

# Evaluation of groundwater sources and partitioning in pre-Andean hard-rock aquifers - Application to the Pirque site (Metropolitan Region)

## General information

The research project is to be carried out within the **Magister de Ciencias de le Ingenieria** of the *Pontifical Catholic University of Chile* (UC).

The research project and the Magister are to start at the **beginning of 2018**.

The supervisor is **Sarah Leray**, Assistant Professor of the *Department of Hydraulic and Environmental Engineering* (DIHA) of the *Escuela de Ingenieria* (IngUC) of the *Pontifical Catholic University of Chile* (PUC). The project involves the following collaborations with: (1) Gonzalo Yañez, Associate Professor from the *Department of Structural and Geotechnical Engineering* (PUC); (2) The Municipality of Pirque; (3) the Nacional Forest Corporation CONAF (in the Metropolitan Region) and the manager of the Reserva Nacional Rio Clarillo.

### Links / contact:

sarah.leray1@gmail.com

[https://www.researchgate.net/profile/Sarah\\_Leray2](https://www.researchgate.net/profile/Sarah_Leray2)

<http://www.ing.uc.cl/hidraulica-y-ambiental/>

### Student profile:

Minimum qualification: Degree in Geology

Preferred competencies: Knowledge in geophysics

## Subject

Context: Highly heterogeneous and fractured media, e.g. hard-rock aquifers, have been historically the poor relation of hydrogeology (Neretnieks, 1990). Recently, they turned out being seen as potential viable water resources mainly because of: (1) the increasing demand and contamination over traditional aquifers (Naik et al., 2001); (2) their productivity surprisingly high in various cases (Ruelleu et al., 2010) and (3) their global abundance (approximately half of the global surface, Singhal and Gupta, 2010). Considering as well the uncertain impact of climate variability over water resources, these underground media are to gain in importance over the century going (Gleeson et al., 2012).

Hard-rock systems typically develop in mechanically active regions including tectonic, unloading, intrusion of igneous rock and fracturing that can induce a significant permeability (Taylor et al., 1999). Although significant advances have been made in the last two decades for understanding the hydrogeological functioning of hard-rock aquifers, a significant effort is still needed and the occurrence of groundwater resources is still unexplained.

Study area: The Pirque area, 50 km south of Santiago, is typical of hard-rock systems. In this context, it is an excellent natural laboratory to study the impact on groundwater flow of the co-existence of faults zones (San Ramon faults system) weathering and crystalline rocks (granitoide La Obra), when hosted in more pervasive rocks (Abanico and Farellones

Formations). Water issues that are facing the area strongly reinforce its interest: no more water rights are granted for superficial bodies and a severe contamination of alluvial groundwater affects the zone. Two projects of groundwater extraction are for that matter under consideration. They not only aim at mitigating the shortage of drinking water but also at exploiting a less vulnerable resource located upstream in the Valley.

Objectives: The main objectives of this proposed research is to get a contextual understanding of the hydrogeological zone upstream of the Pirque valley and the Reserva Nacional Rio Clarillo and then assess the potential for groundwater resource exploitation. Specifically, the objectives are:

- To characterize the contact between the granitic pluton and the Abanico and Farellones formations;
- To quantify the specific role of the fault zone striking North and the geological contact;
- To assess how the weathering observed in some areas affects the recharge and flow pattern;
- To identify the presence of regional cordilleran groundwater flow.

Work plan: The research will hinge on three main activities, which are:

- Carrying out a structural study to identify the main active geological structures and to characterize their geometry;
- Carrying out water budget analyses and geochemical analyses to identify possible deep or large-scale flow pattern;
- Evaluating the interest of temperature study to characterize possible upwelling flow and groundwater-surface water interaction.

The research closes with the proposition of a conceptual description of the hydrogeological functioning of the region: building a 3D visualisation of the geological framework and proposing a hydrochemical framework including possible recharge sources, flow pattern and relevant timescales. Based on this contextual understanding of the system, borehole sittings will be proposed as well.

Perspectives and significance of the study: The interest of the study does not only limit to the Pirque site. Plutonic and volcanic rocks sprinkle all along Chile, and are often associated with active tectonic. They may be of interest for groundwater resources ([Moreno et al., 2007](#)). Even when being local kilometric structures, they can constitute an attractive alternative resource satisfying for instance water need of local communities or scattered settlement (say about 10,000 inhabitants), constituting as well a less contaminated temporary resource, or an in-situ and easily-accessible resource for irrigation in agricultural settings ([Lachassagne, 2008](#)).

## References

- Armijo, R., R. Rauld, et al. (2010). "The West Andean Thrust, the San Ramón Fault, and the seismic hazard for Santiago, Chile." *Tectonics* 29(2). doi: <http://dx.doi.org/10.1029/2008tc002427>.
- Charrier, R., O. Baeza, et al. (2002). "Evidence for Cenozoic extensional basin development and tectonic inversion south of the flat-slab segment, southern Central Andes, Chile (33°–36°S.L.)." *Journal of South American Earth Sciences* 15(1): 117-139. doi: [http://dx.doi.org/10.1016/S0895-9811\(02\)00009-3](http://dx.doi.org/10.1016/S0895-9811(02)00009-3).
- Gleeson, T., Y. Wada, et al. (2012). "Water balance of global aquifers revealed by groundwater footprint." *Nature* 488(7410): 197-200. doi: <http://dx.doi.org/10.1038/nature11295>.
- Lachassagne, P. (2008). "Overview of the Hydrogeology of Hard Rock Aquifers: Applications for their Survey, Management, Modelling and Protection. Groundwater Dynamics in Hard Rock Aquifers". S. Ahmed, R. Jayakumar and A. Salih. Dordrecht, Springer Netherlands: 40-63.
- Moreno, T., W. Gibbons, et al. (2007). "The Geology of Chile", Geological Society of London.
- Naik, P. K., A. K. Awasthi, et al. (2001). "Hydrogeologic framework of the Deccan terrain of the Koyna River basin, India." *Hydrogeology Journal* 9(3): 243-264. doi: <http://dx.doi.org/10.1007/s100400100123>.
- Neretnieks, I. (1980). "Diffusion in the rock matrix: An important factor in radionuclide retardation?" *Journal of Geophysical Research: Solid Earth* 85(B8): 4379-4397. doi: <http://dx.doi.org/10.1029/JB085iB08p04379>.
- Ruelleu, S., F. Moreau, et al. (2010). "Impact of gently dipping discontinuities on basement aquifer recharge: An example from Ploemeur (Brittany, France)." *Journal of Applied Geophysics* 70(2): 161-168. doi: <http://dx.doi.org/10.1016/j.jappgeo.2009.12.007>.
- Singhal, B. B. S. and R. P. Gupta (2010). *Applied Hydrogeology of Fractured Rocks*. Dordrecht, Netherlands, Kluwer Academic Publishers (Springer)
- Taylor, W. L., D. D. Pollard, et al. (1999). "Fluid flow in discrete joint sets: Field observations and numerical simulations." *Journal of Geophysical Research: Solid Earth* 104(B12): 28983-29006. doi: <http://dx.doi.org/10.1029/1999jb900179>.
- Thielle, R. (1980). "Hoja Santiago, Región Metropolitana. Carta Geologica de Chile, escala 1:250000": Instituto de investigaciones Geológicas, Santiago, p.21.
- Vargas, G., Y. Klinger, et al. (2014). "Probing large intraplate earthquakes at the west flank of the Andes." *Geology* 42(12): 1083-1086. doi: <http://dx.doi.org/10.1130/G35741.1>.
- Yáñez, G., Muñoz, M., Flores-Aqueveque, V., and Bosch, A. (2015) "Gravity derived depth to basement in Santiago Basin, Chile: implications for its geological evolution, hydrogeology, low enthalpy geothermal, soil characterization and geo-hazards." *Andean Geology* 42(2): 147-172., doi: <http://dx.doi.org/10.5027/andgeoV42n2-a01>