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IDENTIFICATION

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PROFILE

Michael Verreault holds a bachelor's degree in Geological Engineering, a Master degree in hydrogeology and he has about 20 years of experience. He developed an expertise in groundwater and surface water tracing applied to mine dewatering. He has great skill in mine dewatering strategy, and he has been working in mines all over the globe for years.

As hydrogeologist, Mr. Verreault obviously made numerous water supply projects. He worked on projects with water supply flow rates that encompass 12 000 usgpm.

In recent years he has been working mainly in mining, conducting projects around the world. He adapted a tracer test method called a Profile Tracer Test (PTT). This technique allows to locate the contrasting flow zones in fractured rock medium, which is very helpful for mine dewatering. He also developed an electromagnetic flowmeter that allows to measure longitudinal water velocity along boreholes with high accuracy. Coupled together, PTT's and velocity measurements are impressively efficient to locate water bearing structures and optimize mine dewatering.

SPECIFIC SKILLS AND EXPERTISE

- Numerical flow simulation using Feflow, MODFLOW and Comsol

- All types of tracer tests (convergent, divergent, recirculation)
- Profile tracer tests for mine dewatering
- Standard field test, such as packer test, slug test and pump test
- Optimisation for mine operational dewatering
- 3D software, such as Leapfrog and Discover 3D

EMPLOYMENT HISTORY

Hydro-Ressources – Canada – 2011 to present Hydrogeologist - President

Selected projects (within the framework of this job)			
TMAC Resources	Mining Hydrogeology	Mine dewatering of Doris mine in Nunavut area. Field testing, dewatering strategy, optimisation for operation, grouting advices, etc.	2020 ...
AEX Gold	Mining Hydrogeology	Dewatering planning of the mine located in Greenland. Field testing, strategy, etc.	2020 ...
Osisko Metals	Mining Hydrogeology	Investigation for the Pine Point project located in NWT, south of the Great Slave Lake	2020 ...
Wallbridge Mining	Mining Hydrogeology	Mine dewatering of Tabasco and 51 zones for Wallbridge, including field investigations and numerical modeling.	2020 ...
Quebec Iron Ore	Mining Hydrogeology	Global dewatering of pits at Bloom Lake operation. Our mandate includes operational dewatering by phases, field works, strategy and planning.	2018 ...
Les Escoumins	Hydrogeology	Groundwater supply for Les Escoumins	2019 ...
Hébertville	Hydrogeology	Water protection and vulnerability of their groundwater wells	2020
Sunshine Silver	Mining Hydrogeology	Dewatering of Los Gatos Mine in Chihuahua State, Mexico. Los Gatos Mine has major inflow and expected inflow of 35 000 gpm	2019 ...
Bonterra Resources	Mining Hydrogeology	Mining hydrogeology for various properties of Bonterra Resources, including Gladiator and Barry sites. Field investigations includes lug testing, pump tests, water sampling, etc	2018 ...
Newmont-Goldcorp	Mining Hydrogeology	Mine dewatering analysis for Eleonore mine in Canada. The project was mainly associated to grouting strategy and testing of a few stopes in 2019, dewatering strategy for 2020 and analysis for crown pillar mining under the Opinaca Reservoir	2019 ...
Silvercrest Resources	Mining Hydrogeology	Field testing and data analysis for Las Chispas project in Mexico.	2019 ...
Agnico-Eagle Meliadine	Mining Hydrogeology	Global mine dewatering, strategy, field testing for Meliadine mine in a permafrost environment	2019 ...
Critical Elements	Mining Hydrogeology	Field testing using profile tracer test for the Rose Lithium Project	2019
Bontera/Metanor	Mining Hydrogeology	Analysis for water well supply	2017 ...

Kirkland Lake Gold	Mining Hydrogeology	Global dewatering of the Taylor underground mine in Ontario	2019 ...
Quintana Minerals	Mining Hydrogeology	Global dewatering at their mine nearby Zacatecas, Mexico.	2019 ...
Troilus Gold	Mining Hydrogeology	Dewatering of 2 flooded pits. Our mandate includes dewatering planning, surface water and environmental impact assessment	2018 ...
Raglan Mine	Mining Hydrogeology	Raglan is a Glencore property, located North of Quebec. HRI is in charge of the dewatering at Mine 2 and Katinniq. Field works are ongoing to assess inflows underneath the permafrost	2016 - 2018
Ascendant Resources	Mining Hydrogeology	Operational dewatering at El Mochito mine in Honduras. Planning and strategy.	2018 ...
Foran Resources	Mining Hydrogeology	Feasibility study for a new mine in Saskatchewan. Works includes field testing and flow simulations	2018-2019
Stornoway Diamonds	Mining Hydrogeology	Renard mine is an underground operation having significant water inflow. HRI has been involved since 2017, and the first stage is now dewatered.	2017 ...
Freeport McMoran	Mining Hydrogeology	HRI is involved in the mine dewatering of Bagdad in AZ (USA). Problems are mostly associated to pore pressure affecting walls stability. PTT and other measurements will allow to increase efficiency	2017 ...
Freeport McMoran	Mining Hydrogeology	TFM is one of the largest mining operation in the world (DRC – Africa). HRI is in charge of data acquisition using PTT and in charge of the next pit dewatering.	2017-2019
Goldcorp	Mining Hydrogeology	Borden is a new underground project. HRI has been involved in some water issue recently, including infiltration underground and surface water issues	2018 ...
Canadian Malartic	Mining Hydrogeology	MCM is a gold open pit in Canada. Pore pressure and water in the pit bottom is causing problems at various places into the mine. HRI is responsible of dewatering.	2018 ...
Nyrstar	Mining Hydrogeology	Coy and Young are 2 underground operations located in East Tennessee nearby Knowville. Significant water inflows have forced Nyrstar to closed various areas of the mine. HRI is in charge of dewatering.	2018 ...
Arcelor Mittal	Mining Hydrogeology	Arcelor is a large iron ore pit in Canada. HRI has been involved in the dewatering since 2017. Currently, the focus is in the pit bottoms, and may be transferred to pore pressure as well	2017 ...
Agnico Eagle Mexico	Mining Hydrogeology	Pinos Altos is an Underground / pit operation. HRI is involved at various stage of operation, with things related to water	2016 ...
Victor Mine	Mining Hydrogeology	Victor mine is a diamond mine located North of Ontario. The actual pumping rate exceed 20 000 usgpm and the pit is going deeper. My involvement on this project is related to optimisation of wells drilling and field works.	2015

		For now, few Velocity flow profile and Profile Tracer Test were done in order to localise natural flow zones. Also, I am involved on a day-t-day basis trying to improve the dewatering system.	
Scozinc	Mining Hydrogeology	Scozinc project was a due diligence mandate in order to assess the best method available to dewater the pit and optimise investment. This property is located in Nova Scotia	2014
Premier Gold Mines	Mining Hydrogeology	Hardrock property is an ongoing project for an open pit above an existing underground mine. This project was consisting of conducting a series of test in existing exploration holes, for open pit operation. Investigation program was a sequence of slug test and profile tracer test. During this program, 12 holes have been tested with the PTT technique, allowing us to understand the flow with a significant accuracy	2014 - 2015
Premier Gold Mines	Mining Hydrogeology	Premier Gold is the only owner of Cove Pit, in Nevada, USA. This pit has been operated by Newmont during the 90's, but Newmont stopped the operation because of water problems. Hydro-Ressources has the mandate to define a potential solution for water control around the pit. Grouting have been analyse in combination with pumping.	2014
Excellon Resources	Mining Hydrogeology	This project was consisting of conducting a series of test in existing exploration holes, for both surface and underground dewatering. Actually, the mine is having serious problem of water, with pumping of 17 000 usgpm in a limestone formation. The project is consisting of adding four large surface wells to increase pumping capacity to 34 000 usgpm. To locate the wells, a series of tests has been done on the field. These field works includes slug test, injection test, profile tracer test, velocity flow profile (spinner log), hole drilling and core description (RQD, IDF, etc), drill crew management, underground drilling, pressure test, pump test, etc. On this project, Hydro-Ressources act as an internal consultant, helping the mine on a day-to-day basis.	2014 ...
		Mine is currently dry.	
Commerce Resources	Mining Hydrogeology	Field investigation for Commerce Resources in Kuujuaq area. This project is consisting of doing field investigation on a PFS level for an open pit operation. Field works includes velocity flow profile (spinner log), slug test and packer test. Packer test was conducted using double straddle packer and velocity flow profile was conducted on reverse mode, injecting water instead of pumping water	2015 - 2016
Nyrstar	Mining Hydrogeology	Field works and data analysis for the Cumberland zinc mine in Nashville, Tennessee area. Nyrstar is having problem with high H2S content in water, slowing down the production. This water is circulating in Karst environment, what complicate things.	2014 ...

		Investigation program is ongoing in order to find solution on a day-to-day basis for water control and/or dewatering. Field works includes velocity flow profile, pressure variation, underground pump test, water sampling, etc. On this project, Hydro-Ressources act as an internal consultant, helping the mine on a day-to-day basis.	
Hecla Mining	Mining Hydrogeology	Operational dewatering of the whole mine, from underground to open pit. Hydro-Ressources is also implicated in the surface water analysis.	2014 ...
Rio Tinto	Mining Hydrogeology	Rio Tinto is operating the IOC open pit in Labrador. Since 2005, they have significant problems with water, always drilling and blasting in groundwater : they were concerned about the location of the flow zones. During this program, Hydro-Ressources conducted a series of injection/slug test and profile tracer test in order to locate the flow zone. At the end, a huge deep flow zone have been identified on the field for large well drilling	2013-2015
Osisko	Mining Hydrogeology	Dewatering analysis of the upper Beaver mine. The challenge is related to a major fault zone located in the center of the ore body. Packer testing, tracer test and numerical modeling is ongoing..	2013-2014
Hecla Mining	Mining Hydrogeology	Dewatering analysis of the future East pit. The challenge is related to thick layers of till and clay over the bedrock. Solution have to be determine for overburden excavation. Other pits are to be developed. HRI manage all the water at site	2013 ...
Detour Gold	Mining Hydrogeology	Dewatering analysis of the main pit and data review as a subcontractor for Technosub.	2012-2013
Arianne Resources	Mining Hydrogeology	Impact assessment and dewatering planning of the Paul pit. On this project, the pit is very close to some lakes and rivers and the impact assessment is a huge concern.	2012-2013
Goldcorp	Mining Hydrogeology	Dewatering and water control of the Eleonore mine. This underground mine is particularly affected by the presence of several major fault zones. Tracer test has been done in order to assess the fractured system.	2012 - 2016
Iamgold	Mining Hydrogeology	Assessment of the water infiltration and impact analysis of a new bloc caving mining method. A thick layer of fractured limestone is located over the igneous rock mass and could bring a lot of water during the caving process.	2012-2014
Quebec Lithium	Mining Hydrogeology	Pumping test of several wells in order to plan the mine water for the metallurgical process.	2012
Focus Graphite	Mining Hydrogeology	Realisation of several packer tests in many boreholes. Focus graphite is ongoing for an open pit	2012
Mines Arnaud	Mining Hydrogeology	Realisation of several packer tests in many boreholes. Mine Arnaud is ongoing for an open pit	2013
Cameco	Mining Hydrogeology	Tracer test in order to find a water inflow zone in the Cigar Lake mine.	2009

City of Saguenay – Canada – 2009 to 2011
Landslide manager

Selected projects			
Ville de Saguenay	Hydrogeology	Groundwater supply of the Kenogami area	2009-2011
Ville de Saguenay	Hydrogeology	Assessment of the La Baie water supply system and wells pumping optimisation	2010-2011
Ville de Saguenay	Hydrogeology	Assessment of the water supply of the whole Chicoutimi-Jonquiere areas, with wells from Laterriere. Project of more than 50 M\$	2011
Ville de Saguenay	Geotechnics	Assessment of the risk area regarding the landslides occurrence on the whole area of Saguenay City. The project consisted of determining the risk area in some parts of the city, not covered by the MTQ	2009-2011
Ville de Saguenay	Geotechnics	Intervention on more than 60 landslides across the city of Saguenay over this period.	2009-2011
Ville de Saguenay	Civil	Construction of an access road, aqueduc et waste system refecton. Project of 9M\$	2011
Ville de Saguenay	Civil	Construction of a bike road of 22km all along the Aux Sable River on the territory of Jonquiere. This project implicates both political and technical skills.	2009-2011
Ville de Saguenay	Civil	Assessment and cotation of all the tennis court of Saguenay city.	2010-2011
Ville de Saguenay	Civil	Responsible of safety associated with dams on the Saguenay city.	2009-2011
Ville de Saguenay	Civil	Surface runoof assessment problems on a part of the Chicoutimi area.	2011
Ville de Saguenay	Geotechnics	Erosion control and landslides reduction on several rivers and creeks.	2009 – 2011

Dessau – Canada – 2002 to 2009
Chief Hydrogeologist

Selected project (within the framework of this job)			
Municipality of Ferland-et-Boileau	Hydrogeology	Convergent flow tracer tests to locate a source of bacterial contamination.	2008
Municipality of St-Charles de Bourget	Hydrogeology	Analysis of the groundwater supply system and design of new wells.	2008
Private	Hydrogeology / Geotechnical	Analysis of slope stability (hydrogeological facet) through numerical simulation using FEFLOW software. This simulation made it possible to determine the degree of ground saturation, underground	2008

		pressure and flow, and to assess the stability of the slope.	
Municipality of Val-Morin	Hydrogeology	Water research (phase I) for the municipality. Analysis of available data, recommendations, etc.	2008
Town of Victoriaville	Hydrogeology	Water research for the Town of Victoriaville. The flow rate sought: approx. 15,000 l/min. At this time, two drilling campaigns have been conducted in an effort to determine a suitable pumping location. A pumping well was recently put in.	2007
Alcan	Hydrogeology	Comprehensive water research for Alcan at Chute des Passes with the installation of piezometers and one pumping well.	2007
Girardville	Hydrogeology	Estimating a pumping well's contributing areas using numerical modelling with FEFLOW software. Various work was carried out on the site.	2007
Bergeronnes	Hydrogeology	Phases 1 and 2 of a groundwater search. The drilling campaign will begin shortly.	2007
City of Saguenay	Hydrogeology	Surface water tracer tests to evaluate water losses to an aquifer resulting from the pumping of groundwater.	2007
Private	Hydrogeology	Numerical modelling of underground flow and the behaviour of certain compounds in solution using FEFLOW software. The analysis was supported by natural gradient tracer tests.	2006
City of Saguenay	Hydrogeology	Estimating the contributing areas of the aquifer's seven wells using numerical simulation (FEFLOW). The analysis is supported by different site work, including five tracer tests involving a drinking water well.	2006 - 2009
Municipality of Laverlochère	Hydrogeology	Comprehensive drinking water research, from the analysis of available data to exploratory drillings and the construction of the pumping well A convergent flow tracer test was conducted in order to accurately estimate the size of the bacterial and viral protection areas.	2006
Municipality of Notre-Dame-du-Bon-Conseil	Hydrogeology	Analysis of the groundwater operating system including convergent flow tracer tests involving a drinking water well.	2006 (ongoing)
Town of Chapais	Hydrogeology	Estimation of the contributing area of pumping wells using FEFLOW software. The simulation was supported by different investigation work.	2006 - 2007
Municipality of Hébertville	Expertise	Estimation of a pumping well's contributing area within the framework of an expropriation file (TAQ - Administrative Tribunal of Quebec).	2006
Private	Expertise	Analysis of surface and groundwater drainage causing water infiltrations.	2006
Private	Expertise	Analysis of a parking lot's surface drainage (Quebec Court).	2006
City of Saguenay	Expertise	Analysis of fill during the excavation of a main (Hearing pending).	2006

City of Saguenay Borough of La Baie	Hydrogeology	Installation of an additional production wells (500-mm diameter), with telescopic screen. Flow rate sought: approx. 3,600 l/min.	2005-2009
Private	Hydrogeology	Numerical simulation (FEFLOW software) of groundwater runoff, the degree of saturation and pressure in an aquifer.	2006
Municipality of St-Fulgence	Expertise	Analysis of the mass balance of the aquifer north of St-Fulgence, for review of the decision of the Commission for the Preservation of Agricultural Land (Administrative Tribunal of Quebec). This work was handled using FEFLOW software.	2005-2006
Municipality of Rigaud	Hydrogeology	Analysis of available data to assess the feasibility of putting in an additional well in the municipality. Flow rate sought: approx. 400 l/min.	2004-2005
Municipality of Moisie	Hydrogeology	Water research. Flow rate sought: 120 l/min. The main groundwater catchment problem in this sector related to the water's iron, manganese and sulphur content. Several multi-level piezometers were installed, two (2) wells were put in and pumping tests were conducted.	2004
Private	Hydrogeology	Water research for a bottled water project. Installation of piezometers and a catchment well (250-mm diameter) and a telescopic screen. Analysis of results and project management.	2004
Municipality of St-Esprit	Hydrogeology	Evaluation of the aquifer's maximum yield and recharge. The aquifer consists of fractured limestone. There are three (3) existing wells and the flow rate sought was approx. 1,400 l/min.	2004
City of Saguenay Chicoutimi-North	Hydrogeology	<ul style="list-style-type: none"> ▪ Various numerical simulations were conducted using Visual MODFLOW software in order to: evaluate recharge, design a collector well, evaluate the effects of high-discharge pumping on other users and estimate the well protection area. ▪ Groundwater research in a former river delta. Several operators collect groundwater from the same aquifer, which covers an approximate area of 45 km². Flow rate sought: approx. 12,000 l/min. Since the material consists of very fine sand, a collector with a horizontal screen was considered. 	2003-2005
Municipality of Ste-Marguerite d'Estérel	Hydrogeology	Water research starting with the low-permeability fluvioglacial deposits (silty sand). Confirmation of the bedrock with a borehole allowed us to identify a highly permeable fractured zone. A production borehole was built and appropriate tests were conducted. Flow rate sought: 1,800 l/min.	2003-2004
Municipalities of Hébertville-Station and St-Bruno	Hydrogeology	Phase I of the water research project (work underway) including the analysis of maps and aerial photographs. Flow rate sought: approx. 5,300 l/min.	2003-2009
Municipality of St-Stanislas	Hydrogeology	Improvements to the existing water catchment system in an aquifer that it neither thick nor deep. Modifications involving the installation of drains. Flow rate sought: approx. 150 l/min.	2003-2009

Private	Hydrogeology	Comprehensive water research project including the installation of a piezometer and production borehole as well as pumping tests. Flow rate sought: approx. 200 l/min.	2003
Private	Hydrogeology	Phases I and II of a water research project, including the analysis of available information, the production of boreholes, and the evaluation of an artificial recharge system. Flow rate sought: approx. 2,000 l/min.	2003
Town of Chapais	Hydrogeology	<ul style="list-style-type: none"> ▪ Convergent flow tracer tests involving a pumping well were conducted during the pumping test. The objective of the test is to evaluate if the well receives water from Presqu'île Lake as well as assess the transfer time between two (2) points for a set flow rate. ▪ Phases I and II of the water research project including the analysis of maps and aerial photos. The targeted aquifer is an esker and the flow rate sought is in the order of 7,200 l/min. Phase III of the work calls for the production of a well with a diameter of 760 mm.. 	2002-2009
Municipality of St-Fulgence	Hydrogeology	<ul style="list-style-type: none"> ▪ Numerical simulation of underground flow using Visual MODFLOW software. The project consisted in estimating the protection and catchment zones of the production borehole located in unconsolidated deposits. The conceptual model was developed thanks to piezocones, drillings, pumping and tracer tests. ▪ Convergent flow tracer tests to assess, among others, the average transfer time between different points in the aquifer, the dispersive properties of the environment, and the bacterial and viral protection areas. ▪ Phases II and III of the water research, including the installation of piezometers, a pumping well and tests. Flow rate sought: approx. 1,500 l/min. 	2002-2007
Municipality of St-Félix-d'Otis	Hydrogeology	<p>Phases I, I and III of the water research, including the analysis of maps, the installation of piezometers, the design of wells and the supervision of pumping tests. Flow rate sought: approx. 400 l/min.</p> <p>Convergent flow tracer tests were carried out during the pumping tests.</p>	2002-2006
Municipality of Sacré-Cœur	Hydrogeology	<ul style="list-style-type: none"> ▪ Numerical simulation of underground flow using Visual MODFLOW software. The project consisted in estimating the protection and catchment zones of the production borehole in unconsolidated deposits. The conceptual model was designed thanks to piezocones drillings and pumping tests. Calibration was con- 	2002-2006

		<p>ducted using the levels of the groundwater table as well as the elevation and measured flow rates of streams.</p> <ul style="list-style-type: none"> ▪ Convergent flow tracer tests involving a pumping well during the pumping test. The objective of this test was to estimate groundwater transfer time at a given flow rate, as well as the long-term quality of the water. ▪ Phases I to III of the water research, including the analysis of available information, piezocone testing, the installation of piezometres and a pumping well (500 mm in diameter). Flow rate sought: approx. 1,740 l/min. 	
Municipality of St-Eugène	Hydrogeology	Phases I to III of the groundwater research, including the installation of piezometers, a production borehole and the execution of pumping tests. Flow rate sought: approx. 400 l/min.	2002-2003
Municipality of St-Edmond-Les-Plaines	Hydrogeology	Numerical simulations of the transport of various chemical compounds and underground flow. Evaluate the impact of the spreading of chemical and organic fertilizers on the quality of groundwater in the municipal well. Work was carried out in two (2) stages, i.e. the estimate of the well's catchment zone and simulations of various fertilizer spreading scenarios in the catchment zone. The creation of the conceptual model required that we conduct, on the work site, piezocone tests, drillings and the evaluation of infiltration and exfiltration of streams and rivers.	2002-2003
City of Saguenay Shipshaw Borough	Hydrogeology	Numerical simulation of underground flow using Visual MODFLOW software. The project consisted in estimating the protection and catchment zones of the production borehole in unconsolidated deposits. The conceptual model was designed thanks to piezocone, drilling and pumping tests.	2002
Municipality of Hébertville-Village	Hydrogeology	Phases I to III of the water research including, notably, the installation of several piezometers and two (2) pumping wells (500 mm in diameter) Flow rate sought: approx. 3,200 l/min.	2001-2004
Town of St-Félicien	Hydrogeology	Convergent flow tracer test involving the municipality's drinking water supply well. The aquifer consists of fractured limestone. This is one of the few tracer tests of this type to be scientifically documented (see Publications).	2001
Miscellaneous	Environment	Supervision of more than 200 Phase I, II and III environmental site assessments and site decontaminations.	2005 to 2009

**Techmat – Canada – 2001 to 2002
Hydrogeologist**

Rio Tinto	Hydrogeology	Characterization of the contamination of ground-water from the Vaudreuil plant's #4 basin and the development of action plans for recovering the contamination through underground pumping, leading, among others, to a numerical simulation of underground flow and the transportation of contaminants (cyanide).	2001
Rio Tinto	Environment	Environmental evaluation and tracking study of basins #2 and 3A, and leaks to the south of local and gypsum basins (SDDS and SDDI).	2001
Municipality of St-Henri-de-Taillon	Hydrogeology	Phase IIIa of the water search including the installation of a pumping well and pumping tests. Flow rate sought: approx. 950 l/min.	2001
Municipality of Anse St-Jean	Hydrogeology	Evaluation of the yield of the Mont-Edouard resort's two (2) pumping wells. Flow rate sought: approx. 350 l/min.	2001

SCIENTIFIC PUBLICATIONS AND REVIEW

Verreault M. and Rouleau A., 2005. *Les essais de traçage comme aide pour une meilleure protection de captage d'eau souterraine*. Summary of the conference of the *Association Francophone pour le Savoir*, 73rd edition.

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Verreault M., Rouleau A., Daigneault R. and Roy D.W., 2004. *An optimal Piezometric Implantation Pattern to Estimate the Contributing Area of a Pumping Well by Piezometric Mapping*. 5th joint CGS/IAH-CNC conference, session 5A, pp. 25-31.

Field, M.S., 2003. Tracer Test Planning Using the Efficient Hydrogeologic Tracer-Test Designs (EHTD) Program. USEPA report: EPA/600/R-03/034, Washington DC, 165p (review)

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Verreault M., 2003. *Étude méthodologique pour l'estimation de l'aire d'alimentation de captage d'eau souterraine en milieu complexe*. Mémoire de maîtrise, Université du Québec à Chicoutimi, Chicoutimi, 131p.

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Verreault M., Rouleau A. and Rasmussen H., 2002. *Estimating the area of contribution to a pumping well: application of seismic refraction and tracer testing*. 3th joint CGS/IAG-CNC conference, pp. 197-204.