

**metROSTAV**



# Injektáže proti přítokům podzemní vody

**Ing. Petr Kučera, Minova Bohemia s.r.o**

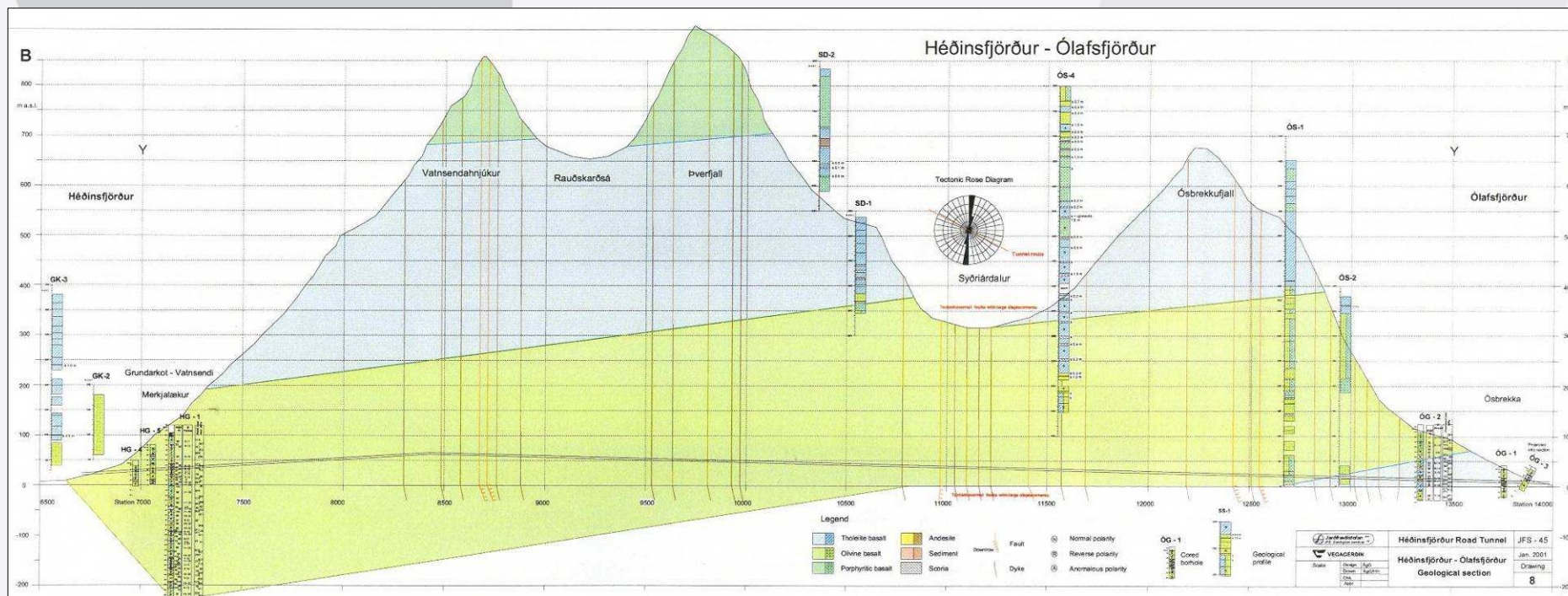
Tunelářské odpoledne 3/2009  
Česká tunelářská asociace ITA-AITES

Solutions from materials technology



# Geologický profil Ólafsfjörður

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# Geologická situace čelby tunelu

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		HEÐINSFJARDARGONG		HEÐINSFJÖRDUR-ÓLAFSFJÖRDUR		<b>metr@stau</b>	
<b>Geological Tunnel Mapping</b>							
STRUCTURE: Tunnel A route		DATE: 12.04.07	TIME: 10:00	STATION: 12690,4	ROUND No: 254	ROUND LENGTH 4,9 (m)	Q = 2,2
SAMPLE NO.	FOTO NO.	WATER TEMPERATURE:					
WEATHERING unweathered W 0   slightly W 1   moderately W 2   highly W 3   completely W 4   eluvium W 5							
ROCK STRENGTH R0   R1   R2   R3   R4   R5   R6							
VOLCANOCLASTICS, TUFFS very soft   soft   NO   firm   stiff   very stiff   hard							
WATER CONDITION <i>all water (preborings + joints): ±300 l/min</i> dry   damp   wet   dripping   seepage   <u>flowing</u> (Vsec)							
CHARACTERISTICS OF DISCONTINUITIES							
TYPE	ORIENTATION Dip Director / Dip	ROUGHNESS S U P r s sl	PERSISTENCE <1   1-3   3-10   >10	SPACING (mm) <20   20-50   50-200   200-500   500-2000   >2000	WIDTHS <2mm   2-10   10-50   >50mm	FILLING	
J1	30°/80°	X	X	X	X	X	Fe, clay
J2	19°/40°	X	X	X	X	X	Fe, clay
J3	4°/85°	X	X	X	X	X	Fe, clay
J4	2°/85°	X	X	X	X	X	Fe, clay
J5	26°/80°	X	X	X	X	X	Fe, clay
J6	230°/60°	X	X	X	X	X	Fe, clay
Type of Discontinuity		Roughness	Persistence	Spacing	Widths	Filling	
Fault	F	STEPLED	rough	Extremely close	< 20 mm		
Joint	J		smooth	Very close	20 - 60 mm		
Slacksided	Sl		slacksided	Close	50 - 200 mm		
Fractured	Fr	UNDULATING	rough	Moderate	200 - 600 mm		
Bedding Plane	B		smooth	Wide	500 - 2000 mm		
Shear	Sh	PLANAR	slacksided	Very wide	> 2000 mm		
Persistence		Type of filling		Rock strength			
Very low	< 1m	clay	cl	R 0	extremely strong	>250 MPa	
Low	1-3m	Mn/Fe-mineralisations	m, fe	R 1	very strong	100 - 250 MPa	
Medium	3 - 10m	mylonic fault gouge	fg	R 2	strong	50 - 100 MPa	
High	> 10m	mylonic fault breccia	fb	R 3	medium strong	25 - 50 MPa	
Widths		cementec, other	c, o	R 4	weak	5 - 25 MPa	
<2mm		zeoliths	ze	R 5	very weak	1 - 5 MPa	
2 - 10mm				R 6	extr. weak	< 1 MPa	
10 - 50mm							
>50mm							

**Lithological Properties:**  
Basalt, dark gray, fine grained, R12

**Rock Mass Behaviour**  
J1-6: joints with Fe and clay

Contractor: ŠTOVIČEK      Client: \_\_\_\_\_  
Date: 12.04.2007      Date: \_\_\_\_\_



# Záznamy z průzkumných vrtů

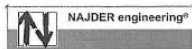
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<input type="checkbox"/> SIGLUFJARÐARGÖNG <input checked="" type="checkbox"/> ÓLAFSJARÐARGÖNG		Staðn:	RUDLOF	Predák:		Stöð:	12.690,4	Staničenf:		Dags:	12.4.2007	Dne:	Nr:	54	Č:					
①	Stefna holu:	↗ 5°	Byrjað kl:	13 00	Q <sub>1</sub> =	1200	l/min	Hlftastig:	3	°C	Bormunstur: 									
	Smér vrtu:	↘ 10°	Zač. prací:	13 40	Q <sub>2</sub> =	1200	l/min	Teplota:		pH:										
	Halli holu:		Lokið kl:	13 40							Athugasemdir: Poznámky 5 RODS OF 4,2 M USED FOR DRILLING OUTFLOW TOGETHER 1400 l/min									
	Sklon vrtu:		Kon. prací:																	
Lengd stangar (m)	0	5	10	12	14	15	20	25	30	35										
Leki í lengd	Ø										1000 l/min									
Množství vody																				
Berggerð	BASALT										FAULT									
Typ horniny	BASALT										BASALT									
Borhraði	0,51	0,55	0,52	0,74	0,61															
Rychlost vrtání	GREY										ORANGE					GREY				
Litur á skolvatni																				
Barva výplachu																				
Athugasemdir	5 RODS OF 4,2 M USED FOR DRILLING																			
Poznámky																				
②	Stefna holu:	↗ 5°	Byrjað kl:	13 45	Q <sub>1</sub> =	100	l/min	Hlftastig:	3	°C	Athugasemdir: Poznámky 5 RODS OF 4,2 M USED FOR DRILLING									
	Smér vrtu:	↘ 10°	Zač. prací:	14 30	Q <sub>2</sub> =	100	l/min	Teplota:		pH:										
Halli holu:		Lokið kl:	14 30								Undirskrift: <i>Marcus J. J.</i> Podpis Verktaki / Zhotovitel Undirskrift: <i>[Signature]</i> Podpis Verkkaupi / Objednatel									
Sklon vrtu:		Kon. prací:																		
Lengd stangar (m)	0	5	10	12	14	15	20	25	30	35										
Leki í lengd	Ø										100 l/min									
Množství vody																				
Berggerð	BASALT										FAULT					BASALT				
Typ horniny	BASALT										BASALT									
Borhraði	0,48	0,5	0,52	0,73	0,56															
Rychlost vrtání	GREY										ORANGE					GREY				
Litur á skolvatni																				
Barva výplachu																				
Athugasemdir	5 RODS OF 4,2 M USED FOR DRILLING																			
Poznámky																				

# Method statement

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## Metrostav- Héðinsfjarðargöng Project

Ing. Eirín Stehlík  
Contract Manager

Metrostav a.s. Divize S.N a Zlatáec 1350/13,1 50 00 Praha 5  
The Czech Republic  
Metrostav a.s.á úřibhá 4 Íslandi, S keifnumi 11,1 08 Reykjavík,  
Iceland

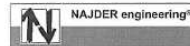
### Next grouting at ch. 12,054,5

Before any further efforts will be taken the Owr consider following changes:

1. The another type ofm aterial will be used for gr huge ingress ofv **ery cold water** like +2,6° C i grouting is obviously none effective and time cc
2. The drilling pattern mustb e adjusted to the cas actual face- pleased find attached Appendix no. drill the hole along the tunnel axis (perpendicular umbrella drilling.
3. The holes will be drilled to the length of 8 m on the hole will be drilled to max 12 m (to the first
4. Due to growing pressure the inflatable packers cases with IRMA packers (Appendix 2). The out will be as closed as possible to the leaking joint Due to lack of original IRMA packers the BVS in with ordinary steel pipes. Temporary valves (lik from thick rubber gloves) will be attached with the pipes. The extension pipes will be filled with The another varianti s to install in fronto f the p with small internal diameter like  $\varnothing = 10$  mm, er described above for steel pipe.
5. IRMA packers or "home made" packers will be i expanded with hydraulic oil, water or componer expand **but not to open** packers.
6. Due to high pressure 2 packers system is recor
7. The Owner and the Contractor should consider higher pumping rate or used actual pumps and minimum 10 m<sup>3</sup>/min. The optimal groutd elivery (Appendix 3) and for the SK 90 and be at leastr 2x10 litres/min at the pressure of1 00 bars.

sid 1 av 2

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E-mail: tomasz.najder@hotmail



8. For extremely cases the CT-PM pump (Appendix 4) with capacity 2x24 litres, is recommended. These pumps are available for hiring from Minova CarboT
9. In the case ofo pen faults or caverns the Contractor should have on stock an types ofP U resins like WilkiFoam or GeoFoam (Appendix 5-7). With combin of he stronger pumps and extension pipes for grouting closer the leaking fa the PU resins will be heated to minimum +18° C.
10. The reason is to decrease PU escape due to high velocity of he water in the far away from the hole grouted (Appendix 8).
11. The moste ffective economically is to apply kombi grouting- reversible ceme slurry w/c = 0,40 and PU resin (Appendix no. 1- picture no. 7 and 8).

Regards

Tomasz Najder PhD Civ. Eng.

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E-mail: tomasz.najder@hotmail.com





# Vrtné schéma pro chemickou injektáž

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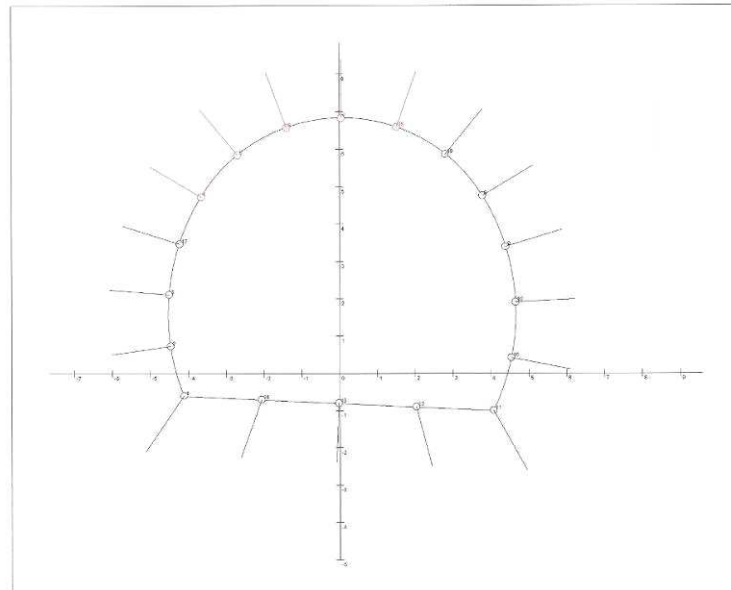
## Drill Plan

1/1

Worksite : Olaf

Drift/Round :  
Drilling pattern : DEST004.PLA  
Drig : default.rig

File : C:\#\SLAND\TAMROCK#\ZADANI#\OLAF6-1\DEST004.PLA  
Profile area : 55.7 m<sup>2</sup>  
Holes : 18 (+ 0 dummy holes)  
Drill Meters : 108.0  
Scale : 1 : 100  
Comments :



## Přítoky vody duben/květen 2007

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přehraj



## Ukázka technologie injektáže

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## Čerpadlo GX 45

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## Postupné zvyšování tlaku a množství vody srpen 2007

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# Postupné zvyšování tlaku a množství vody srpen 2007

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**Přítoky vody zastižené  
21. srpna 2007**

**metrocstav**





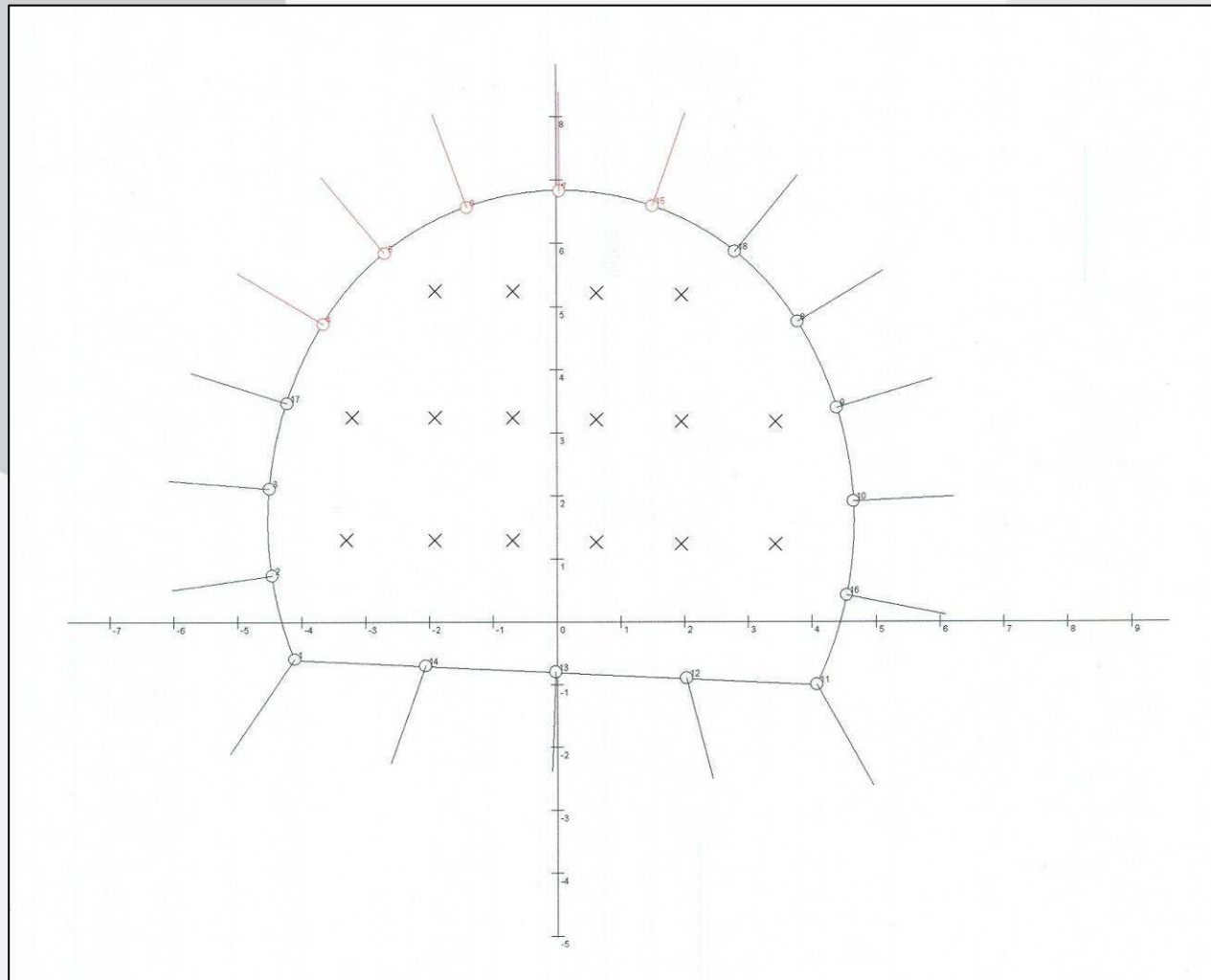
**Přítoky vody zastižené  
21. srpna 2007**

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# Změna injekčního postupu

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## Změna technologie injekčních prací

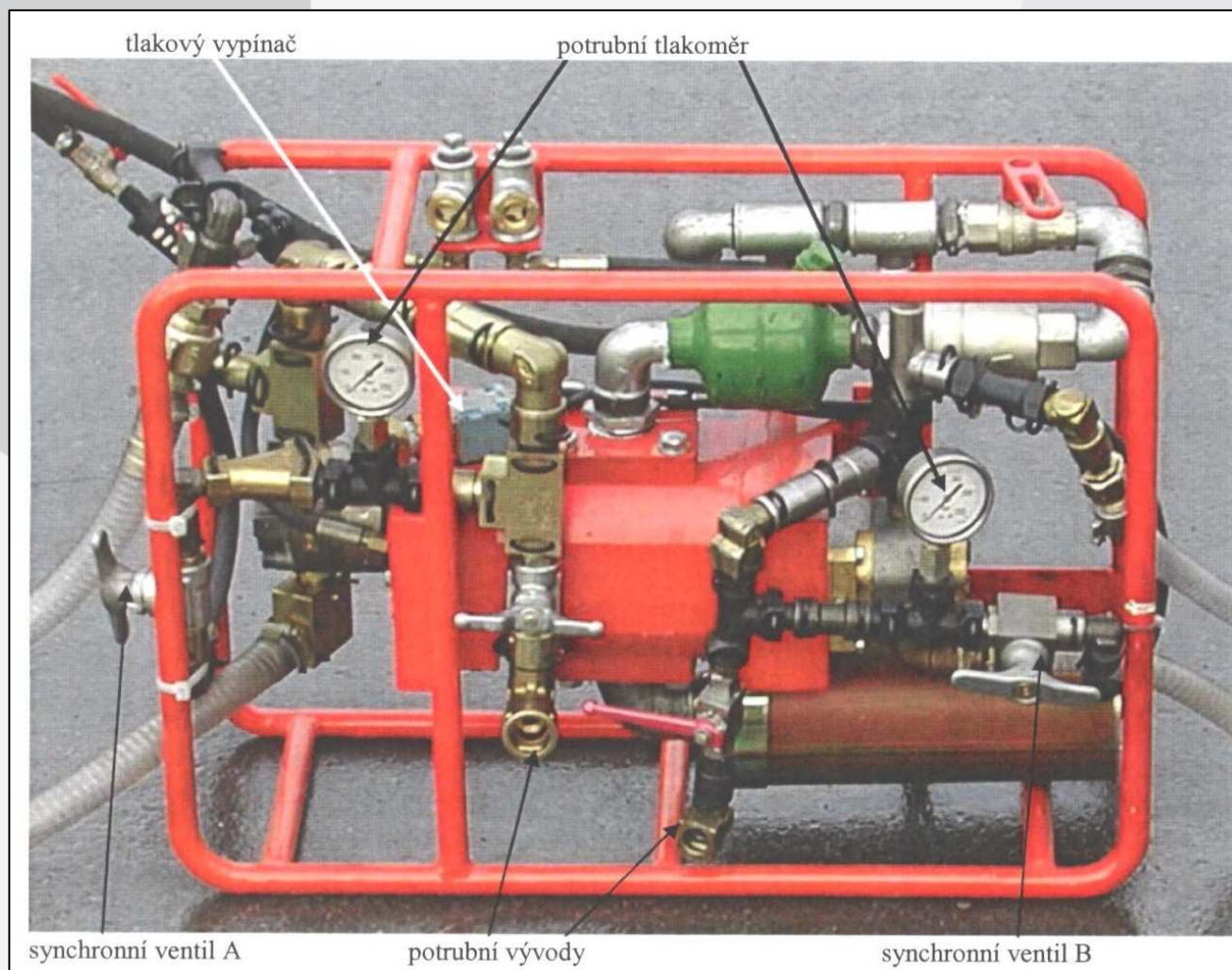
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- situace v srpnu se dramaticky změnila (hydrogeologie)
- nutnost změny technologie:
  - změna injektážního postupu
  - změna používaného zařízení
  - aplikace hmoty GeoFoam

# Čerpadlo SK 90

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**Celoplošná porucha šířky cca 1 m  
(tzv. pirščovka)**

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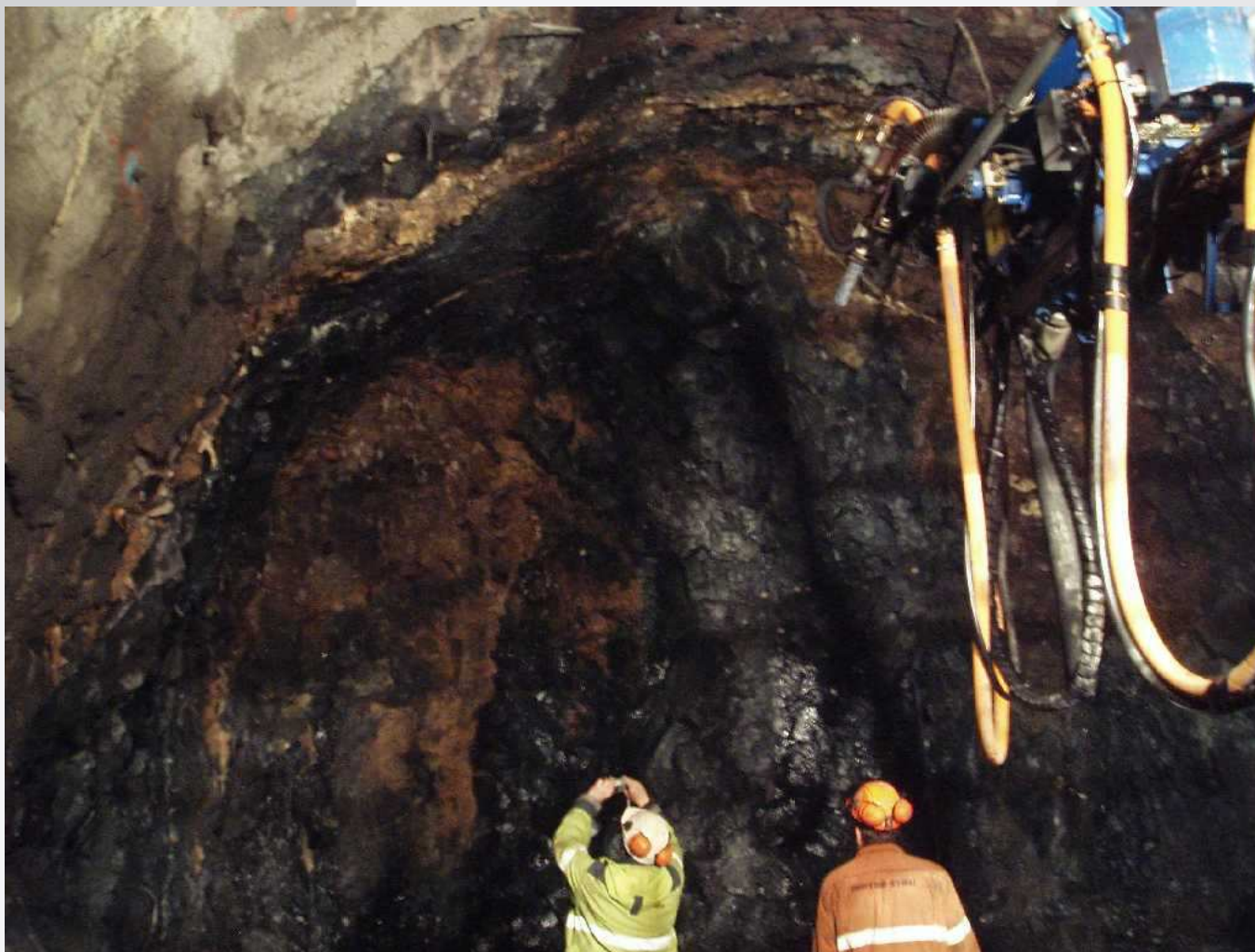
# Čerpadlo CT-PM

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## Výsledek injektáží

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## Výsledek injektáží

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## Odebrané vzorky

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# Záznamy o injektáži

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SIGLUFJARDARGÖNG		ÓLAFSFIJARDARGÖNG		Stöð: 12054 G (Staničeni)		Dags: 11.9. (Dne)		Nr. 62 (Č.)	
Hola nr.	Lengd grautunarholu m	Vatns-leki (V/min)	Vatns-þrygtingur (bar)	Grautunar-þrygtingur (bar)	Magn (l)	% föblöndun 1 p 1	Samtals föblöndun 1 p 1	Deiling tími byrjað	Deiling tími hætt
Č. vrtu	óðilla vrtu	þrökk vöðyz vrtu	blak vöðy ve vrtu	injektáðni tlak	mnoðatvíl Injekt. smásl	injektáðni smés	þrísada 1	začatek Injektáðe	konec Injektáðe
29	16/6	30/14m		240	130 L	PU		13:15	13:40
30	12/6	200/9m		220	200 L	PU		13:40	14:10
32	16/6	20/12m		220	70 L	PU		14:55	15:05
31	16/6	5/14m		140	40 L	PU		15:35	15:45
33	16/6	5/14m		200	50 L	PU		16:15	16:20
34	14/6	130/12m		230	120 L	PU		15:50	16:15
35	16/6	20/9m		0	10 L	PU		17:02	17:22
36	15/6	400/13m		230	75 L	PU		17:02	17:22
37	11/6	800/9m		180	180 L	PU		19:20	19:55
38	12/6	850/11		220	60 L	PU		19:15	19:25
40	12/2	0		110	20 L	PU		01:30	01:40
42	12/2	0		200	20 L	PU		01:50	02:00
44	12/18	850/10m	17 bar	200	100 L	PU		02:10	02:30
39	12/6	2000/10m	17 bar	200	700 L	PU + 2% URÝCHLOVAČE		03:30	05:10
41	12/6	1600/10m	17 bar	200	460 L	PU + 1% URÝCHLOVAČE		02:35	03:20
43	12/6	1850/11	17 bar	200		PU + 1% URÝCHLOVAČE		02:35	02:57

Grautunarnustur:  $\Sigma = 2235 L$

Athugsemdir (Poznámky):  $\Sigma A = 117,5 KG$   
 $\Sigma B = 1341 KG$   
 \* tlak na kumóniternu  
 39 - 2% URÝCHLOVAČE = 14 L  
 41 + 43 - 1% URÝCHLOVAČE = 41,6 L

Undirskrift (Podpis):  
 V. CELUŠ Verktaki (Zhotovitel)  
 Undirskrift (Podpis):  
 Verktaki (Objednatel)



## Použité materiály Minova

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### ○ injekční hmoty:

- CarboPur WF
- CarboAdd Thix 1
- CarboAdd Thix 2
- GeoFoam

### ○ injekční čerpadla:

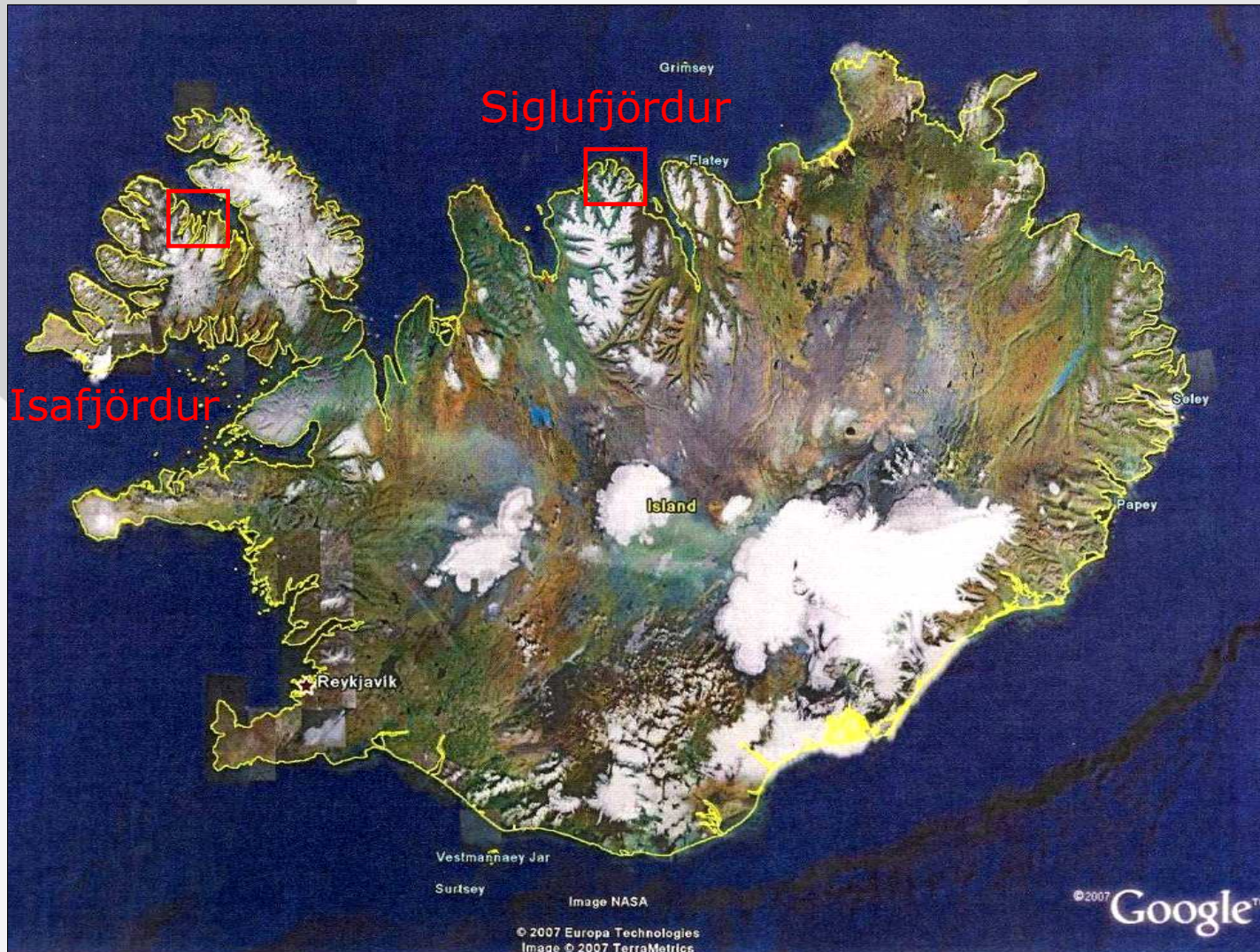
- GX 45
- SK 90 s regulací

### ○ injekční příslušenství:

- pakry BVS 40
- a další

# Tunely na Islandu

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**Děkuji za pozornost**



**Minova Bohemia s.r.o**

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