WEDGE STABILITY ANALYSES ON THE STRENGTH OF FRACTURE ORIENTATION AND FILLING PATTERNS IN THE MÓRÁGY GRANITE FORMATION

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Aim of the research

(1) Block stability analysis

- *Planning of the new repository chambers needed*
  - Fracture orientation analysis and evaluation
  - Main fracture orientation determination in all part of analysis
  - Correlation beetween orientation and types of fracture filling

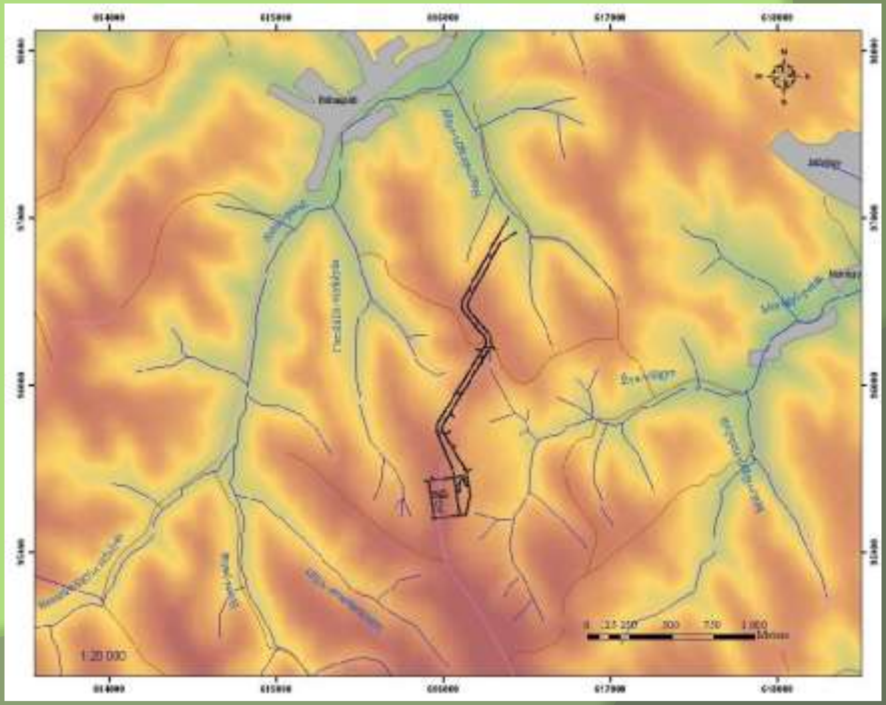
(2) Analysis of the effect of main tectonic structure

- Fracture orientation changes in the surroundings of the main tectonic structures

Introduction

- National Radioactive Waste Repository

  - Mórágy Granite Formation
  - Two chamber were finished
  - Plan of another two chamber

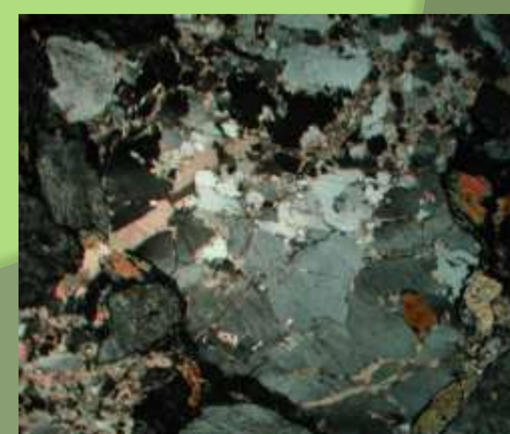


Országh et. al., 2012.

The main geological properties of Mórágy Granite Formation

- Magmatic evolution → heterogenous rock texture
- Difficult deformation history → complex tectonic structures
- Hydrothermal effect → multi-phase fracture-filling

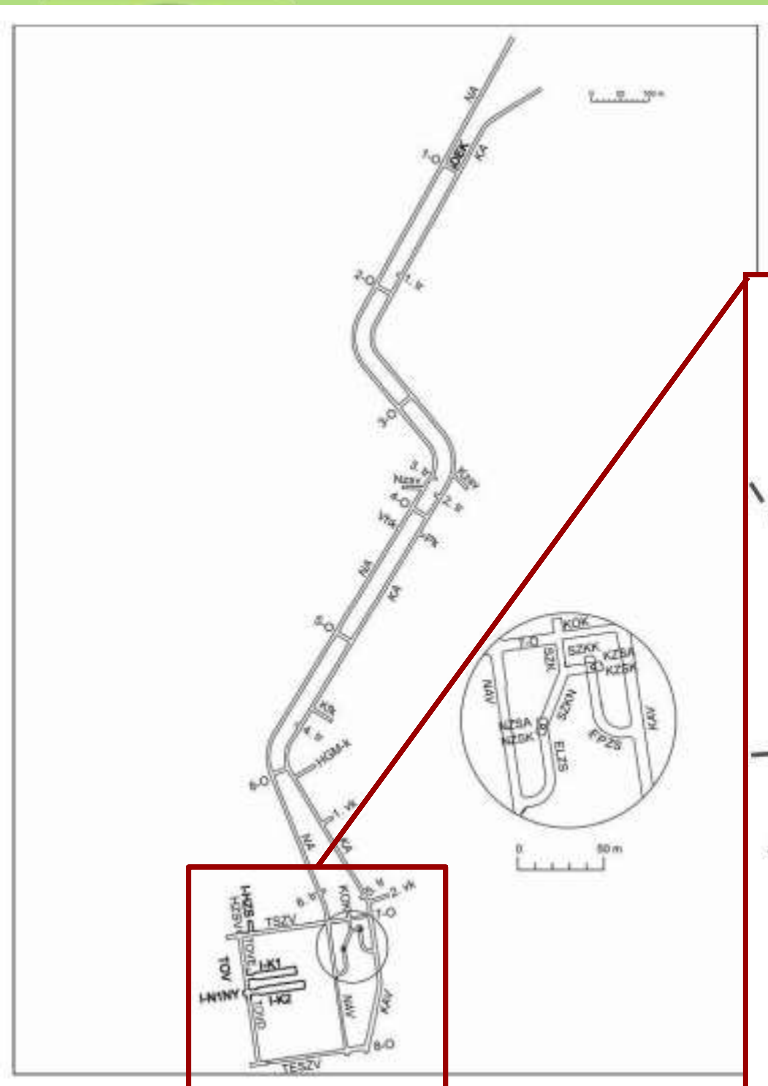
These led to dense network of fractures with different size, orientation and fillings



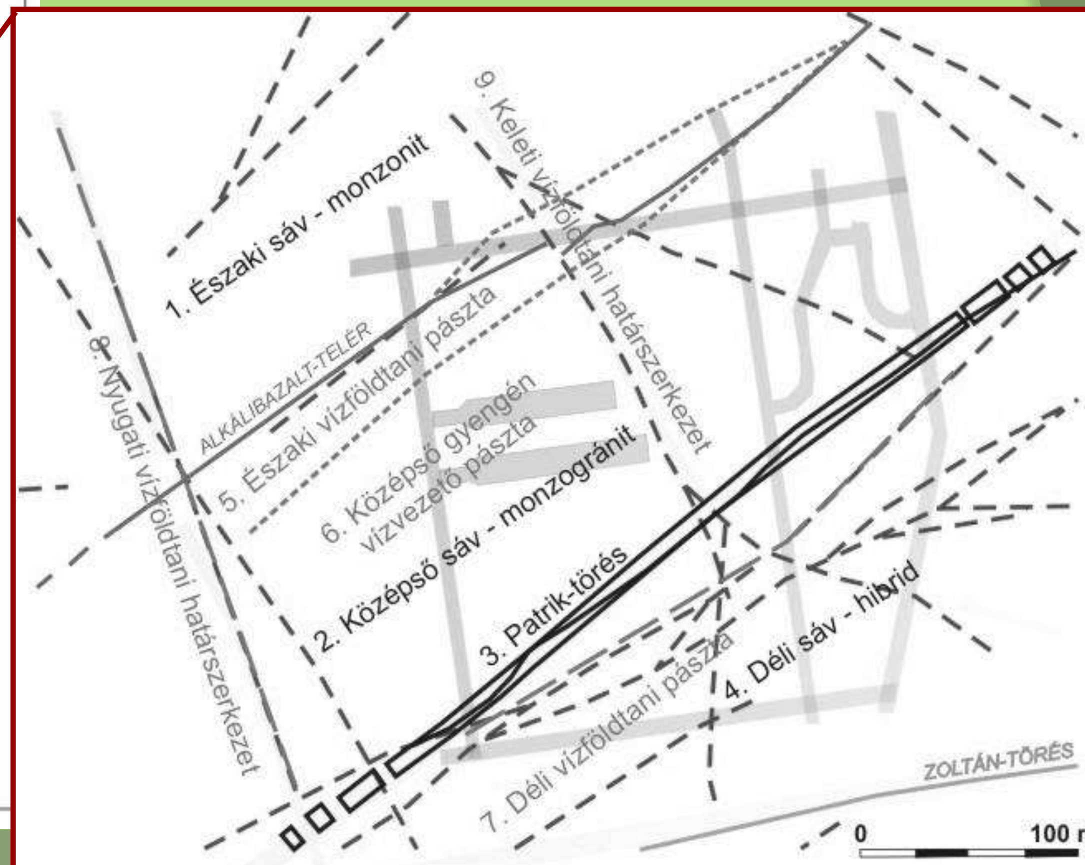
Geotechnical aspects

- Blocky granitic rock alternate with crushed rock of tectonic zones which means different rock strength properties
- Complex fracture orientation
- Different fracture filling type which means different shear strength properties

Overview of the site and the surroundings of the chambers



(Balla, András, 2013)



(Dankó et al., 2012)

Datasets

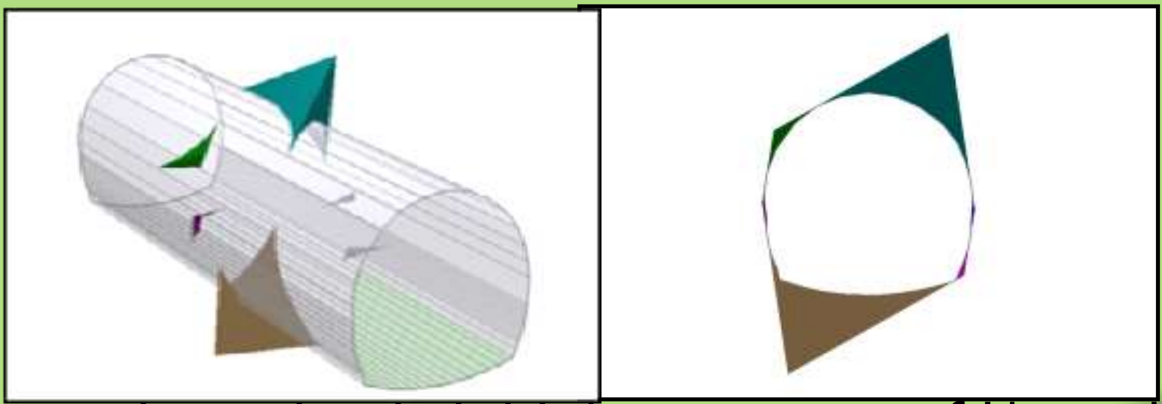
- Two dataset with different point of view
  - Geological (MÁFI)
  - Geotechnical (Kőmérő Kft.)

Tunnel face documentation

- Different evaluation neccesity and validation possibility
- Data interpretation in different ways
  - Full dataset
  - Selected data

Block stability analyses (Unwedge)

- Underground spaces needs tunnel support and tunnel support system needs preliminary design and modelling
- Instabil wedges have the most dangerous factor
- Falling wedges analyses with Unwedge

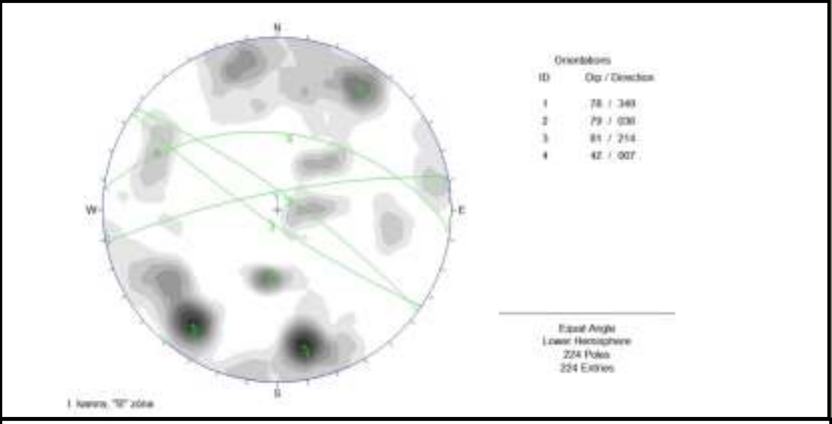


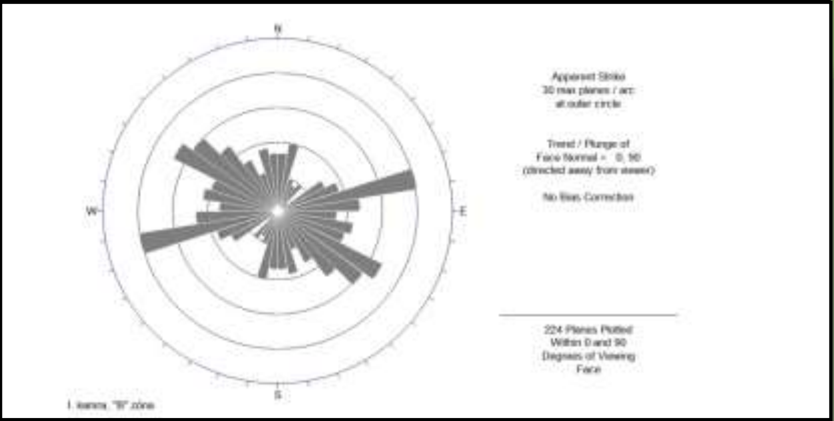
Somodi et. al, 2013.

- Fracture orientation is initial parameter of Unwedge.

Fracture orientation analysis with Dips

- Input: Face mapping data of surrounding area of repository chambers





- Two different type of output
- Average of main orientation
- Determination of the most important orientation

Istovics K.

Results

- ## Results I.
  ↳ Fracture orientation is initial parameter of Unwedge.
  - **Evaluation of geological and geotechnical dataset**
  - Summarization in tables
  - Graphic outputs of orientation analyses
  - Graphic outputs of thickness filling analyses
- ## Results II.
  ↳ *Effect of main tectonic structures*
  - Research area
  - Tunnel face mapping and ABC zones of surroundings of main tectonic structures
  - Summarization in table

Analyses

Geotechnical dataset

- Number of all fracture: 3362 pc
- Type of selection:

  In aspects of fracture filings

  - Filling material → primary
    - Clay fillings, coatings > risky
  - Thickness of fracture fillings → secondary
    - 0,1-1 mm
    - 1-5 mm
    - >5 mm

KŐMÉRŐ	Adatok száma
Összes törés	3362
Összes, vast. < 0.1	16
Összes, vast. 0.1-1	727
Összes, vast. 1-5	1419
Összes, vast. > 5	1198
Agyagos törések	1180
Agyagos, vast. < 0.1	0
Agyagos, vast. 0.1-1	35
Agyagos, vast. 1-5	360
Agyagos, vast. > 5	785

(Istovics K., in: Somodi et al., 2013)

Analyses

Geological dataset

- Number of all fracture: 3337 db
- Type of selection:
  - In aspects of fracture filling material
    - Clay fillings, coatings > risky

- Two analyses to check geotechnical dataset

MÁFI	Adatok száma
Összes	3337
Agyagos	1201

(Istovics K., in: Somodi et al., 2013)

Summary table

- Ten analyses were made and became input into the Unwedge modelling

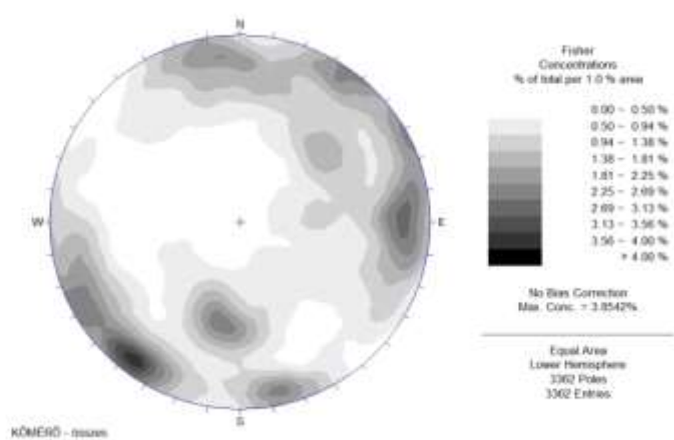
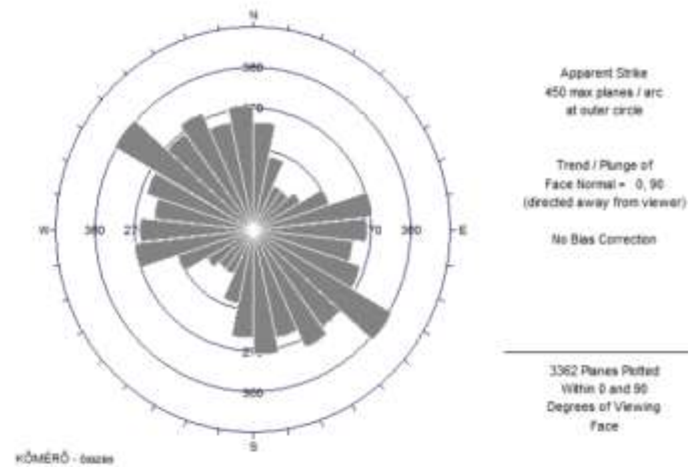
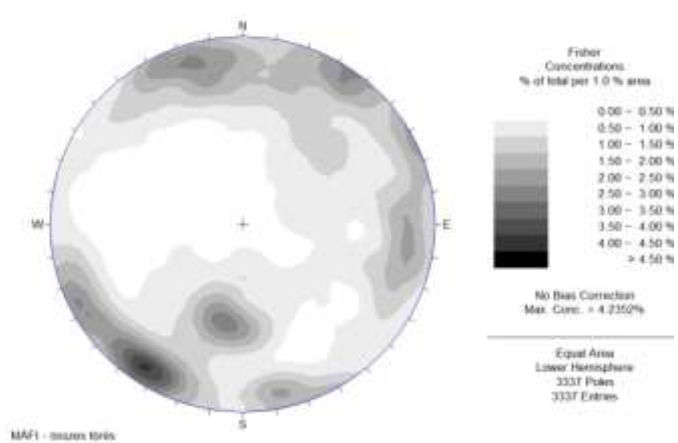
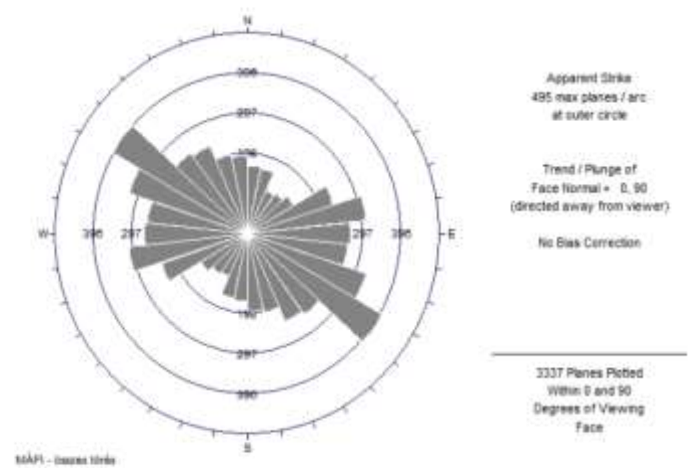
- Result of the analyses

(the most frequent dip angle/direction in degree)

		1	2	3	4	5	6	7	8
KŐMÉRŐ	Összes törés	81/37	74/269	82/60	81/347	45/10	78/174	87/215	89/243
	Össz., vast. > 5 mm	81/37	82/347	81/162	50/7	88/217	84/239	75/274	46/230
	Össz., vast. 1-5 mm	82/63	77/263	78/174	52/230	42/13	83/35	33/262	84/215
	Össz., vast 0.1-1 mm	75/272	76/40	72/83	68/65	87/213	55/165	62/184	33/291
	Agyagos törések	82/37	79/163	81/347	86/62	76/273	49/9	88/243	87/218
	Agyag, vast. > 5 mm	82/37	79/163	82/346	49/9	76/275	89/218	86/243	45/234
	Agyag, vast. 1-5 mm	87/62	89/243	71/263	73/298	78/216	81/164	61/187	78/80
	Agyag, vast. 0.1-1 mm	85/292	84/284	60/188	31/60	82/201	33/216	54/289	39/310
MÁFI	Összes törés	80/33	83/62	44/9	78/164	87/215	88/244	75/275	81/348
	Agyagos törések	45/9	80/163	80/35	86/55	81/346	88/214	87/240	76/264

(Istovics K., in: Somodi et al., 2013)

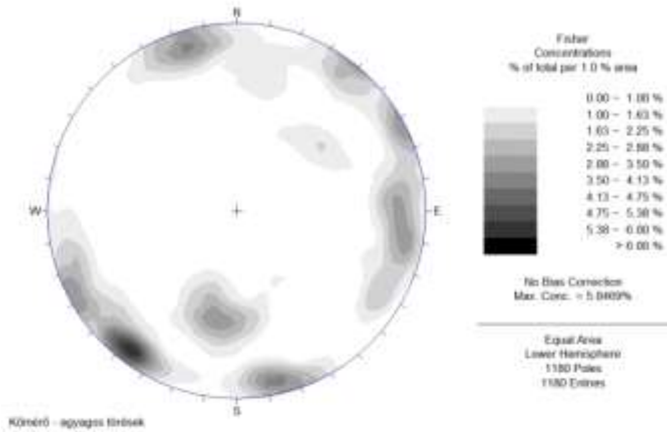
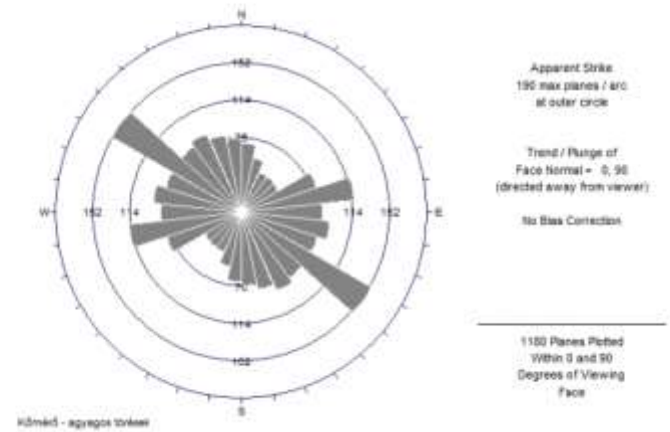
Graphical summary I.

	Fracture density	Plunges
Geotechnical (KŐMÉRŐ) ***Whole dataset***		
Geological (MÁFI) ***Whole dataset***		

(Istovics K., in: Somodi et al., 2013)

Graphical summary II.

<table>
<tr><th></th><th>Fracture density</th><th>Plunges</th></tr>
<tr><td>Geotechnical (KŐMÉRŐ)

Clay filling</td><td>
</td><td>
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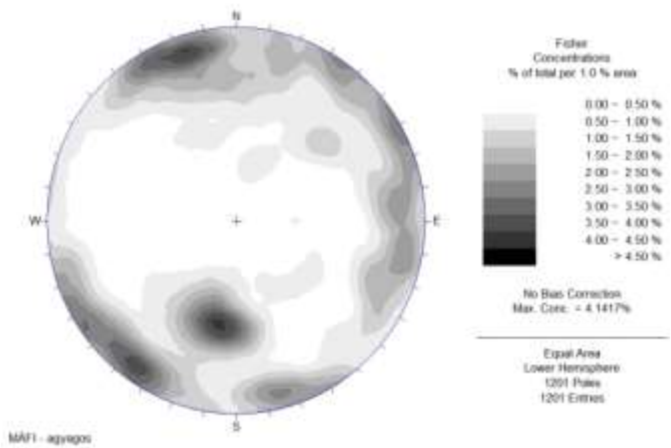
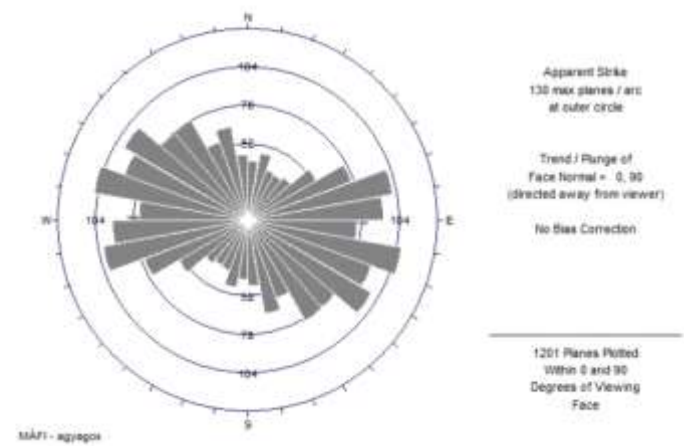
<tr><td>Geological (MÁFI)

Clay filling</td><td>
</td><td>
</td></tr>
</table>

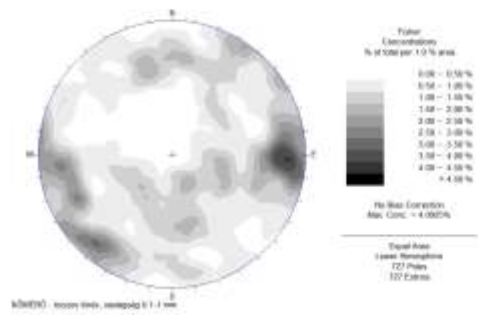
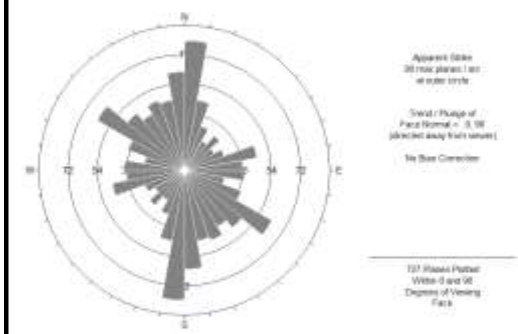
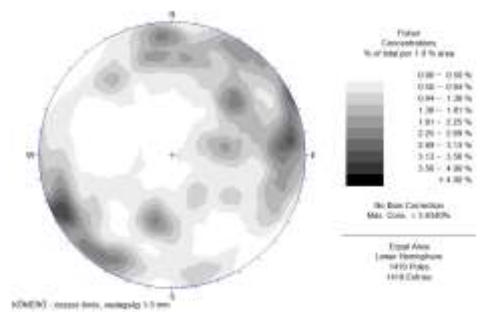
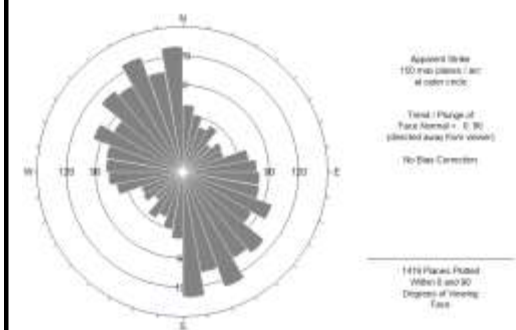
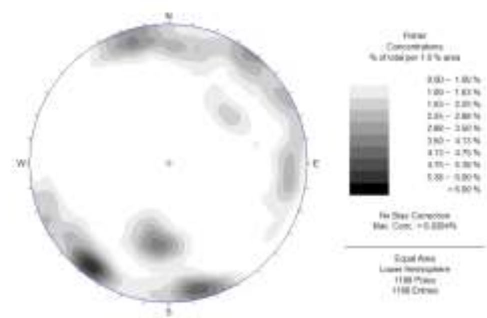
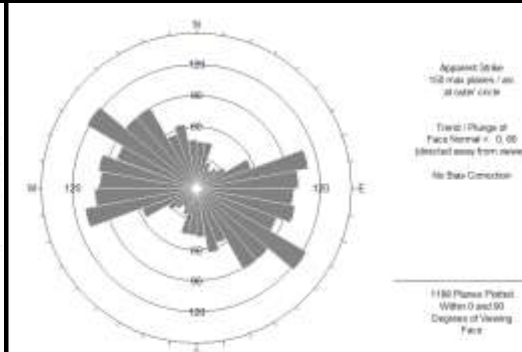
(Istovics K., in: Somodi et al., 2013)

Discussion – I.

- Two dataset fits well with each other
- Analyses of all fractures and clay filling fractures show similar patterns
  - The only difference is a more domnant North direction dipping pattern in geotechnical dataset
- Database:
  - Number are similar
  - Fractures with clay fillings: → It has bigger scatter in geological database
  - Dominant orientations: - NW-SE with northern dip
    - E-W, with southern dip
  - Theres is no presence of NE-SW

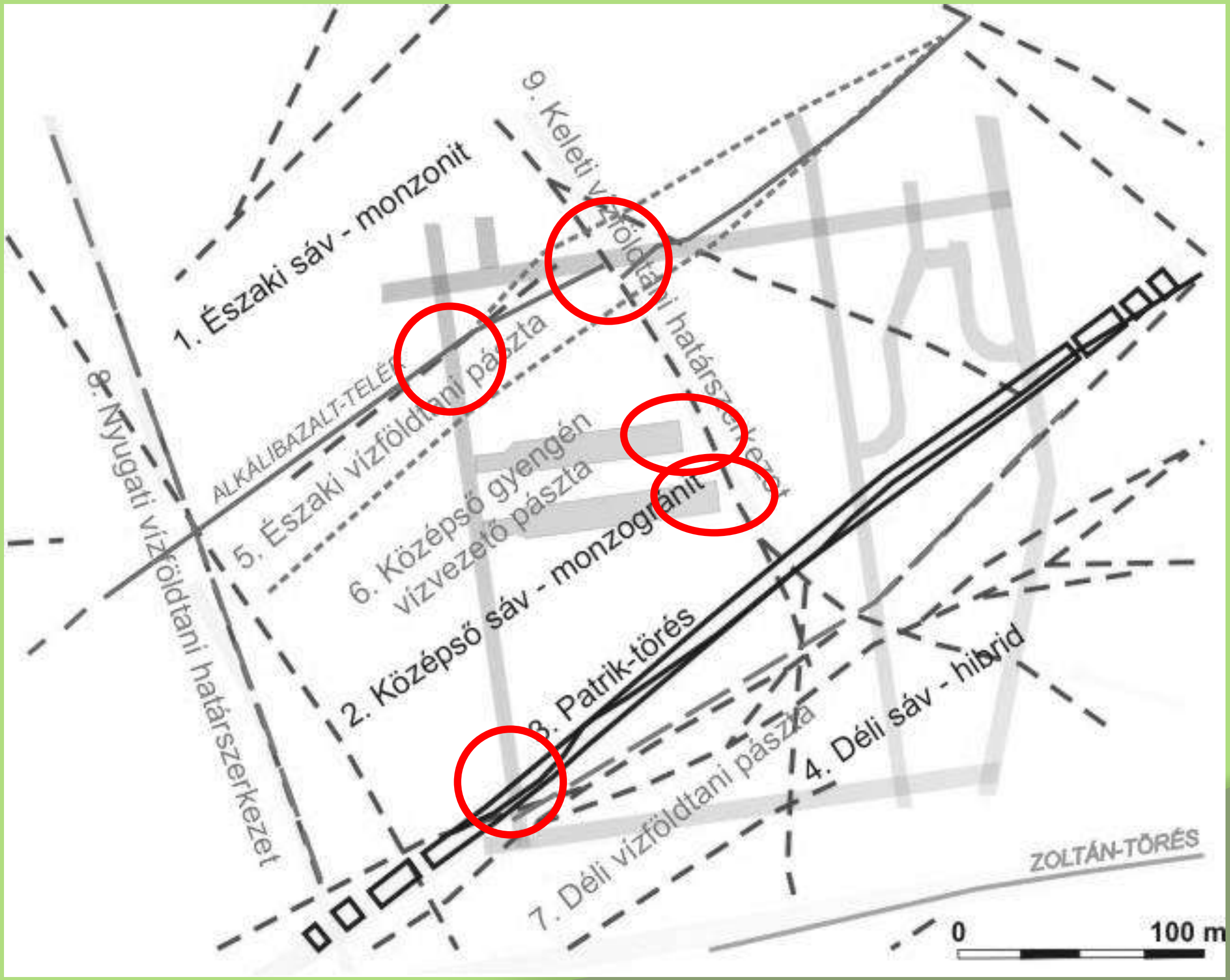
Discussion – II.

- Some filling material is charachteristic in different dominant fracture orientation and filling thickness

Thickness of fracture fillings	**Fracture orientation density plot**	**Rose diagram**
0,1-1 mm		
1-5 mm		
>5 mm		

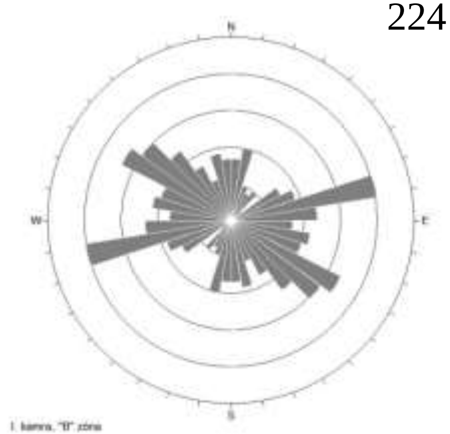
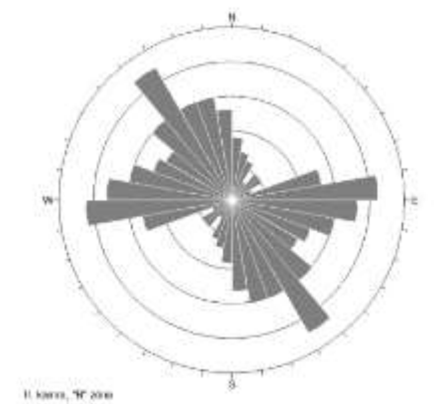
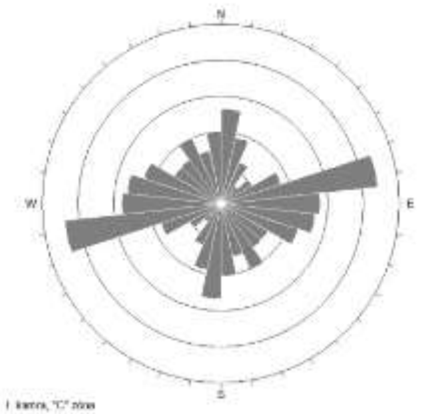
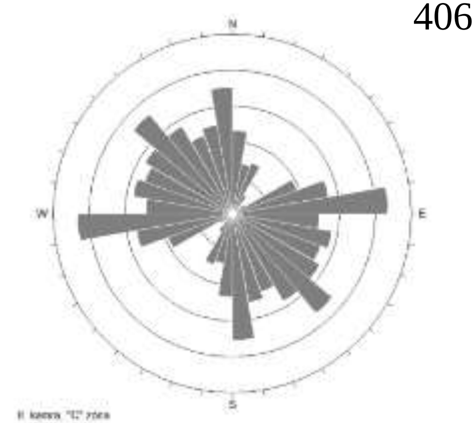
(Istovics K., in: Somodi et al., 2013)

Analysis of the effect of main tectonic structure



Dankó et al., 2012

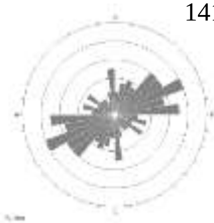
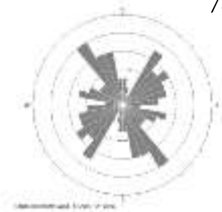
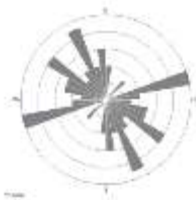
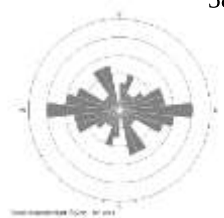
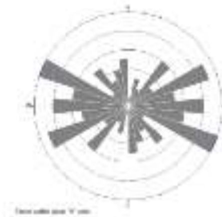
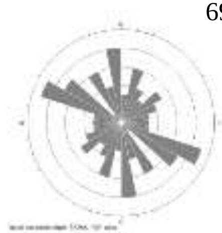
Supposed orientation: NNW-SSE

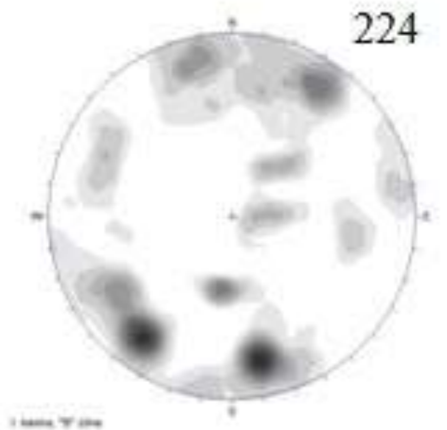
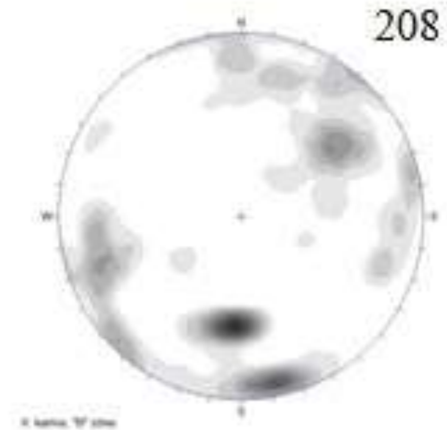
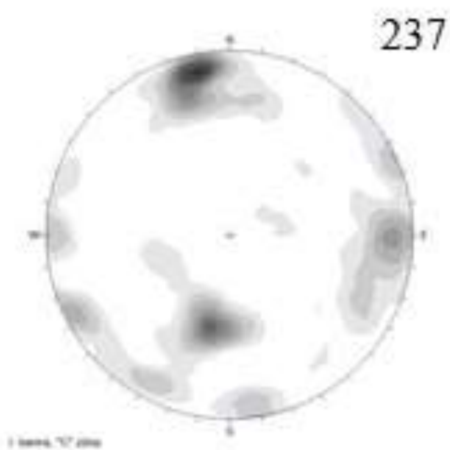
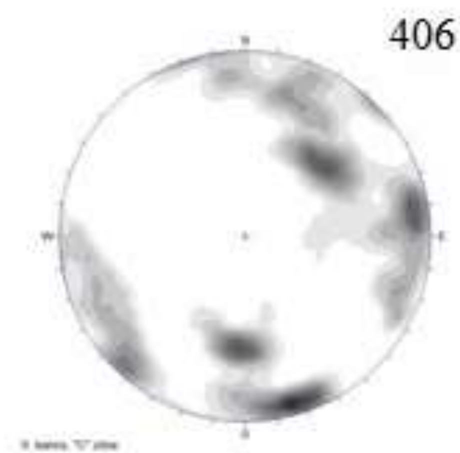
Names of the zones	I-K1 repository chamber	I-K2 repository chamber
„B" zone	224 	208 
„C" zone	237 	406 

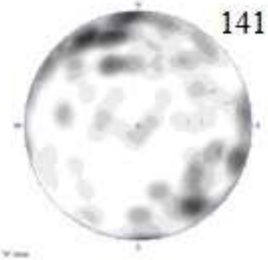
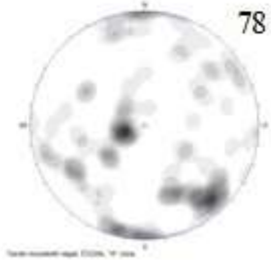
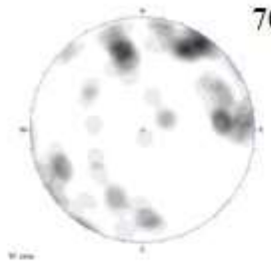
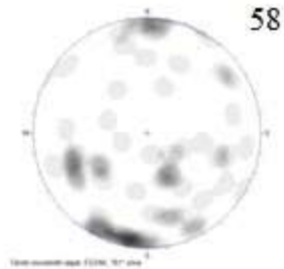
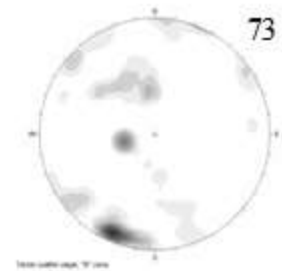
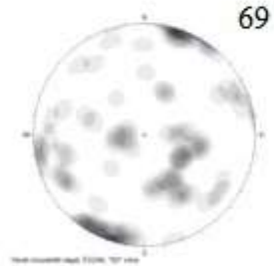
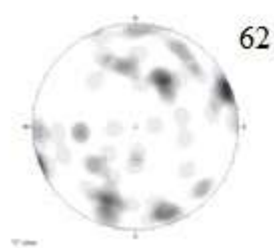
Supposed orientation NE-SW

Supposed orientation NE-SW

Supposed orientation NNW-SSE

Names of zones	TOVD	TOVE	TSZV
„A” zone	141 	78 	85 
„B1” zone	70 	58 	73 
„B2” zone		69 	
„C” zone	62 	72 	

Fracture orientation density	**I-K1 chamber**	**I-K2 chamber**
„B” zone		
„C” zone		

Fracture orientation density	TOV - D	TOV - É	TSZV
„A” zone	141 	78 	85 
„B1” zone	70 	58 	73 
„B2” zone		69 	
„C” zone	62 	72 	

- The most frequent fracture orientations:

	I-K1 **(NNW-SSE)**	**I-K2** **(NNW-SSE)**	**TOV-E** **(NE-SW)**	**TOV-D** **(NE-SW)**	**TSZV** **(NNW-SSE)**
A zone			NE-SW NW-SE	NE-SW	NE-SW E-W
B zone	NW-SE WEW-ENE	NW-SE E-W	E-W	NW-SE NE-SW	NE-SW E-W
(B_2 zone)			N-S NW-SE		
C zone	E-W N-S	E-W N-S	N-S	NW-SE N-S	

Discussion – III.

- Our results are not conform with Benedek & Molnár (2013).
- Differences may come from:
  - Scale effect (borehole ⇔ tunnel)
  - Different type of fracture mapping:
    - Borehole TV: wider range of fractures
    - Tunnel face mapping: some kind of ordinary geological documentation
- „Patrik fracture zone” and „East-hydrogeological boundary” (EHB) have strongly affect on the orientation of fractures.
- B zone of Patrik fracture zone become input dataset of Unwedge.

Conclusion

- General fracture properties:
  - Geotechnical and geological documentation results are similar in spite of different aspects
  - Fracture with clay fillings and all fractures have the same dominant orientations.
  - Differences comes from the distribution of the thickness of the filling material.
- Porperties of main tectonic structures:
  - Surroundings of „Patrik fracture” and „EHB” shows more dominant and clear structure patterns than others
  - In other cases → *research needs new approaches*

Further research

- Revelation of relationships in MGF
  - Is there any correlation beetween orientation of fracture zone, orientation of fractures with clay filling and results of in-situ stress measurements? (overcoring, CSIRO-HI)
  - Has the main structures and clay filling structures any in situ stress-modification effect?

Acknoledgement

- *László Kovács, Kőmérő Kft*.
- *PURAM (Radioaktív Hulladékkezelő Közhasznú Nonprofit Kft.*)
- Last but not least we are thankful to **M. Tóth Tivadar** for advices.

Thank you for your attention!