Comparison of different technologies for geological site characterization With examples from different sites

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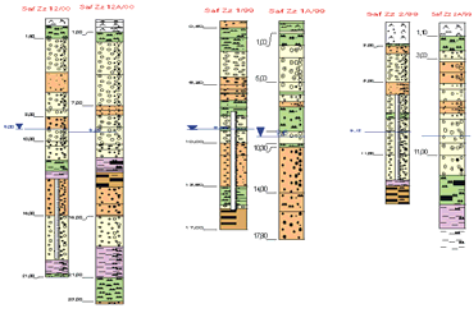
Outline

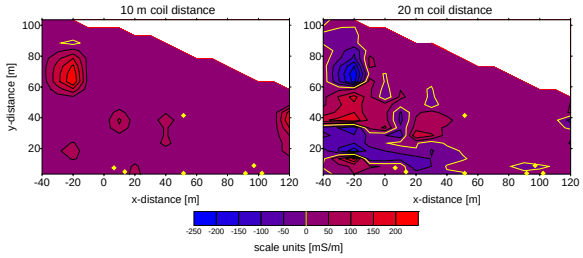
- Investigation approaches
- Comparisons and applications for site characterization
- Conclusions
- Outlook: MOSAIC

Lithology logs from borehole



Geophysical surface measurement I

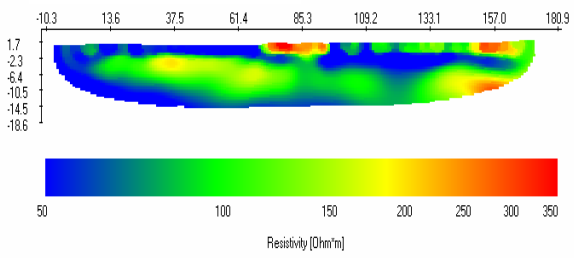
EM measurements with vertical dipoles



Method	Effective petrophysical parameter
gravimetrical methods	density d
geomagnetic methods	magnetic susceptibility κ
geoelectrical resistivity methods	specific electrical resistivity ρ
electromagnetic methods	specific electrical resistivity ρ, dielectric constant ε
seismic methods	velocity v and absorption coefficients of elastic waves α, reflection coefficient
geothermal methods	heat conductivity λ, temperature conductivity α
radiometric methods	activity of natural radiation
nuclear physical methods	parameters that are decisive for the interaction processes radiation - matter

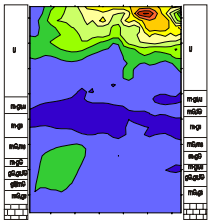
Geophysical surface measurement II

Results of DC geoelectrical measurements

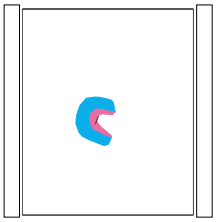


Tomographic investigations

exploration of structures

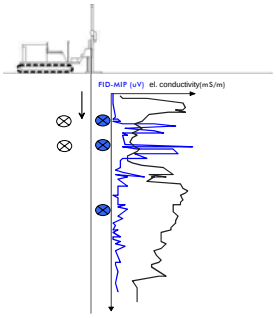


monitoring of processes



"Direct Push" –Technologies

Use of "Direct Push" - technologies

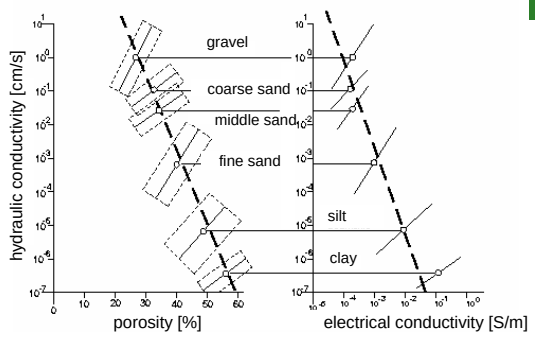


- **profile measurements**
  - electrical conductivity
  - contaminant parameter
  - hydraulic conductivity
  - ..
- **sampling** ⊗
  - ground water samples
  - soil samples
  - soil gas samples
- **installation** ⊗
  - sampling points
  - dosimeter
  - sensors

Case study Nauen

Importance of Parameter Relations

Importance of site specific parameter relations



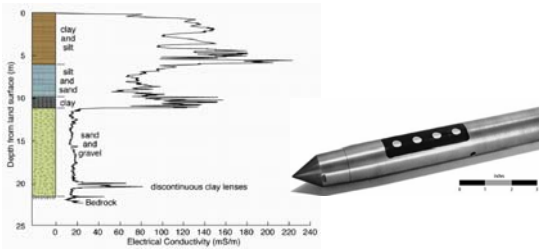
(Chouker, 1970)

Comparison of different DP-techniques for the characterization of hydraulic conductivity distribution

- EC-Logging
- Injection Logging
- Slug tests
- Permeameter measurements

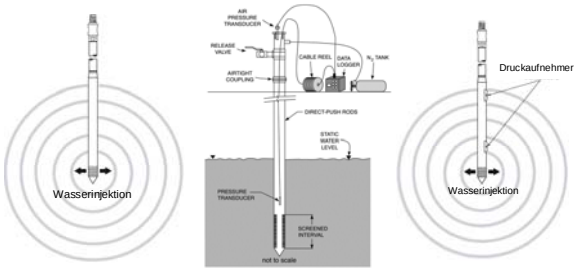
"Direct Push"-Technologies: Profiling

Electrical conductivity

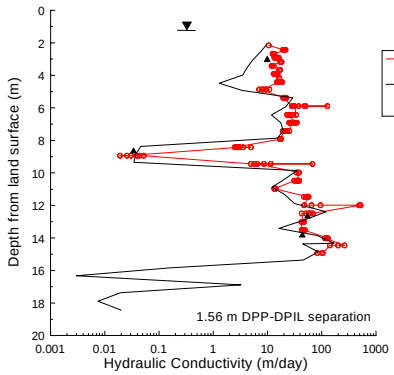


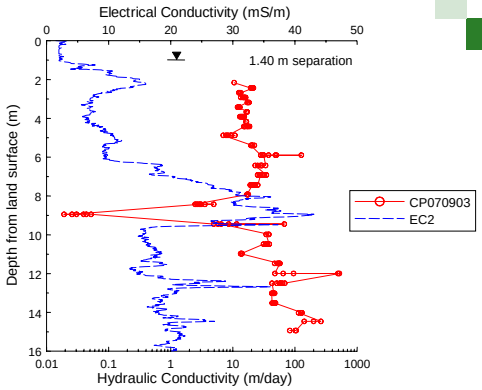
(Butler et al., 2000)

DP methods for the characterization of K-distribution



Injection logger (DPIL) | Slug tests | Permeameter (DPP)





Comparison of probes in terms of the characterization of K-distribution

	Determ. of K-value	Speed	Robust-ness
EC logging	site specific	continuous	very high
Injection logging	relative	ca. 1 min / MP	high
Slug test	absolute	ca. 60 min / MP	very high
Permeameter	absolute	ca. 10 min / MP	low
Incektion logging + Slug tests	absolute		high

Case study Zeitz I

Geophysical Surface Measurements in Comparison with Direct Push Measurements

Project frame:

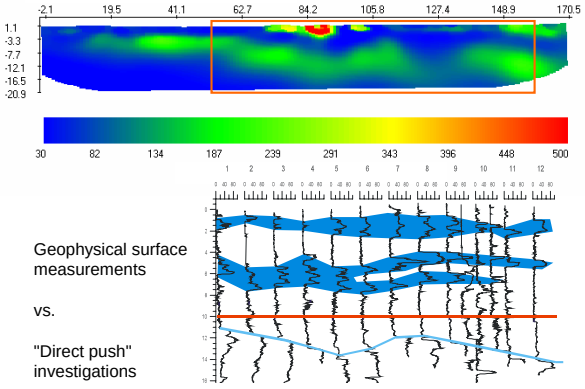
RETZINA: **RE**ference **T**estfield **Z**eitz for **I**mplementation of the **N**atural Attenuation **A**pproach

Project partners:

- Umweltforschungszentrum (UFZ) Leipzig / Halle
- Institute of Applied Geology, Uni Kiel
- Center of Applied Geosciences, Uni Tübingen

Project objective:

Developement of methods to quantify contaminant degradation and retention properties at field conditions



Geophysical surface measurements

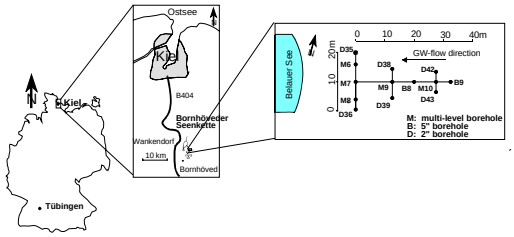
vs.

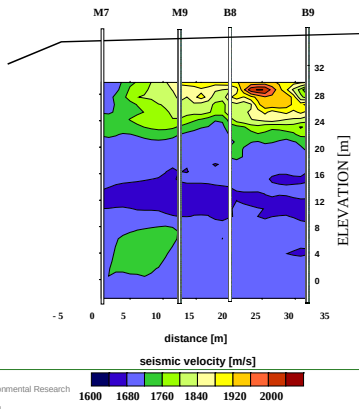
"Direct push" investigations

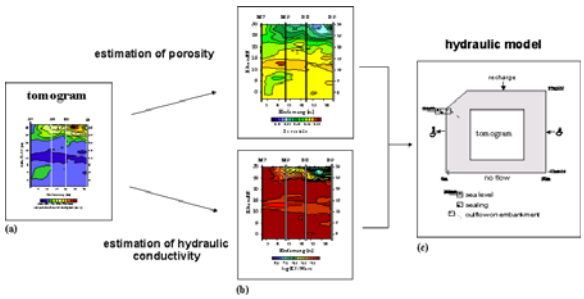
Case study Lake Belau

Tracer Tests
vs
Geophysical Site Characterization

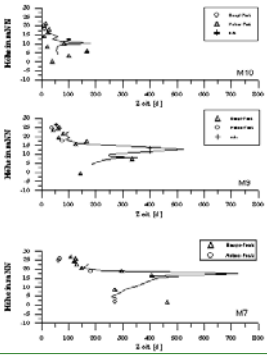
Identification of sediment structures
Prediction of transport behaviour





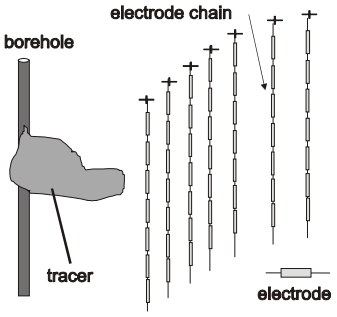


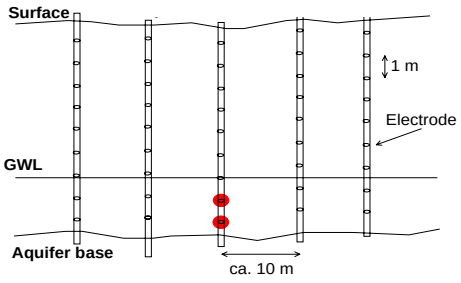
tracer arrival times



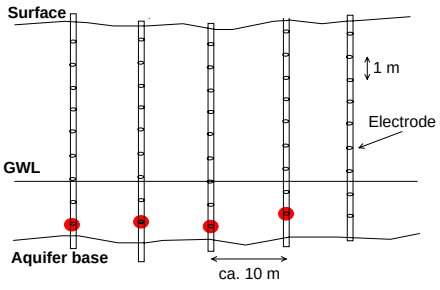
Case studies
Zeitz II and Karlsruhe-Knielingen

Colour Tracer Tests
and
Geoelectrical Tracer Tests



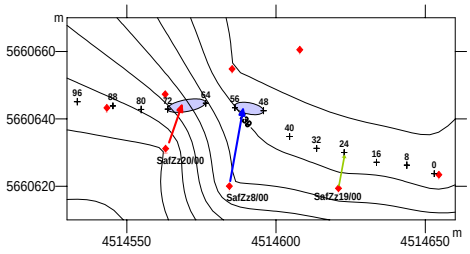


● Two electrodes of a pole-pole configuration



● Four electrodes of a Wenner configuration

First estimate of groundwater flow velocities



Flow path: → Borehole SafZz20/00 Electrodes (64-72)
Flow velocity: v = 3 m/d

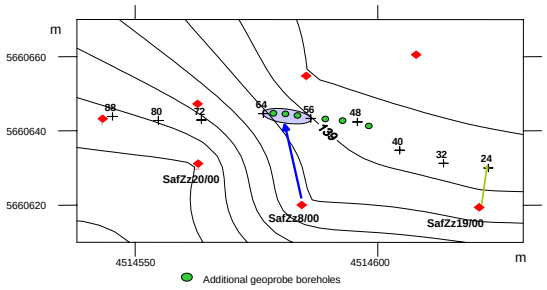
Flow path: → Borehole SafZz8/00 Electrodes (48-56)
Flow velocity: v = 1-2 m/d

Flow path: → Borehole SafZz19/00 Electrodes (24-26)
Flow velocity: v < 0,3 m/d

Colour tracer tests

- Tracer injection into SafZz 8/00 →

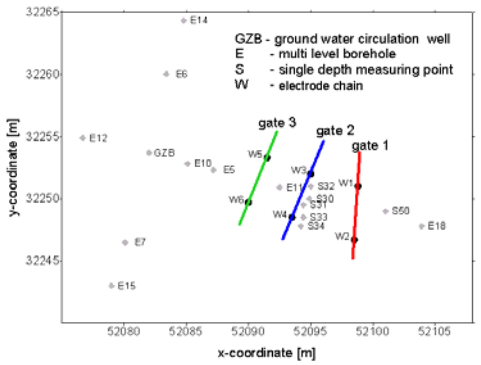
Result of colour tracer test

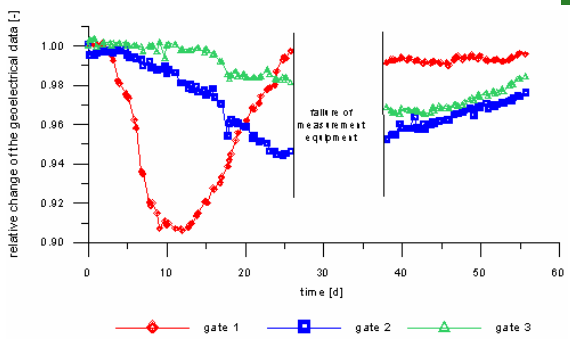


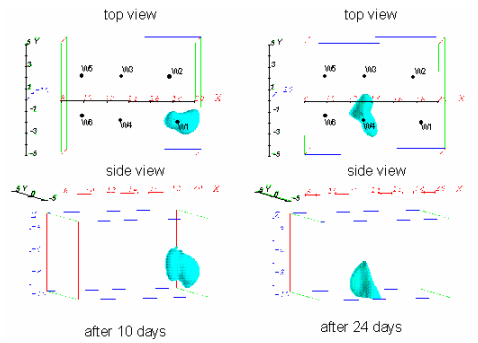
Flow path: → Borehole SafZz8/00
Flow velocity: v = 2-3 m/d

Flow path: → Borehole SafZz19/00
Flow velocity: v < 0,3 m/d

Test site Karlsruhe-Knielingen







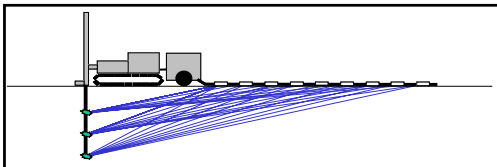
Conclusions

- Direct Push can be a very useful supplement for borehole and surface measurements.
- By using different kinds of logging tools at the same location, it is possible to determine site specific relationships between geophysical, geotechnical and hydrogeological parameters.
- Geophysical methods are suitable for spatial continuous exploration of structure and monitoring of processes in the subsurface.
- The combination of Direct Push technologies and geophysical measurements can significantly increase the quality of subsurface characterization.

Outlook

UFZ Research Platform MOSAIC

(**Mo**del Driven **S**ite **A**ssessment, **I**nformation and **C**ontrol)

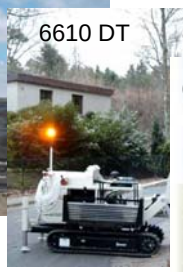


Direct Push - Trailer

- EC-Log
- MIP-log
- Injection-Log
- Permeameter
- Slugtest
- SPT-log
- …
- soil samples
- gas samples
- water samples

- Seismic
- Geoelectrics
- Georadar
- EM
- Gravimetry
- Magnetic
- Radioactive Methods
- …

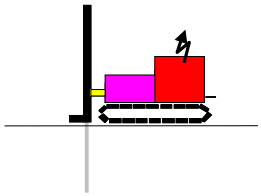
7730 DT

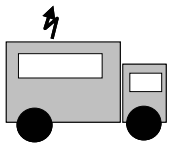


6610 DT

6625 CPT

C4-'Direct Push'-Machine



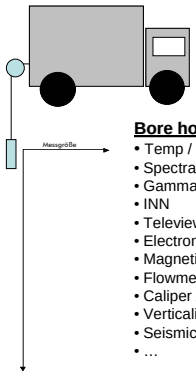


'Direct Push' unit, which can operated for profiling and sampling by remote control (e.g. for work of highly contaminated sites)

Sonic Drill

- obtain large volumes of undisturbed continuous core samples
- installation and exploration in hard rock

Borehole logging unit



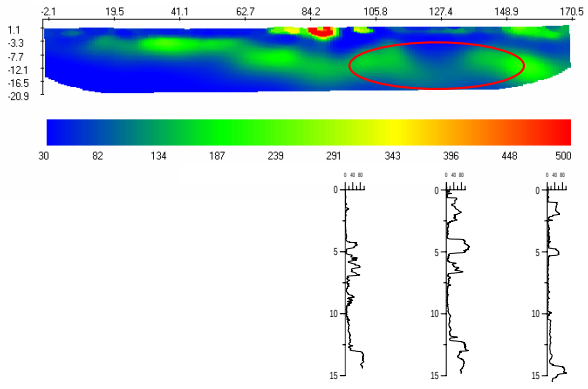
Bore hole logging

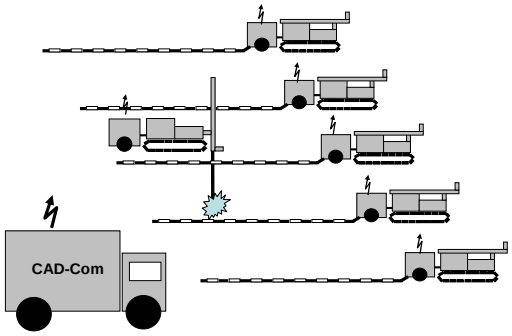
- Temp / EC-Log
- Spectral Gamma
- Gamma-Logs
- INN
- Televiewer (opt. / acoust.)
- Electromagnetic Logs
- Magnetic Logs
- Flowmeter
- Caliper / borehole geometry
- Verticality
- Seismic Logs
- …

Hydrogeolog. equipment

- equipment for pumping tests (Pumps, pressure transducer, data logger, etc.)
- tracer test equipment

Field lab

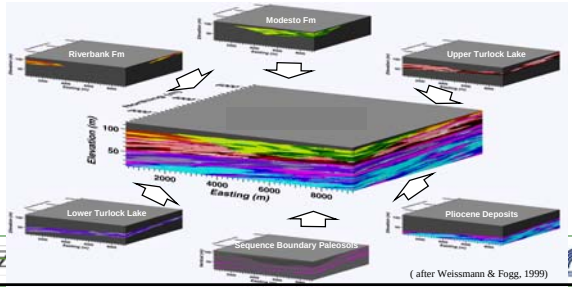




Erkundungsskala: **lateral** 100 m …10 km **vertikal** bis 50 m

Final aim

Delineation of major subsurface units with detailed information about the internal parameter structure



(after Weissmann & Fogg, 1999)

Concept for the use of MOSAIC

- Development and evaluation of monitoring and exploration technologies
- Parameterization of environmental system for process studies
- Platform for joint research of UFZ with universities and other research institutions
- Technology transfer
  (summer schools, pilot studies)