EUROCK 15
64th GEOMECHANICS COLLOQUIUM

geomecon GmbH

Re-evaluation of the in situ stress field at Forsmark, Sweden

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INTERNATIONAL SOCIETY FOR ROCK MECHANICS

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Why stress is important

> stress defines the mechanical performance of rock

> stress influences the behaviour of fractures and faults

> stress determines the hydraulic behaviour of the geosphere system

Stress field understanding is a prerequisite for any geomechanical analysis!

Content

> consolidation of the stress field information available on the Forsmark area

> discussion of consistency of data interpretation

> derivation of an alternative stress model

Existing basic stress models (500m level)

SH [MPa]	Sh [MPa]	SV [MPa]	P_P [MPa]	stress regime	reference
41.0 ± 6.2	23.2 ± 4.6	13.3 ± 0.3	5	reverse	Martin, 2007: SKB's "most likely"
22.7 ± 1.1	10.2 ± 1.6	13	5	strike-slip	SKB, 2009: SKB's "unlikely minimum"
56 ± 6	35 ± 15	13.3 ± 0.3	5	reverse	SKB, 2009: SKB's "unlikely maximum"
22.7 ± 1.1	10.2 ± 1.6	13	5	strike-slip	Ask et al. 2007

Comments on stress field models

> SKB: hydraulic data omitted, as results contradict general regime in Fennoscandia

but: Stephansson et al. (1991) suggest a transition regime (RF to SS) for that depth

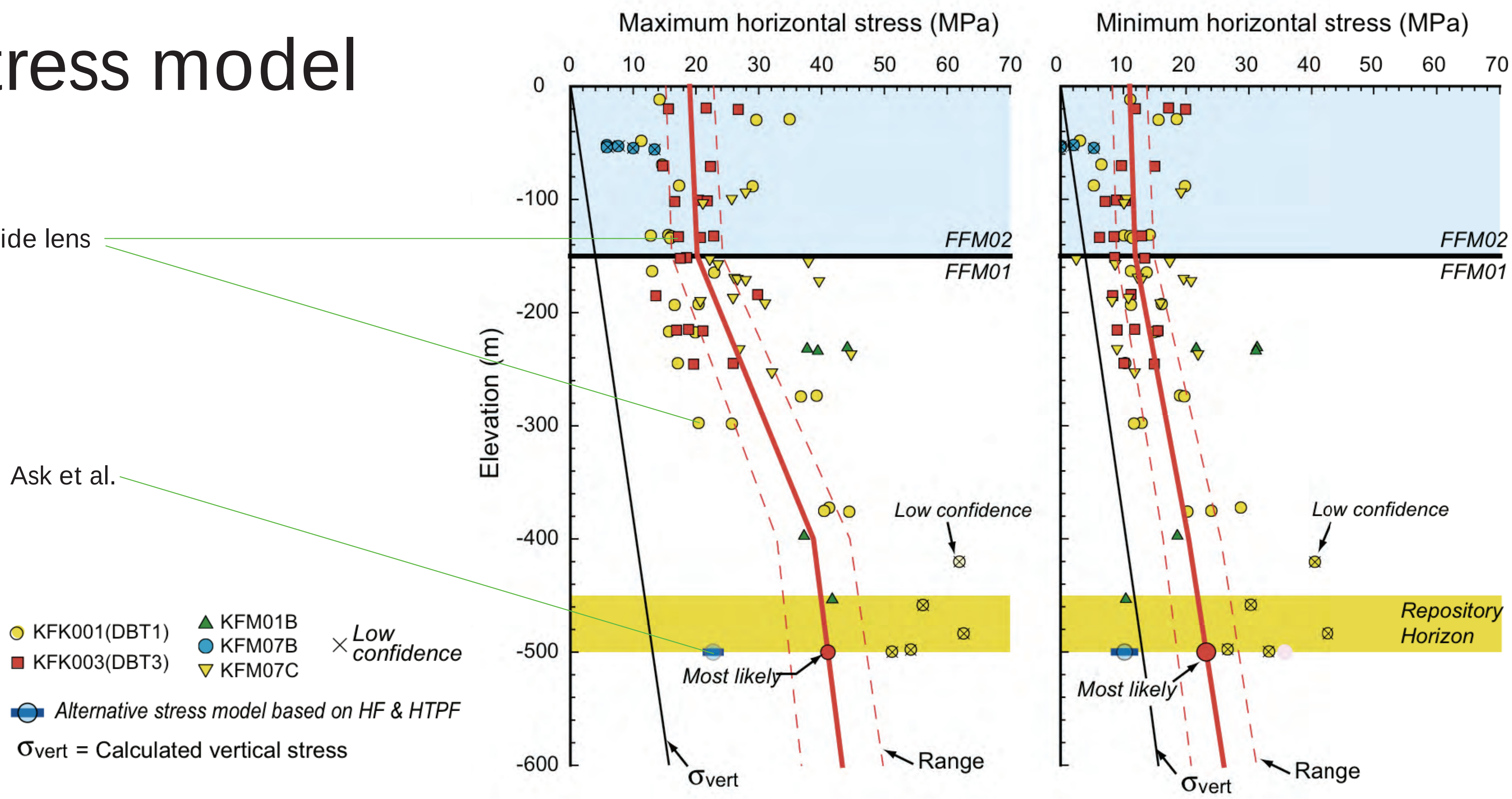
> SKB: individual measurements omitted

> Ask: relies heavily on hydraulic data

SSM stress model

wells DBT 1 and 3 outside lens

Ask et al.



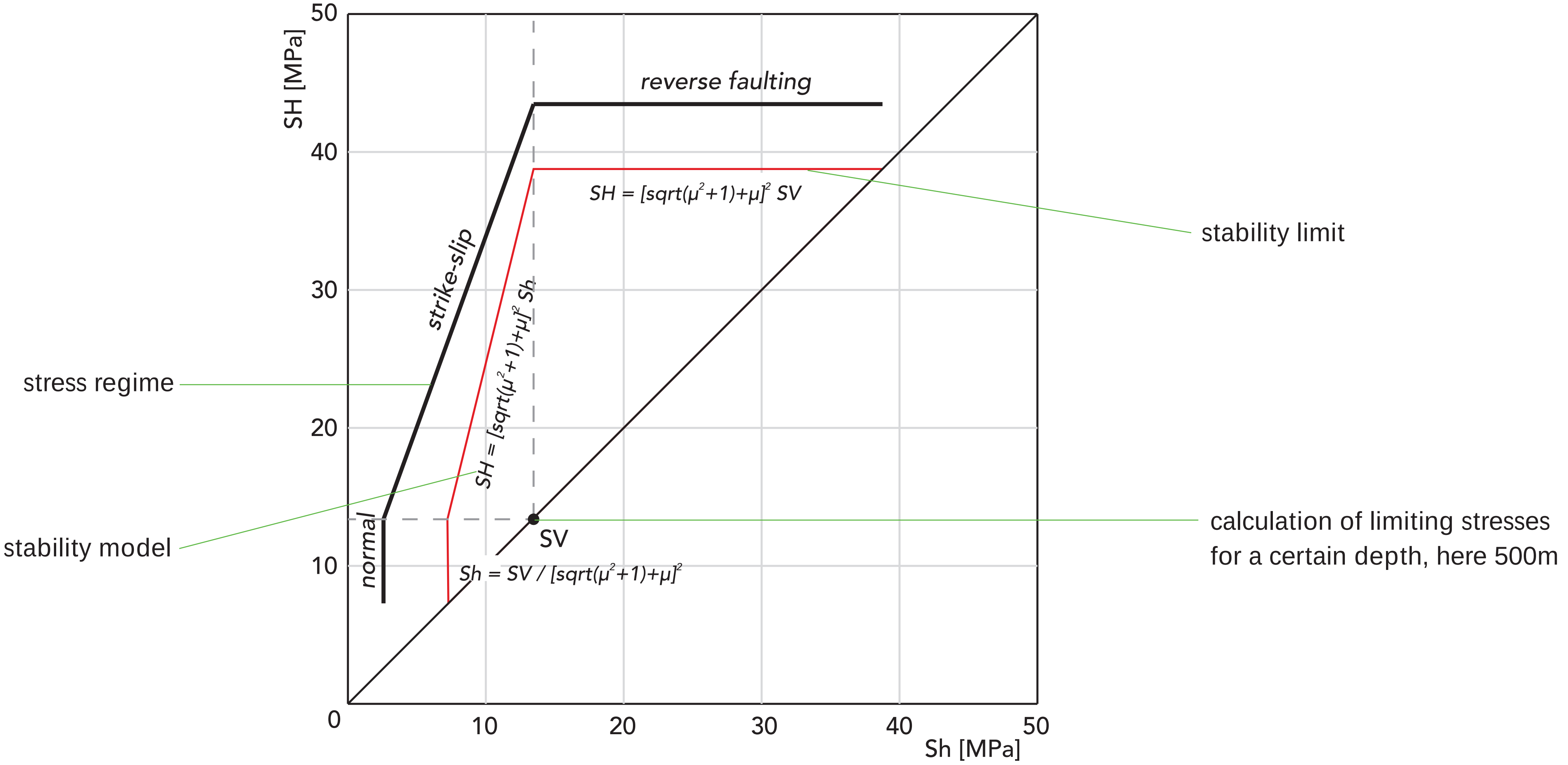
Applied methodology

Stress polygon analysis (aka concept of limited stress ratios)

> assumption: unfavourably oriented fractures limit the strength of the rock mass

> hence, the frictional strength of the fractures limits the possible stress states

references: Peska and Zoback 1995, Jaeger et al. 2007


SH [MPa]
Sh [MPa]
0
10
20
30
40
50
reverse faulting
strike-slip
normal
SH = [sqrt(μ²+1)+μ]² SV
SH = [sqrt(μ²+1)+μ]² Sh
Sh = SV / [sqrt(μ²+1)+μ]²
SV
stability limit
stress regime
stability model
calculation of limiting stresses
for a certain depth, here 500m

SSM most likely

> outside stability limit as reported by SSM

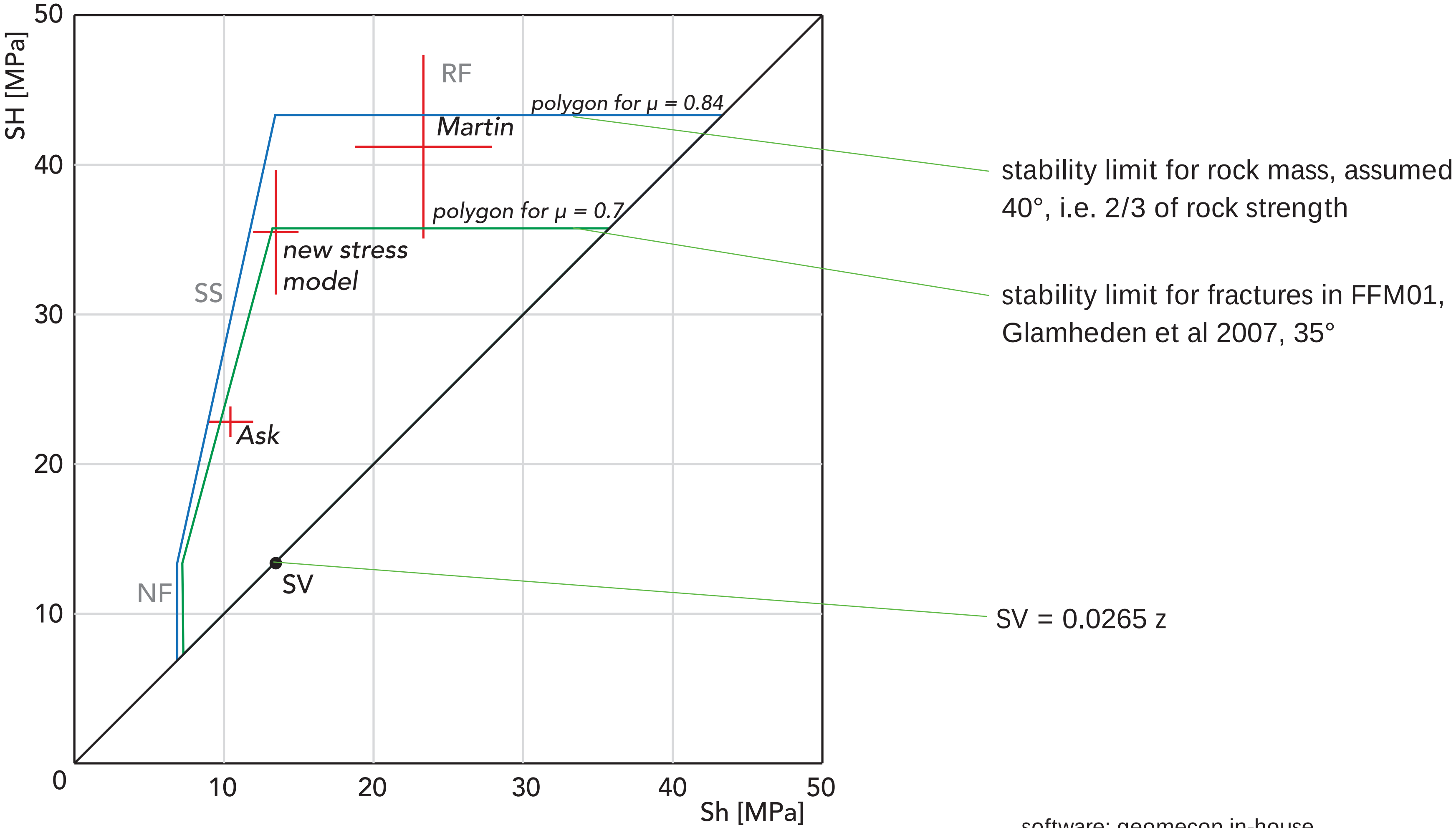
> but still within rock strength

> critical fracture orientations would be gently dipping like ZFMF1 or ZFMF2

> but healed fractures would allow for larger stresses

Ask et al.

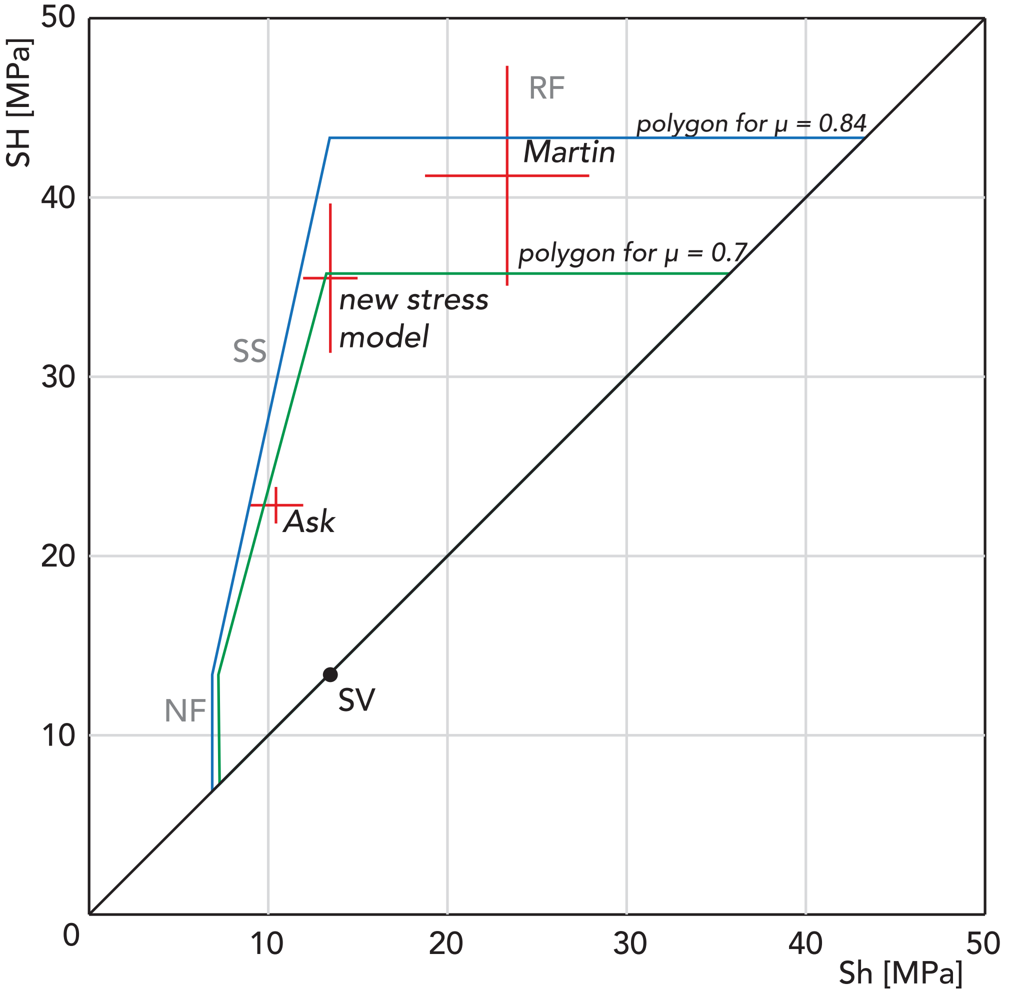
> within and close to the stability limit



software: geomecon in-house

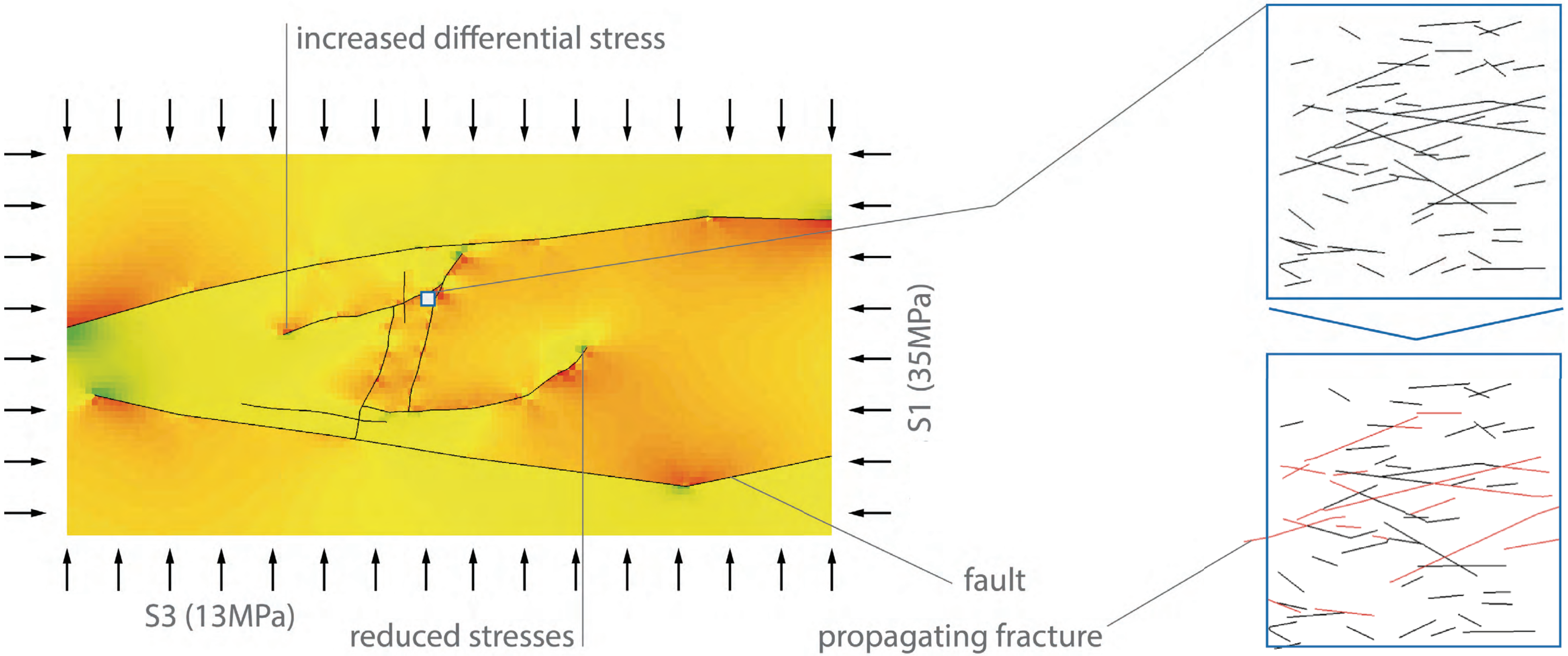
new stress model

> structural geology indicates transitional regime
> indication of SV and Sh convergence in hydraulic data (Ask et al. 2007, Lindfors et al. 2005, Klee and Rummel 2004)
> below 300m there is only limited data, except the hydraulic measurements



software: geomecon in-house

local stress variations (simulation with roxol, www.roxol.de)



Conclusions

> indications for transitional regime (RF to SS) consistently in literature for repository level

> with considerations about rock mass strength, we propose an estimate with
$SH \approx 35MPa$, $Sh \approx SV \approx 13MPa$

> data density very limited, additional parameter determination and stress measurements are needed

> stress field inversion modelling suggested

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