00 m ztráta jád			Mlčoch	11.10.2010
DIAMO	3367/65	-848003,07	-1003589,2	478,52	CMK	S	82,1	396,42	11-212	912				F	F2	Y						84,1	Mlčoch	15.11.2011
1	3061	-852786,5	-1007851	424,7	CMK	S	22,6	402,1	11-214	ELV				F	F3A							31,9	Mlčoch	15.11.2011
1	5051	-852753,2	-1007551,2	432	CMK	S	44,3	387,7	11-214	ELV				F	F3A							52	Mlčoch	15.11.2011

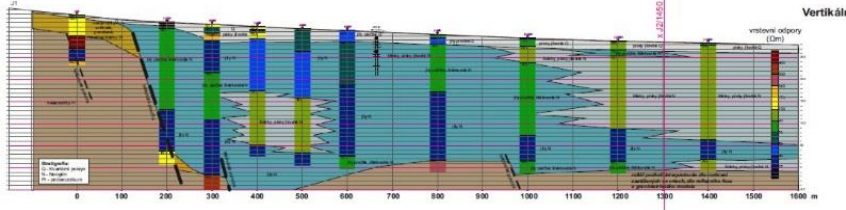
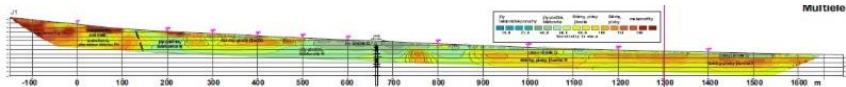
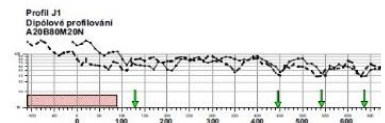
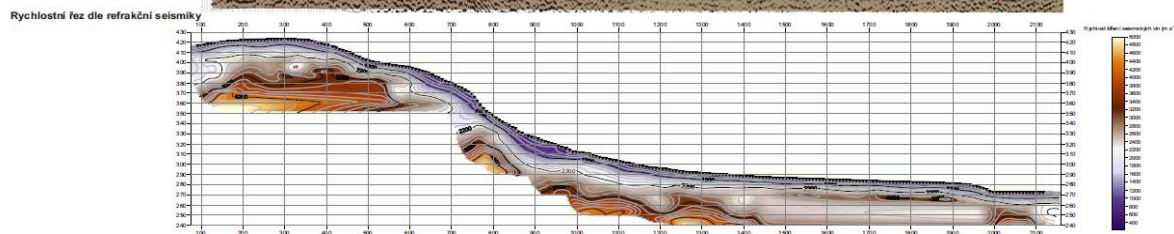
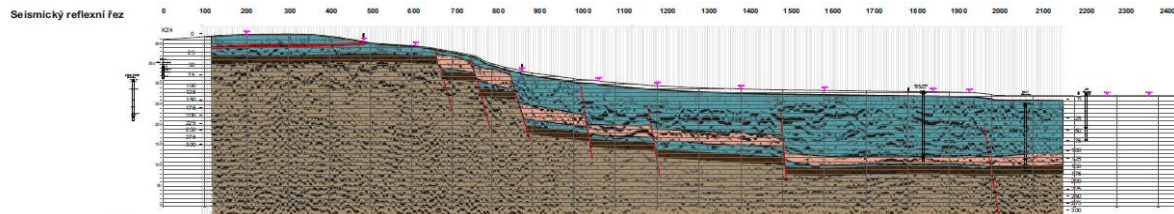
Storage of processed data – database CGS Postgre SQL

- **Input** – .xls format
- solid structure of table
- not all attributes are required

Data from CGS archives – technical reports with the coordinates of profiles, points
Processing – manual, determination of depth

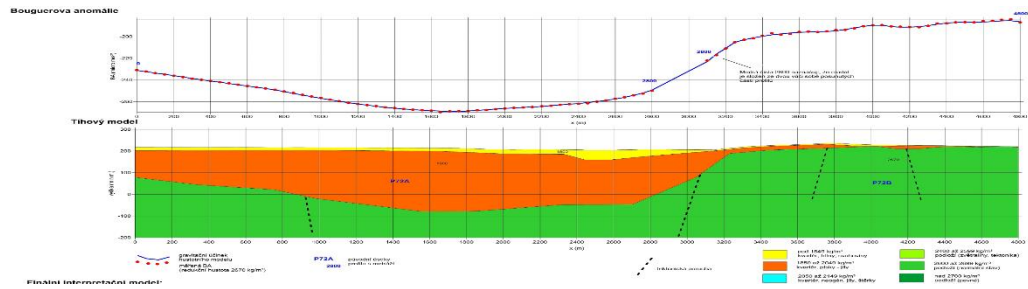
Reflection seismic

Refraction seismic



Electrical and electromagnetic sounding

Gravity modelling

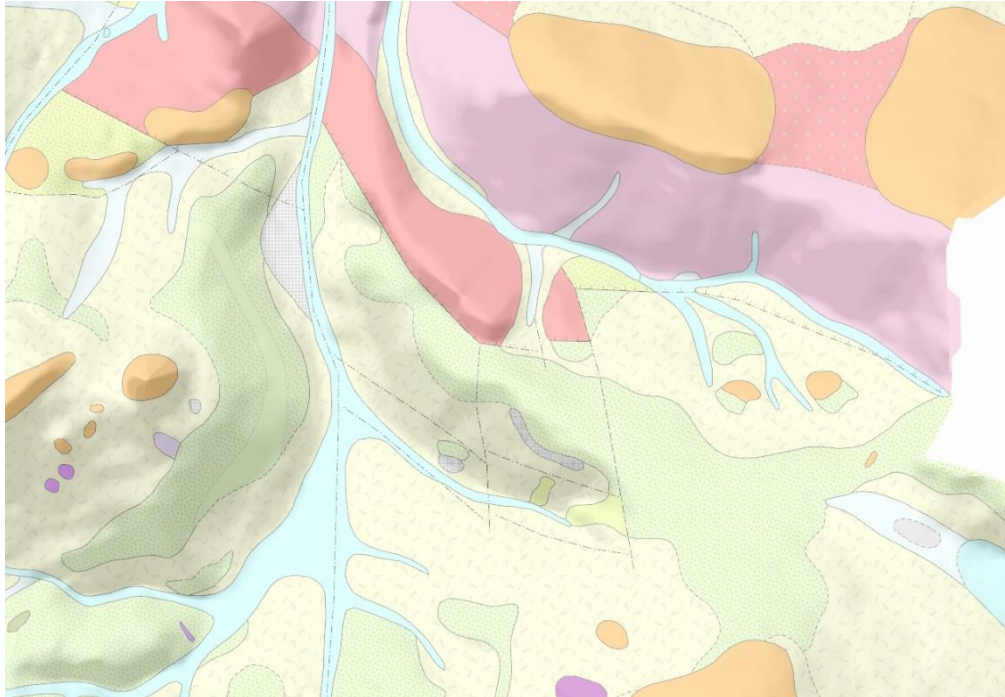


Output – data fill in Excel table .xls – points of measurement

Bod nazev	Metoda	Rozhrani x	y	z	Typ rozhrani	Hloubka rozhrani ve vrtu	Z rozhrani	Mapa ZM 25	Oblast	Region	Jednotka	Souvrství	Vrstva	Poznámka	Autor	Datum
0,2/P26A	seism_reflexni	KRY	-726686	-994074	S		100	02-444	D	DP	LUZ				Skácelova	27.3.2013
1,3/P26A	seism_reflexni	KRY	-726417	-995123	S		80	02-444	D	DP	LUZ				Skácelova	27.3.2013
1,7//P26A	seism_reflexni	KRY	-726364	-995523	S		60	02-444	D	DP	LUZ				Skácelova	27.3.2013
8/P26A	seism_reflexni	KRY	-723887	-1001162	S		120	02-442	D	DP	LUZ				Skácelova	27.3.2013
8,7/P26A	seism_reflexni	KRY	-723820	-1001866	S		140	02-442	D	DP	LUZ				Skácelova	27.3.2013
9,2/P26A	seism_reflexni	KRY	-723697	-1002389	S		140	02-442	D	DP	LUZ				Skácelova	27.3.2013
1 VES			-710025	-1042655	210 S	63	147	13-131	F	F2	F2A				Skacelova	21.4.2008
2 VES			-710808	-1042771	218 S	127	91	13-131	F	F2	F2A				Skacelova	21.4.2008
3 VES			-711517	-1043206	200 S	90	110	13-131	F	F2	F2A				Skacelova	21.4.2008
1 VES			-688559	-1040416	187 S	275	-88	13-124	F	F2	F2A				Skacelova	21.4.2008
2 VES			-689352	-1039862	187 S	350	-163	13-124	F	F2	F2A				Skacelova	21.4.2008

Storage of processed data – database CGS Postgre SQL

- **Input** – .xls format
- solid structure of table
- not all attributes are required



Polygons of outcrops
(e.g. basement, granite
massif, Cretaceous –
Cenomanian, Turonian,
Coniacian, volcanic rocks) –
recent relief (ASCII format
.txt – contour line or grid)

Storage of processed data – database CGS Postgre SQL

- **Input** – .xls format
- solid structure of table

```

04_44_21 - Poznámkový blok
Soubor Úpravy Formát Zobrazení nápověda
X;Y;Z
-551649,6;-1031863,16;260
-551649,56;-1031863,13;260
-551649,56;-1031863,13;260
-551715,28;-1031856,17;258
-551636,44;-1031854,98;260
-551768,1;-1031850,56;256
-551768,08;-1031850,54;256
-551768,08;-1031850,54;256
-551625,26;-1031848,69;260
-551795,62;-1031847,63;254
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-551607,63;-1031841,4;260
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-551607,55;-1031841,38;260
-551858,03;-1031841,251
-551858,02;-1031840,99;251
-551858,02;-1031840,99;251
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-551691,81;-1031837,15;258
-551788,81;-1031836,45;254
-551844,53;-1031833,11;251
-551940,67;-1031832,21;251
-551940,66;-1031832,14;251
-551940,66;-1031832,14;251
-551970,42;-1031829,05;252
-551970,42;-1031829,04;252
  
```


Search after:

- ✓ ID
- ✓ Coordinates
- ✓ Name of boreholes
- ✓ Geophysical method
- ✓ Strata, rocks types etc.

Hledat záznam GA

Hledat záznam GA	
ID GA	<input type="text"/>
Klíč GDO	<input type="text"/>
Metoda	
Název vrtu	<input type="text"/>
Název bodu	
Hloubka vrtu	Od: <input type="text"/> do: <input type="text"/>
Typ rozhraní	<input type="text"/>
Rozhraní	<input type="text"/>
Souvrství	<input type="text"/>
Hornina	<input type="text"/>
Vrstva	<input type="text"/>
Levý horní roh X	<input type="text"/>
Levý horní roh Y	<input type="text"/>
Pravý dolní roh X	<input type="text"/>
Pravý dolní roh Y	<input type="text"/>
Číslo mapy ZM	<input type="text"/>
<input type="button" value="Najdi"/>	<input type="button" value="Zrušit filtr"/>

Export:

- ✓ xls. format
- ✓ csv. format

Nalezené záznamy GA

Počet záznamů:

BA GDO	Vrt	Název	Rozhraní	Z rozhraní	Hornina	Oblast	Region	Autor	detail
103960	H-2	KRY:KRY	205			F:sasko-durynská oblast (saxothuringikum)	F3:krušnohorský pluton	MlČoch	Detail
102600	HV2	KRY:KRY	135.6			F:sasko-durynská oblast (saxothuringikum)	F3:krušnohorský pluton	MlČoch	Detail
102601	HV3	KRY:KRY	154.7			F:sasko-durynská oblast (saxothuringikum)	F3:krušnohorský pluton	MlČoch	Detail
102604	HV6	KRY:KRY	123			F:sasko-durynská oblast (saxothuringikum)	F3:krušnohorský pluton	MlČoch	Detail
103132	SS-1	KRY:KRY	178.4			F:sasko-durynská oblast (saxothuringikum)	F3:krušnohorský pluton	MlČoch	Detail

3D model in Surfer software

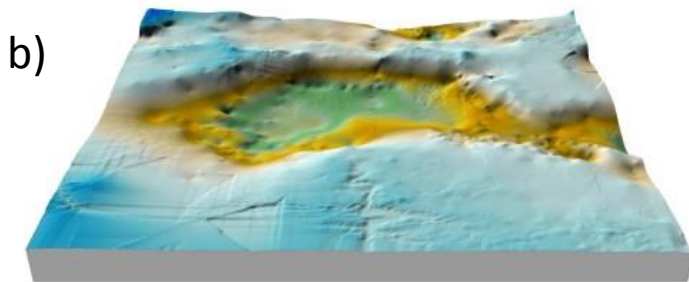
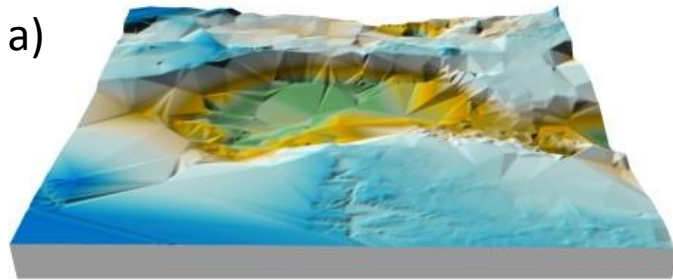
Method:

Use **Surfer** software

Processing all available data for each strata (boreholes, geophysisc) to input file (.dat) including outcrops on the surface - relief (from geological maps).

Gridding methods:

a) triangulation with linear interpolation, b) kriging

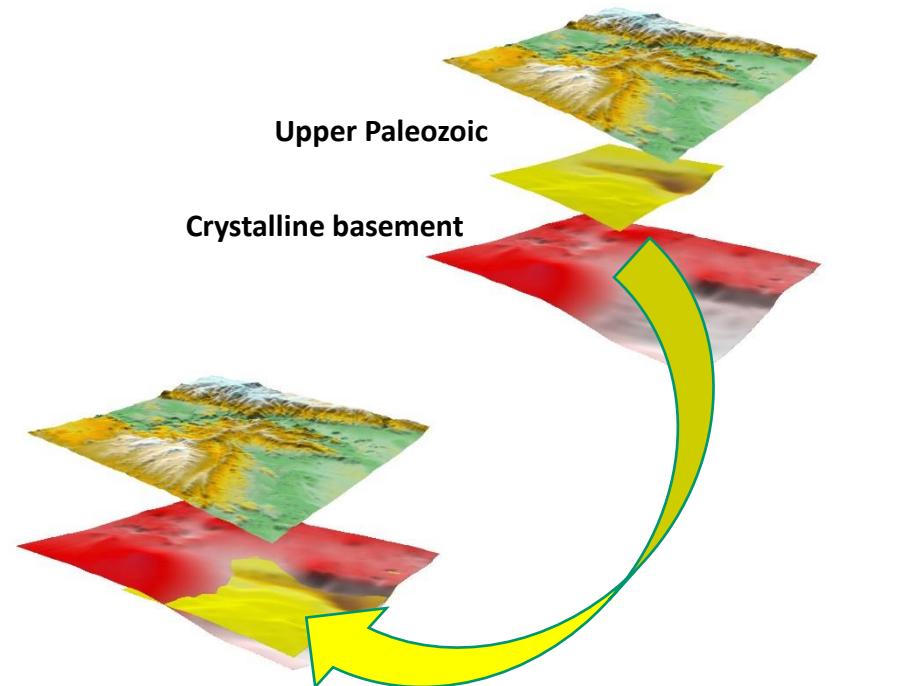


Combination of surface

Recent relief

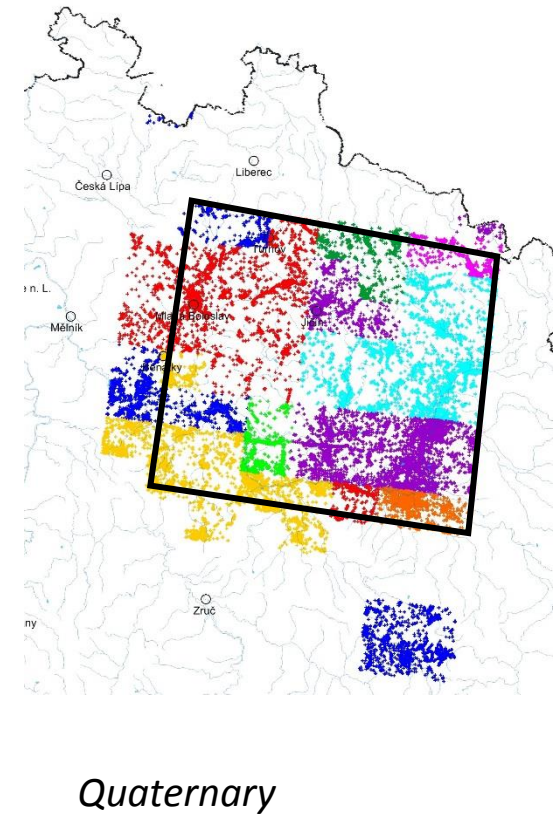
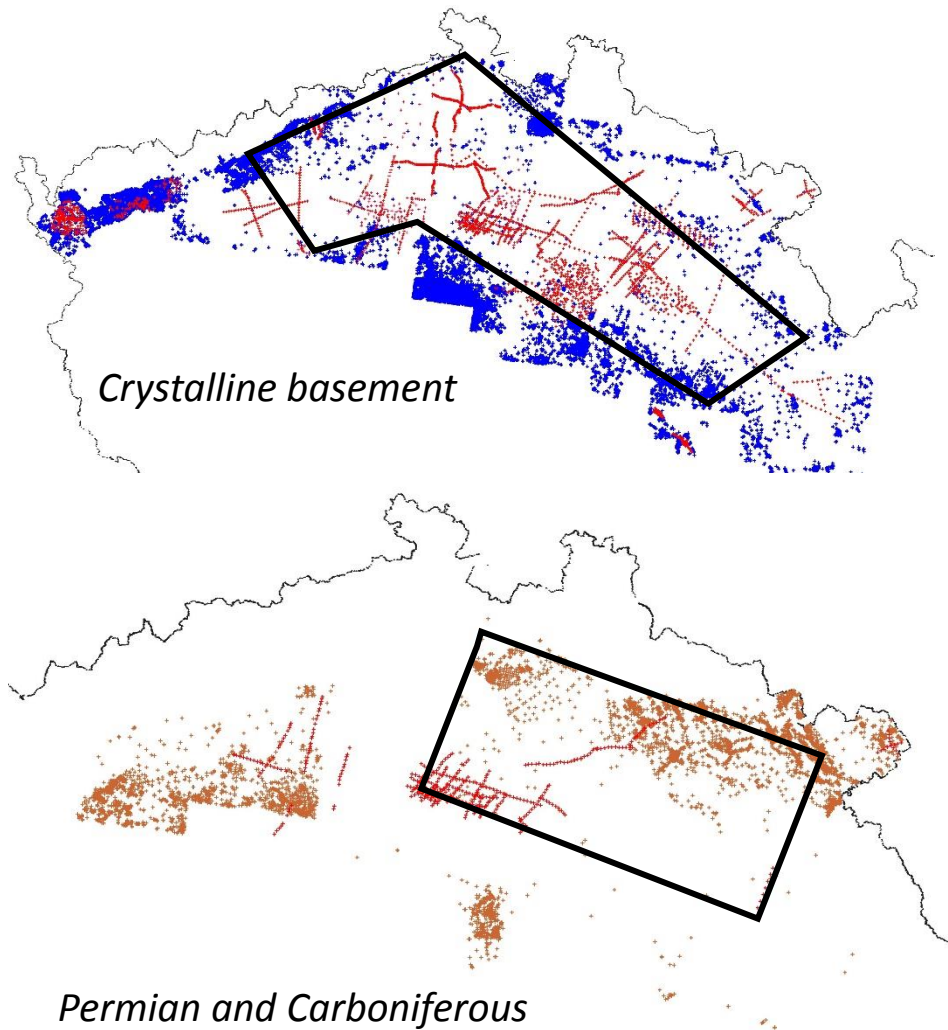
Upper Paleozoic

Crystalline basement



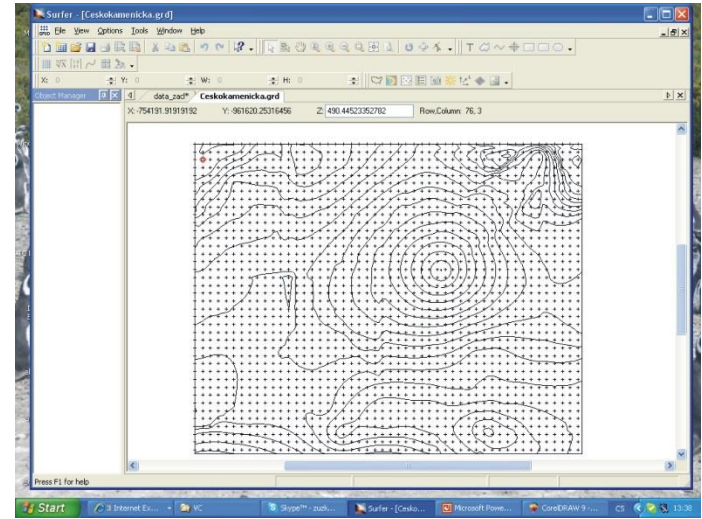
3D model in Surfer software

Model accuracy – number of data and coverage of study area

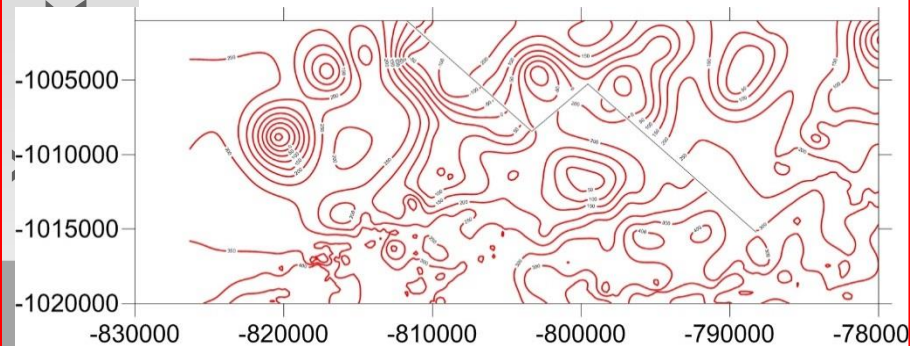
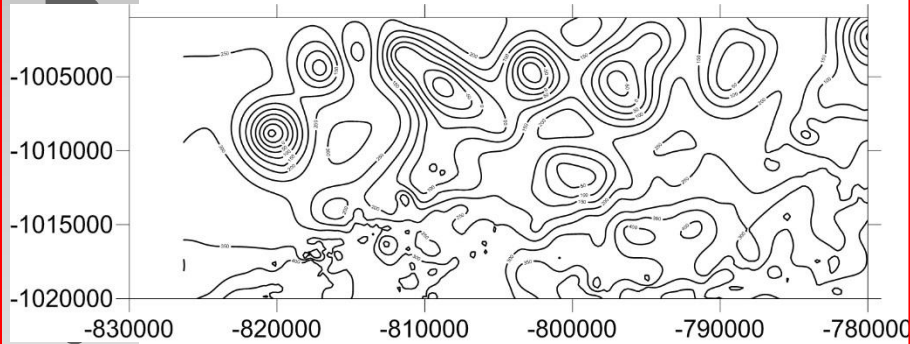


Surfer – suitable SW for checking and removing data errors, fast and user-friendly

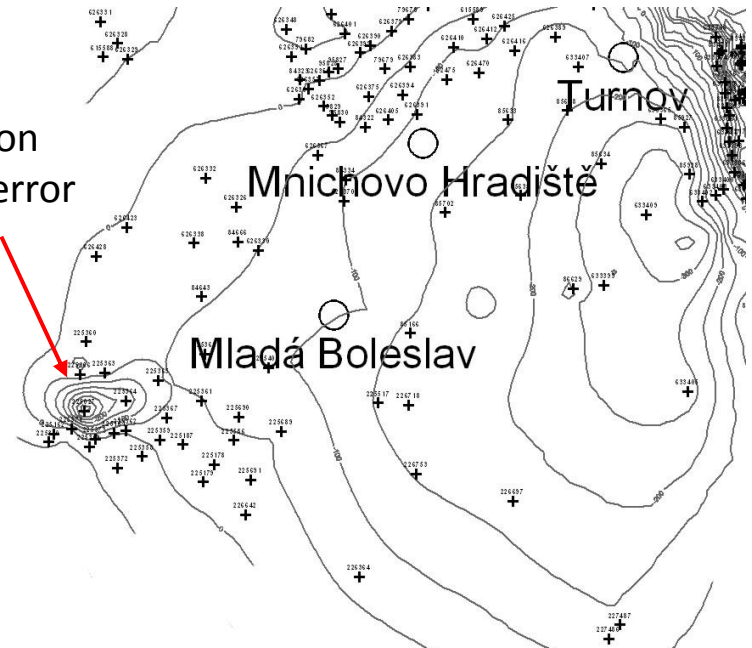
Grid point density selection – precision of 3D model



Modelling without and with faults

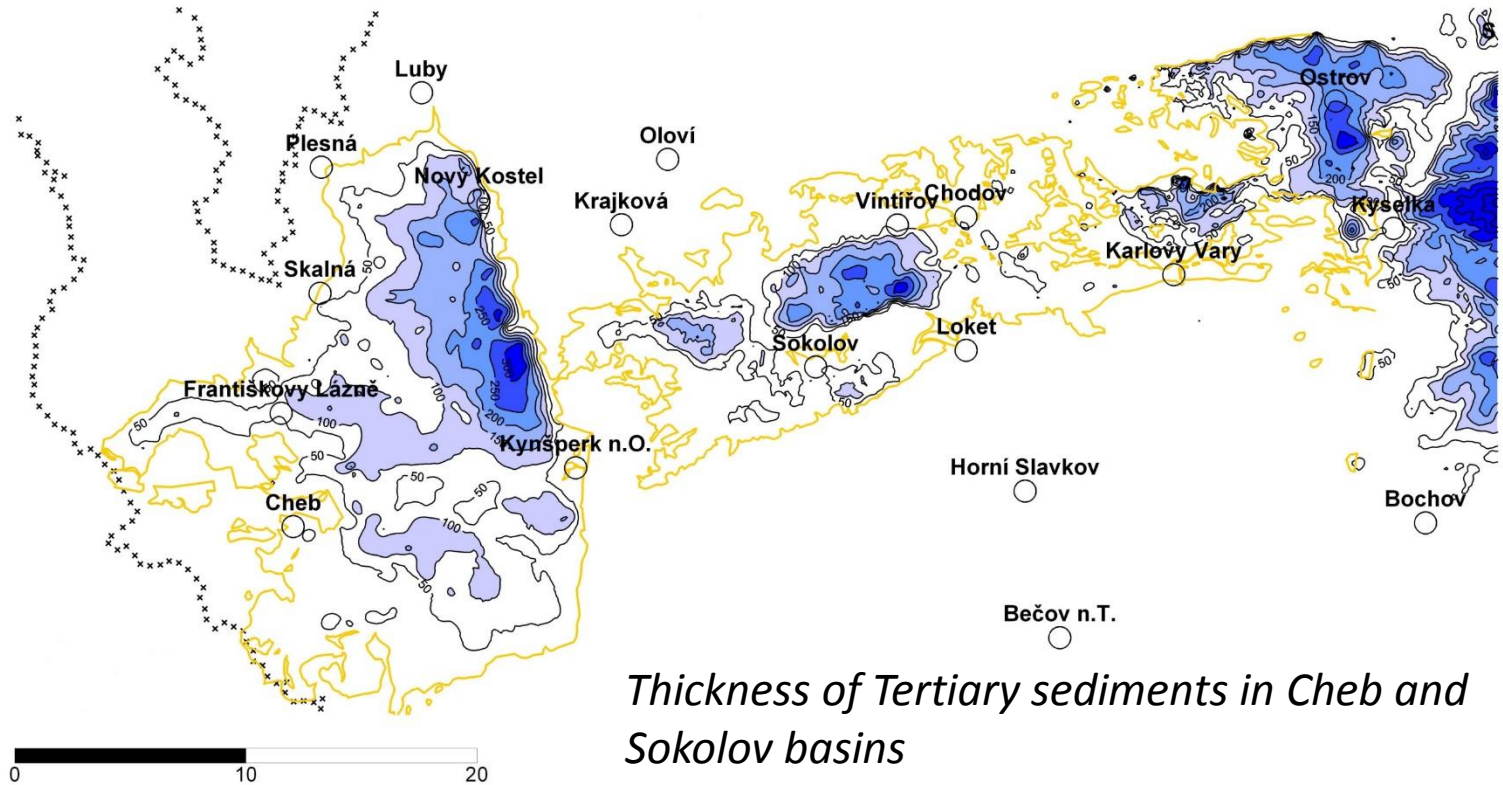


Correction of data error



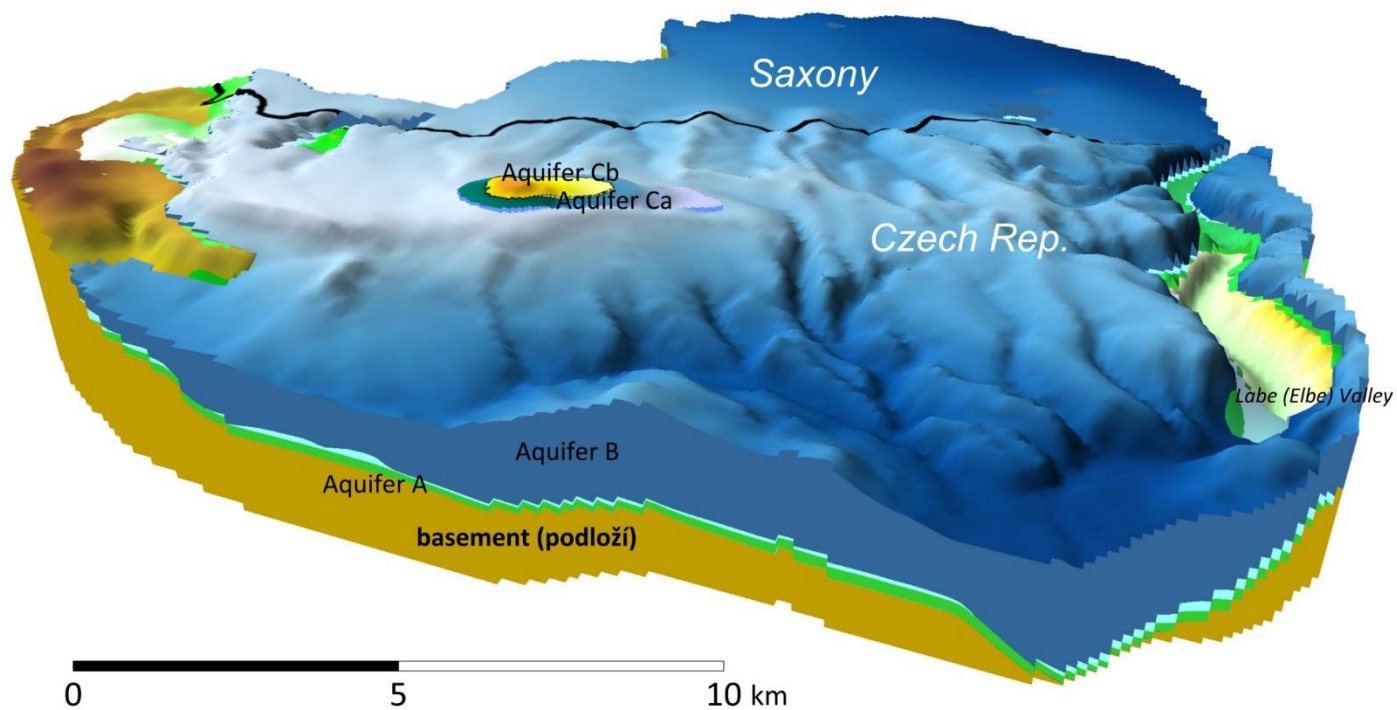
Outputs: isolines of surface strata (grid)

Options presentation: e.g. Contour line map of surface, map of thickness, 3D model, cross-section

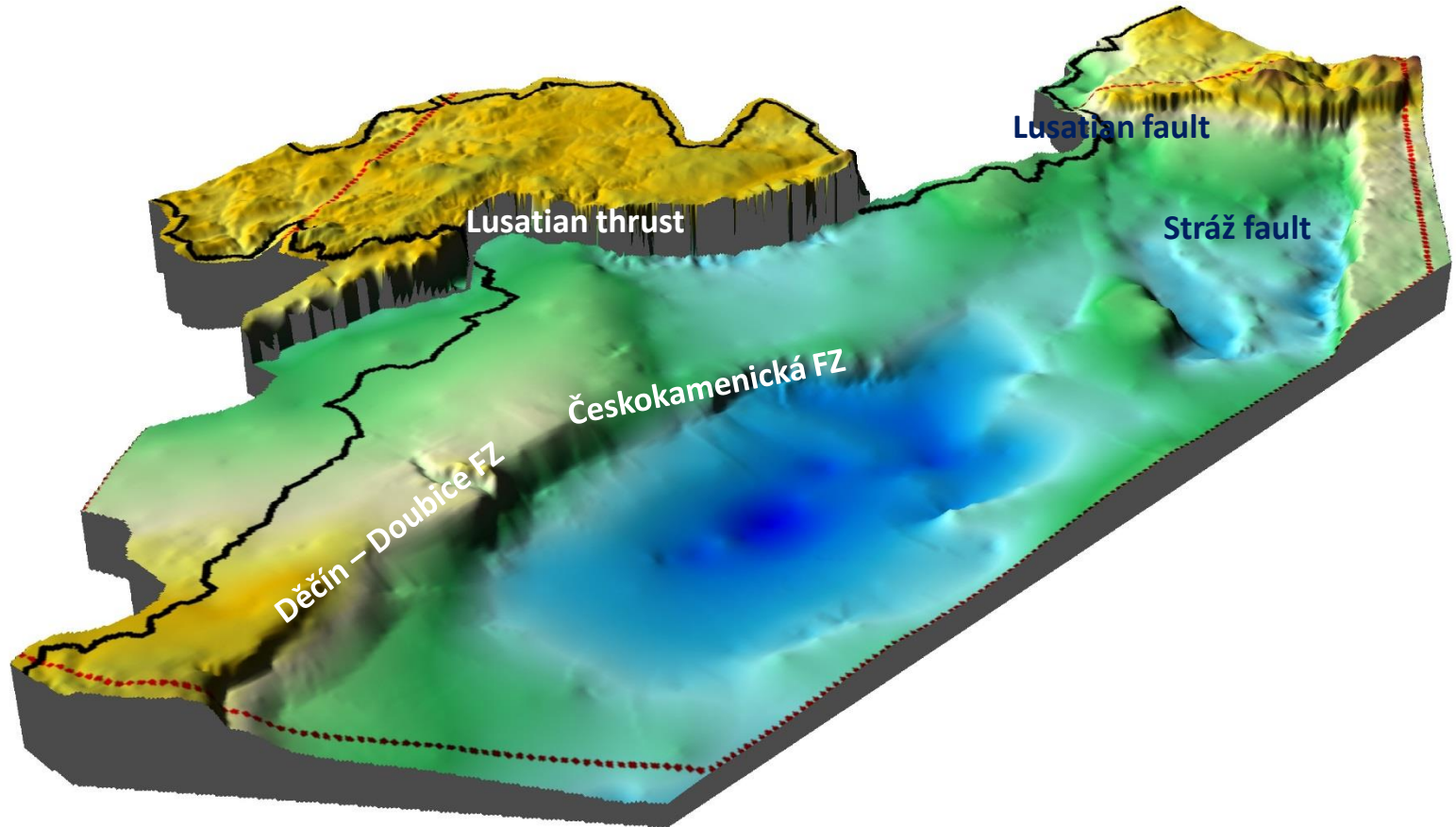


Thickness of Tertiary sediments in Cheb and Sokolov basins

ResiBil – 3D geological model of Děčínský Sněžník pilot area – aquifers and aquitards



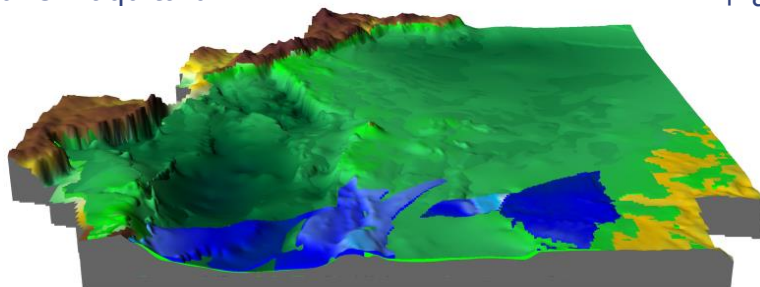
ResiBil study area – 3D model of basement



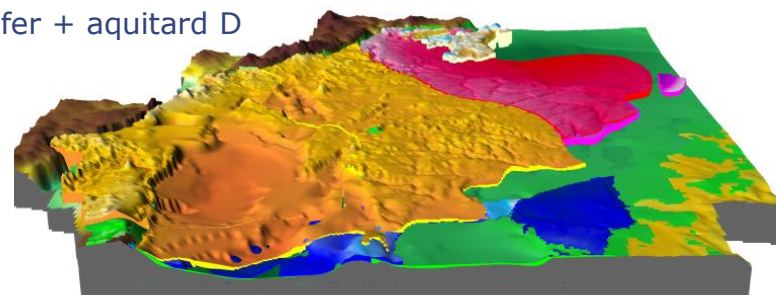
3D Model of aguifers A, B, BC – February 2019

Project REBILANCE – 3D model of aquifers in area 3

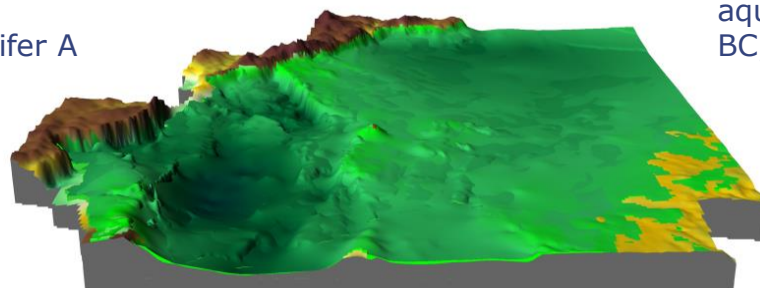
+aquifer+aquitard B



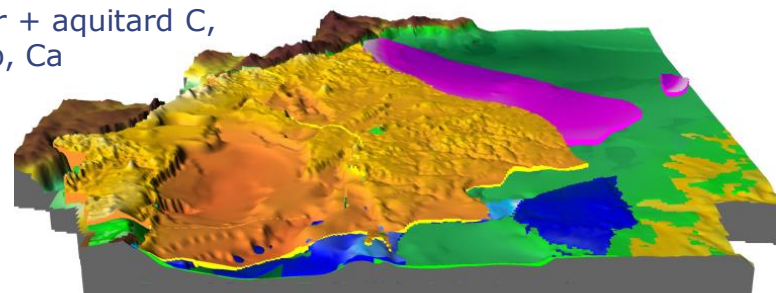
+ aquifer + aquitard D



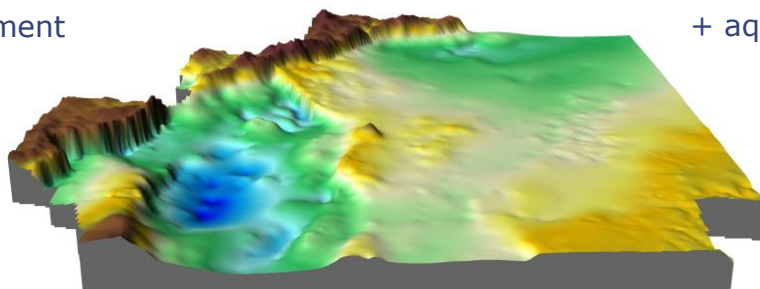
+aquifer A



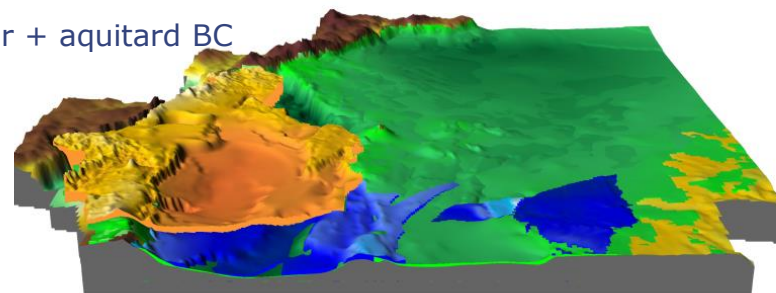
aquifer + aquitard C,
BC, Cb, Ca

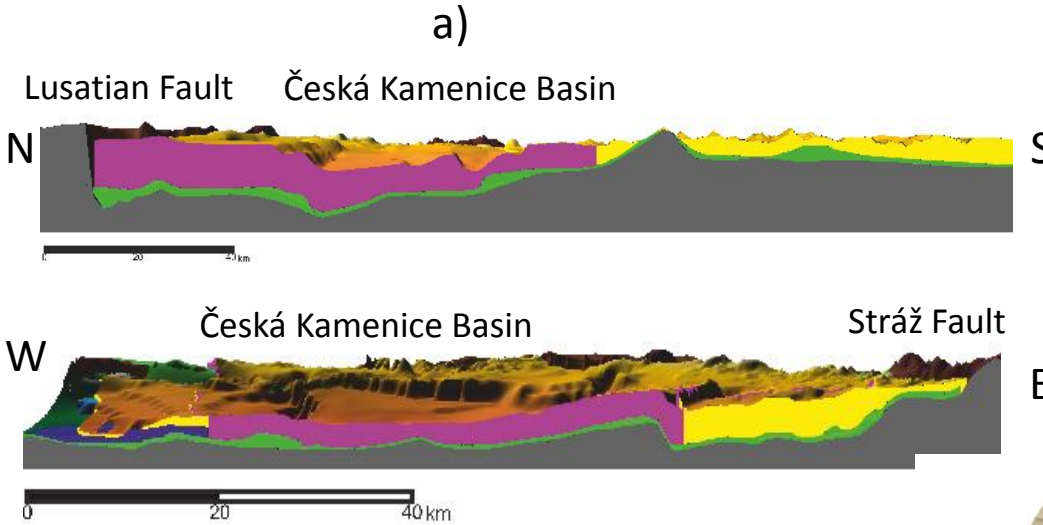


basement



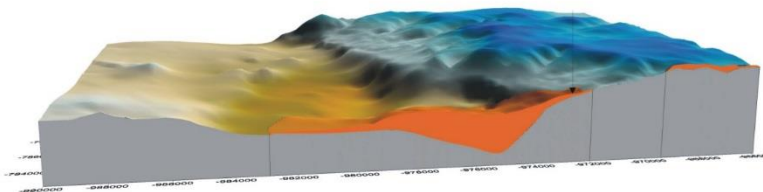
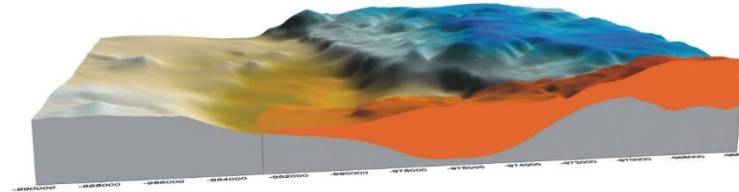
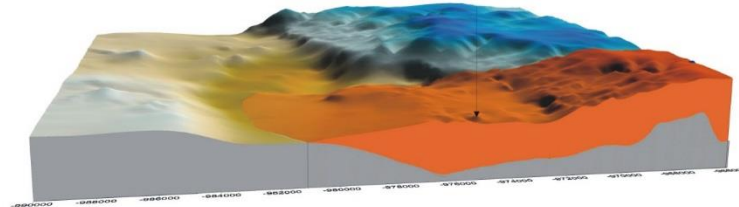
+ aquifer + aquitard BC





b)

Ryolite body in Altenberg-Teplice
Caldera

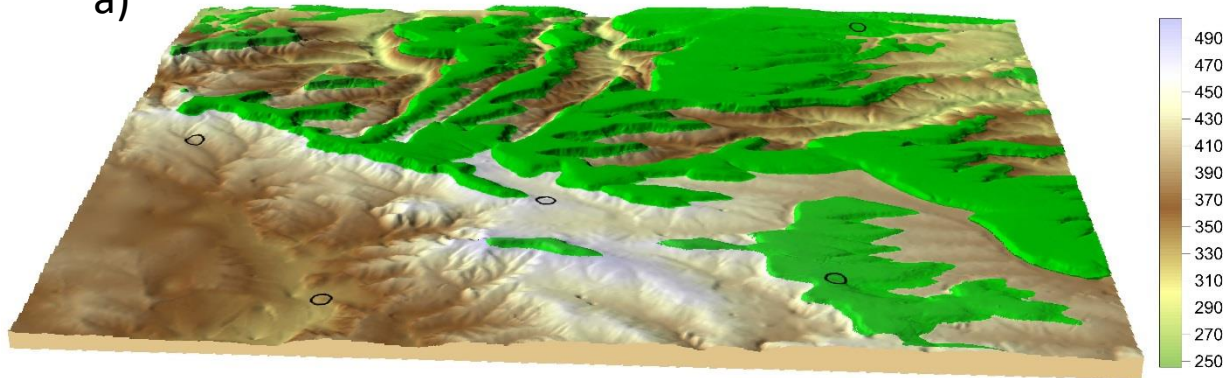


The 3D geological model allows to
create depth cross-section:

- a) cross-section of Cretaceous
Basin – aquifers A, B, BC, C
- b) cross-section of ATC ryolite



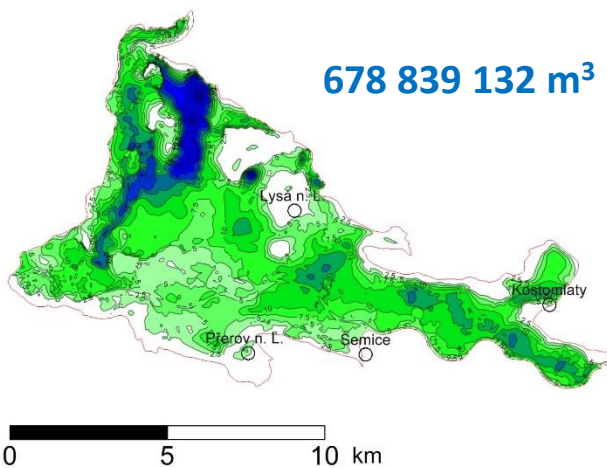
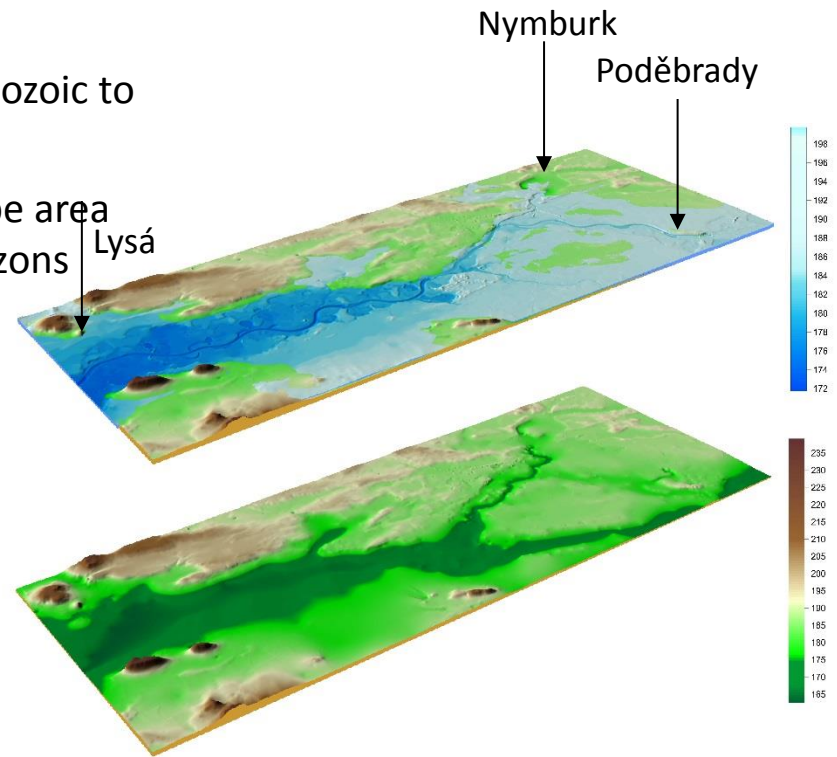
a)

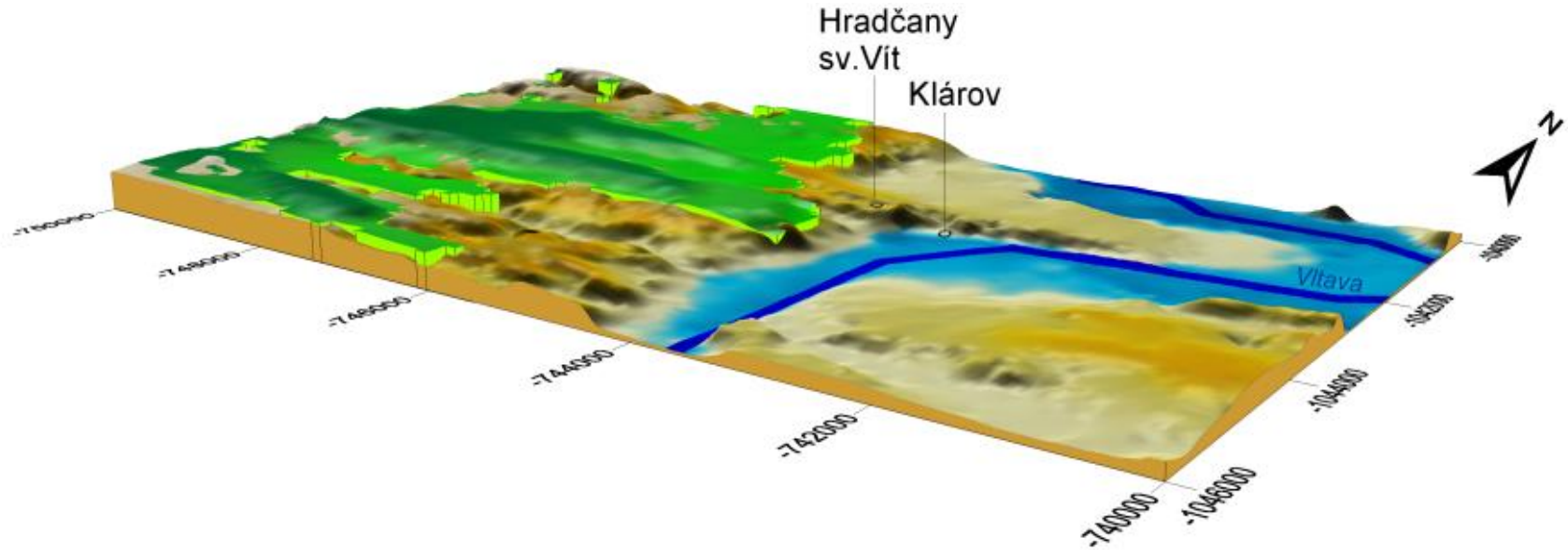


Presentation of geological model for public:

a) Model of Cretaceous sediments on Upper Paleozoic to determine of slope instability

b) Model of Quaternary sediments (aquifer) in Labe area with the volume calculation of groundwater horizons





Thanks for your attention.