Applying sensors for environmental monitoring and restoration

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Range of activities Sensatec

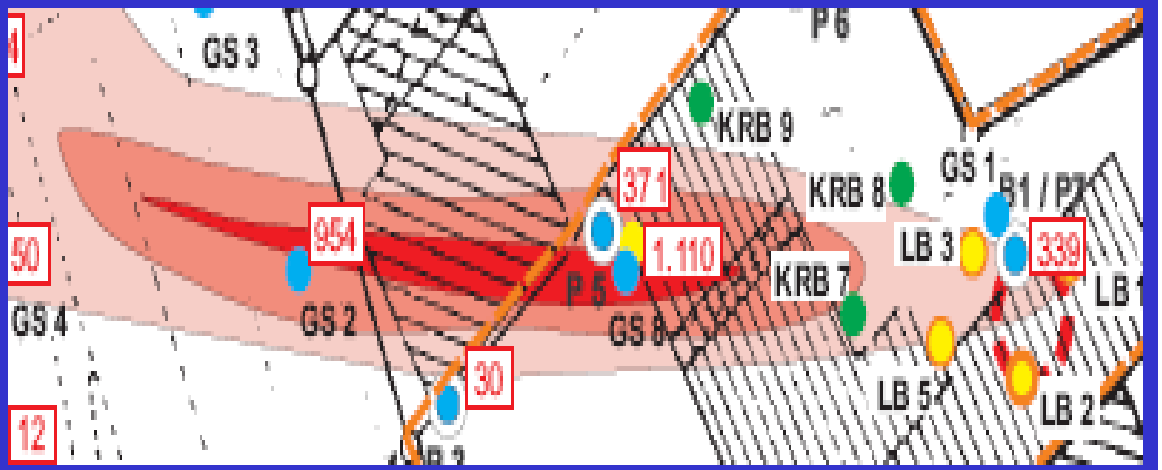
Application of innovative remediation technologies for contaminated sites

Environmental laboratory

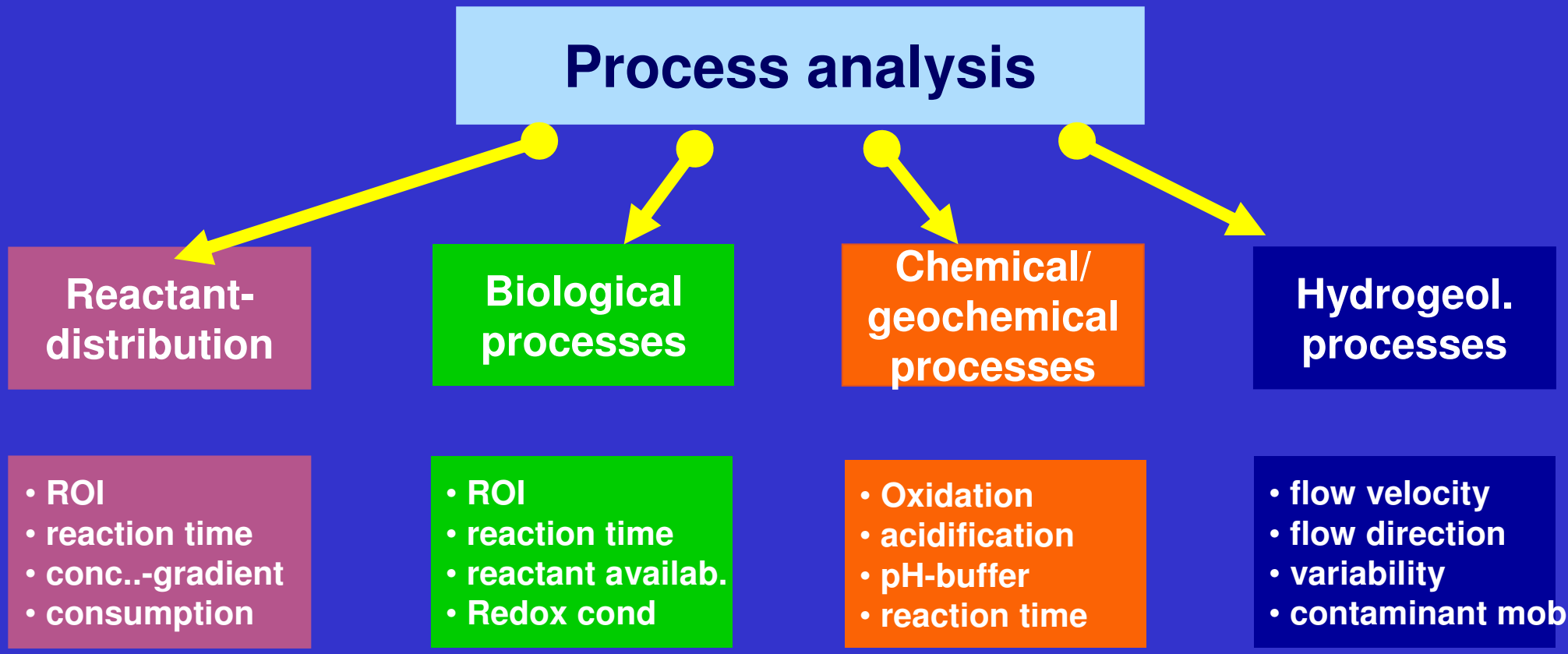
Development and application of environm. In-Situ-sensor technology

Remediation technologies

1. Reactive gas injection
2. Redoxbased fluid zones
3. In-Situ-Chemical Oxidation (Fenton‘s, MnO_4^-, Ozon)
4. Physical Contaminant extraction (Airsparging / SVE)
5. Chemical contaminant mobilisation
6. Pump and Treat



Analysis of dynamic In-Situ-Processes



Which tool are useful for the observation of dynamic processes in the groundwater?

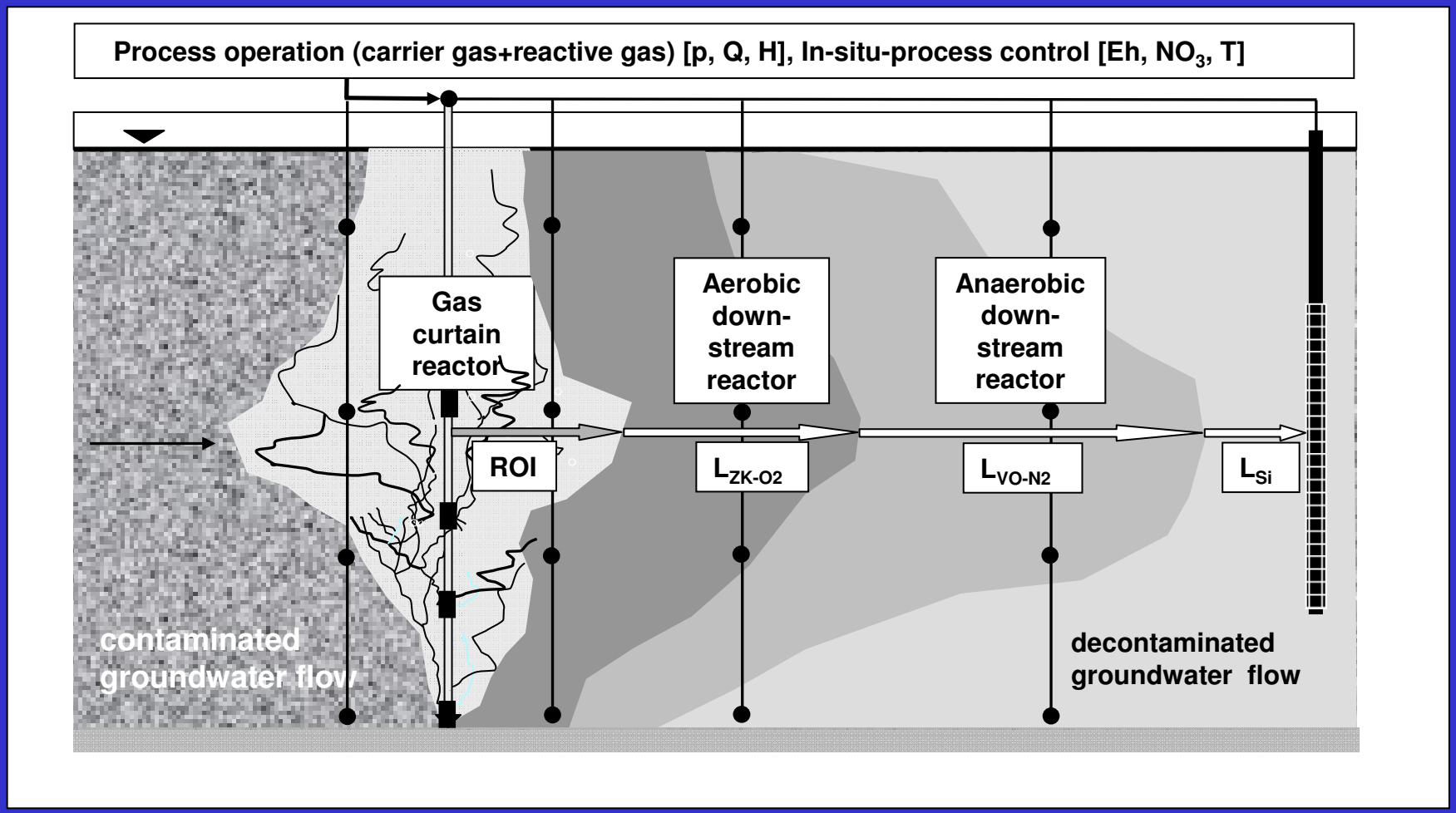
Sensor based environmental monitoring

1. General characterization (pH, Lf, t, Eh)
2. Ion-selective Sensors (O_2, NO_3, NH_4, Br-, Cl-)
3. Pressure, flow velocity
4. Gas saturation (Lf, t, Geophysical measurements)
5. CAN-Bus based sensor systems, remote data transfer
6. Aquifer integrated sensors

Monitoring of distribution processes

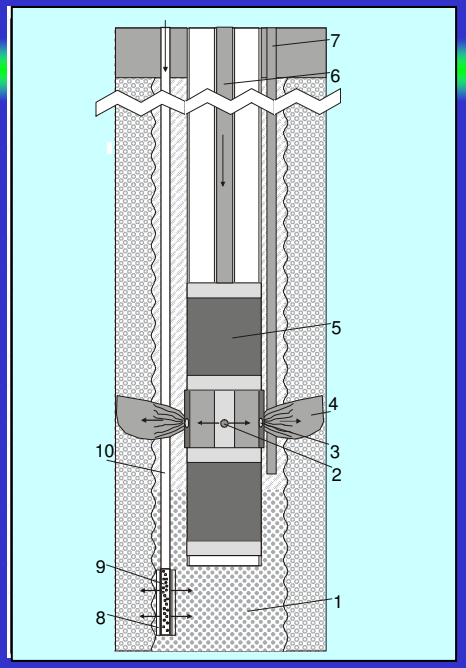
- Radius of Influence of Reactants?
- Reaction time?
- Spatial variability of Reactant concentrations?
- Distribution efficiency?

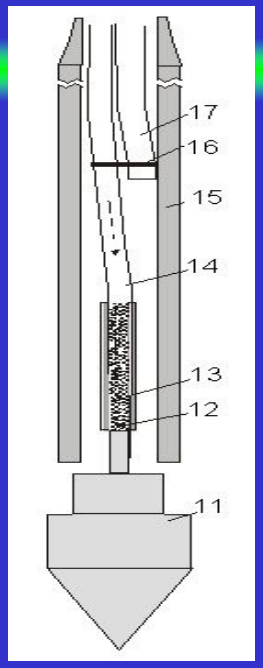
BIOXWAND-Process (AZ: 102004001802-44)



- $v_{Gas} \geq 0{,}5 - 1{,}0$ m/d
- roi $\geq 5 - 20$ m

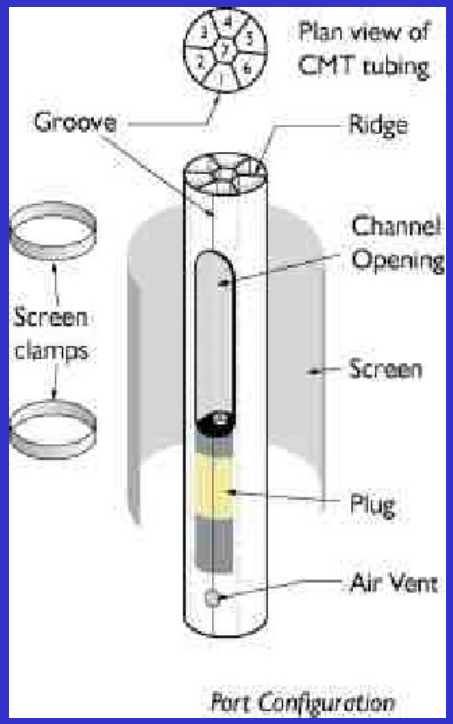
Construction of gas injection technology





Drilling injection lances

- small diameter sonic drilling - tube lances,
  - injection of bentonite mixtures
  - formation of gas blockages
  - survey of layer compaction
  - geophysical underground gas storage



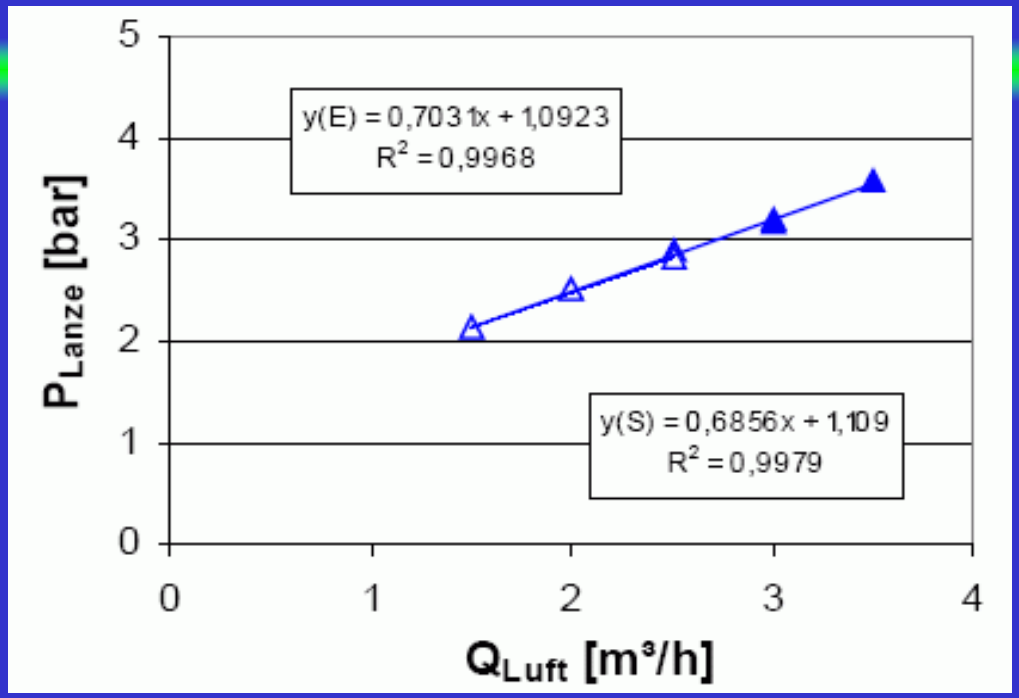
CMT-injection lances

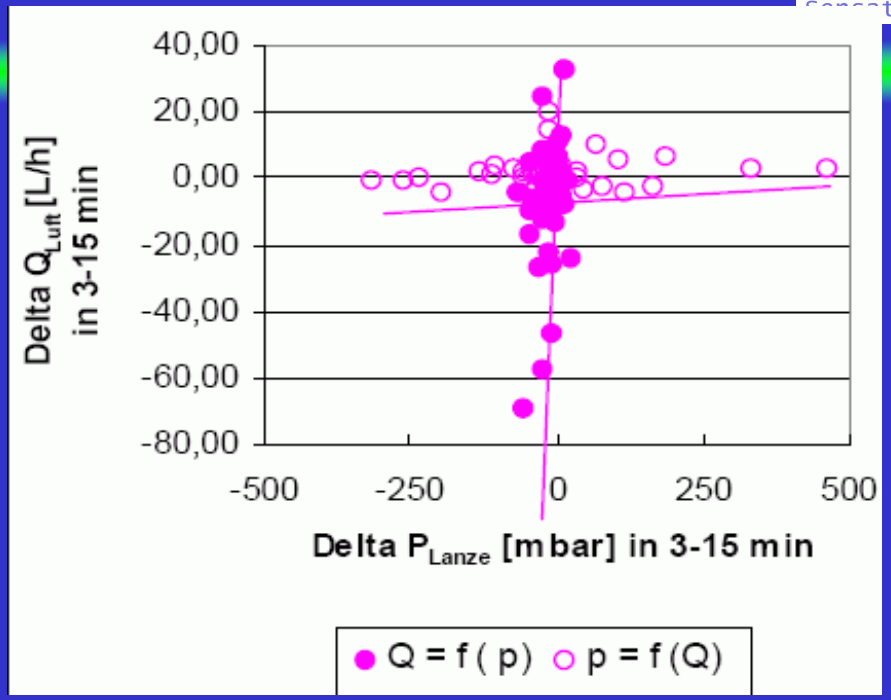
- installation by „lost tip drilling“

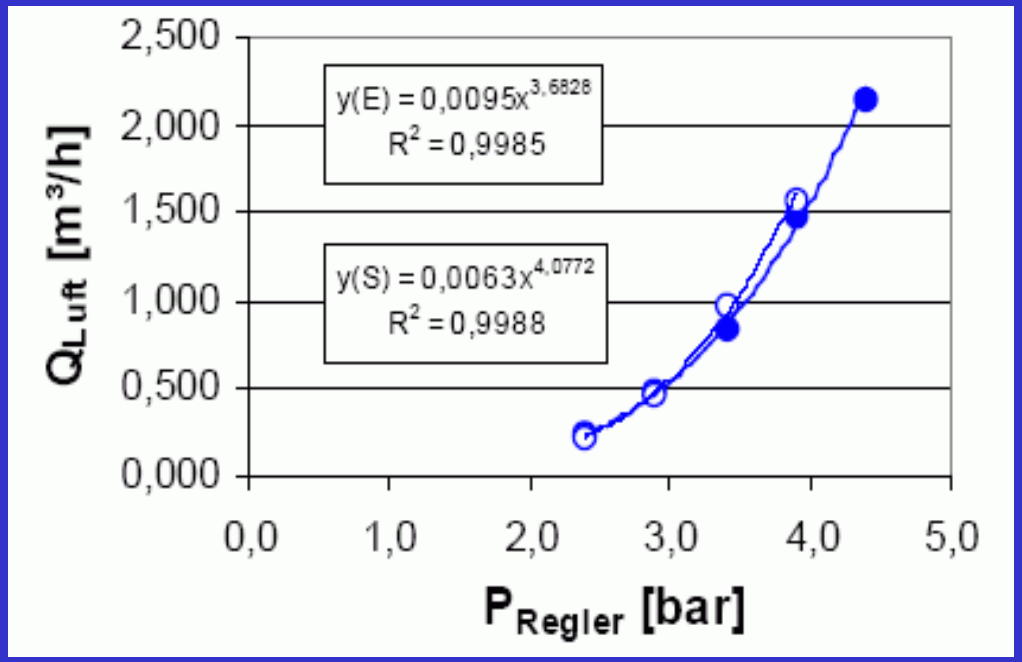
  - groundwater sampling

Robust in-situ Sensors

Quality control gas injection lances

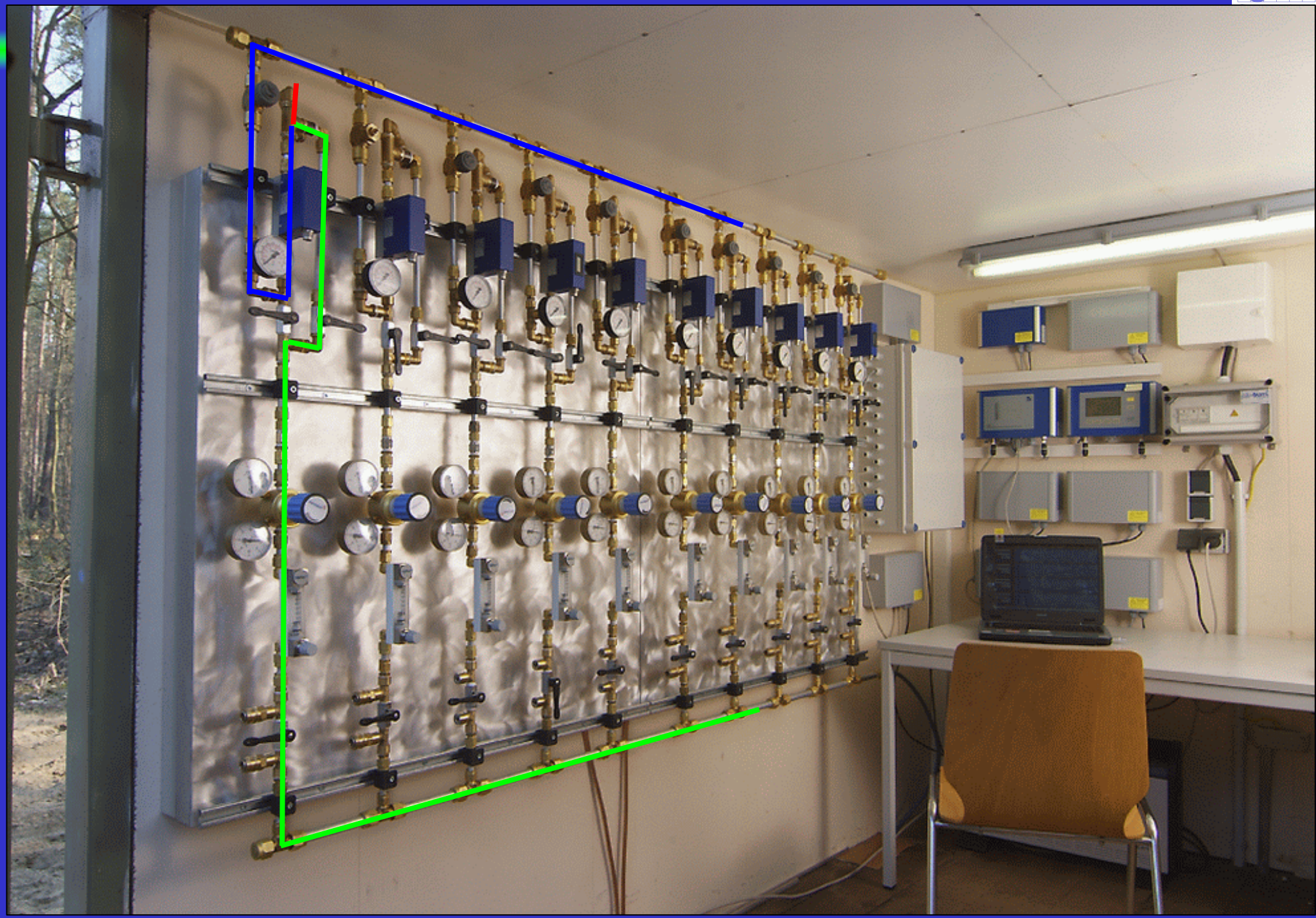






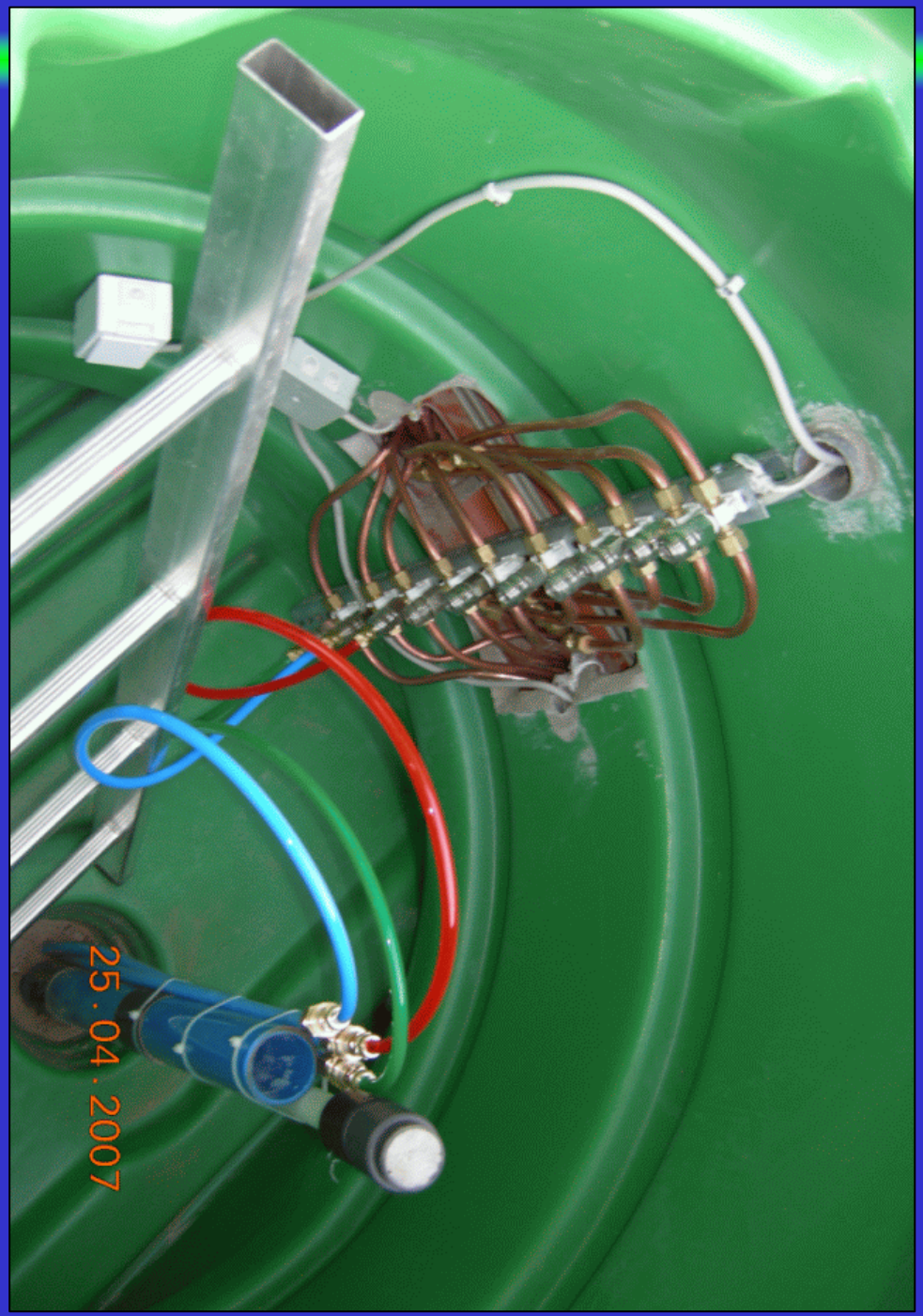
- **q-const. Injection**
  - high balance accuracy
  - high p-amplitudes
- **p-const. Injection**
  - low balance accuracy
  - high q-amplitudes
- **Lance characterization**
  - leak detection

On-site technology – gas distribution

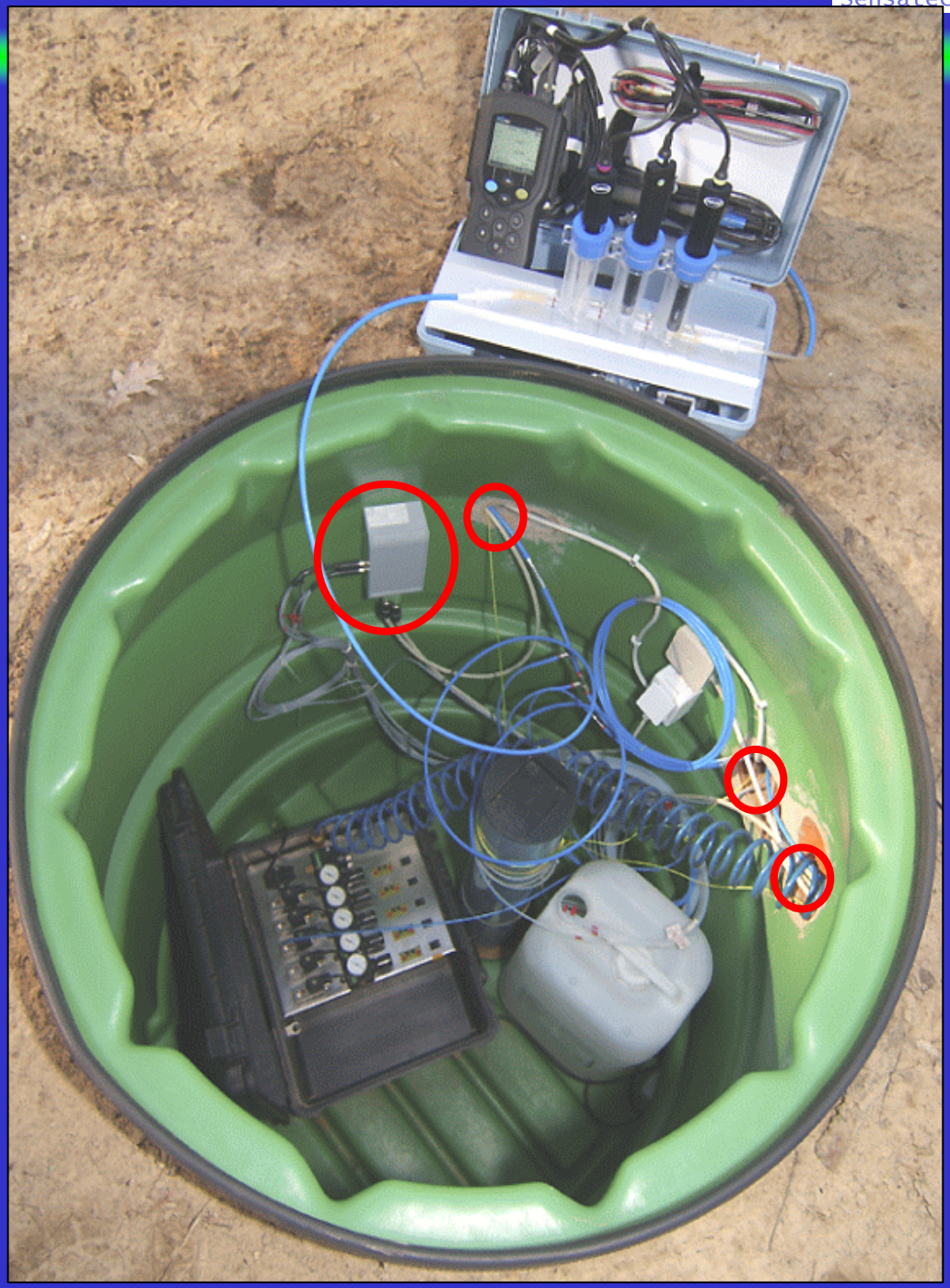


On-site technology – gas supply

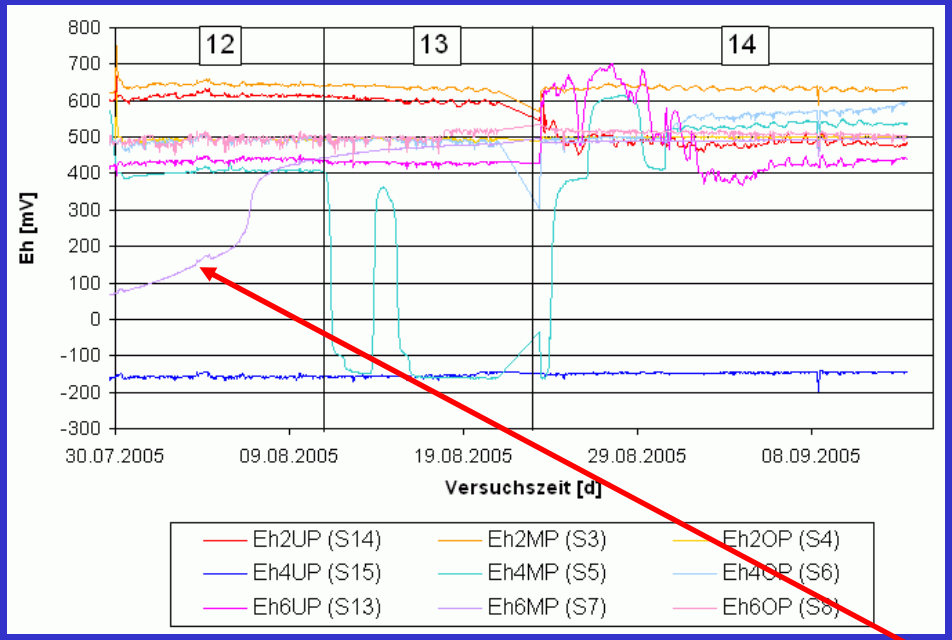
Gas distribution

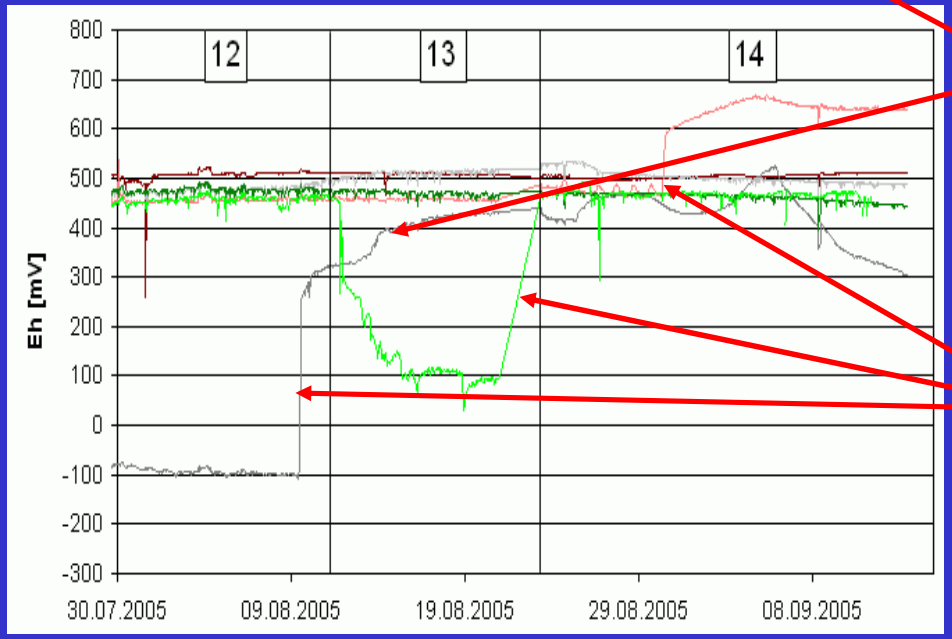


Monitoring wells



Analysis of aquifer gas transport

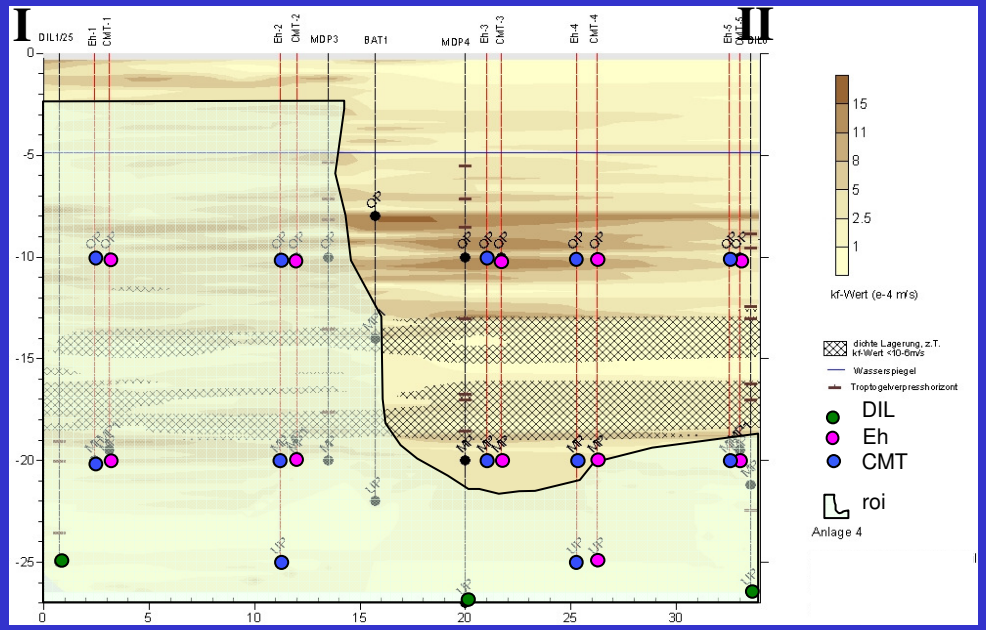




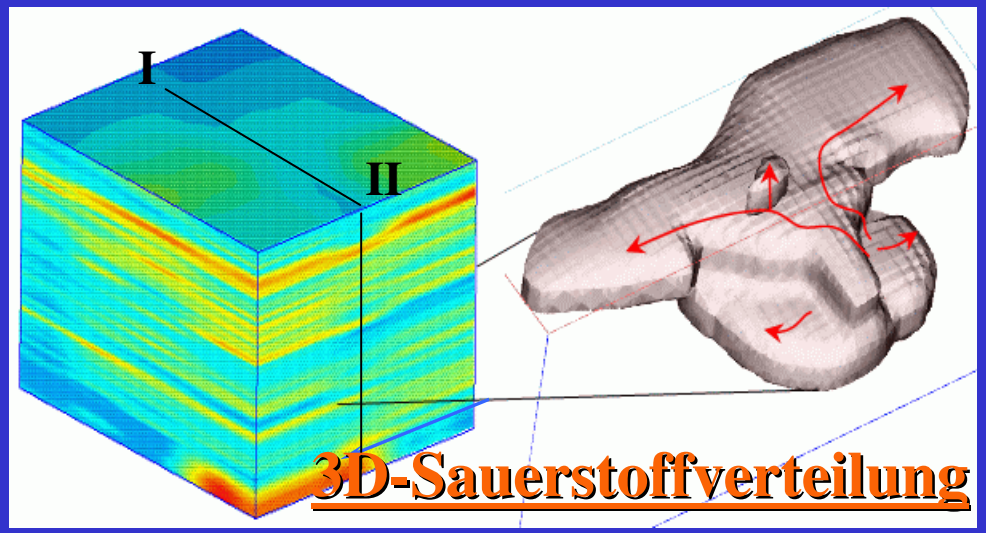
- ☞ **incoherent gas transport**
- ☞ **30 mV/d**

- ☞ **coherent gas transport**
- ☞ **300 mV/d**

Reactant distribution with gas injection



Gaswandtransekte



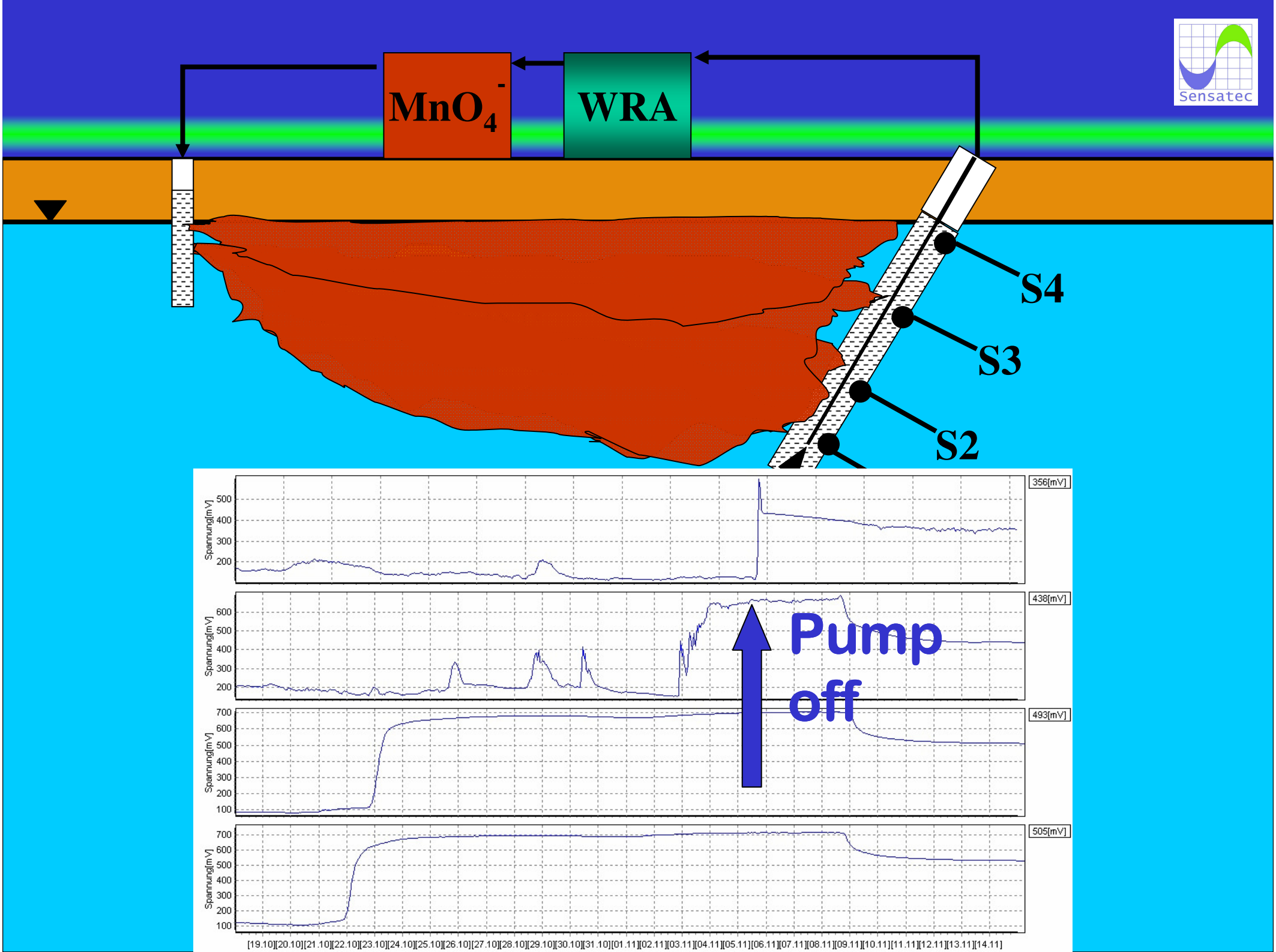
3D-Sauerstoffverteilung

The oxygen distribution is generally complex and dependent on the following factors:

- soil compaction
- flow velocities
- gas flow barriers
- biol. + chem. O_2-consumption

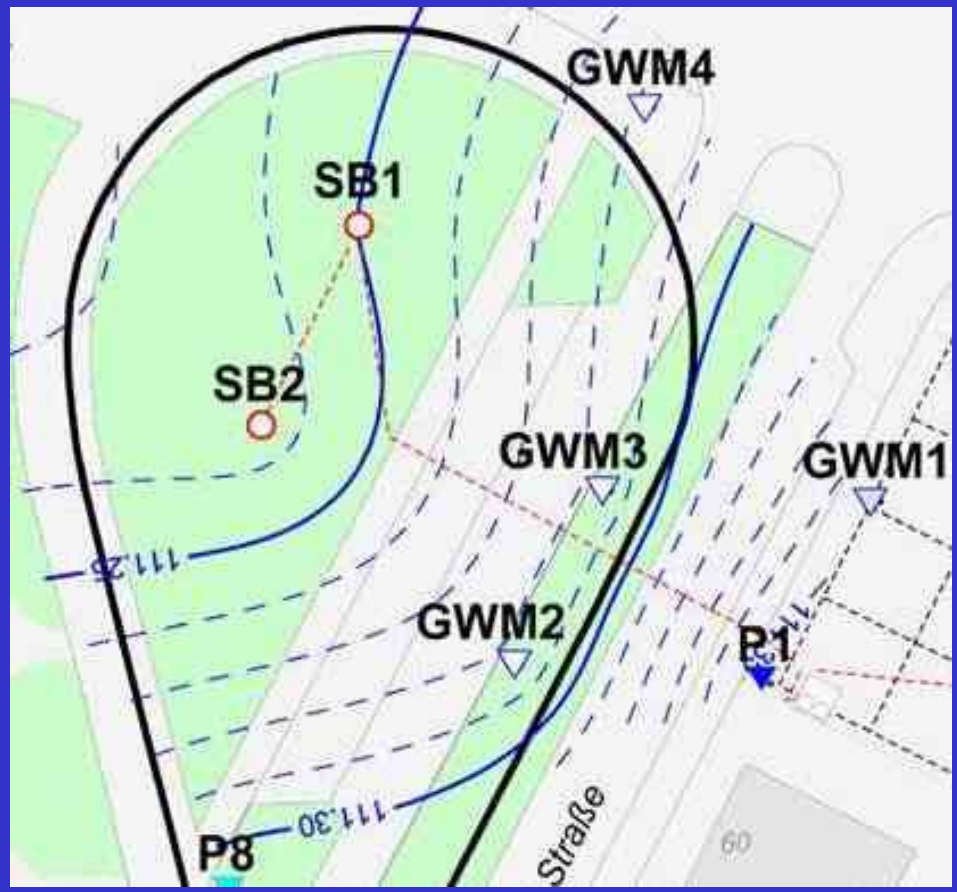
Chemical / geochemical processes

- Radius of Influence for oxidation
- Degree of acidification
- pH-buffer capacity
- spatial variability of redox processes

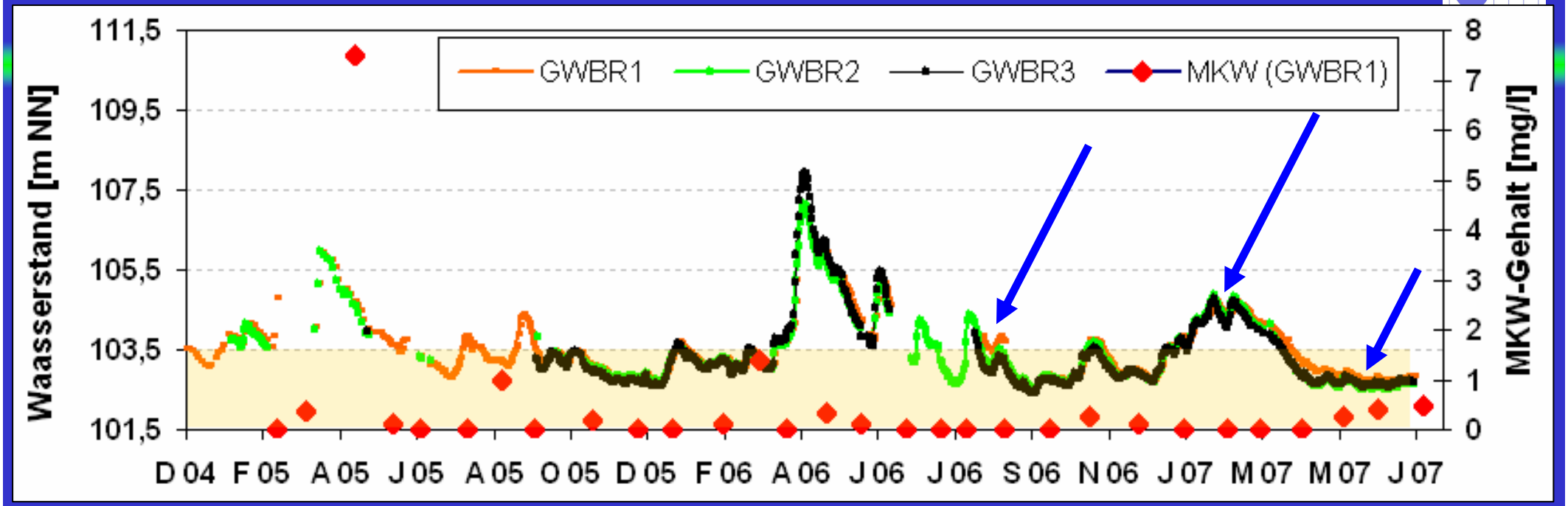

MnO_4^-
WRA
S4
S3
S2
356[mV]
438[mV]
493[mV]
505[mV]
Spannung[mV]
Pump
off
[19.10][20.10][21.10][22.10][23.10][24.10][25.10][26.10][27.10][28.10][29.10][30.10][31.10][01.11][02.11][03.11][04.11][05.11][06.11][07.11][08.11][09.11][10.11][11.11][12.11][13.11][14.11]

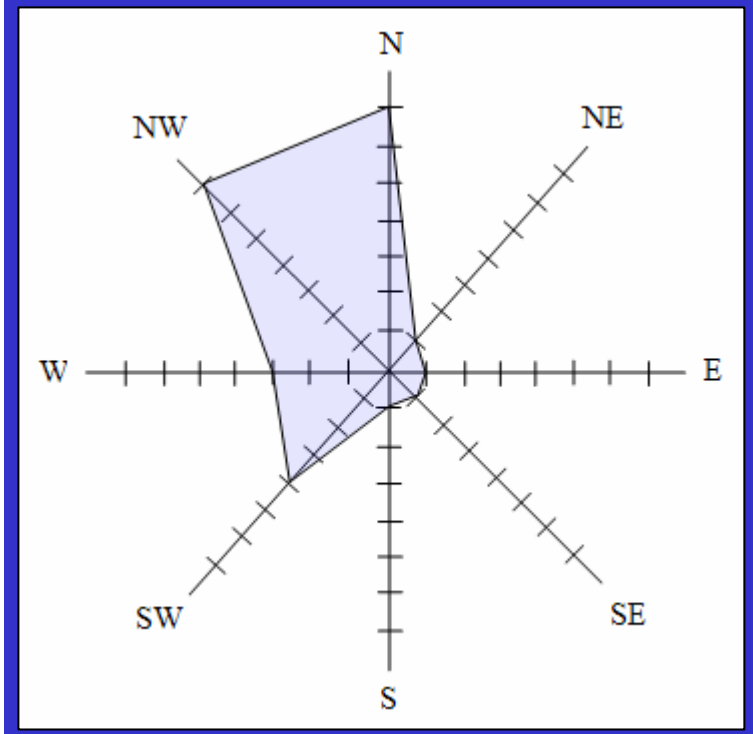
Monitoring of hydrogeological processes

- **water level**
- **flow velocity**
- **flow direction**
- **contaminant mob.**



Contaminant distribution near rivers





Water level changes affect

Groundwater flow direction

Groundwater flow velocity

Contaminant distribution

Requires stable measurement conditions

Summary

What makes the application of in-situ-sensors useful?

1. Analysis of reactant distribution
2. Control of fast processes in the subsoil
3. Monitoring of processes with high spatial variance
4. Monitoring of processes with high data stability

Future requirements

1. Low energy consuming sensors + data collection and transfer technology
2. Powerful wireless sensor networks
3. Long-term stability even under harsh environmental conditions

Thank you for your attention!