Use of a Mobile Downhole Fluorometer and Heat Flow Logging to Understand Tracer Response in Monitoring Wells with Long Screens

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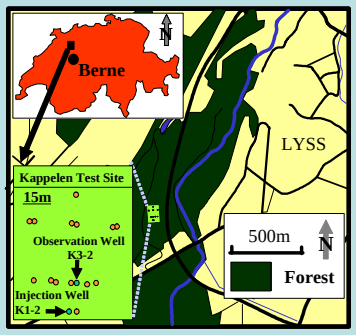
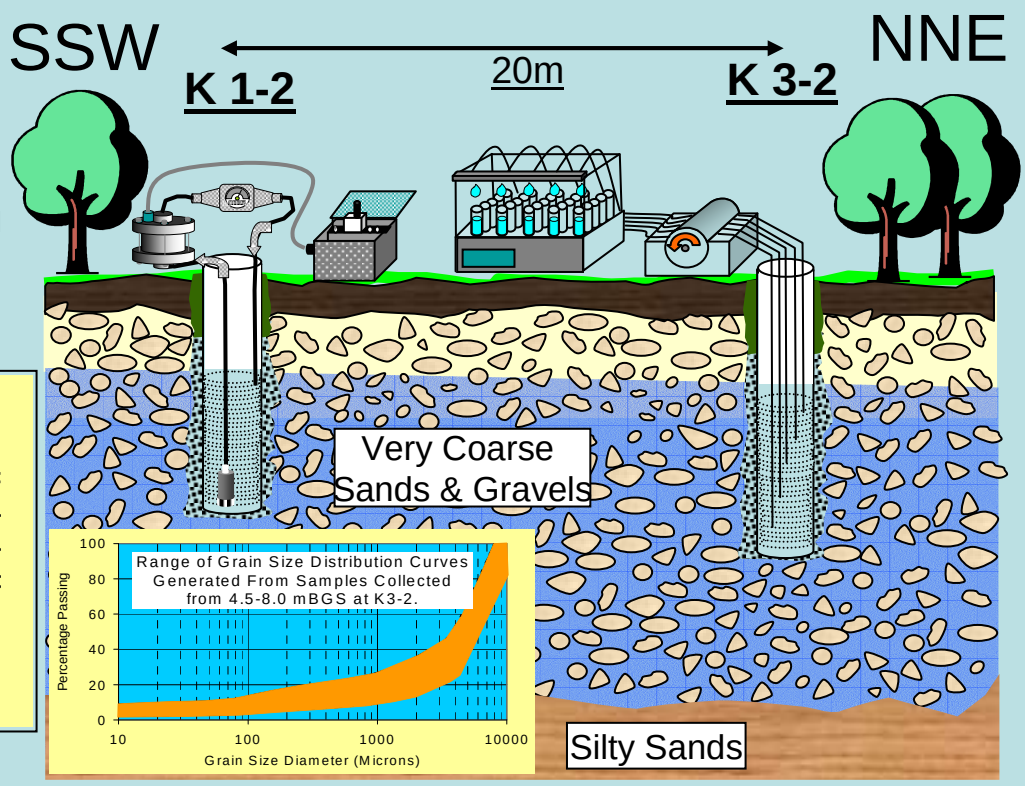
Introduction

Comparative tracer testing is a useful tool for obtaining information concerning many mass transport and attenuation parameters that may be used to assess aquifer vulnerability. Frequently test responses must be measured using wells with long screen intervals, where contributing horizons are difficult to identify. This paper presents the results of a test completed in a heterogeneous porous aquifer and uses a newly developed mobile downhole fluorometer, in conjunction with a heat flow meter to explain tracer responses.

Test Site/Methodology

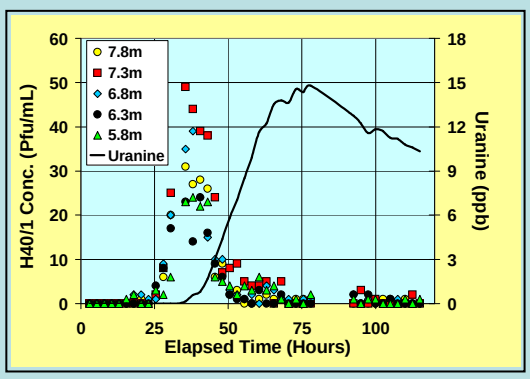


- Located on Swiss Plateau (Left)
- Part of regionally important porous aquifer
- Very coarse sand & gravels.
- Well screens 3 to 5m long
- Granulometry suggest very high gravel hydraulic conductivity 10^{-3} to 10^{-1} cm/sec.
- Initial tracer tests sampled across entire well screen (See setup in K1-2-right)
- Suggested various solute-accessible horizons attenuated viruses differentially.

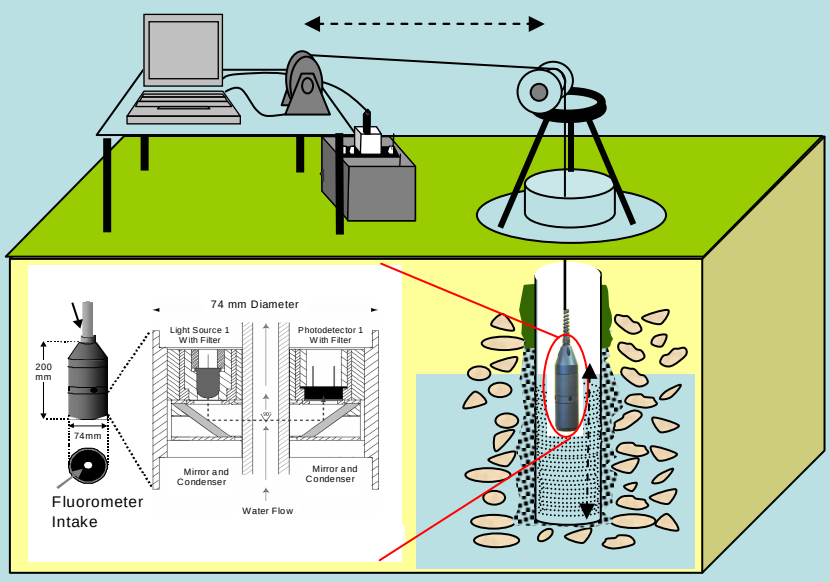


Comparative Tracer Test.

- Multi-channel low-flow sampling investigated responses at different depths in K3-2.
- Responses comparable to those observed in whole well sampling.
- Peak virus concentrations before solutes. Relative recovery ~0.1%
- Similar responses at all depths, despite K variation in deposits.



Gephysical Logging

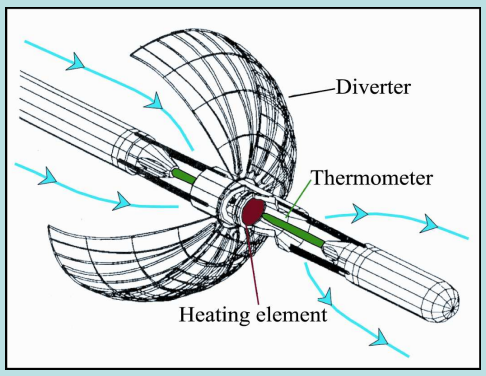


Downhole Fluorometer

- Innovative mobile downhole fluorometer.
- 2” (50mm) or 3” (75mm) diameter
- Permits Uranin detection to 0.1ppb
- Measurements every 5cm.
- Rapid number of measurements – measurements over 3.5m in 4 minutes.
- Direct output of tracer concentration to laptop computer.

Investigation Rationale

- Downhole fluorometer used to identify zones of tracer arrival to ± 15 cm over duration of breakthrough curve.
- Results of measurements coupled with heat flow measurements to see how flow regime in well affects tracer response.

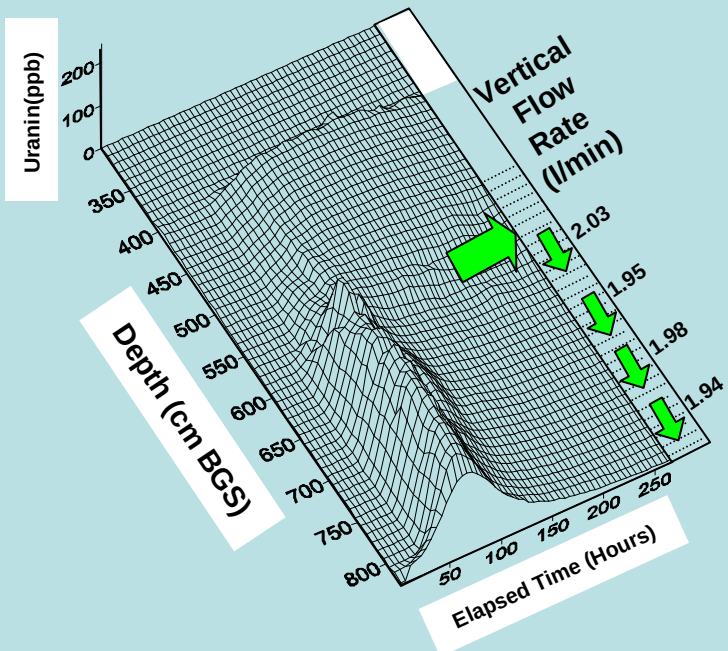


Heat Pulse Flow Meter

- Commercially available Mount Sopris heat pulse flow meter.(HFP-2293).
- Characterises vertical flow regime in borehole in range (0.113≤Q≤3.785 l/min)
- Characterised flow regime every 50cm.

Results

- Downhole fluorometer test results indicate that tracer arrives in K3-2 via a discrete horizon no thicker than 30cm.
- Upon entering the well, tracer flows downwards to the base of the well to re-enter the formation at depth.
- The absence of tracer dilution indicates that insignificant tracer free water entering well from other levels.
- Heat pulse flow meter indicates that little additional water entering well, apart from at main contributing horizon.
- Repeated heat pulse measurements indicate that flow regime change with time and that other horizons against screen not clogged.
- Behaviour explains tracer response in multichannel comparitive tracer test.



Conclusions

- Mobile downhole fluorometer is an effective tool for accurately identifying zones of tracer arrival in wells / boreholes with long exposed intervals.
- The meter can be used as an effective screening tool for selecting sampling depths in comparative tracer tests.
- Long tailing in tracer breakthrough cannot be attributed to contaminant arrival at multiple horizons.
- Study highlights the importance of preferential flow zones in mass transport in porous aquifers.
- Well screens can act as hydraulic short circuits and may rapidly transfer contaminants to multiple horizons.
- Vertical gradients in porous aquifers may change significantly with time.

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