The Hydrogeology Group (GHS) is a team of Professors and Researchers of the Departament d'Enginyeria del Terreny, Cartogràfica i Geofísica; UPC (Universitat Politècnica de Catalunya. BarcelonaTech); and the associated unit of the Institute of Environmental Assessment and Water Research (IDAEA) of the Spanish Council of Scientific Research (CSIC), respectively. The team consists in more than 10 professional experts and about 30 Ph.D. The group has signed more than 1,000 publications, including more than 600 in international journals. Every day contributes to the organization of national and international conferences in the field of underground water. Annually defend dissertations about 3-4 per year and 6 Master or specialization.

Research concentrates in the characterization of permeable media and the human impact by means of hydraulic, hydrochemical, biological and environmental isotope data. Applications include groundwater resources evaluation, aquifer management, ground pollution control, soil and aquifer remediation, acid mine drainage, water passive treatment, seawater intrusion, underground waste storage, human health risk analysis and vadose zone studies. The methods used range from field characterization and laboratory experiments to flow and transport modeling and development of numerical methods.

For further information: [www.h2ogeo.upc.es](http://www.h2ogeo.upc.es)

Main research activities are:

1. Stochastic modeling and probabilistic human-health risk analysis.
2. Development of software.
3. Development of numerical methods.
4. Interactions between civil engineering and groundwater.
5. Multiphase flow and reactive transport.
6. Field characterization and laboratory experiments.
7. Climate change and water/mining resources management.
(1) Stochastic flow and transport modeling

Example: Characterization of the spatial variation of hydrogeologic properties in an aquifer and its proper representation in numerical models is a key issue for environmental risk assessment, remediation engineering of contaminated groundwater and the design of underground repositories for radioactive material. This example presents a stochastic transport model of the Macrodispersion Experiment (MADE) site, Mississippi, USA, using high-resolution conductivity fields derived from a new geostatistical interpretation of the flowmeter data (Salamon et al., 2006).
(2) Development of software

This group develops codes and software for modeling flow and transport, the joint management of surface and groundwater, network design, non-isothermal multiphase flow, reactive transport, GIS-based hydrogeochemical analysis tools, etc..

**QUIMET:** A software platform developed to improve the treatment, analysis, calculations, visualizations and interpretations of hydrogeochemical data in a GIS environment (Velasco et al., 2014).

**TRANSIN:** A software to simulate flow and transport in porous media with automatic calibration and inverse geostatistical modeling tools.

**RETRASO:** coupled to CodeBright, simulates unsaturated flow with heat transport. It uses 1D, 2D or 3D finite elements for the spatial discretization and DSA (Direct Substitution Approach) or Newton-Raphson for the solution of the non-linear reactive transport equations (Saaltink et al., 2001).

**CHEPROO:** simulates complex hydrobiogeochemical processes with object-oriented concepts (Bea et al., 2009).
Example: Modeling multispecies reactive transport in natural systems with strong heterogeneities and complex biochemical reactions is a major challenge for assessing groundwater polluted sites with organic and inorganic contaminants. A large variety of these contaminants react according to serial-parallel reaction networks. In this context, a random-walk particle tracking method is presented. This method is capable of efficiently simulating the motion of particles affected by network reactions in three-dimensional systems, which are represented by spatially variable physical and biochemical coefficients described at high resolution (Henri and Fernàndez-Garcia, 2014).
(4) Civil Engineering & Groundwater

*Example:* Construction practices of underground works suffer problems mostly associated with water inflows during the construction. These problems arise due to lack of ground characterization, especially in those areas with highly heterogeneous geology that are associated with unexpected contrasts of permeability or high hydraulic vertical gradients. This is especially significant in urban areas where accurate characterization is more difficult. Therefore, the knowledge of geology and hydrogeology is usually insufficient for an accurate characterization. This is especially important during the construction phase, where the work could be affected by unpredicted events or processes (Vilarrasa et al., 2011).


Broken shaft structure by stability failure, Barcelona.
(5) Multiphase flow and Reactive transport

Example: For reactive transport with various flowing phases, such liquid and gas as in unsaturated soils, one has to take into account the transport of species in the various phases and the chemical reactions involved (e.g., aqueous and gaseous CO2). Simulation becomes particularly difficult when an important part of the phase may react. In that case flow and reactive transport becomes coupled. An example is the injection of CO2 in deep carbonate aquifers where the CO2 can dissolve in water, dissolve calcite and increase porosity.

Saturation (volume of water/volume of pore)

Porosity

Calcite dissolution as a result of injection of CO$_2$. Calcite dissolves below the CO$_2$ plume, indicated by the white discontinuous line. Calculations were done by a modified version of CodeBright (Saaltink et al., 2013).
(6) Field & laboratory experiments

Example 1: Infiltration through sediments is linked to complex biogeochemical processes occurring at small spatial scales, often leading to a progressive reduction in infiltration rates due to microbial growth and/or mechanical clogging. Unraveling the linkage between microbial dynamics and water infiltration in a heterogeneous medium is of concern in artificial recharge ponds and natural infiltration systems. We present an 84-day laboratory infiltration experiment that aims at studying the temporal variation of selected biogeochemical parameters at different depths along the infiltration path (Rubol et al., 2014).

Example 2: The performance of managed artificial recharge (MAR) facilities by means of surface ponds (SP) is controlled by the temporal evolution of the global infiltration capacity of topsoils. Cost-effective maintenance operations that aim to maintain controlled infiltration values during the activity of the SP require the full knowledge of the spatio-temporal variability. We suggest a method to obtain infiltration capacity maps suitable to be extended to engineering risk assessment concerning management of SP facilities (Pedretti et al., 2011).
(7) Resources Management & Climate Change

Example: Mining exploitations typically aim to maintain acceptable mineral laws during the production of commercial products based upon demand. This example presents a mineral distribution model of a salt basin in South America developed based on hydraulic test data, the evolution of concentrations from packer tests and production wells, and hydraulic head variations.