Rock fracture simulation

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Geocomputing Seminar

CSC, Espoo

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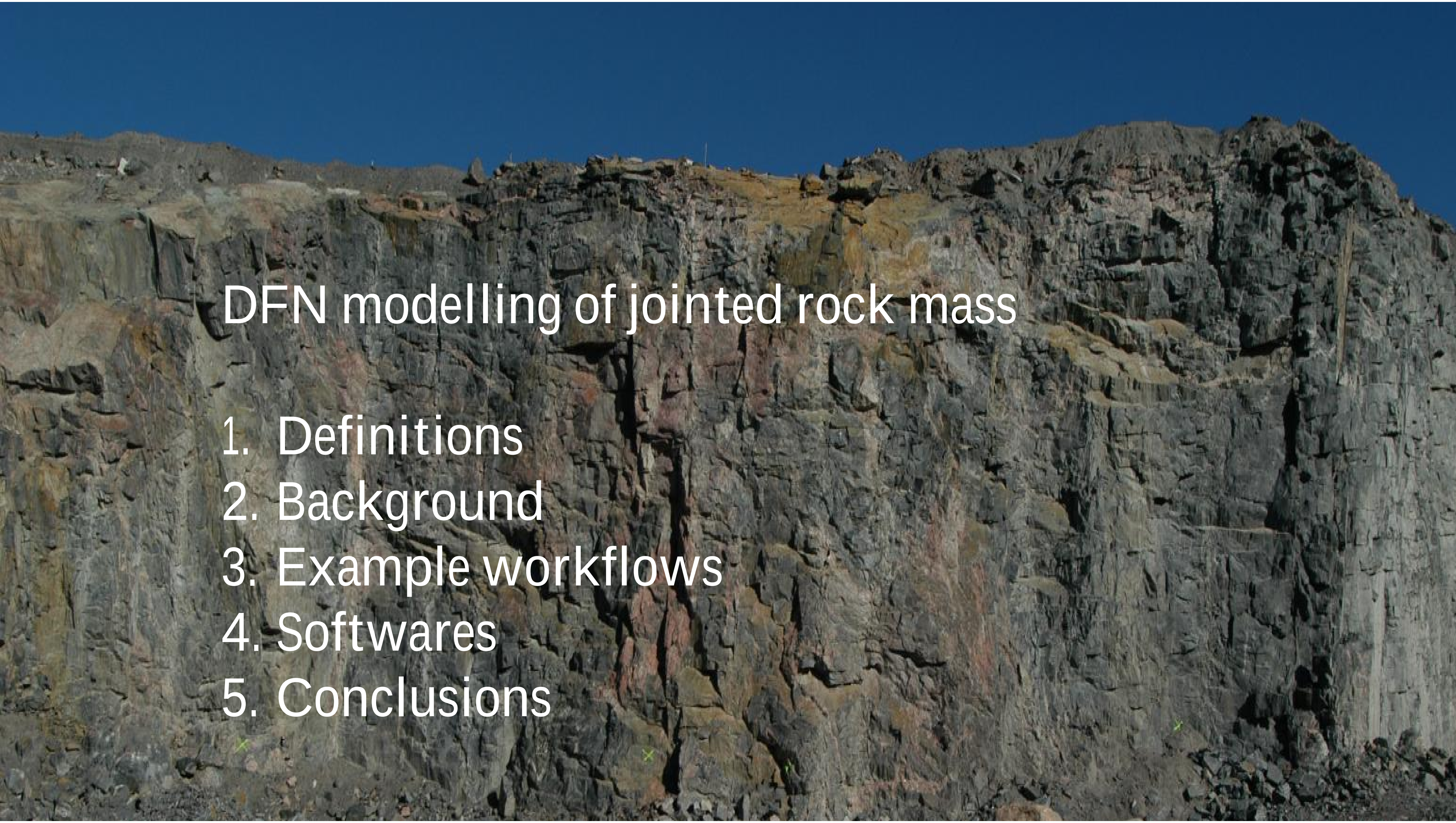
gtk.fi


DFN modelling of jointed rock mass
1. Definitions
2. Background
3. Example workflows
4. Softwares
5. Conclusions

Rock brokenness

- Comprised from fractures and faults
- Caused by:
  - tectonic movements
  - thermal effects
  - land uplift…
- Result:
  - a complicated fracture pattern → difficult to model using deterministic methods

Rock brokenness continue…

- Discontinuities are critical factors for:
  - rock strength
  - flow characteristics
  - thermal properties of the rock mass

Fracture properties

- Azimuth and dip
- Fracture dimensions
- Roughness of fracture surfaces
- Fracture filling
- Fracture aperture
- Density: number of fractures per unit length P10, area P20, volume P30
- Intensity: length P10, area P21, volume P32

Fracture observations

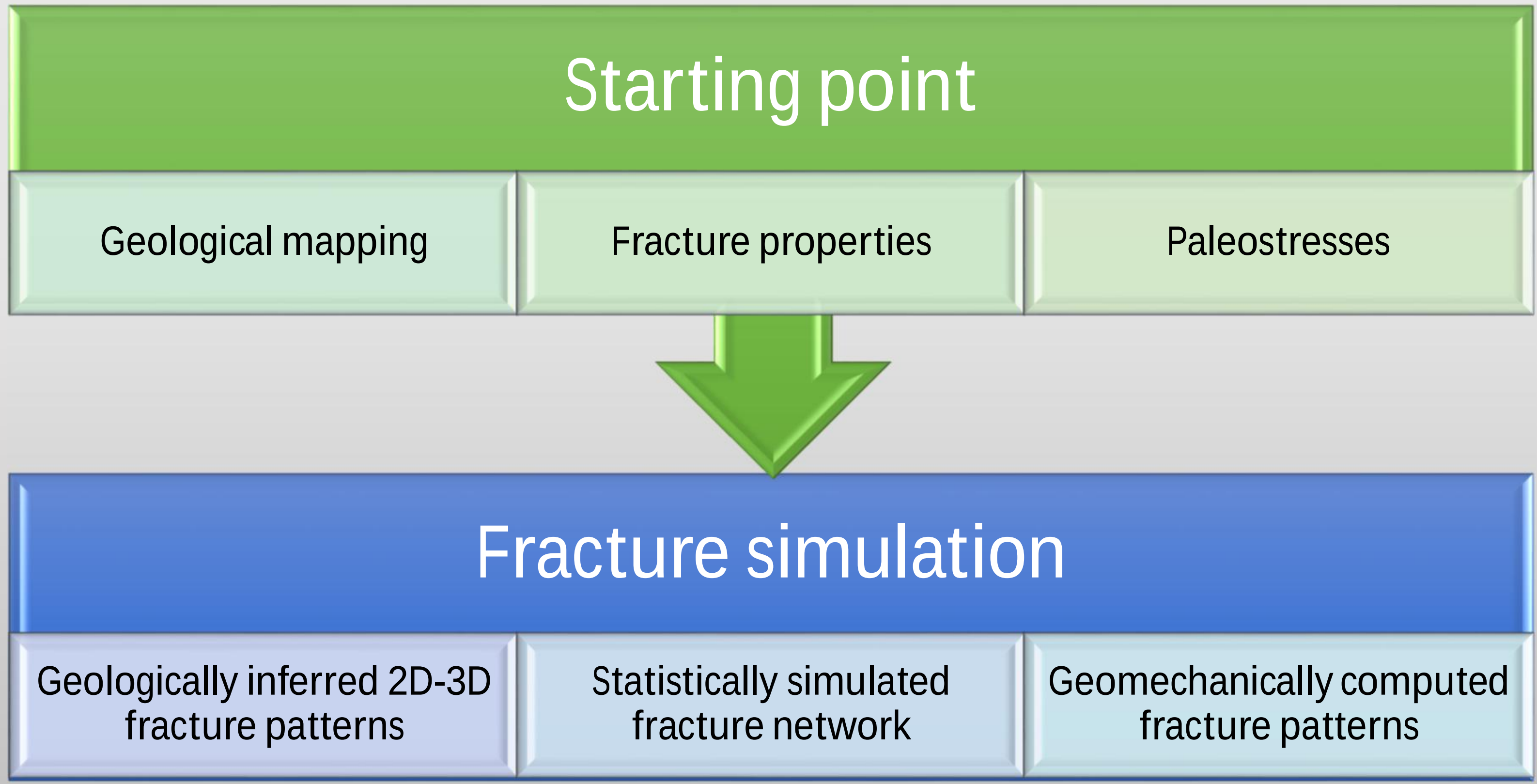
- Fracture properties vary in short distances
- Fracture observations
  - Scanline measurements along the lines and drill holes
  - Areally e.g. from lidar data or drones: fracture patterns, fracture intensity and density
  - Window mapping
  - Circular scanlines: fracture density, intensity and mean length
  - Outcrop mapping (Pajunen et al. 2008) using a specific fracture mapping form
  - Mapping along underground tunnels
- Problem: difficult to predict subsurface 3D fracture patterns based on the surficial 2D fracture patterns

DFN = ”discrete fracture network”

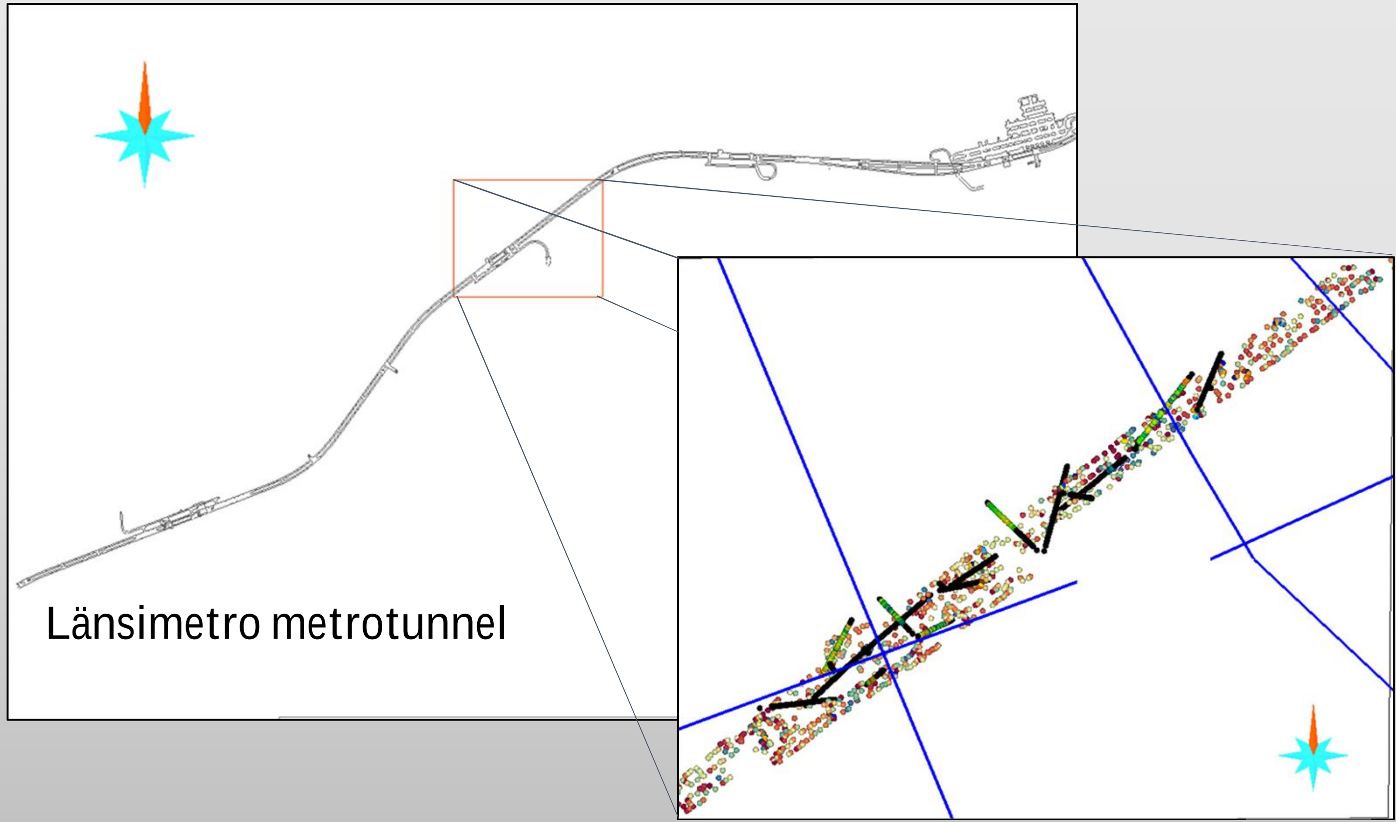
- Refers to a computational model that represents the geometrical properties of each individual fracture, and the topological relationships between individual fractures and fracture sets. (Lei et al. 2017)
  - From geological mapping
  - Stochastic realization
  - Geomechanical simulation

→ Conventional definition: stochastic fracture network

DFN – fracture simulation



Data from Niittykumpu metro tunnel as an example case



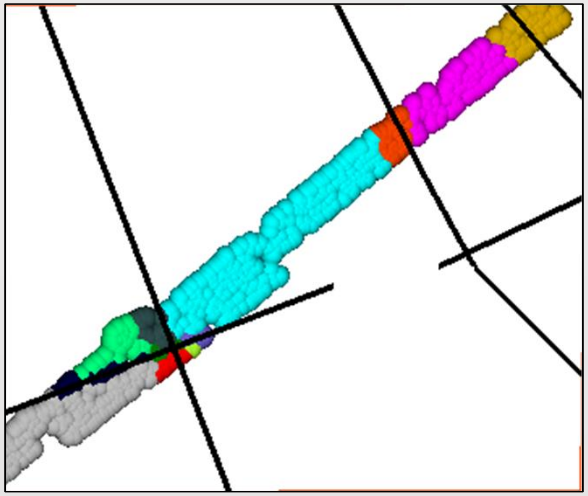
The purpose of this study

Spatial distribution of fractures and fracture properties in order to find out possible stress field that created the fractures

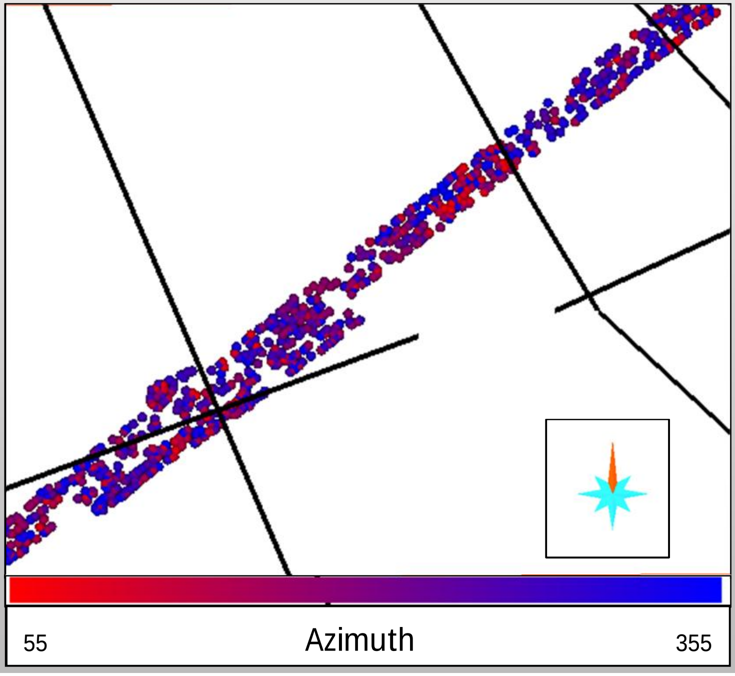
Available data

- Fracture observations made by GTK
  - Versatile data; including more specific data from the fractures
- Fracture observations from Länsimetro Oy
  - Only engineering geological data
- Fault data
  - Interpreted by Tuija Elminen (GTK) from laser scnning data and magnetic low altitude maps
- Laser scanning from Land Surveys of Finland

Case study workflow in nutshell



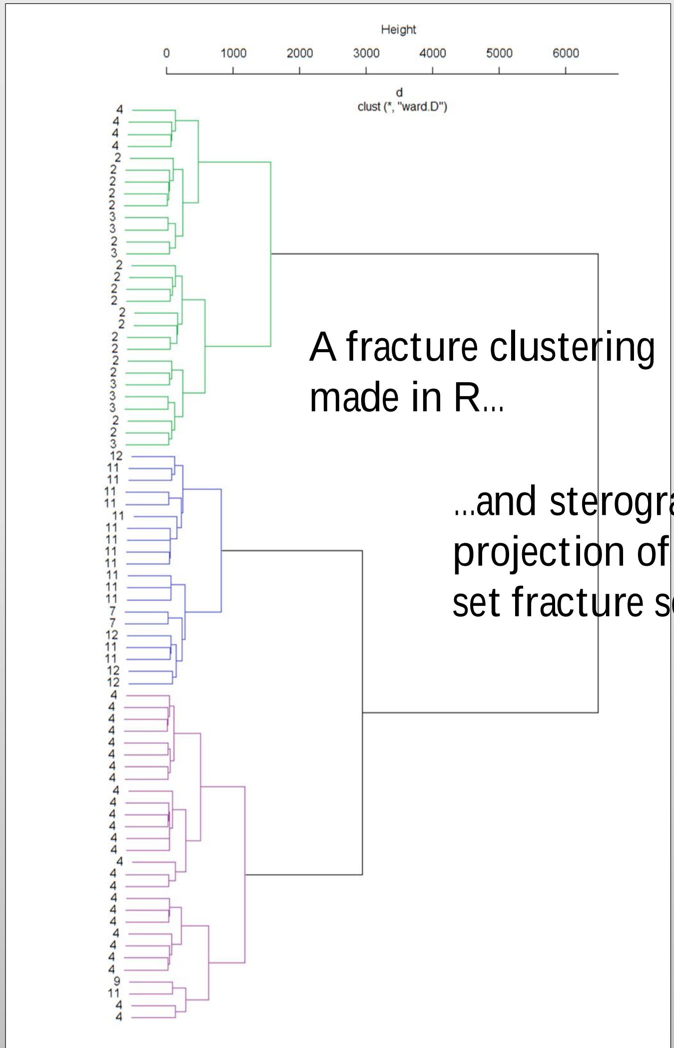
- Four faults crossing the tunnel → division of the tunnel in sectors based on these faults
- Preliminary comparison of orientation and properties of the fractures in visually in 3D-software
- Next step: fracture classification in hierarchical clustering method
- Final step: testing of possible stress field causing the fracturing



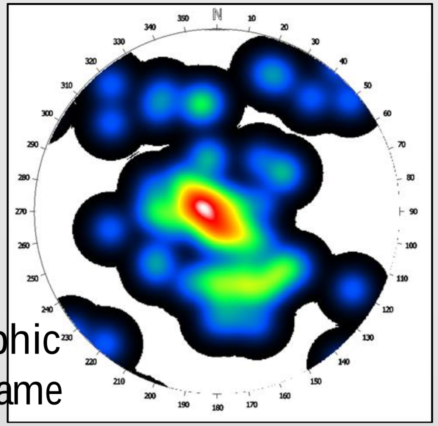
Fracture simulation softwares

- Different simulation softwares
  - FracSim3D
  - Fracman
  - MOVE
  - GOCADplugin Fractcar
  - Geovariances ISATIS
  - Open R, Octave, Julia,… -koodit
- Each software has pros and cons

Fracture simulation

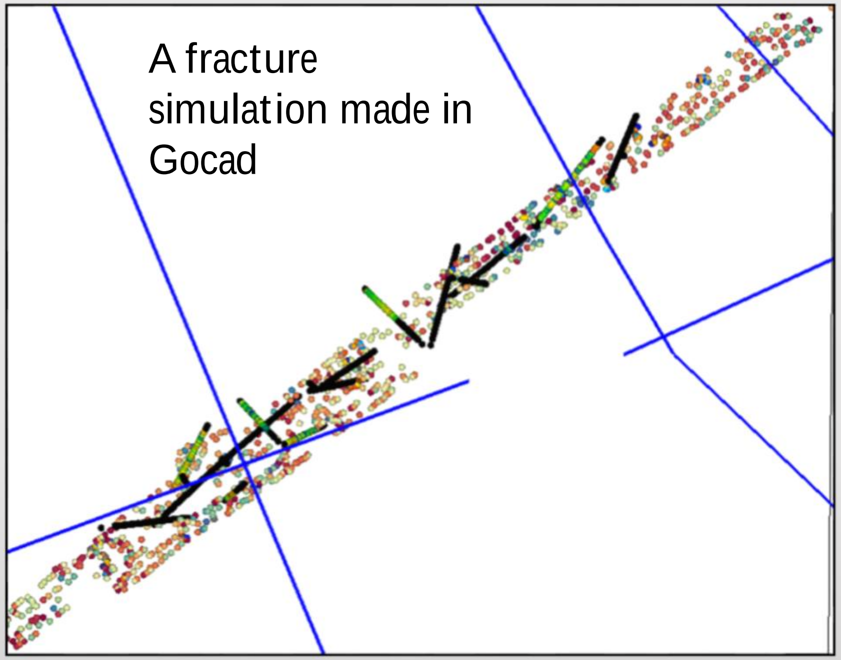


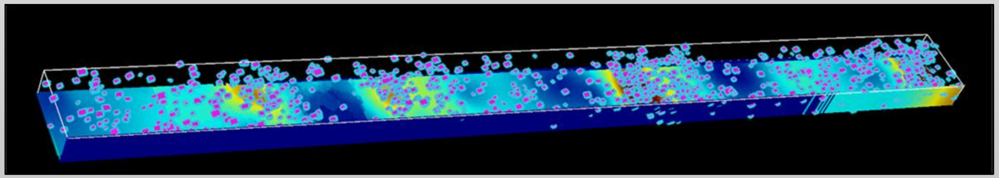
A fracture clustering made in R...



...and sterographic projection of same set fracture set

A fracture simulation made in Gocad





A fracture simulation example using Gocad Fractcar plugin and ISATIS software

Conclusions

- Fracture simulation happened now basically different geological 3D-simulation softwares, where data is input in table-based files
- Lot of fractures in one cubic meter and when this applied to the bigger volume the computing power is not enough in most computers → need for high performance computing