# Interpretation of hydraulic and tracer tests in highly heterogeneous fractured media by geostatistical inversion

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## *1 – Introduction*

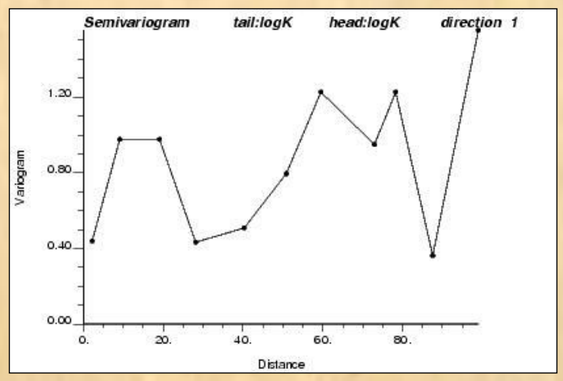
**The objective**: showing the applicability of the geostatistical inverse method to the interpretation of hydraulic tests in a highly complex environment.

**The starting point**: a number of hydraulic tests (slug, pumping and recovery,…) performed in a site in southern Spain.

**The site**: a highly heterogeneous fractured medium, where the geological formations and structures are well known to have significant anisotropy at the global scale. The changes of material are visible in superficial.

## *2 – Previous Information and Semivariogram*

- Using the slug test information we estimated an experimental semivariogram for transmissivity




- The experimental semivariogram is not reliable due to the limited number of observation points, the high heterogeneity of the medium and injectability ≠ transmissivity
- Additional hypothesis are needed to find a "proper" variogram

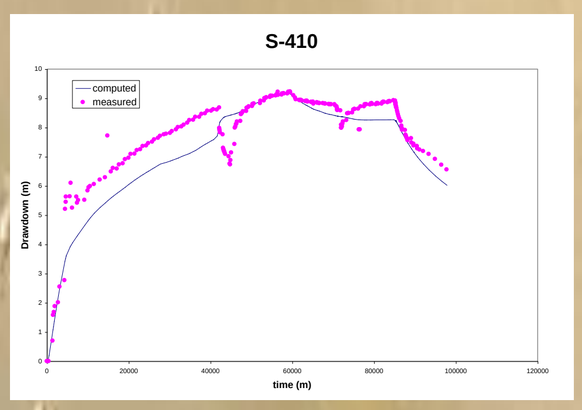
## *3 – Pilot Point Method Incorporating Prior Information*

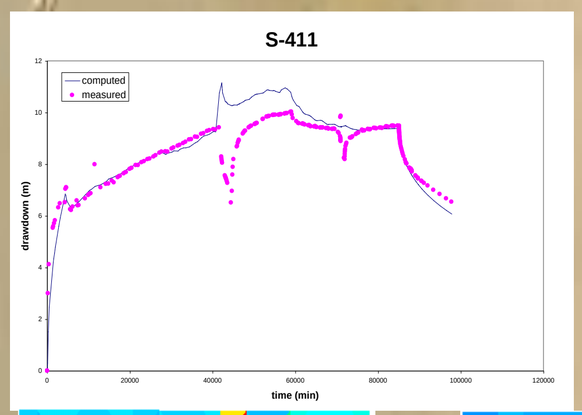
The Pilot Point Method is often applied in geostatistical inverse problems and consists in calibrating the hydraulic properties of an arbitrary number of (pilot) points in order to get the best fit of the aquifer response (DeMarsily et al., WRR, 1995;Gómez-Hernández et al., JH,1997 ). We are using a modification of this method (Alcolea et al,2006) which includes prior information in the optimization process making it more stable and allowing to use a larger number of pilot points.

## *4 – Application to the Pumping Tests*

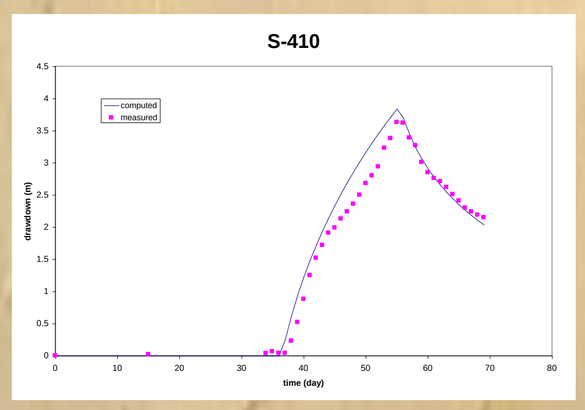
A first pumping test was carried out in 1990. The depth of the well was approximately 60 m. The well was re-drilled until 120m of depth and a second pumping test was performed (2002).

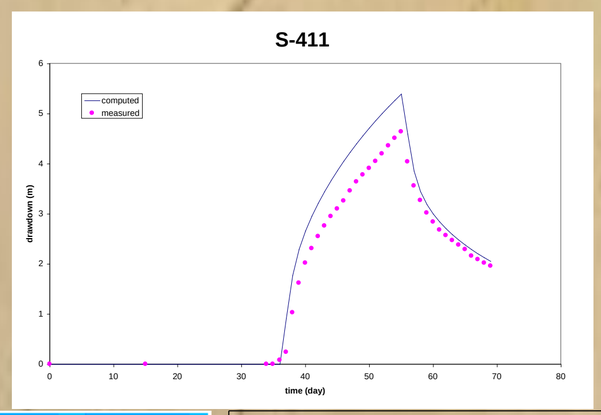
***1990***

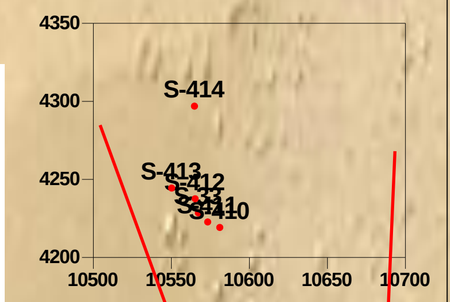


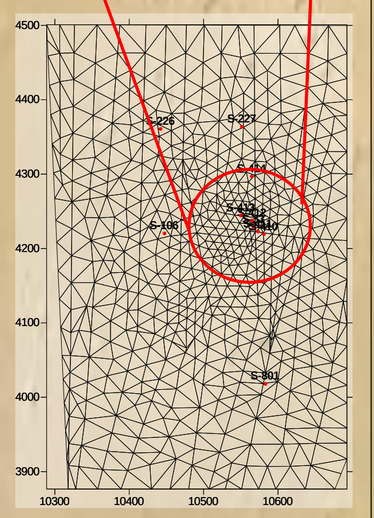



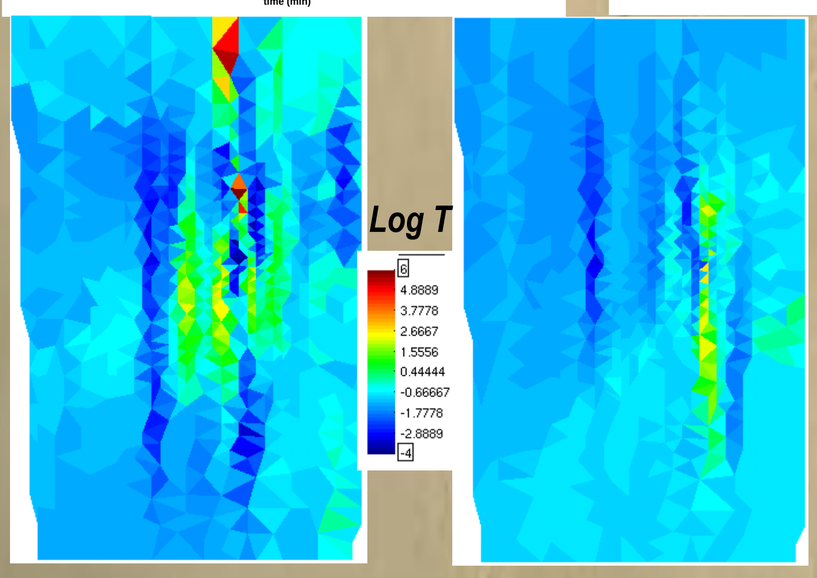

***2002***



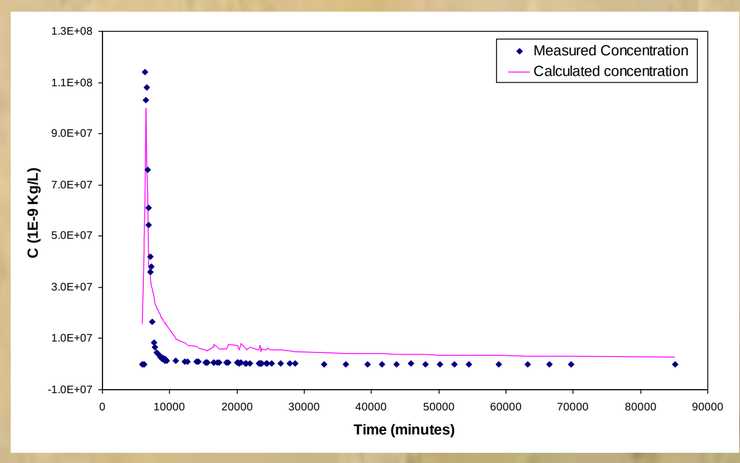




## *5 – Tracer Tests*

- A series of tracer tests under convergent flow were performed during 1990 following the first pumping test
- 6 tracers were injected in 6 different wells
- A preliminary interpretation using a BTC for Iodine is shown here. The results strongly suggest a high anisotropy ratio for dispersivity.

The interpretation calls for a non-linear mass transfer process not included so far (MRMT, CTRW, ….)




## *6 – Conclusions*

- The classical, deterministic approach needs a priori zonification while geoestatistical approach allows a posteriori characterization of the field
- The two pumping tests confirm a high heterogeneity of the medium: the response of the depth zone is very different from the superficial. Both fields confirm the anisotropy of the geological formation
- High anisotropy ratio in dispersion is masking other relevant processes taking place in the system. These should be recognized for developing proper tracer tests interpretation methods

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