

00-94

Environment Canada

Water Science and
Technology Directorate

Direction générale des sciences
et de la technologie, eau

Environnement Canada

Regional Hydrogeology of Fractured Rock Aquifers
in Southwestern Quebec (St. Lawrence Lowlands)

By:

M. Savard, M. Nastev, R. Lefebvre, P. Lapcevic...

NWRI Contribution # 00-94

TD
226
N87
no.
00-94

00-94

Regional Hydrogeology Of Fractured Rock Aquifers In Southwestern Quebec (St.Lawrence Lowlands)

M.M.Savard, M.Nastev, R. Lefebvre, R. Martel, N. Fagnan, E. Bourque, V. Cloutier, K. Lauzière, P. Gélinas, D. Kirkwood, P. Lapcevic, G. Karanta, A. Hamel, A. Bolduc, M. Ross, M. Parent, J.-M. Lemieux, E. Boisvert, O. Salad Hersi, D. Lavoie, F. Girard, K. Novakowski, R. Therrien, M. Etienne, R. Fortier

MANAGEMENT PERSPECTIVE

This paper presents an overview and first year results of the «Aquifères Fracturés du Sud-Ouest Québécois » (AFSOQ) project. This project on regional hydrogeological mapping of fractured aquifers from southwestern Quebec is a four year multidisciplinary and multi-institutional initiative. The project aims to provide: key knowledge required for the sustainable development of groundwater; a quantitative evaluation of the resource exploitation potential in the study area; recommendations on the protection and use of the resource; and a technical protocol for the hydrogeological mapping of fractured sedimentary rock aquifers. Our involvement in the project has been primarily to provide expertise, training and equipment in the field characterization of fractured rock aquifers. Increasingly, it is becoming clear that the groundwater contamination is intimately linked to the groundwater quantification and protection. This work will further our understanding of the hydrogeology of heterogeneous rock systems and improve our ability to predict and prevent the environmental effects of toxic substances in groundwater and help to conserve and restore priority ecosystems in Canada.

Work is ongoing in the study. A second field season was completed in September and analysis and compilation are planned for the next year. Regional scale hydrogeological modelling will be a major component of the next year's work and finally the project will complete a reporting phase.

Hydrogéologie régionale des aquifères de roches fracturées dans le sud-ouest du Québec (basses terres du St-Laurent)

M. M. Savard, M. Nastev, R. Lefebvre, R. Martel, N. Fagnan, E. Bourque, V. Cloutier, K. Lauzière, P. Gélinas, D. Kirkwood, **P. Lapcevic**, G. Karanta, A. Hamel, A. Bolduc, M. Ross, M. Parent, J.-M. Lemieux, E. Boisvert, O. Salad Hersi, D. Lavoie, F. Girard, K. Novakowski, R. Therrien, M. Etienne, R. Fortier

SOMMAIRE À L'INTENTION DE LA DIRECTION

Cet article présente un aperçu de la première année du projet « Aquifères fracturés du sud-ouest québécois » (AFSOQ), ainsi que ses résultats. Ce projet de cartographie hydrogéologique régionale de d'aquifères fracturés du sud-ouest du Québec est une étude pluridisciplinaire de quatre ans faisant appel à plusieurs institutions, en vue : d'obtenir les connaissances clés requises pour le développement durable des eaux souterraines; de réaliser une évaluation quantitative du potentiel d'exploitation des ressources dans la zone de l'étude; de faire des recommandations pour la protection et l'utilisation des ressources, et de préparer un protocole technique pour la cartographie hydrogéologique des aquifères de roches sédimentaires fracturées. Notre participation au projet consistait surtout à fournir l'expertise, la formation et l'équipement pour la caractérisation *in situ* des aquifères de roches fracturées. Il est de plus en plus clair que la solution des problèmes de contamination des eaux souterraines passe par la quantification et par la protection des eaux souterraines. Cette étude doit améliorer notre compréhension de l'hydrogéologie des systèmes de roches hétérogènes, ainsi que notre capacité à prévoir et à prévenir les effets environnementaux des substances toxiques dans les eaux souterraines, afin de contribuer à la conservation et à la remise en état des écosystèmes prioritaires au Canada.

Les travaux se poursuivent . On a terminé une deuxième saison de l'étude sur place en septembre, et on prévoit l'analyse et la compilation des résultats au cours de l'année prochaine. La modélisation hydrogéologique à l'échelle régionale sera l'un des éléments majeurs des travaux de l'année prochaine et, à la fin, on rédigera un rapport sur les réalisations du projet.

REGIONAL HYDROGEOLOGY OF FRACTURED ROCK AQUIFERS IN SOUTHWESTERN QUEBEC (ST. LAWRENCE LOWLANDS)

M.M. Savard¹, M. Nastev¹, R. Lefebvre², R. Martel², N. Fagnan¹, E. Bourque¹, V. Cloutier², K. Lauzière¹, P. Gélinas³, D. Kirkwood³, P. Lapcevic⁴, G. Karanta², A. Hamel³, A. Bolduc¹, M. Ross², M. Parent¹, J.-M. Lemieux³, E. Boisvert¹, O. Salad Hersi², D. Lavoie¹, F. Girard¹, K. Novakowski⁵, R. Therrien³, M. Etienne³, R. Fortier³

1: Commission géologique du Canada, CGC-Q, 880 Chemin Ste-Foy, Québec, C.P. 7500, G1V 4C7

2: INRS-Géoressources, 880 Chemin Ste-Foy, Québec C.P. 7500, G1V 4C7

3: Département de géologie et génie géologique, Université Laval, Québec, G1K 7P4

4: Environment Canada, NWRI, 867 Lakeshore Rd, P.O. Box 5050, Burlington, Ontario, L7R 4A6

5: Brock University, St-Catherines, Ontario L2S 3A1

ABSTRACT This project on regional hydrogeological mapping of fractured aquifers from southwestern Quebec is a four year multidisciplinary and multi-institutional initiative. The project aims to provide: key knowledge required for the sustainable development of groundwater; a quantitative evaluation of the resource exploitation potential in the study area; recommendations on the protection and use of the resource; and a technical protocol for the hydrogeological mapping of fractured sedimentary rock aquifers. The approach we advocate is to closely link the regional hydrogeological surveys to the recently revised geology of the Lower Paleozoic sedimentary formations of the aquifer system, and of the Quaternary sediments covering this aquifer. The hydrogeological surveys include a fracture study, piezometric mapping, hydrogeochemical sampling, surficial and borehole geophysics, and Lugeon and pumping tests. This paper describes the project progress after one year of work and the planned activities for the remainder of the project.

RÉSUMÉ Le projet de "cartographie hydrogéologique régionale des Aquifères Fracturés du Sud-Ouest Québécois" (AFSOQ) est une initiative multi-disciplinaire et multi-institutionnelle d'une durée de quatre ans. Le projet veut fournir: les connaissances nécessaires à la gestion durable des eaux souterraines; une évaluation du potentiel exploitable de la ressource en eau souterraine de la région d'étude; des recommandations sur la protection et l'utilisation de la ressource; et un guide méthodologique pour la cartographie hydrogéologique régionale des aquifères en roches sédimentaires fracturées. L'approche que nous préconisons est de lier étroitement les levés hydrogéologiques régionaux à la géologie récemment révisée des roches sédimentaires des Basses-Terres du St-Laurent du système aquifère, et des sédiments de surface du Quaternaire recouvrant cet aquifère. Les levés hydrogéologiques incluent l'étude des fractures, la piézométrie, l'échantillonnage hydrogéochimique, la géophysique de surface et diagraphique, ainsi que des essais Lugeon et de pompage. Cet article décrit les progrès du projet après une année d'exercice et les activités prévues jusqu'à la fin du projet.

1. THE OBJECTIVES

In a broad perspective, this regional hydrogeological mapping project (1998-2002) primarily aims to further our understanding of the distribution and availability of Canadian groundwater, and at answering the needs of decision makers relative to the use and protection of groundwater resources. Three levels of government, federal (Economic Development Canada, Natural Resources Canada), provincial (Ministère de l'Environnement du Québec: MENV) and municipal (Conseil Régional de Développement-Laurentides, four Regional County Municipalities (RCM)), work together through this partnership to solve key issues related to groundwater management. Specifically, the goals of the project are to: (1) develop an approach for the regional scale characterization of fractured sedimentary rock aquifers; (2) develop a technical protocol to guide regional mapping in such a context; and (3) quantify groundwater availability of the St. Lawrence Lowlands in southwestern Quebec, e.g. of the RCM of Argenteuil, Deux-Montagnes, Mirabel and Thérèse-de-Blainville (over 1500 km²; Figure 1). The research project is conducted by the Geological Survey of Canada (GSC) through a multi-institutional collaboration with INRS-Géoressources, Laval University, Brock

University, Environment Canada, the United State Geological Survey, Ministère des Transports du Québec, and Ministère de l'Environnement du Québec. A strength of the present initiative is in teaming up scientists from numerous disciplines: computer modelling, geophysics, hydrogeochemistry, hydrogeology, isotope geochemistry, Quaternary geology, sedimentology, stratigraphy, and structural geology.

The aquifer system characterization program integrates revised geological information and newly collected hydrogeological data, uses the large 1:100 000 mapping scale, and explores the third dimension of the system at depth. The regional study includes aquifer delineation in sedimentary rocks of the St. Lawrence Lowlands, the measurements of hydraulic properties, the chemical and isotopic characterization of groundwaters, and the quantification of groundwater recharge. The main objective for the first year of the program was to obtain a preliminary regional view of the fractured sedimentary rock aquifer system using the characterization of fractures, water level measurements in numerous wells, water level monitoring in selected wells, pumping and Lugeon tests, and sampling of groundwater for hydrogeochemical characterization (Table 1). In this paper, we present progress after the field

campaign carried out during the summer 1999 and the planned activities for the coming years.

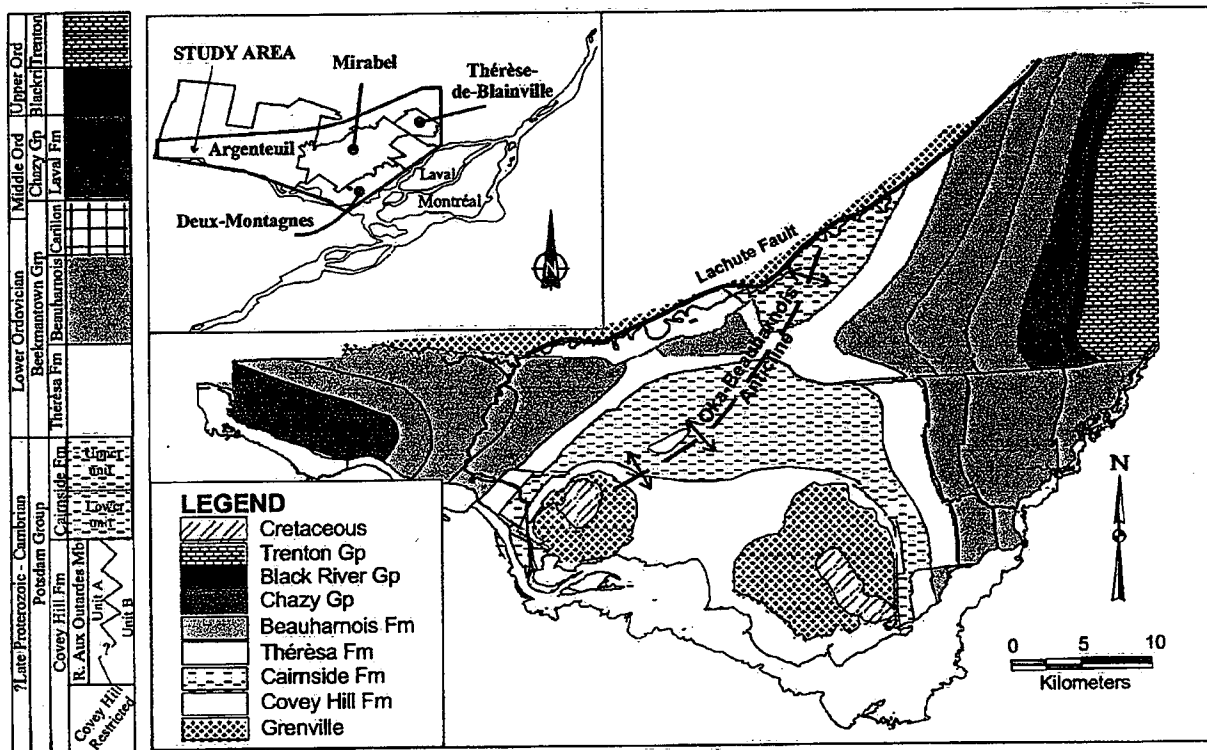


Figure 1. Stratigraphy of the St. Lawrence Lowlands, and location and geological maps of the study area.

2. GEOLOGICAL AND HYDROGEOLOGICAL CONTEXT

The aquifer system of southwestern Quebec consists in Lower Paleozoic sedimentary rocks of the St. Lawrence Lowlands, a geological province bordered by the Laurentians (Precambrian, Grenville) to the North, and the Appalachians (Cambrian to Upper Ordovician) to the South. The geological mapping of the Cambrian to Upper Ordovician sedimentary rocks and of the overlying Quaternary sediments was performed by the GSC NATMAP team in coordination with the Ministère des Ressources Naturelles du Québec (MRNQ). The MRNQ compiled the recent and older data in a new map, whereas GSC was responsible for thematic surveys including sedimentology and stratigraphy.

The recently revised regional stratigraphic succession in the southwestern St. Lawrence Lowlands includes, from bottom to top: the Potsdam (Covey Hill and Cairnside formations), Beekmantown (Thérèse and Beauharnois formations), Chazy, Blackriver and Trenton groups (Figure 1). The primary pores of these sedimentary units are totally occluded by diagenetic calcite and quartz cements, except for the dolostone of the Beekmantown Group which locally shows some open pores (Bertrand et al., 1995; Chi et al., 2000). Most of the rock units would be impermeable if it

Table 1. Summary of hydrogeological activities.

Characterization Activity	1999	2000
Fracture characterization (sites)	22	3
New observation well drilling	9	31
Water level measurements	500	50
Wells with GW level monitoring	27	30
Borehole geophysics (wells)	-	22
Seismic survey (km)	-	3
GW sampling		
- Bulk samples	69	100
- Multi-level samples	15	100
Lugeon Tests (packers)		
- Number of wells	10	12
- Number of intervals	166	300
Pumping tests	2	4
Slug tests	3	19
Rain sampling (number of samples)	20	70
Snow sampling (number of samples)	3	7
GW sampling with 3 lysimeters	-	25

were not for secondary apertures such as joints and fractures.

The Lower Paleozoic strata of the studied area are mostly flat-lying, but some major structures exist such as the Oka-Beauharnois anticline, the Lachute fault and the Cretaceous intrusions (Figure 1). Folding of the strata occurred during the Appalachian Lower and Upper Paleozoic orogenies which resulted from plate convergence compression, and the Cretaceous plutonism. The brittle structures such as fractures were produced from the Cambrian to the Mesozoic (Rocher and Tremblay, 2000). The faults and joint sets represent the main conduits for groundwater flow (see section 4.1). Taking into account deformation due to dissimilar physical properties under tectonic constraints, we can group the southwestern Quebec Paleozoic sedimentary rocks into three main lithological units: silicoclastic units (Covey Hill, Caimside, Lower Chazy), dolostone (Thérèse, Beauharnois), and limestone (Upper Chazy, Blackriver and Trenton). *A priori*, according to their individual physical behavior, the main lithological units should harbour distinct hydrogeological properties.

Quaternary sedimentation took place over the eroded strata of the Cambrian to Upper Ordovician sedimentary rocks. During the latest glaciation, the Paleozoic sedimentary rocks became covered with thick deposits of tills, which can have variable permeability. The tills were later covered by Champlain Sea minor sands and widespread clays which are well known for their cohesive and impermeable properties (Figure 2). Understanding the spatial relationship between these Quaternary deposits and the underlying fractured Paleozoic rocks is essential to delineate the aquifer and its recharge system, it therefore constitutes one of the main purposes of the NATMAP project (transect No. 1; e.g., Salad Hersi and Lavoie, 2000). This initiative aims to provide a 3-D representation of the Quaternary and Paleozoic geology for the territory of the four RCM involved, a prerequisite to developing a regional hydrogeological conceptual model.

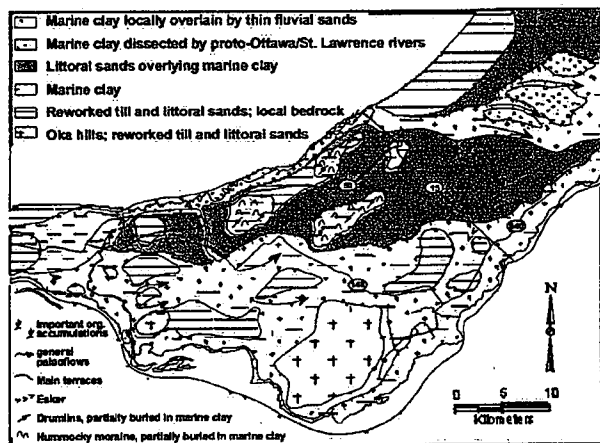


Figure 2. Preliminary geological map of the Quaternary deposits.

Surface water is drained by the Mascouche and the Rivière-du-Nord rivers and their tributaries, the two main streams being located in the east, and the northeast to southwest of the study area, respectively. Where the confining clay layers are not present, the streams are hydraulically connected to the aquifer system. As mentioned above, the Paleozoic rocks constitute the regional aquifer system, but locally, perched aquifers occur in sand underlain by clays. At the contact of the Paleozoic rocks and Quaternary sediments, a very permeable layer of either altered rocks or till is commonly described in driller reports. The nature and extent of this layer will be defined through the regional mapping program as this permeable unit might play a significant role in groundwater dynamics.

The distribution of the Quaternary sediments and their thicknesses allows the identification of direct groundwater recharge areas and a first approximation of the fractured aquifer vulnerability (Figure 3). Areas where the Paleozoic rocks are outcropping or are only covered by till are the most sensitive to contamination, whereas areas with a thick clay cover represent well protected portions of the aquifer.

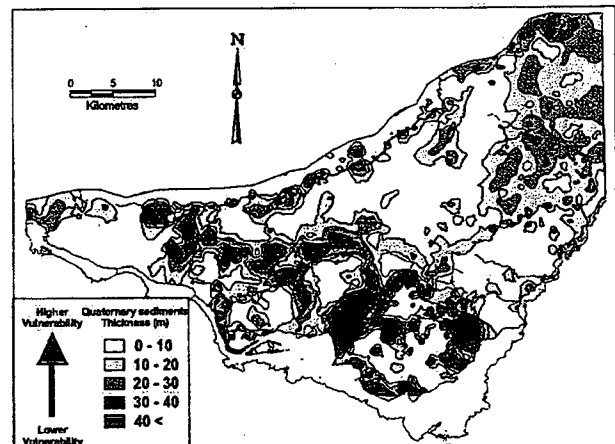


Figure 3. Thickness of Quaternary sediments and first approximation of the fractured aquifer vulnerability.

3. SPECIFIC HYDROGEOLOGICAL INVESTIGATIONS

3.1 Recharge Study

The study of the recharge is based on: (1) an analysis of 15 well hydrographs monitored between 1975 and 1993, and five river hydrographs measured since 1930; (2) an analysis of meteorological data; (3) interstitial water sampling; (4) water level survey in Quaternary deposits characteristic of the region (till, sand and clays); (5) characterization of infiltration with double ring infiltrometers; and (6) slug tests in tills. These investigations will help to estimate regional groundwater recharge.

3.2 Local Investigation Areas

Based on the available hydrogeological information, the geological setting and the specific needs of the individual RCM, six sites were selected for detailed hydrogeological investigations. The investigations will include local piezometric mapping, pumping and Lugeon tests, vertical flow profiling in dynamic and static conditions, and borehole geophysics (see 4.2). During the summer of 1999, one of the six selected sites, the Ste. Anne-des-Plaines municipal pumping station, has been partly investigated with piezometric mapping, Lugeon and pumping tests. This site lies in a confined portion of the aquifer system hosted by the upper Chazy Group (limestone). Data analysis of one pumping test indicates a transmissivity between 10^{-1} and 10^{-2} m²/s.

4. REGIONAL HYDROGEOLOGICAL INVESTIGATIONS OF THE ST. LAWRENCE LOWLANDS FRACTURED ROCKS

4.1 Characterization of Fracturing and Hydrostratigraphic Rock Units

Structural features of the Paleozoic sedimentary rocks at 22 locations (15 outcrops and 7 quarries) were characterized using their orientation, dip, spacing, length and connectivity (Lemieux, 2000). The systematic structural survey of five quarries which accounts for 700 to 800 individual joints at each quarry, resulted in the identification of regionally distributed sets of joints. A maximum of four sets of subvertical joints were recognized with their orientation mostly around 355-10°, 70-90°, 140-160°, 20-40°, but regional variations frequently occur (Figure 4). The survey also suggests that the dolostone of the Beauharnois Formation is the most fractured unit in the studied area, followed by the silicoclastic dolostone of Thérèse Formation, both forming the Beekmantown Group.

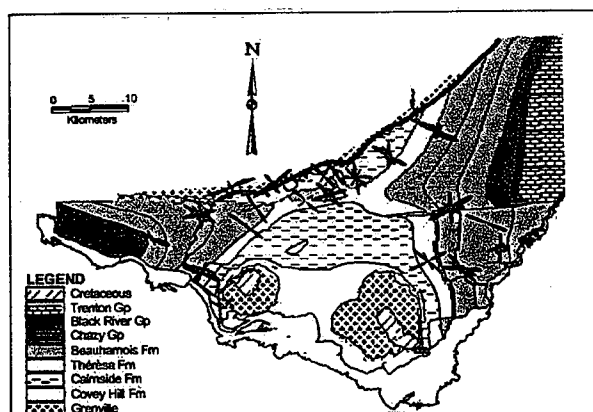


Figure 4. Rose diagrams of the joints sets.

4.2 Planned Geophysical Surveys

All newly drilled wells for the regional hydrogeological survey will be characterized by borehole geophysics. The geophysical equipment will be provided by Laval University and the USGS (Morin et al., 2000). The tools to be used include: caliper, impeller, flow meter, acoustic and optic televiwers; probes for fluid resistivity, normal resistivity, induction resistivity and temperature; and natural gamma, sonic, neutron and gamma-gamma logs. In order to obtain characteristic geophysical profiles, boreholes with known stratigraphy including the main geological Paleozoic and Quaternary units will be characterized with geophysics. Borehole geophysics will then help the stratigraphic studies in new boreholes for which there is no drill cores available, i.e. with unknown bedrock stratigraphy. A surface geophysics survey will also be conducted to support the stratigraphic interpretation and the mapping of the Quaternary sediments, to define the rock subsurface topography, and also to determine the morphology of buried troughs. Surface geophysics will use high frequency common depth point seismic reflection with split spread geometry, six-fold, and twenty four channels. This type of survey will cover sectors of very thick Quaternary deposits such as the southern central portion of the study area.

4.3 Water Levels and Regional Groundwater Flow

Over 500 water levels measurements were made regionally in July and August of 1999. In addition, a regional water level monitoring network of twenty-seven wells was set up during July 1999, with seven automated data loggers and twenty monthly manual measurements. The compiled data suggest that the regional groundwater flow in the fractured rock aquifer system is controlled by regional topography. Therefore, the main groundwater flow direction is from northwest to southeast, with local disturbances near the Cretaceous intrusions (Figure 5).

4.4 Hydrogeochemistry and Water Quality

The regional investigation of hydrogeochemistry aims to provide a data set that will: (1) allow the comparison of surficial freshwater with groundwater chemical properties, and the identification of groundwater sources; and (2) allow the study of water-rock interactions along groundwater flow paths. Ten rain collectors were installed to obtain rainwater samples monthly, starting in September 1999. For winter precipitations, twenty five composite snow samples were taken in March 2000, and monthly water samples from 3 lyzimetres will be collected from May to November 2000. Sixty nine regionally distributed bulk groundwater samples were collected from private and municipal wells during the summer 1999. For the summer of 2000, the collection of one hundred other composite samples as well as one hundred multilevel samples is planned.

The complete hydrogeochemical characterization (see Cloutier et al., this volume) will include stable isotope ratios of H, C, N and O (analyses at the Delta-Lab of GSC-Q), ⁸⁷Sr/⁸⁶Sr (analyses by GSC-CGD), radiodating tracers such as ³H and ¹⁴C (external contract), and bacteriologic parameters, major and minor element concentrations

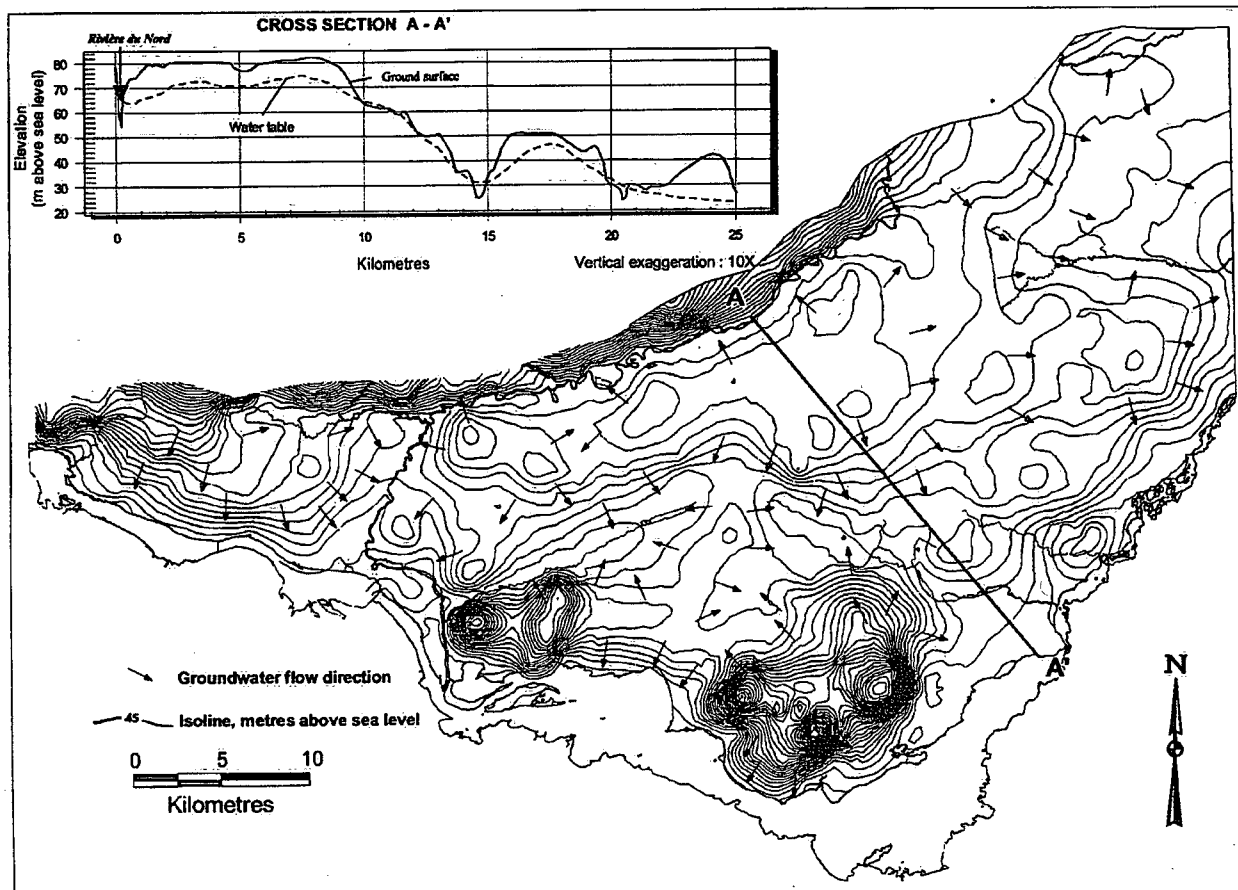


Figure 5. Piezometric map and groundwater flow direction in the fractured rock aquifer and cross section of the water table in the fractured rock aquifer.

(MENV). The preliminary regional distribution of total dissolved solids (TDS) in groundwater sampled in 1999 is presented in Figure 6. The recharge areas of the aquifer generally contain groundwater with low TDS. The wells with high TDS are mainly associated with high sodium-chloride concentrations.

In the central southern part of the study area, the groundwater with high TDS comes from a portion of the bedrock aquifer located below valleys mostly filled with marine clays of the Champlain Sea.

4.5 Lugeon Tests and Transmissivity of the Fractured Rocks

Ten boreholes previously characterized with a caliper probe were investigated with Lugeon tests. Testing was done on 166 four meter intervals with a constant head injection system using two inflatable packers. At this stage, we have begun the characterization of the Beauharnois, Thérèse, Cairnside and Covey Hill formations and of the Chazy Group. Preliminary results suggest that rock transmissivity has a weak decreasing trend with depth. Variations in transmissivity of numerous orders of magnitude were observed in all the investigated rock units (Nastev et al., this

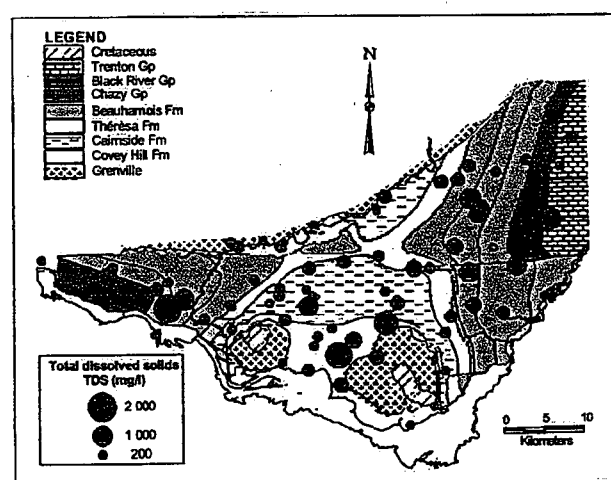


Figure 6. Concentrations in Total Dissolved Solids in groundwater of the fractured rock aquifer.

volume).

Preliminary Lugeon test results also suggest that the dolostone of the Beekmantown Group would be the most permeable unit of the studied area (Nastev et al., this volume). This interpretation is in agreement with the fracture study performed regionally which revealed a higher density of fractures within the Beekmantown dolostone (see section 4.1).

4.6 Data Base Management

Hydrostratigraphic and hydrogeological data of 8000 drill holes from water well records were filed into our database after validation of their well collar altitude, longitudinal and latitudinal locations, and water levels. In addition, the database includes results from one hundred technical reports and from our hydrogeological surveys in the summer of 1999. The database uses Microsoft Access and a modified version of the GSC-Q GIMS as the interface software (Boisvert and Michaud, this volume). GIMS is a stand alone application communicating with the database using ODBC (Open DataBase Connectivity), hence opening possibilities to interact with other database engines. The advantage of GIMS is that it allows central management of information and avoids the duplication of a multitude of software-specific files. The data are held in a relational database that can be accessed by several users at the same time. The database structure follows a simple scheme that can be expanded to accomodate new data types.

5. MAPPING SCALE AND THE PLANNED OUTPUTS

Proposing a regional hydrogeological mapping protocol poses the problem of selecting the optimal scale to collect and report hydrogeological data. The present research approach consists in soundly defining the geological context as a basis for hydrogeological mapping at the scale of 1:100 000. This approach allows the integration of regional surveys of piezometry and hydrogeochemistry, with local characterization of key hydrogeological properties such as transmissivity and conductivity in the main geological units. The scale of 1:100 000 is considered a practical hydrogeological mapping scale in the perspective of groundwater management for a sustainable development of the resource. In that context, the research team has designed a hydrogeological research program that will assess the mapping approach. The team will also provide outputs to support decision makers of southwestern Quebec by filling up the lack of information on groundwater resources in the St. Lawrence Lowlands, and contribute to the canadian groundwater inventory. For these purposes, the project will provide a better understanding of regional groundwater flow obtained from the regional integration of data, and of the hydraulics of groundwater flow in fractured media from hydraulic characterization and detailed studies.

ACKNOWLEDGEMENTS

GSC paper 20000041. The authors wish to acknowledge financial support from Economic Development Canada, Conseil Régional de Développement-Laurentides, Ministère de l'Environnement du Québec, the Regional County

Municipalities of Argenteuil, Deux-Montagnes, Mirabel and Thérèse-de-Blainville, and the Association des Professionnels de Développement Économique des Laurentides. Part of the drilling was supported by the Ministère du Transport du Québec. We want to thank John Voralec, Jacques Roussin, Eric Granger, Marjolaine Bessette and Caroline Meilhac for their technical assistance; and Alfonso Rivera for reviewing the manuscript. Sincere thanks to Jean-Luc Riopel, Marc Carrière, Carole Hart and Guy Raynault for their constant support.

REFERENCES

- Bernstein, L., 1992. A revised lithostratigraphy of the Lower - Middle Ordovician Beekmantown Group, St. Lawrence Lowlands, Québec and Ontario. *Canadian Journal of Earth Sciences*, 29, p. 2677-2694.
- Bertrand, R., Chagnon, A., Savard, M.M., 1995. Etude de l'histoire de la porosité de la cimentation, de l'eau et du gaz dans les dolomies du Groupe de Beekmantown du puits SOQUIP, Lemaire et al., Joly No. 3, Centre géoscientifique de Québec report, 40 p.
- Boisvert, E., Michaud, Y., this volume. GIMS: un plaidoyer pour la gestion centrale des données. First Joint IAH-CNC and GSC Goundwater Specialty Conference, Montreal Octobre 2000, volume of proceedings. Specialty Conference, Montreal Octobre 2000, volume of proceedings.
- Chi, G., Lavoie, D., Salad Hersi, O., 2000. Dolostone units of the Beekmantown Group in the Montreal area, Quebec: diagenesis and constraints on timing of hydrocarbon activities. *Geological Survey of Canada*, 2000-D1, 8 p.
- Cloutier, V., Bourque, E., Savard, M.M., Lefebvre, R., Therrien, R., this volume. Regional hydrogeochemical characterization of groundwater in fractured aquifers of the St. Lawrence Lowlands. First Joint IAH-CNC and GSC Goundwater Specialty Conference, Montreal Octobre 2000, volume of proceedings.
- Lemieux, J.-M., 2000. Caractérisation structurale locale et régionale des aquifères fracturés du sud-ouest du Québec. Projet de fin d'étude (GGL-14305), Département de Géologie et Génie Géologique, Université Laval, 19 pages, 2 tableaux, 37 figures, 5 annexes, et 2 disquettes en pochette.
- Morin, R.H., Senior, L.A., Decker, E.R., 2000. Fractured-aquifer hydrogeology from geophysical logs: Brunswick Group and Lockatong Formation, Pennsylvania. *Ground Water*, v. 38, p. 182-192.
- Nastev, M., Lapcevic, P., Voralec, J., Girard, F., Étienne, M., Savard, M.M., this volume. Hydraulic characterization of fractured aquifers of St. Lawrence Lowlands in southwestern Quebec. First Joint IAH-CNC and GSC Goundwater Specialty Conference, Montreal Octobre 2000, volume of proceedings.
- Pullen, S.E., and Hunter, J.A., 1999. Land-based shallow seismic methods. In "A handbook of geophysical

techniques for geomorphic and environmental research", Geological Survey of Canada, open file 3731, in collaboration with the Canadian geomorphological research group, p. 31-56.

Rocher, M., Tremblay, A., 2000. Evolution tectonique de la plate-forme du St-Laurent dans la région de Montréal: apport de la reconstitution des paléocontraintes et de l'analyse structurale. Document du Ministère des Ressources Naturelles du Québec, en préparation.

Salad Hersi, O., Lavoie, D., 2000. Stratigraphie et paloenvironnements des unités de la marge passive (groupes de Potsdam et de Beekmantown), région de Montréal. Document du Ministère des Ressources Naturelles du Québec, en préparation.

MANAGEMENT PERSPECTIVE

Title: Regional Hydrogeology Of Fractured Rock Aquifers In Southwestern Quebec
(St. Lawrence Lowlands)

Authors and Affiliations:

M.M. Savard¹, M. Nastev¹, R. Lefebvre², R. Martel², N. Fagnan¹, E. Bourque¹, V. Cloutier², K. Lauzière¹, P. Gélinas³, D. Kirkwood³, P. Lapcevic⁴, G. Karanta², A. Hamel³, A. Bolduc¹, M. Ross², M. Parent¹, J.-M. Lemieux³, E. Boisvert¹, O. Salad Hersi², D. Lavoie¹, F. Girard¹, K. Novakowski⁵, R. Therrien³, M. Etienne³, R. Fortier³

1: Commission géologique du Canada, CGC-Q, 880 Ch. Ste.Foy, Québec, C.P. 7500, G1V 4C7

2: INRS-Géoressources, 880 Ch. Ste.Foy, Québec C.P. 7500, G1V 4C7

3: Dép. de géologie et génie géologique., Univ. Laval, Québec, G1K 7P4

4: Environment Canada, National Water Research Institute, Burlington, Ont. L7R 4A6

5: Brock University, St-Catherines, Ont. L2S 3A1

NWRI Contribution Number: 00-94

Citation: To be included in proceedings of 1st Joint IAH-CNC / CGS conference, Montreal, Quebec October 15-18, 2000.

EC Priority/Issue:

EC Business Line: Nature

Outcome: Conservation of biodiversity in healthy ecosystems

Results: Priority ecosystems are conserved and restored

Current status:

This paper presents an overview and first year results of the «Aquifères Fracturés du Sud-Ouest Québécois» (AFSOQ) project. This project on regional hydrogeological mapping of fractured aquifers from southwestern Quebec is a four year multidisciplinary and multi-institutional initiative. The project aims to provide: key knowledge required for the sustainable development of groundwater; a quantitative evaluation of the resource exploitation potential in the study area; recommendations on the protection and use of the resource; and a technical protocol for the hydrogeological mapping of fractured sedimentary rock aquifers. Our involvement in the project has been primarily to provide expertise, training and equipment in the field characterization of fractured rock aquifers. Increasingly, it is becoming clear that the groundwater contamination is intimately linked to the groundwater quantification and protection. This work will further our understanding of the hydrogeology of heterogeneous rock systems and improve our ability to predict and prevent the environmental effects of toxic substances in groundwater and help to conserve and restore priority ecosystems in Canada.

Next steps:

Work is ongoing in the study. A second field season was completed in September and analysis and compilation are planned for the next year. Regional scale hydrogeological modelling will be a major component of the next year's work and finally the project will complete a reporting phase.

Environment Canada Library, Burlington



3 9055 1017 5541 0



Environment
Canada

Environnement
Canada

Canada

Canada Centre for Inland Waters

P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6 Canada

National Hydrology Research Centre

11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5 Canada

St. Lawrence Centre

105 McGill Street
Montreal, Quebec
H2Y 2E7 Canada

Place Vincent Massey

351 St. Joseph Boulevard
Gatineau, Quebec
K1A 0H3 Canada

Centre canadien des eaux intérieures

Case postale 5050
867, chemin Lakeshore
Burlington (Ontario)
L7R 4A6 Canada

Centre national de recherche en hydrologie

11, boul. Innovation
Saskatoon (Saskatchewan)
S7N 3H5 Canada

Centre Saint-Laurent

105, rue McGill
Montreal (Québec)
H2Y 2E7 Canada

Place Vincent-Massey

351 boul. St-Joseph
Gatineau (Québec)
K1A 0H3 Canada