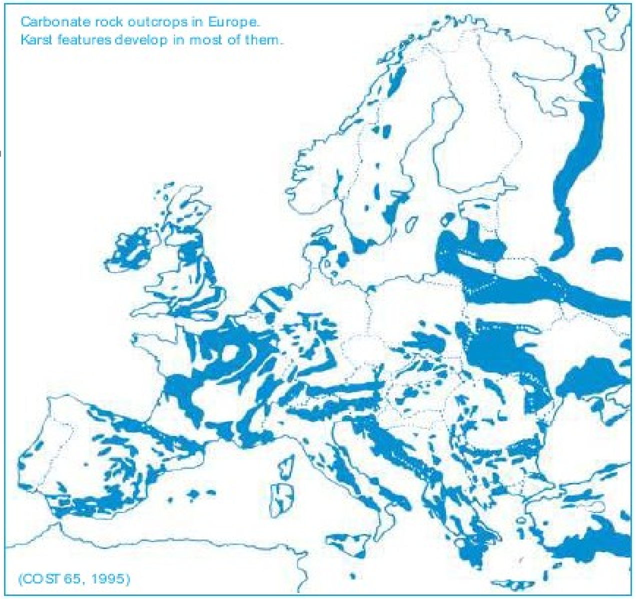
Risk Assessment for Fractured-Matrix-Systems

by Dipl.-Ing. Rainer Enzenhoefer

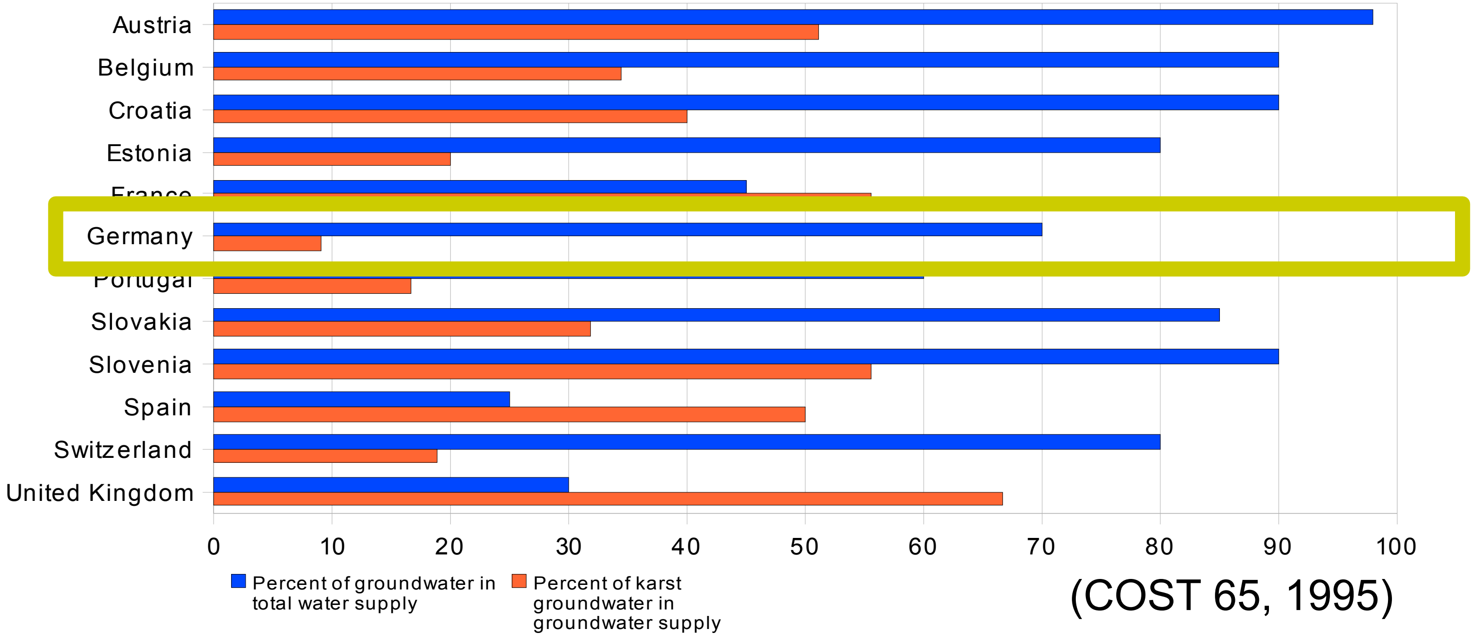
(Pliezhausen, Dietrich 2005)

„Drinking water is essential for life and can't be substituted“
(DIN 2000)

Motivation

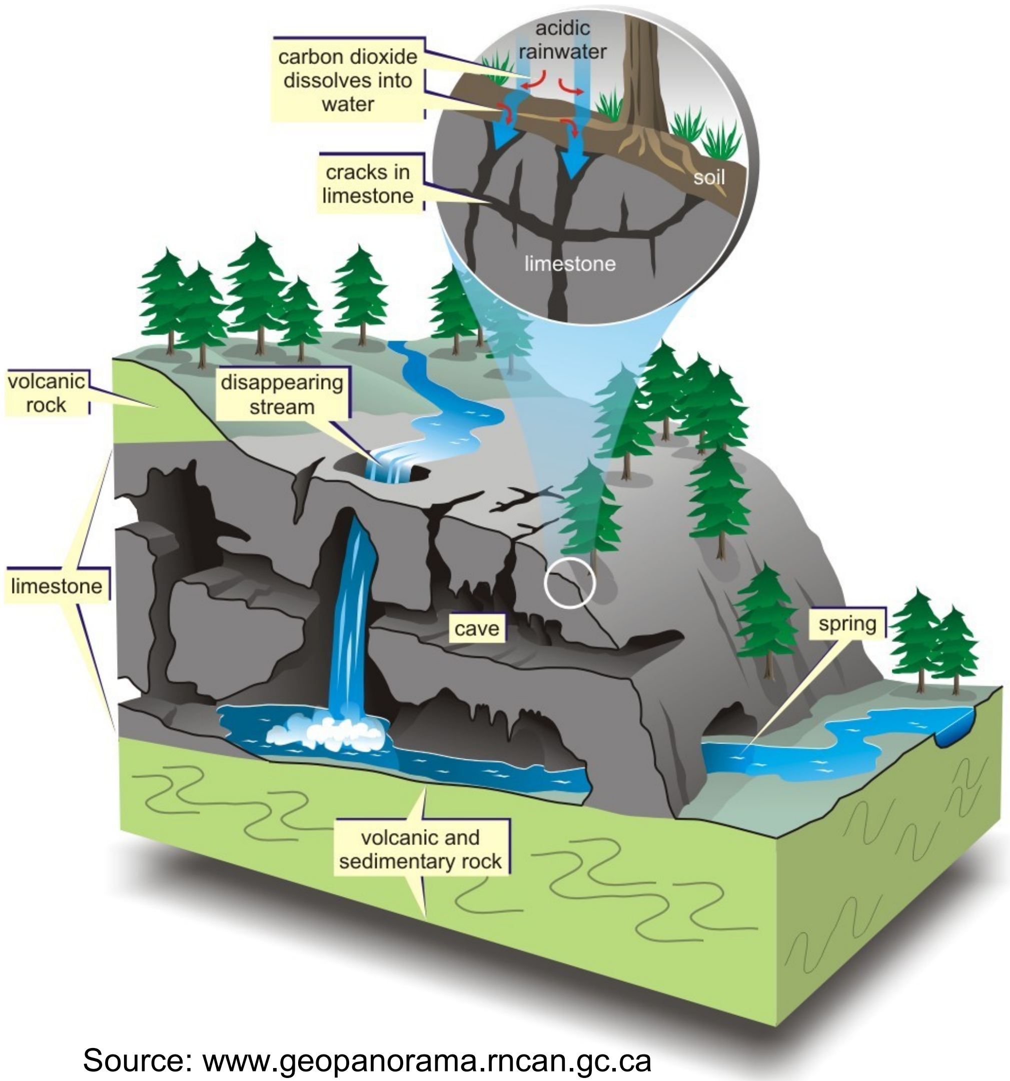


- Groundwater use for water supply
- Carbonate rock outcrops



(COST 65, 1995)

Introduction to Karstic Systems



Source: www.geopanorama.rncan.gc.ca

- huge catchment areas
- low storativity
- high flow velocities
- Scale dependancy

Motivation

Potential sources of contamination

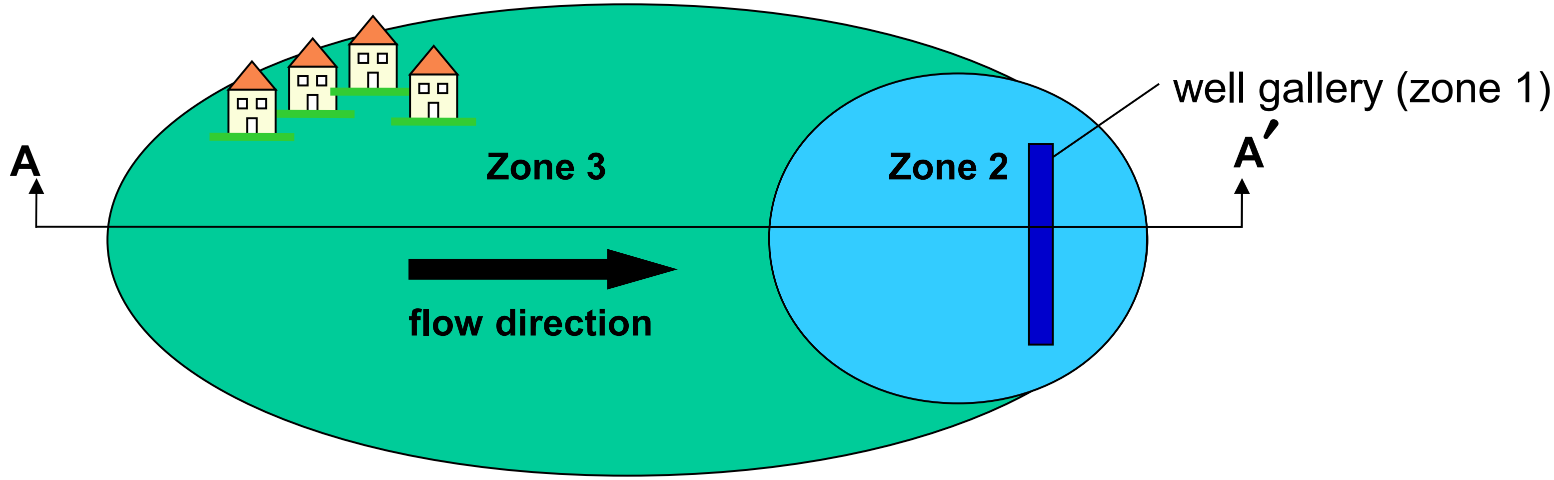
- ➡ Groundwater Protection
  - WFD: Groundwater Quality the biggest problem
- ➡ Multi-barrier concept – Risk Assessment
  - Source, Pathway, Receptor
- ➡ Water Safety Plan

Challenges within a karstic system

- ➡ reduced surface protection cover
- ➡ fast fracture flow
- ➡ high matrix storage

Model concept

Model sketch for the possible investigation site:



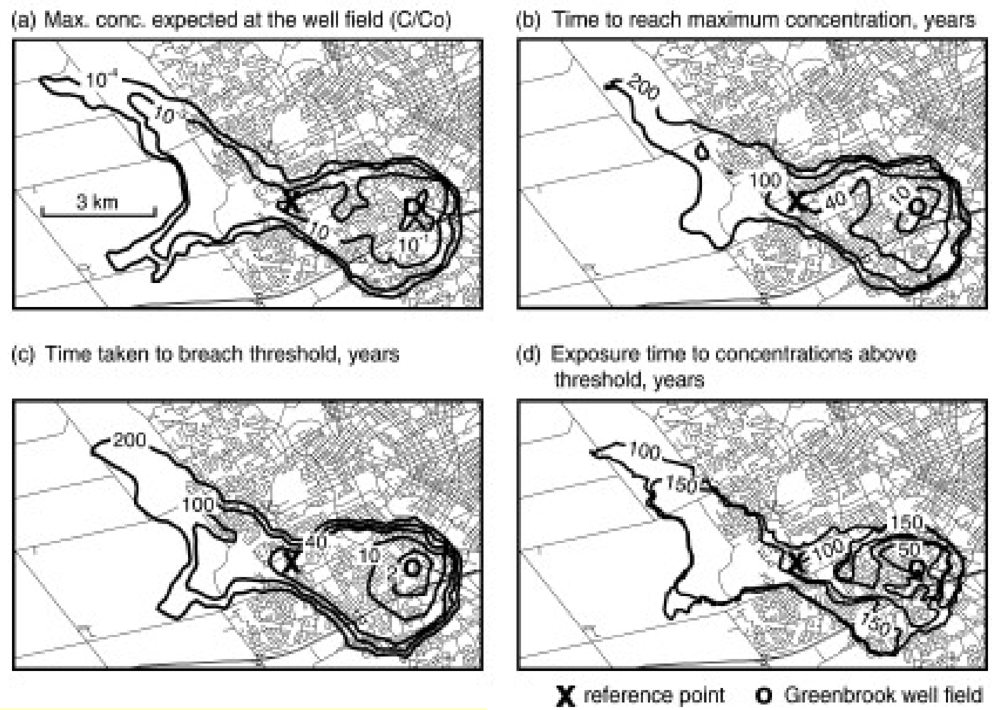
1) How long does it take, that a contaminant reaches the well?
2) How long does it take, that a concentration limit is reached?
3) How long will the concentration be above the limit?
4) Where are the most sensitive zones within the catchment area?
5) How sure can be a supplier to pump „clean“ drinking water?

Aim

- Develop an approach to assess the risk towards a well within a karstic aquifer system by identifying vulnerable sites on catchment scale.
  - Quantify actual threats
  - Prioritize vulnerable areas in protection strategies
  - Easy in application - overview over the catchment area
- Accounts for uncertainty
- Application for a real case scenario

Example in Porous Media

1. Expected maximum concentration
2. Average travel time
3. Time until threshold is breached
4. Exposure time



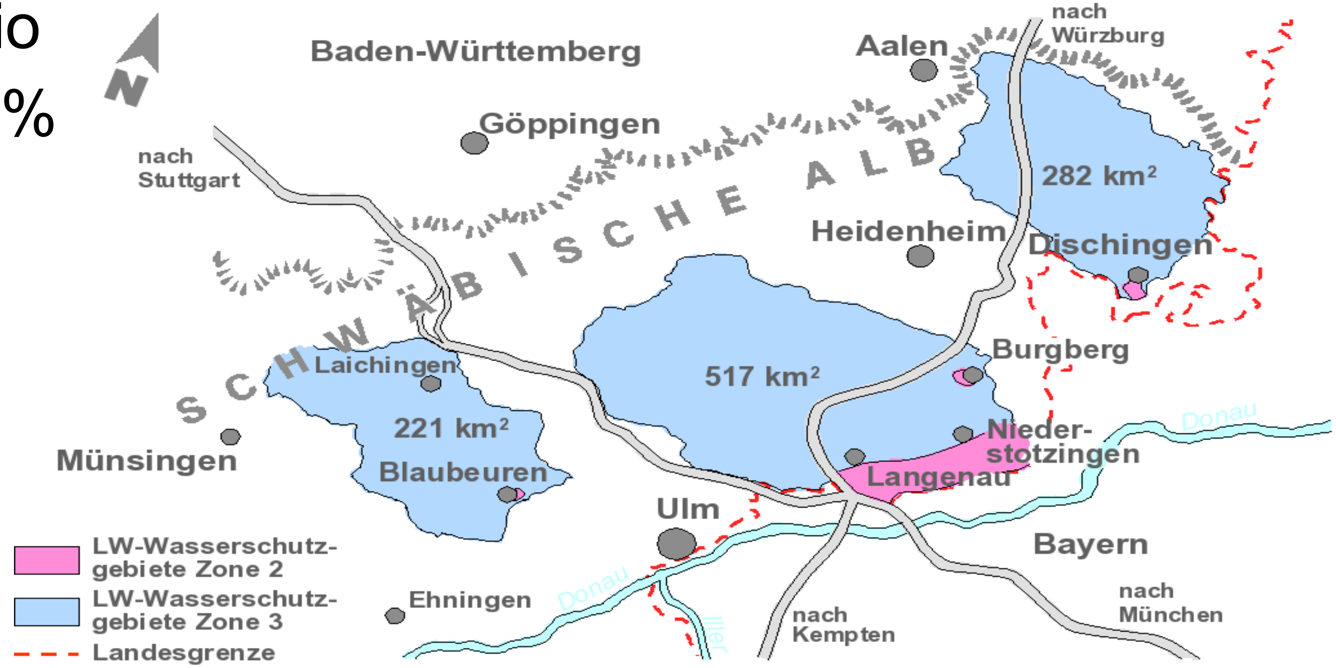
(Frind et. al, 2006)

Example ($c/c_0 = 1.0$):
- Max. concentration in ~ 40 yrs (2.)
- Expected maximum concentration 10^{-2} (1.)
- Threshold level 10^{-4} in ~ 35 yrs. (3.)
- Prevails for ~100yrs. (4.)

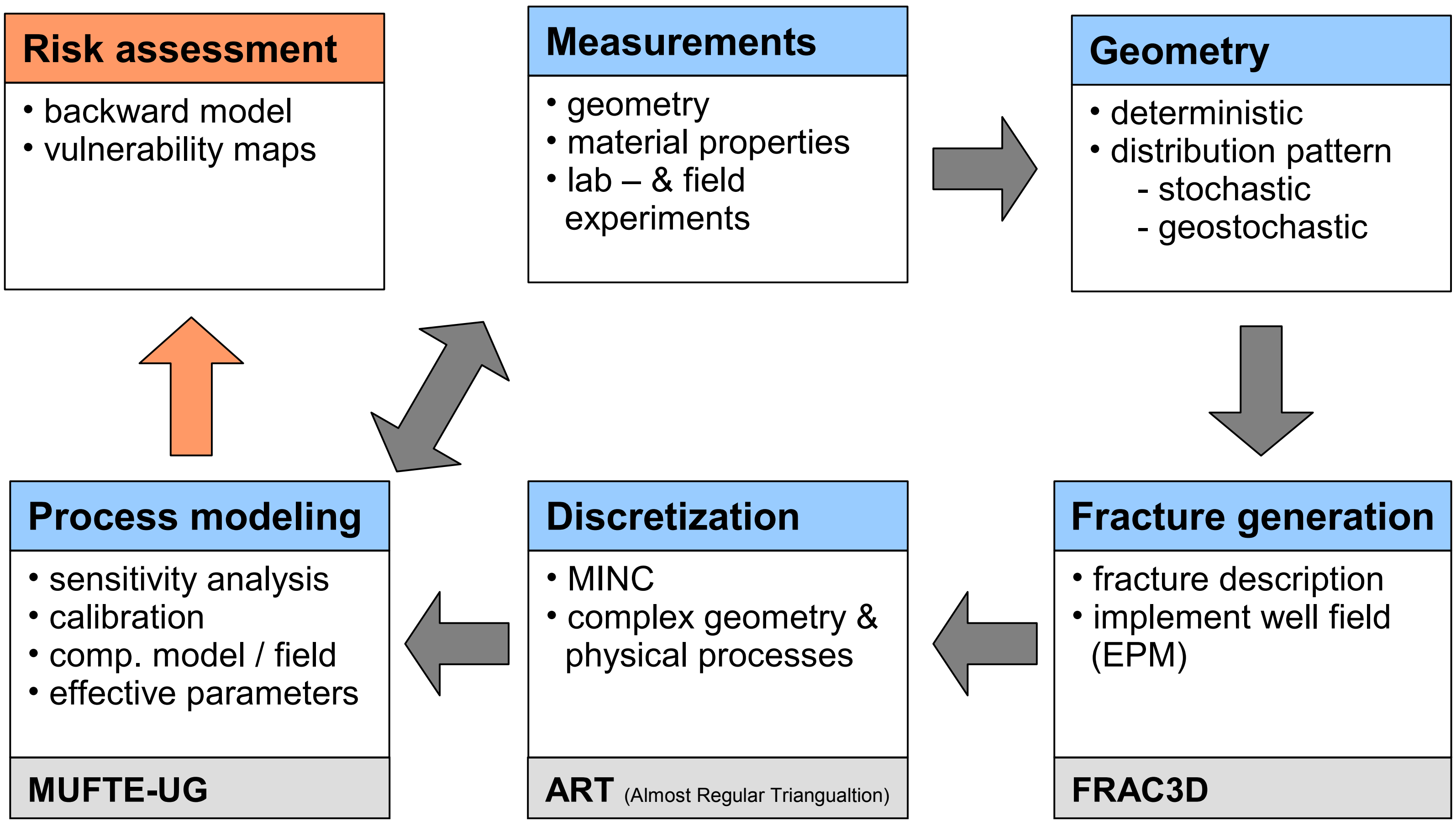
Test site

- Baden-Wuerttemberg, Germany
- Zweckverband Landeswasserversorgung
- Q = ~ 100 Mio m³/a
- Population: 3Mio
- GW-Anteil ~ 65%

www.google.de/maps



Overview – Vulnerability assessment

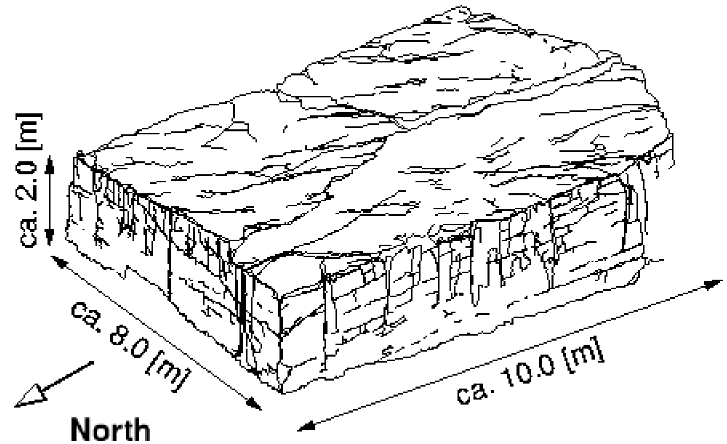


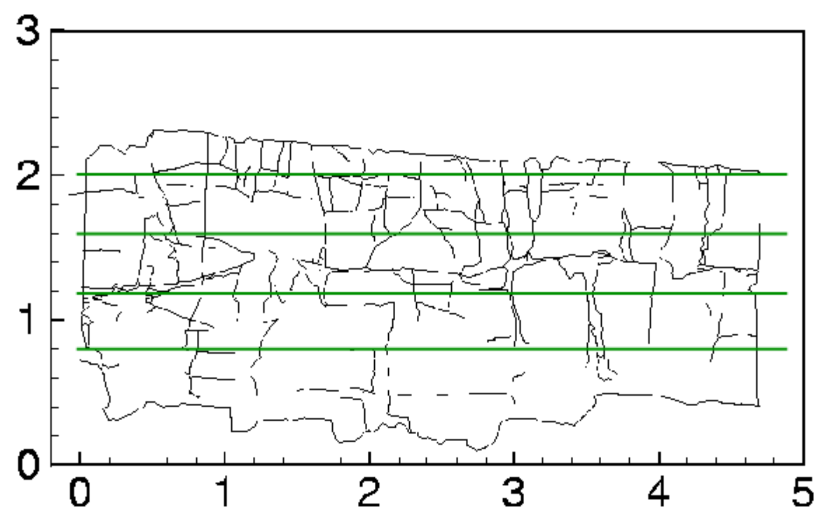
(modified from: Silberhorn-Hemminger, 2002)

Measurements – fracture characteristics

- fracture aperture
- fracture density
- fracture orientation:

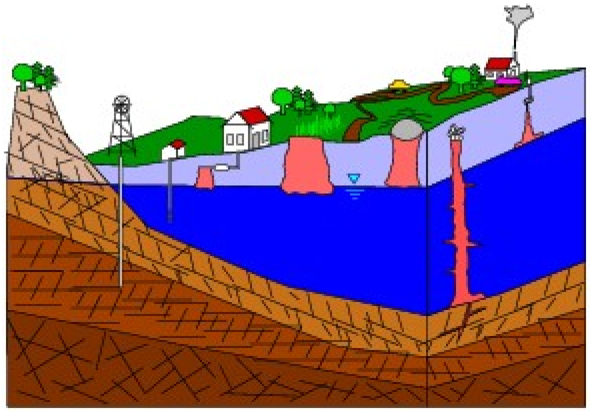
  strike (or azimuth) and dip
- fracture size: shape
- fracture trace: length
- fracture connectivity
- ....

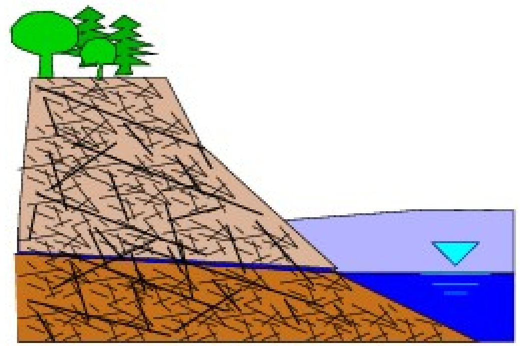


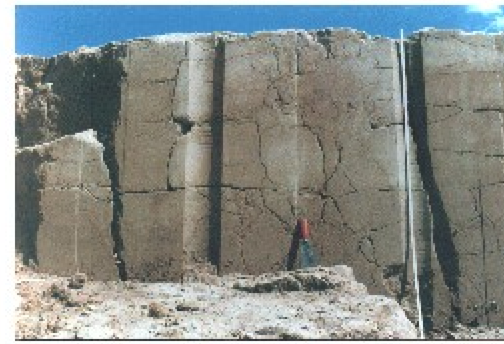


(Assteerawat, 2008)

Scale Model approach

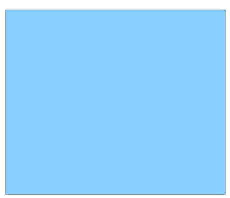






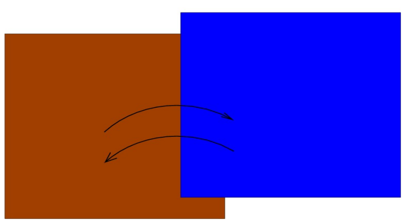
km — m

Continuum Model



EPM

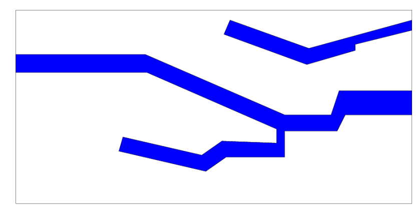
matrix



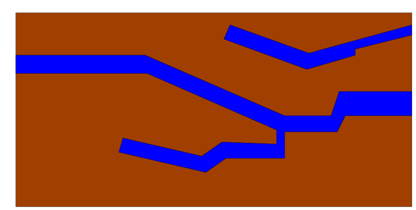
fracture

Discrete Model

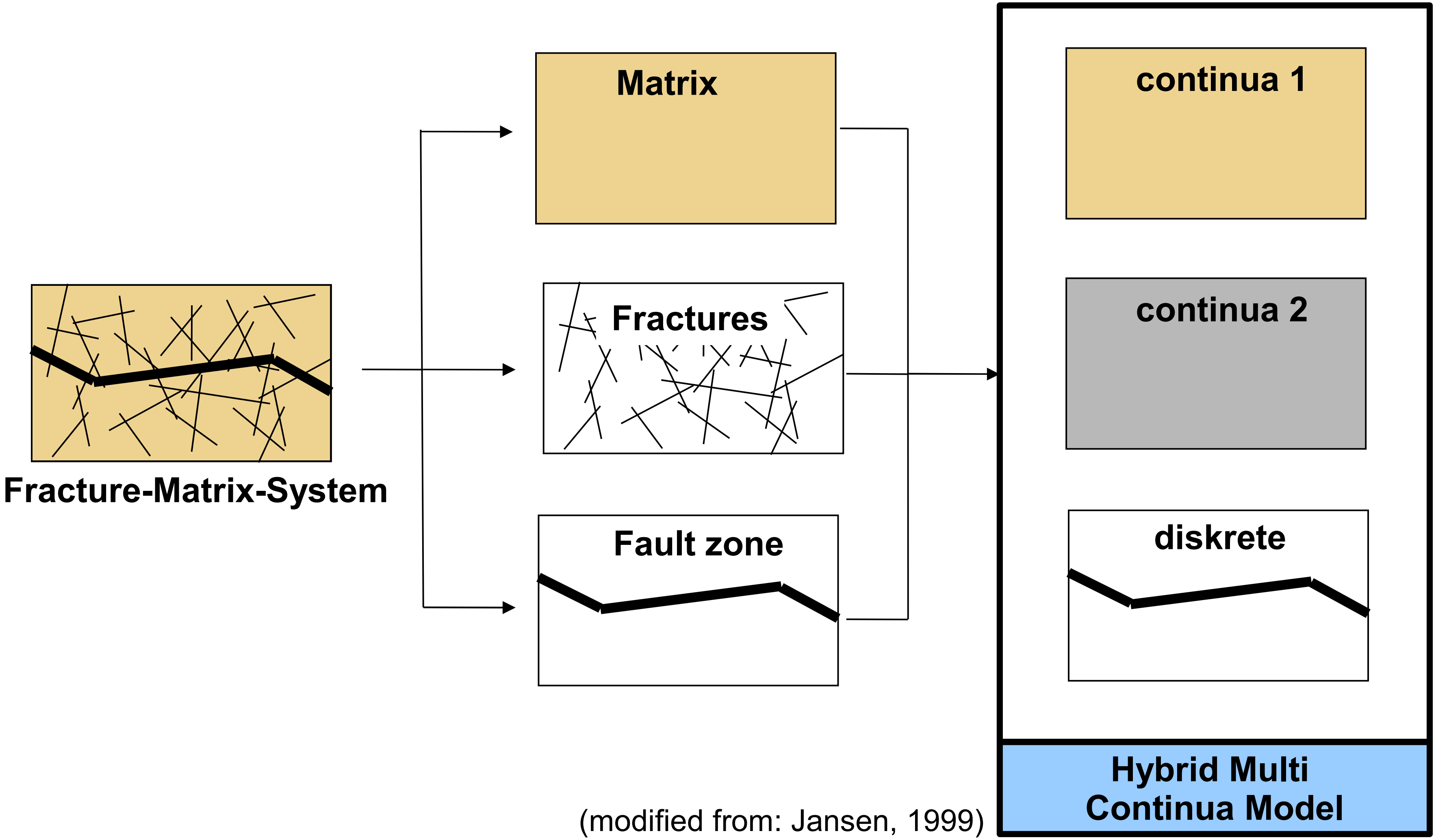
fracture - rock



fracture - matrix



Flow concept – Hybrid Multi Continuum Model



(modified from: Jansen, 1999)

What to expect from the course?

- Learn to introduce risk into the field of karstic modeling and groundwater protection
  - Risk assessment on local and on catchment scale
- Risk assessment is fundamental to describe the 4 well vulnerabilities
- Enhance the concept of the actual risk assessment
  - Implement fate and attenuation processes
- Learn about the weaknesses and strength of the presented risk model concept

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