X

Memo – Comments on SSM's review of SKB's earthquake modelling

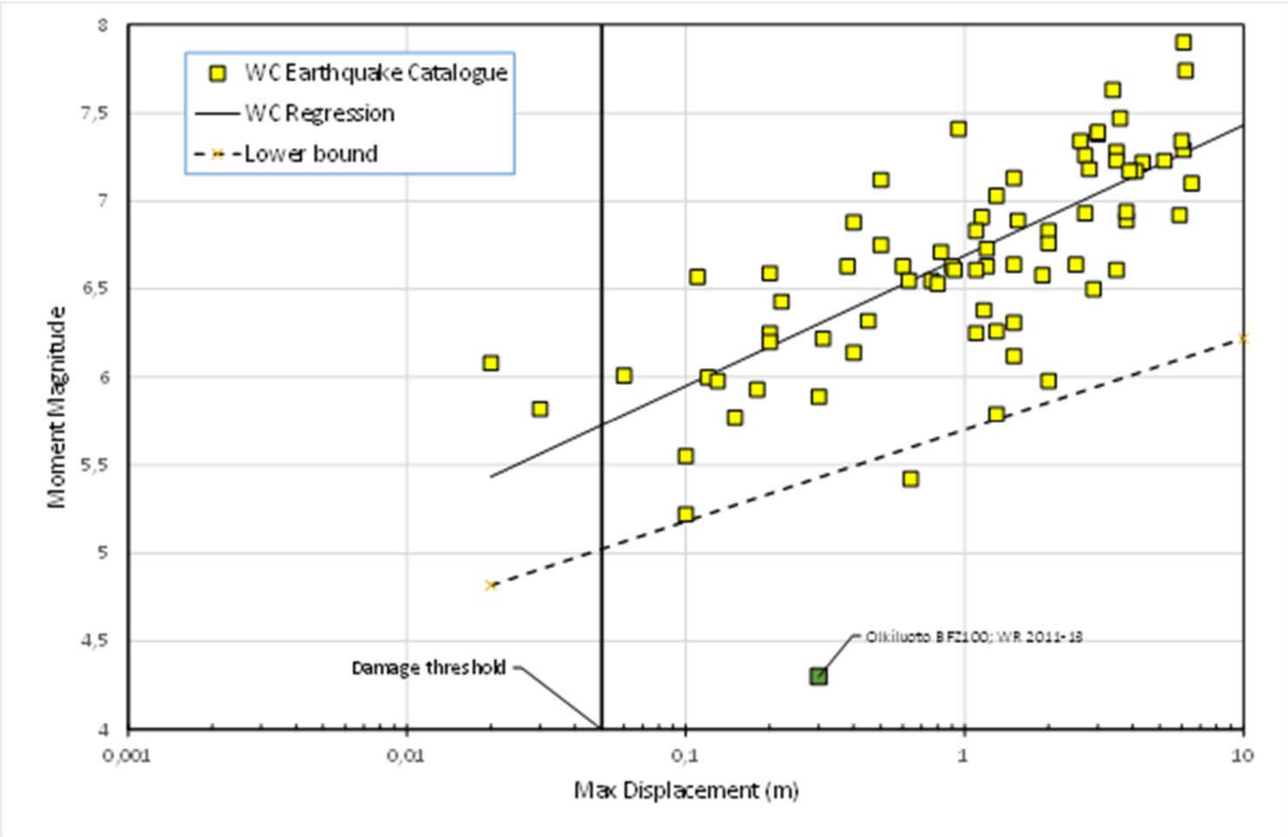
Valda bilder, kapitelvis presenterade, som underlag för diskussion.

1

Introduktion

1

Respektavstånd kring mindre zoner



En primärrörelse av 50 mm fordar ett skalv skalv av (minst) magnitud 5.

Ingen sekundärrörelse i någon av de modeller som hittills analyserats har varit större än 10% av primärrörelsen, inte ens för fall där målsprickan har skurit genom primärzonen. I själva verket behövs därför ett skalv av minst magnitud 5.5, vilket svarar mot en ”rupture area” av ca 20 km^2 .

Här finns dessutom marginaler:

- Lower bound – regressionen
- Rupture area – fault area

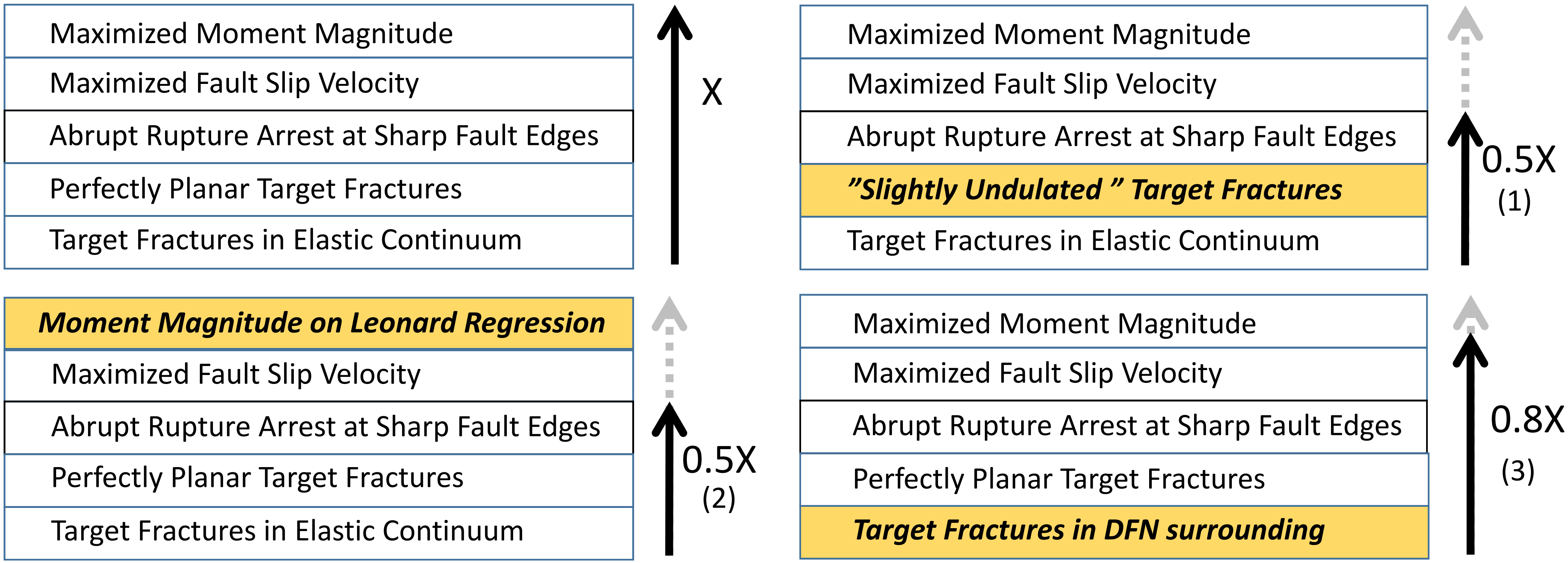
2

3DEC modelling approach

Perspectives on Conservativeness in 3DEC ”What-if” Approach

Approximate impact of more ”realistic” input assumptions: Examples

X = largest target fracture slip (e.g. mm of slip per mm of target fracture diameter)



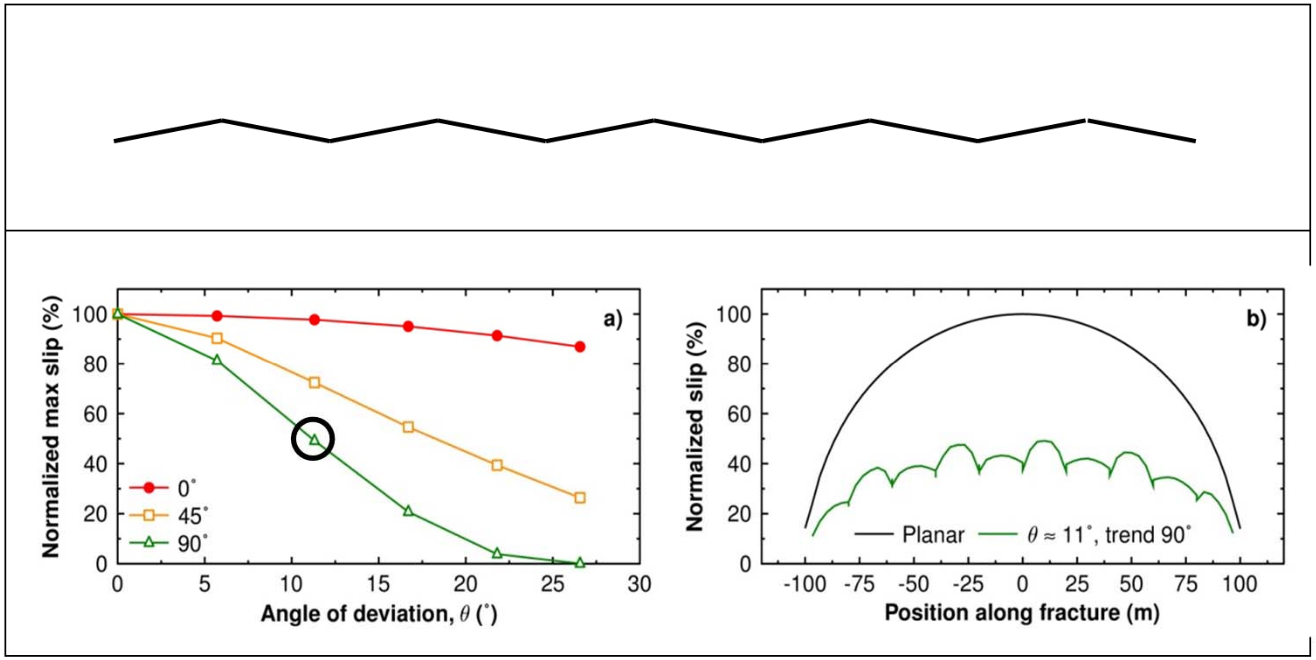
(1) Lönnqvist M, Hökmark H, 2015. Assessment of method to model slip of isolated, non-planar fractures using 3DEC. ISRM Congress 2015 Proceedings - Int’l Symposium on Rock Mechanics - ISBN: 978-1-926872-25-4.

(2) Fälth B, Hökmark H, 2015. Effects of Hypothetical Large Earthquakes on Repository Host Rock Fractures. Posiva Working Report 2015-18, Posiva Oy

(3) Test model, not published

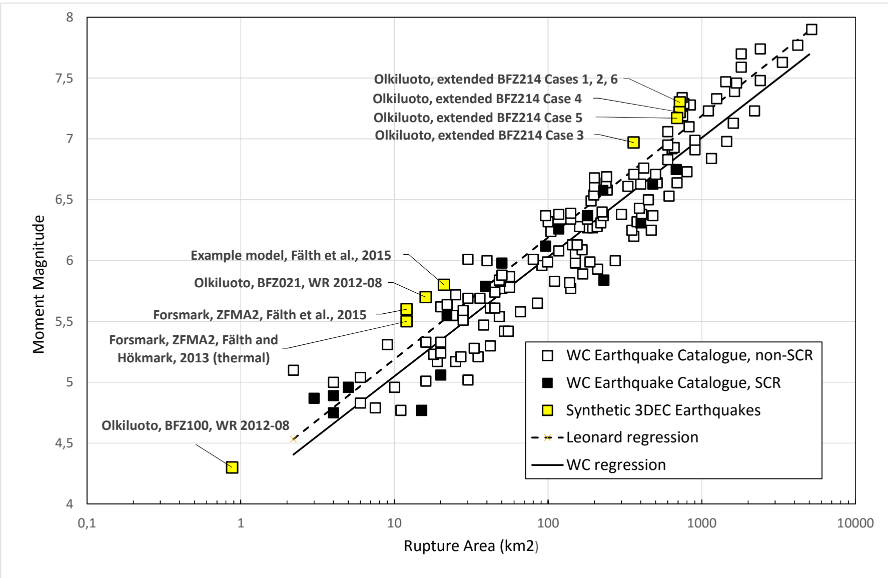
2

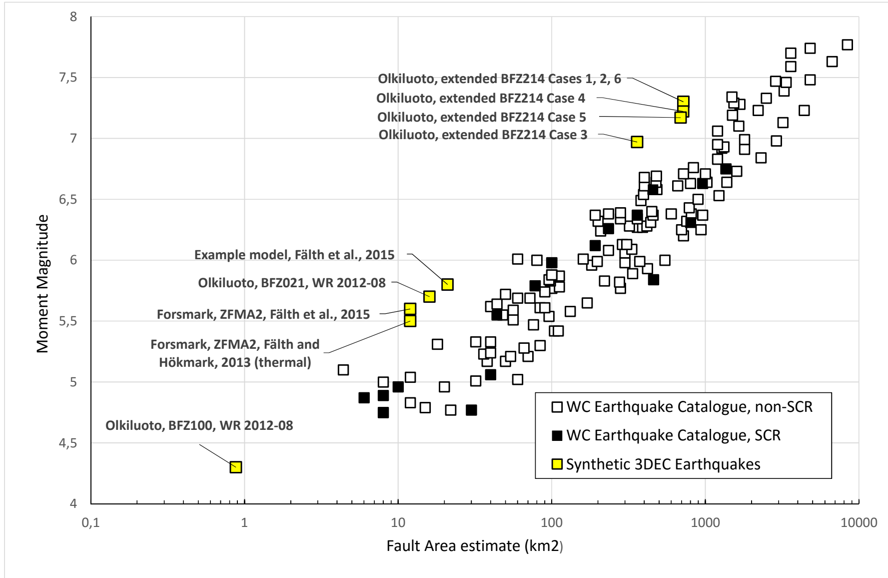
Planar fractures vs undulated fractures



2

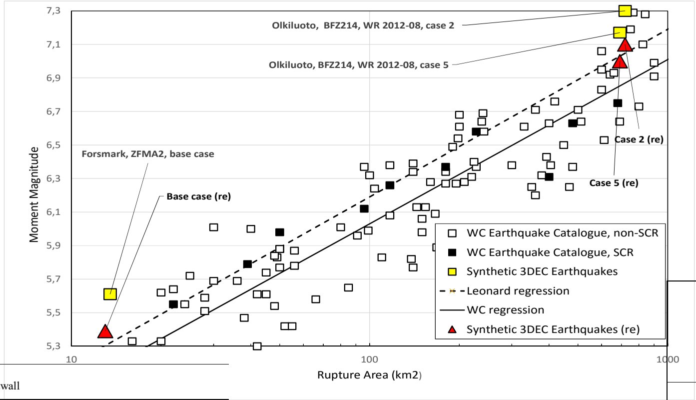
Magnitude overestimates

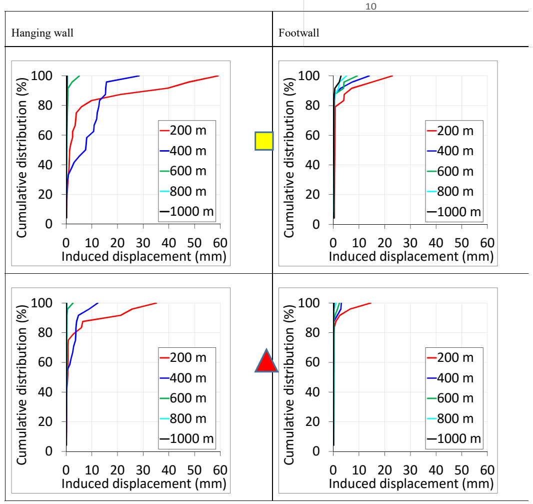




2

Magnitude overestimates



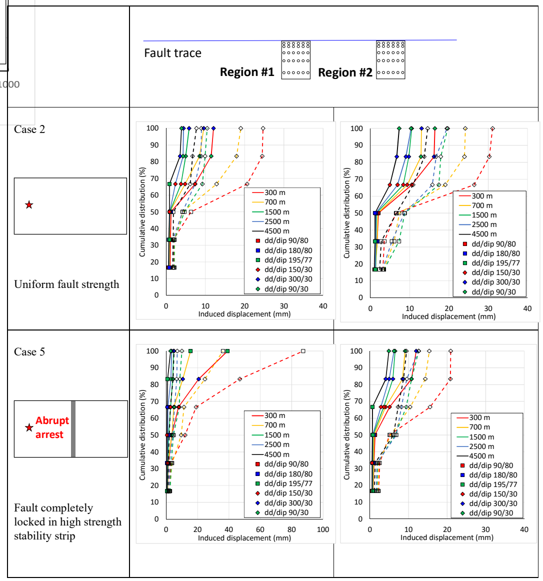


Forsmark ZFMA2, endglacial

Olkiluoto BFZ214, Present day

Dotted lines

Full lines



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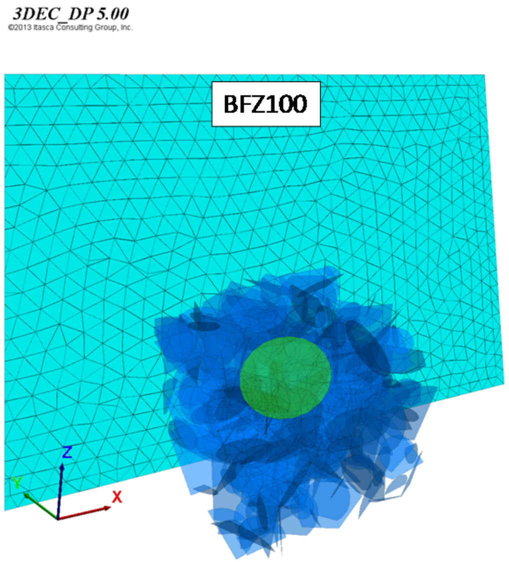
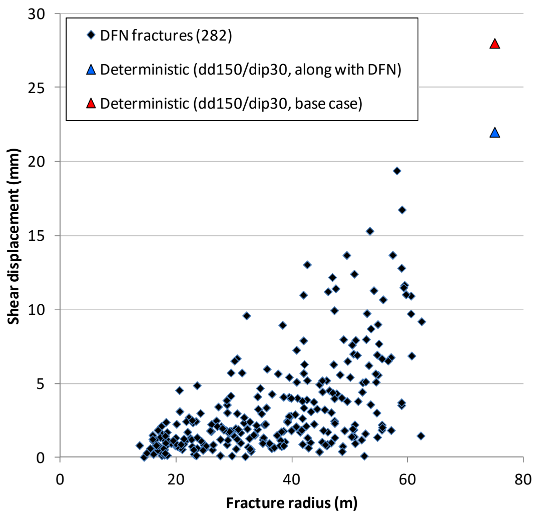
Target fractures in DFN surrounding





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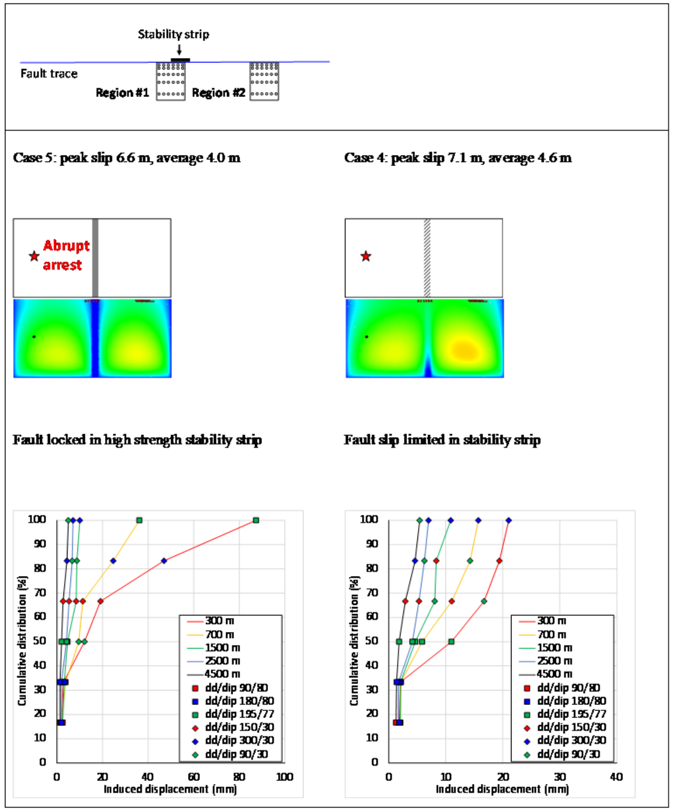
Sharp fault edges
(or edges of fault inhomogeneities)



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Comments on Technical Note 2014:59

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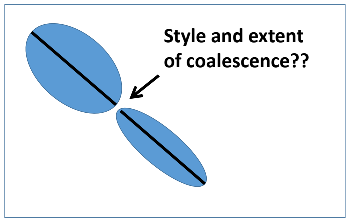
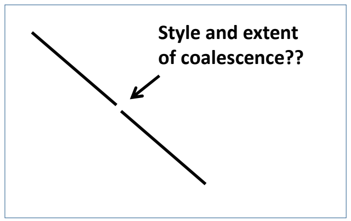
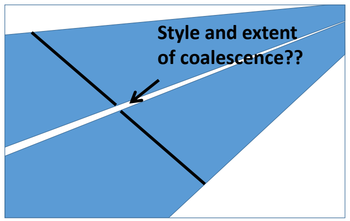
2D – 3D, coalescence

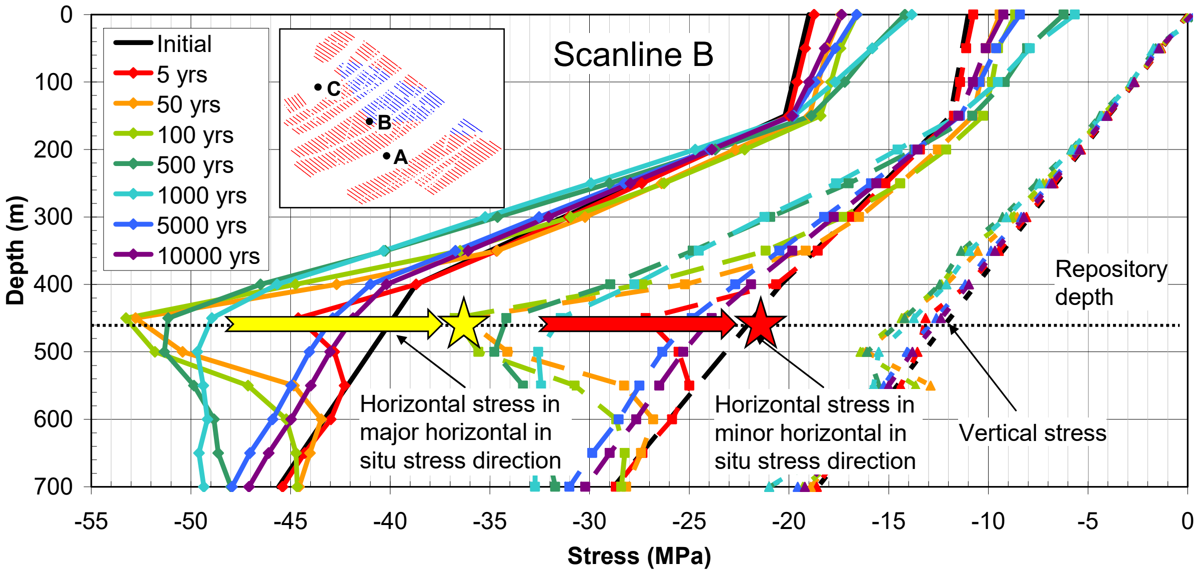
		
Rock bridge between two neighbouring 3D fractures	2D representation of rock bridge	3D equivalent of 2D representation of rock bridge

3

2D – 3D, thermal load

Major horizontal principal stress in PFC2D model after 25 years of heating

Minor horizontal principal stress in PFC2D model after 25 years of heating



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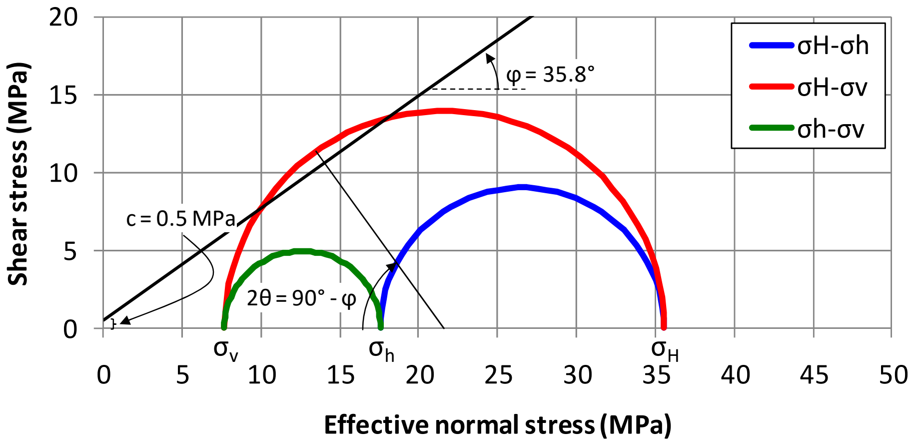
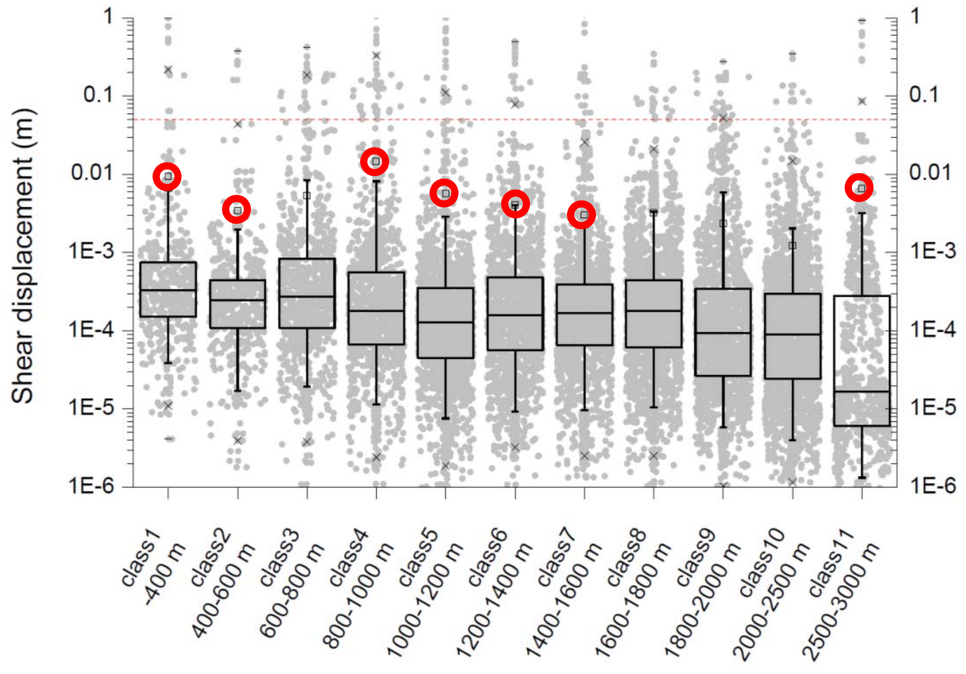
2D – 3D, thermal load



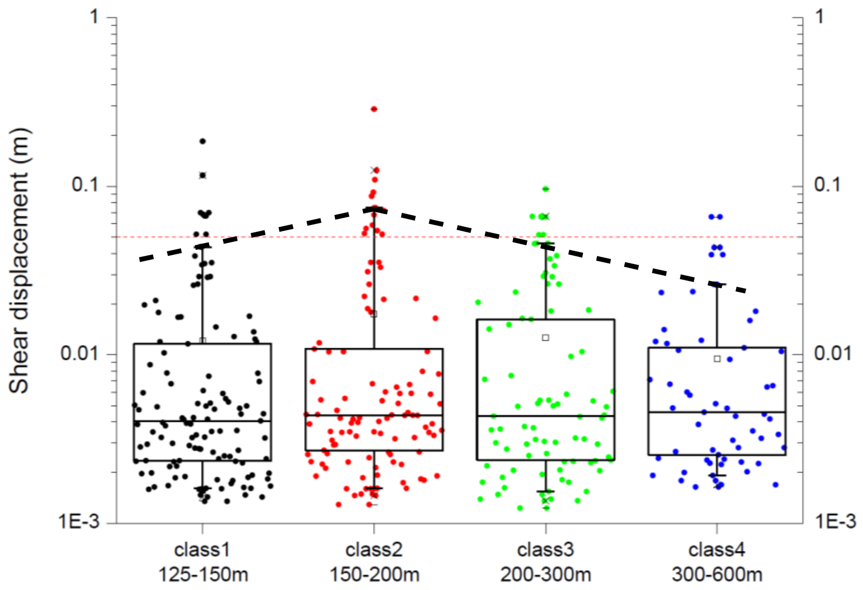
Blue Mohr circle shows stability of the vertical fractures considered in the horizontal 2D sections analyzed in the thermomechanical PFC models. Stability margins are 10 MPa and more (if pore pressure is accounted for as in this figure. If not, stability margins are even larger). Within the repository footprint, both horizontal stresses increase during heating, pushing the blue Mohr circle further to the right.

3 Impact and handling of outliers



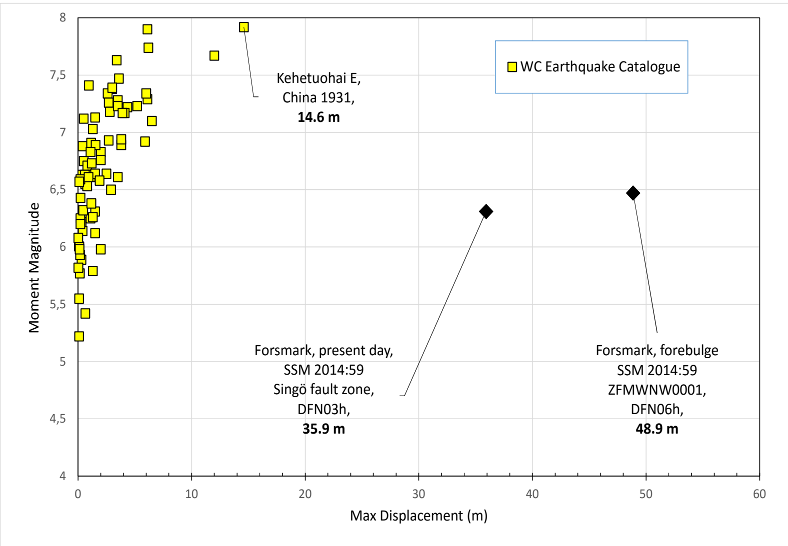
Mean displacements in most distance classes are non-trusted outliers, i.e., :
> 50 % of the smooth joint slip caused by numerical errors.

3 Impact and handling of outliers



50 mm slip on 195 m long fracture counts as trusted result. Same slip on 205 m long fracture counts as ”outlier”, caused by numerical errors.

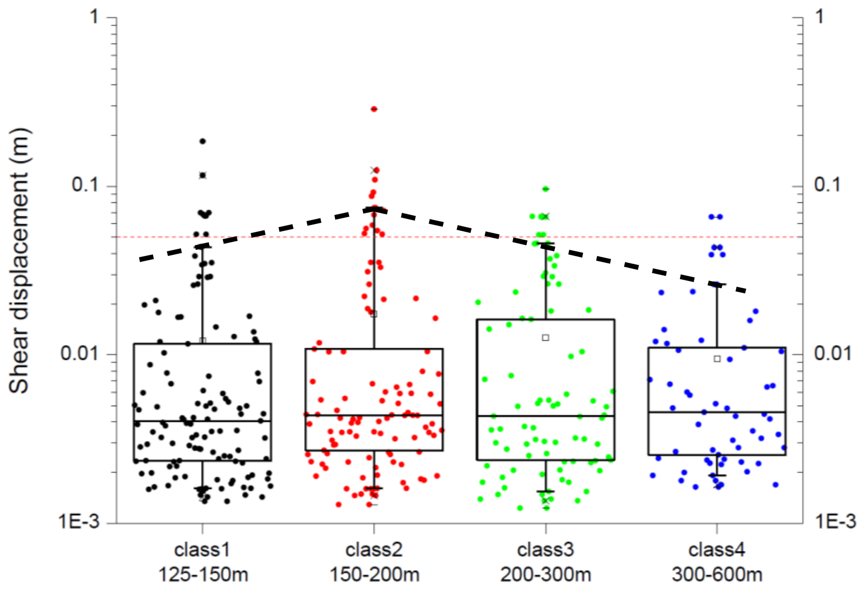
3 Unrealistic results



2D representation of Singö fault zone produces 3 times larger fault slip than maximum slip documented in WC crustal earthquake database.

To match these slip results, one needs to compare with the largest subduction zone earthquakes ever instrumentally recorded, such as the Tohoku 2011 earthquake with a 400 km by 200 km rupture area.

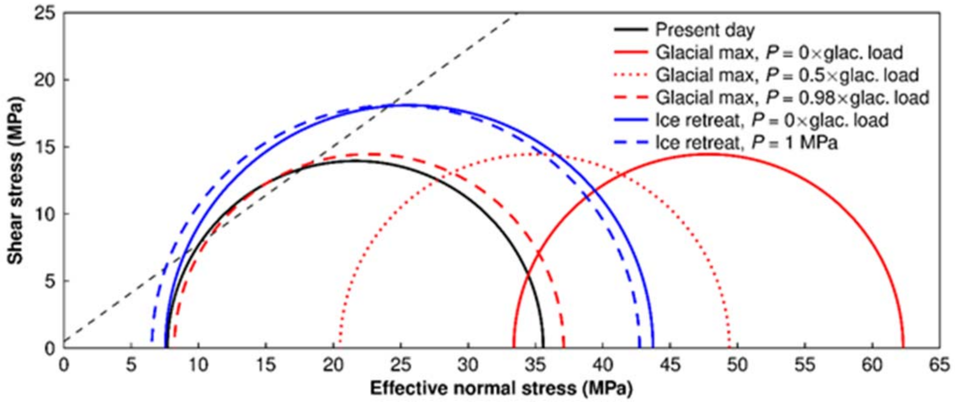
3 Unrealistic results



Maximum displacement along large Class 3 and Class 4 fractures systematically significantly smaller than largest displacement along smaller Class 2 fractures subjected to same load.

No explanation given.

3 Choice and outcome of modelling cases



11 modelling cases out of 38 regard the time of the stable glacial maximum.
8 cases regard the time of potential instability during ice retreat

Stabilized ZFMA2 produces larger earthquake at time of glacial max than destabilized ZFMA2 at time of ice retreat. No explanations given.

4

As demonstrated and discussed in the previous chapter, there is a range of issues regarding the approaches and the results in Yoon et al. (2014) that, according to our view, render the suggestions and recommendation based directly on results presented in that report highly questionable.

Some of the recommendations are judged to be relevant, regardless of the PFC2D results. Analysing models with interacting neighbouring deformation zones, for instance, is a natural extension of the modelling efforts. It may also be necessary to ensure, specifically, that deformation zones with trace lengths smaller than 3 km will not require any respect distances. These issues are currently being addressed using the 3DEC modelling approach.

We should also point out that we have no objections regarding the Synthetic Rock Mass approach in general or the PFC code in particular. However, to arrive at credible quantitative stress and slip estimates, it is essential that modelling of systems with 3-dimensional fracture networks, complicated stress gradients and seismic sources are modelled in three dimensions. It is also necessary to make systematic reality checks and to ensure that couplings between input assumptions and modelling results are logical and understandable.

Att tänka på för oss alla; kanske fortfarande håller?

(Starfield and Cundall, 1988, ”Towards a Methodology for Rock Mechanics Modelling”, Int J. Rock Mech. Min. Sci.& Geomech.Abstr. Vol 25, No3, pp 99-106

”A model is a simplification of reality rather than an imitation of reality. It is an intellectual tool that has to be designed and chosen for a specific task.”

”The design of the model should be driven by the questions that the model is supposed to answer rather than the details of the system that is being modelled . This helps to simplify and control the model.”