GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7368

GIS Compilation of Prospective Paleozoic Shale Gas areas of Eastern Canada

Brake, V., Lavoie, D., Huot-Vézina, G., Thériault, R., Kennedy, G., MacDonald, A., Drage, J., Bianco, E., Hall, M., Pupek, D., Daigle, A., Hinds, S., Rennick, P., Lamontagne, C.

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Natural Resources Canada Ressources naturelles Canada

Canada

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2013

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Introduction

Shale gas production is rapidly increasing in North America and is projected to continue. Presently, shale gas production represents approximately 25% of production in the U.S and is predicted to make up 40% of production within 20 years. Canada has an estimated marketable shale gas resource on the order of 100-300 trillion cubic feet (Tcf), the production of which was initiated in northeast British Columbia in 2007. Shale gas clearly has the potential to increase long-term natural gas supplies in Canada. However, environmental concerns related to the shale gas frenzy have arisen and have even resulted in public demands for restrictions on development. Although shale gas development provides jobs, economic activity and public revenue, more environmental and geological studies by independent scientific authorities are required.

A modern understanding and appraisal of shale gas is challenged by two major issues that control the social acceptability and economic pertinence for development: local and regional water management issues. More specifically, preoccupations concerning groundwater and geological characteristics of shale gas and overlying cap units inhibit acceptability. This pertinent double research issue forms the foundation of a 4-year (2011-2015) research project supported by PERD funding with project activities planned in Quebec (Utica Shale), New Brunswick (Frederick Brook Shale) and Nova Scotia (Horton Bluff Shale). In collaboration with provincial departments of natural resources, energy, and environment, common research interest has been established in each jurisdiction. The ultimate goal of the project is to address the issue of potential natural connectivity and hence the sealing capacities of the rock unit(s) between the deep-seated target shales and the shallow groundwater aquifers.

For each geoscientific issue, it is proposed to first synthesize the available public domain data and second, in part based on the conclusions of the first phase, to develop research initiatives to fill perceived or identified knowledge gaps. This Open File report presents the results of the first year synthesis and consists of an ArcGIS database where the most significant publicly available information on shale geological characteristics and shallow groundwater data are integrated for the first time (Figure 1). This digital database provides a one-shop access for interested stakeholders to available geoscience data with information on how to access the more complete provincial databases that have been upgraded through this first phase of the project.

The database was also a critical element in the evaluation of knowledge gaps on both the deep shales and the shallow aquifers; this evaluation done jointly between the provincial and GSC personnel led to the definition of new research themes for the second year of the project.

Shale gas issues in Eastern Canada

The issues that will be addressed by this project revolve around three main themes; 1) understanding the hydrogeology of shallow and deep groundwater aquifers, 2) geological characterization of prospective shale gas units and their capping successions and 3) evaluation of the natural and eventually artificially induced connectivity between the deep gas production zones and the shallow water zones used for water supply. Given the diverse stages of shale gas exploration and development in eastern Canada, the breadth of efforts to be invested in these three themes will vary from one jurisdiction to the other.

Groundwater:

The main geoscience knowledge gap that stands out from all others is the need for a better understanding of both deep and shallow groundwater systems and how they might react when disturbed by various industry activities such as groundwater withdrawals, deep disposal of water and gas, and the impacts of hydraulic fracturing. During the first year of the project, syntheses at the prospective basin (provincial) scale have been produced in order to gather the pertinent available groundwater public data. These syntheses were critical to identify the knowledge gaps that need to be filled at the local and regional scales, in areas of potential or ongoing shale gas development.

Regional and local hydrogeological studies of shale gas basins are needed to identify and protect the areas of continuous, large capacity shallow aquifers that are currently exploited for human or industrial purposes. Understanding of the deep and usually saline aquifers is seriously lagging compared to the current, albeit fragmentary, knowledge of the shallow aquifers. The deep aquifers could, at some time in the near future, be considered as source of water for shale artificial stimulation. In addition, safe disposal zones for produced water in these deep aquifers need to be identified and evaluated and, in some areas, for gases such as CO_2. Specific studies are also needed to test for connectivity between different hydrogeological systems before and after hydraulic fracturation or injection of produced water.

For both shallow and deep aquifers, the project ultimately aims at providing a baseline hydrogeological framework. It is anticipated that, given the perceived differences in state of knowledge at the basin-scale, that the detailed research activities will significantly differ from one jurisdiction to the other.

Geological context and reservoir-cap rock properties:

From an economic benefit perspective, regional to detailed scale geological mapping and sampling of prospective shale formations is needed in both frontier and producing basins. Experience in the US and western Canada clearly indicates that all shale basins (and geological context) are different on many regional (e.g. tectonics, stress regime amongst others) to fine-scale (mineralogy, organic matter content, amongst others) grounds.

During the first year of the project, syntheses at the prospective basin (provincial) scale have been produced in order to gather all available geological data on both the prospective shale units and their overlying cap rock. Data from surface outcrop and core samples were synthesized as well as a comprehensive database of pertinent geophysical information (seismic, borehole geophysics). These data include regional and local tectonostratigraphic framework, surface and sub-surface (cross-sections) distribution of shale thickness, depth and structure as well as the fine-scale data on Total Organic Carbon (TOC) content, programmed pyrolized analyses (Rock-Eval), mineralogical composition and other data available in the public geoscience databases.

For the prospective shale and cap formations, the first-year synthesis provides a state-of-the art understanding of the publicly available data set that will be used to identify specific areas or themes in need of new geoscience knowledge to be gained through research work in the following years.

Tying the deep and shallow realms:

One of the most critical issues for the sustainable development of the shale gas industry is the perceived risk of contamination of the shallow aquifers by deep fluids (gas, in situ brines, remaining frack fluids). In the case of the shale-overlying cap strata, significant efforts will be put on the geological parameters that are at the base of a scientific evaluation of the fault/fracture/grain framework permeability of the cap unit to upward fluid - gas migration and its integrity after high-pressure hydrofracturing events.

Shales with gas potential in eastern Canada were deposited in two different geological times, the old Ordovician shales (Quebec) and the younger Carboniferous (Mississippian) shales (New Brunswick and Nova Scotia). These two major packages (shales and cap rock units) were deformed by different tectonic (orogenic) events of diverse intensity (the Ordovician Taconian and the Carboniferous-Permian Alleghenian orogenies). As such, the nature of the natural fracture framework differs in terms of ancient tectonic stress regime (compression, extension) and intensity. Moreover, as a general rule of thumb, the older the fractures, the greater the chances of fracture mineral fill and plug. However, younger events in eastern Canada have been shown to impact some of the old fractures (extensional stress from the Jurassic opening of modern-day Atlantic and the Pleistocene-Holocene glacial events).

The integration of fine-scale structural - geomechanic analysis from cap rock units with various fluid tracers (isotopes, chemistry), most of which derived from study of themes 1 and 2 (above) will lead to the development of a general methodological approach that will be applicable not only to the specific shale basins tackled by this project but also elsewhere.

GIS Compilation

Data were originally formatted for use in ArcGIS™ desktop version 10.0, developed by ESRI®. Data were compiled in a File Geodatabase™ specifically designed for visualization using ArcMAP .mxd format and later published in ArcReader format™. Two files, those for Hydro and Quebec Water Wells are not within the database and require an internet connection.

The Paleozoic shale gas compilation of eastern Canada project consists of a single dataframe containing several groups of data. Data were grouped based on location into their respective province: New Brunswick, Nova Scotia, or Quebec, which contains subgroups for Geology, Groundwater, and Exploration and Analysis. In addition to the provincial divisions, data covering the entire area were separated into the groups: Basemap, Geophysics, Digital Elevation Model (DEM), and Hillshade of the DEM. Key study areas can quickly be accessed via the bookmark tab. Upon selecting the relevant bookmark the project will automatically zoom to the desired area.

The GIS compilation is available as a published map file (PMF) and data package that can be opened with ArcReader. ArcReader is a free ESRI® product that will allow end users to view and explore the compilation with the same layout as the mxd. For more information on ArcReader please refer to http://www.esri.com/software/arcgis/arcreader

Map Projection

All layers are presented in a Geographic Coordinate System, North American Datum 1983 (CSRS) projection.

Associated PDF documents

Several Adobe PDF documents are available for complementary use with the database. The documents are accessible via ArcReader through the use of the hyperlink button () and are stored within the folder “OF 7368\Associated Documents”. When the hyperlink button is used on a layer with an associated document the PDF will pop-up on screen.

Layer Structure

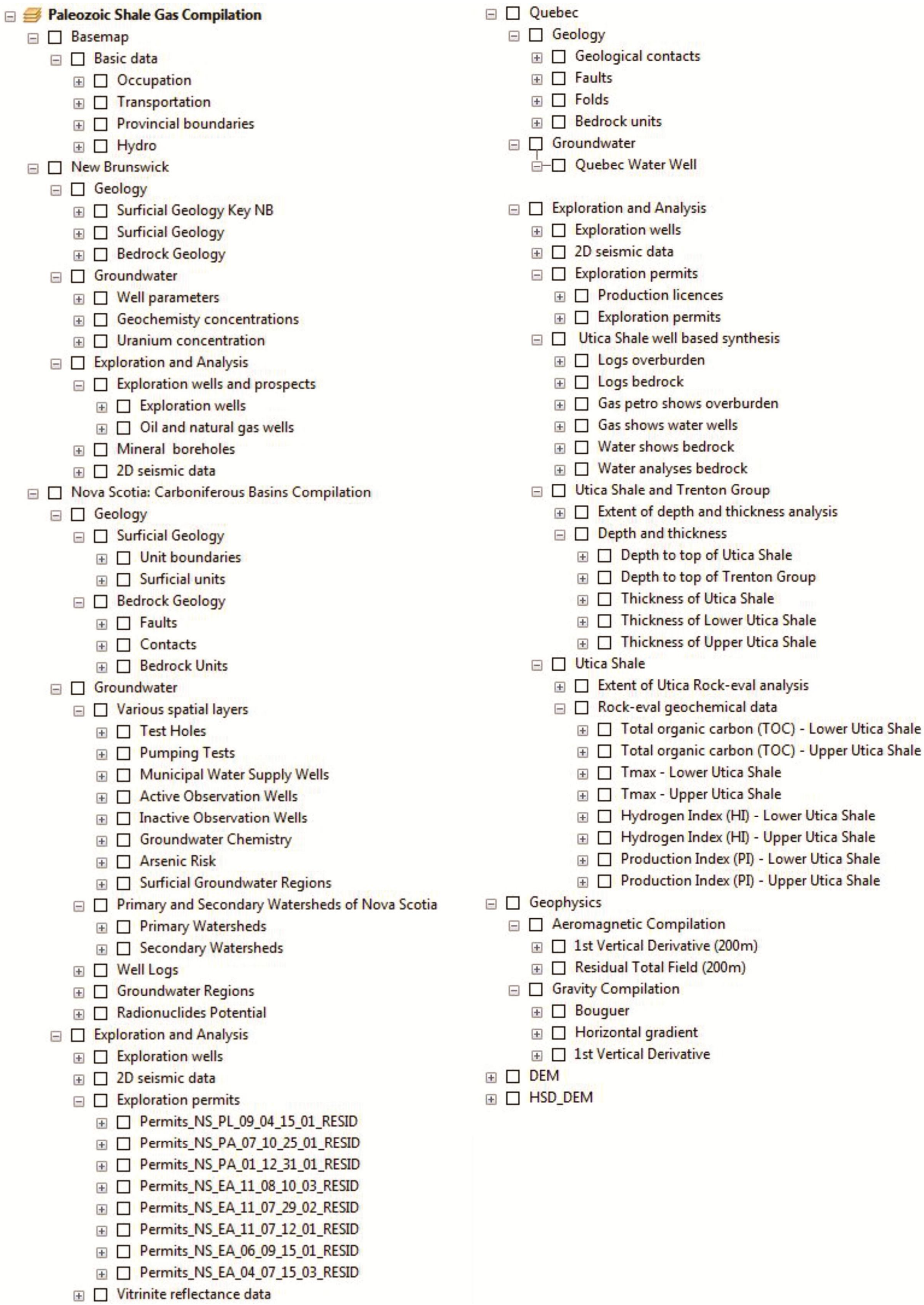

Figure 1: A brief description of the layers founds in the Table of Content (TOC) of the ArcMap project.

Basemap:

Basic data: Occupation

Layers:
Occupation

Description:
The layer was derived from the North American Atlas – Populated Places (download date: 2013/02/01):

http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do;jsessionid=DF512BEB554E0B2BF60DD4204BEEEA1E?id=618ACCE0-0D6B-8A10-A394-B9AEC557406F

For full details of the metadata please refer to:
http://geogratis.cgdi.gc.ca/geogratis/en/collection/metadata.do?id=618ACCE0-0D6B-8A10-A394-B9AEC557406F

Credits:
Government of Canada, Natural Resources Canada, Canada Centre for Remote Sensing; Instituto Nacional de Estadística Geografía e Informática; Geological Survey

Use limitation:
Data are subject to the GeoGratis Licence Agreement for Unrestricted Use of Digital Data:

http://geogratis.cgdi.gc.ca/geogratis/en/licence.jsp

Basic data: Transportation

Layers:
Transportation

Description:
The layer was derived from the North American Atlas – Roads (download date: 2013/02/01):

http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do?id=E10E7645-D2A5-CF2C-8CE8-1BA12C477F9D

For full details of the metadata please refer to:

http://geogratis.cgdi.gc.ca/geogratis/en/collection/metadata.do?id=E10E7645-D2A5-CF2C-8CE8-1BA12C477F9D

Credits:

Government of Canada, Natural Resources Canada, Canada Centre for Remote Sensing; Instituto Nacional de Estadística Geografía e Informática; Geological Survey

Use limitation:
Data are subject to the GeoGratis Licence Agreement for Unrestricted Use of Digital Data:

http://geogratis.cgdi.gc.ca/geogratis/en/licence.jsp

Basic data: Provincial boundaries

Layers:
Provincial boundaries

Description:
This layer is an index of all Canadian Provinces. Topographic maps produced by Natural Resources Canada conform to the National Topographic System (NTS) of Canada. Download date: 2009/08/20

Credits:
Government of Canada, Natural Resources Canada, Earth Sciences Sector

Use limitation:
Data are subject to the GeoGratis Licence Agreement for Unrestricted Use of Digital Data.

http://geogratis.cgdi.gc.ca/geogratis/en/licence.jsp

Basic data: Hydro

Layers:
Hydrography

Description:
Water Body data are created and maintained by the Web Mapping Service and can be accessed through the Groundwater Information Network (GIN) http://gw-info.net/

This Web Mapping Service distributes data through as a series of databases across Canada. The data is accessed through a mediation system that converts stored in local formats and structures into a standard format called GWML. The service is currently distributing data from British Columbia, Alberta, Manitoba, Ontario, Québec and Nova-Scotia.

Credits:
Groundwater Information Network (2012). *Water Wells and Aquifers of Canada*. Available at: http://ngwd-bdnes.cits.nrcan.gc.ca/service/api_ngwds:gin/en/wmc/aquifermap.html (Accessed: 12 July, 2012)

Use limitation:
Data can be freely accessed by the public.

New Brunswick:

Geology: Surficial Geology Key

Layers:

Surficial Geology Key NB 

Description:
Outline of the surficial geology coverage for map NR-8. The layer was created to facilitate access to the hyperlinked surficial geology map.

Credits:
V. Brake, GSC-Québec

Use Limitations:
Data are not subject to use limitations

Geology: Surficial Geology

Layers:

Surficial Geology

Description:
Generalized surficial geology map of New Brunswick

Note:
Please refer to the hyperlinked pdf above, or the Associated Documents folder for details of the lithological units.

Credits:
New Brunswick Department of Natural Resources, Department of Energy and Mines

Rampton, V.N. 1984. Generalized surficial geology map of New Brunswick Department of Natural Resources and Energy, Minerals, Policy and Planning Division, NR-8 (scale: 1: 500 000).

Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2002 and Courtesy of Natural Resources Canada, Geological Survey of Canada.

Use Limitations:
Data are not subject to use limitations and are available from the New Brunswick Department of Energy and Mines.

Geology: Bedrock Geology

Layers:

Bedrock Geology

Description:
Bedrock geology of New Brunswick

Credits:
New Brunswick Department of Natural Resources, 2008. Bedrock Geology of New Brunswick, Minerals, Policy and Planning Division. Map NR-1 (2008 Edition). Scale 1:500 000.

Use Limitations:
Data are not subject to use limitations and are available from the New Brunswick Department of Energy and Mines.

Groundwater

Layers:

Well parameters
Geochemistry concentrations
Uranium concentration

Description:
Aggregate wellhead information and well sample results extracted from ELG Environmental Information (ENVI) database, August 2012.

Processed with:

- Arc GIS 10.0 (build 2414), integrate analysis tool used to aggregate data to a minimum of 10 points per location

Credits:
Government of New Brunswick, Environment and Local Government

New Brunswick Department of Environment, 2008. New Brunswick Groundwater Chemistry Atlas: 1994-2007. Sciences and Reporting Branch, Sciences and Planning Division, Environmental Reporting Series T2008-01, 31p.

Use Limitations:
The Groundwater Chemistry Atlas is not subject to use limitations and can be downloaded from the New Brunswick Department of Environment:

http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Groundwater-CompositionChimiqueLeau/GroundwaterChemistryAtlas-AtlasChimiqueLeauSouterraine.pdf

Exploration and Analysis: Exploration wells and prospects

Layers:

Exploration wells
Oil and natural gas wells

Description:
The New Brunswick Borehole Database

Note:
The development of a new structure and web application is in progress for this database (Hinds in prep).

Credits:
ST. PETER, C.J. 2000. Catalogue of well data for boreholes in the Maritimes Basin and Fundy Subbasin, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 2000-5, 235 p.

The New Brunswick Borehole Database:
http://www1.gnb.ca/0078/GeoscienceDatabase/Borehole/Search.asp (14 May, 2012)

The above layers represent a subset of the New Brunswick Borehole Database, created by selecting wells that fall within the study area. The Oil and Natural Gas prospects layer was derived from the Exploration wells layer.

Use Limitations:
Data are not subject to use limitations and are available from the New Brunswick Department of Energy and Mines.

Exploration and Analysis: Mineral boreholes

Layers:

Mineral Boreholes

Description:
New Brunswick Drill Hole Database

Credits:
The above layer represents a subset of the New Brunswick Drill Hole Database, created by selecting wells that fall within the study area.

Use Limitations:
Data are not subject to use limitations and are available from the New Brunswick Department of Energy and Mines.

Exploration and Analysis: 2D Seismic data

Layers:

2D seismic data

Description:
Onshore New Brunswick 2D seismic data

Credits:
ST. PETER, C.J. and PHILLIPS, R. 2000. Reflection seismic coverage of onshore and offshore New Brunswick, 1948-1999. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 2000-7, 40 p.

Use Limitations:
Data are not subject to use limitations and are available from the New Brunswick Department of Energy and Mines.

Nova Scotia: Carboniferous Basins Compilation:

Geology: Surficial Geology

Layers:

Unit boundaries
Surficial units

Description:
Please refer to the Nova Scotia Department of Natural Resources (NSDNR) digital product download page for a current description and use limitation of the data.

http://www.gov.ns.ca/natr/meb/download/dp036.asp

Credits:
DP ME 36, Version 2, 2006, Digital Version of Nova Scotia Department of Natural Resources Map ME 1992-3, Surficial Geology Map of the Province of Nova Scotia, scale 1:500 000, by R. R. Stea, H. Conley and Y. Brown, 1992

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Geology: Bedrock Geology

Layers:

Faults
Contacts

Bedrock Units

Description:
Please refer to the NSDNR digital product download page for a current description and use limitation of the data:

http://www.gov.ns.ca/natr/meb/download/dp380.asp

Credits:
DP ME 380, Version 1, 2006, Simplified Version of Nova Scotia Department of Natural Resources Map ME 1979-1, Bedrock Geology of Nova Scotia, scale 1:500 000, by J. D. Keppie, 1979, with superimposed Shaded Relief Image (50 m resolution)

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Groundwater: Various spatial layers

Layers:

Test Holes
Pumping Tests
Municipal Water Supply Wells
Active Observation Wells
Inactive Observation Wells
Groundwater Chemistry
Arsenic Risk
Surficial Groundwater Regions

Description:
Data are current as of March 12, 2012. For current information please refer to the Nova Scotia Mineral Resources Branch Digital Products: Nova Scotia Groundwater Maps and Databases (Interactive Groundwater Map),

http://gis4.natr.gov.ns.ca/website/nsgroundwater

Credits:
Nova Scotia Department of Natural Resources (DNR), Mineral Resources Branch, Geological Services Division.

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Groundwater: Primary and Secondary Watersheds

Layers:

Primary watersheds
Secondary watersheds

Description:
Please contact Nova Scotia Environment for a current description and use limitation of the data

Credits:
Primary and Secondary Watersheds of Nova Scotia, Nova Scotia Environment, 2011, Water and Wastewater Branch, ESPM Division

Use Limitations:
Please contact Nova Scotia Environment for a current description and use limitation of the data

Groundwater: Well logs database

Layers:

Well Logs

Description:
Please refer to the NSDNR digital product download page for a current description and use limitation of the data:

http://www.gov.ns.ca/natr/meb/download/dp430.asp

Credits:
DP ME 430, Version 1, 2009, Enhanced Georeferenced Version of the Nova Scotia Department of Environment's Nova Scotia Well Logs Database (2008) compiled by G.W. Kennedy, K.G. Garroway and B. E. Fisher, 2008.

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Groundwater: Groundwater regions map of Nova Scotia

Layers:

Groundwater Regions

Description:

Please refer to the NSDNR digital product download page for a current description and use limitation of the data:

http://www.gov.ns.ca/natr/meb/download/dp428.asp

Credits:
DP ME 428, Version 1, 2008, Digital Version of Nova Scotia Department of Natural Resources Open File Map ME 2008-3, Groundwater Regions Map of Nova Scotia, scale 1:500 000, compiled by G. W. Kennedy and J. Drage, 2008. Digital product compiled by G. W. Kennedy, J. Drage and B. E. Fisher.

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Groundwater: Map showing potential for uranium and related radionuclides in groundwater in Nova Scotia

Layers:

Radionuclides Potential

Description:
Please refer to the NSDNR digital product download page for a current description and use limitation of the data:

http://www.gov.ns.ca/natr/meb/download/mg/ofm/htm/ofm_2009-007.asp

Credits:
Map Showing Potential for Uranium and Related Radionuclides in Groundwater in Nova Scotia [Scale 1:1 000 000], by O'Reilly, G A, Nova Scotia Department of Natural Resources; Goodwin, T A, Nova Scotia Department of Natural Resources; Drage, J M, Nova Scotia Department of Environment, Open File Map ME 2009-007, 2009, 0 page(s), 1 map(s).

Use Limitations:
Digital data licence available at:
http://www.gov.ns.ca/natr/meb/download/dp430dll.asp

Exploration and Analysis: Exploration wells and 2D seismic data

Layers:

Onshore wells
2D seismic data

Description:

Onshore wells and 2D seismic coverage for the province of Nova Scotia as of 30 March, 2012. Layers were created by the Nova Scotia Department of Energy and provided to Agile Geoscience as part of a data availability study for the Program of Energy Research and Development. The onshore wells layer was subsequently modified by Agile Geoscience.

Credits:
Nova Scotia Department of Energy and Agile Geoscience.

Bianco, E. and Hall, M. 2012. Nova Scotia onshore well database: A data availability study for the Program of Energy Research and Development. Internal report prepared for Geological Survey of Canada, Quebec Office.

Use Limitations:
The above layers fall under the creative commons license of Agile Geoscience:
http://creativecommons.org/licenses/by/3.0/

Exploration and Analysis: Exploration permits

Layers:

Permits_NS_PL_09_04_15_01_RESID
Permits_NS_PA_07_10_25_01_RESID
Permits_NS_PA_01_12_31_01_RESID
Permits_NS_EA_11_08_10_03_RESID
Permits_NS_EA_11_07_29_02_RESID
Permits_NS_EA_11_07_12_01_RESID
Permits_NS_EA_06_09_15_01_RESID
Permits_NS_EA_04_07_15_03_RESID

Description:
Exploration permits for the province of Nova Scotia as of 30 March, 2012. Layers were created by the Nova Scotia Department of Energy and provided to Agile Geoscience as part of a data availability study for the Program of Energy Research and Development.

Credits:
Nova Scotia Department of Energy and Agile Geoscience.

Bianco, E. and Hall, M. 2012. Nova Scotia onshore well database: A data availability study for the Program of Energy Research and Development. Internal report prepared for Geological Survey of Canada, Quebec Office.

Use Limitations:
The above layers fall under the creative commons license of Agile Geoscience:
http://creativecommons.org/licenses/by/3.0/

Exploration and Analysis: Vitrinite reflectance data

Layers:

Vitrinite reflectance data

Description:
Vitrinite reflection data from Mukhopadhyay (1991), as compiled by Agile Geoscience.

Credits:
Mukhopadhyay, P. 1991. Source Rock Potential and Maturation of Paleozoic sediments (Devonian-Permian) from onshore Nova Scotia (p.216). Halifax.

Bianco, E. and Hall, M. 2012. Nova Scotia onshore well database: A data availability study for the Program of Energy Research and Development. Internal report prepared for Geological Survey of Canada, Quebec Office.

Use Limitations:
Data compiled by Agile Geoscience fall under a creative commons license:
http://creativecommons.org/licenses/by/3.0/

Quebec:

Geology: Bedrock Geology

Layers:

Geological contacts
Faults
Folds
Bedrock units

Description:
Bedrock geology map of the province of Quebec. Bedrock geology at a variety of scales can be purchased via the Ministère des Ressources naturelles, Direction de Géologie Québec:

http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a

The recently released 1: 2 000 000 scale bedrock geology map (report number DV 2012-07) can be purchased via:

http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a

Credits:
Direction de Géologie Québec, Ministère des Ressources naturelles, Québec.

Use Limitations:
See, terms of use and information about data at:
ftp://ftp.mrnf.gouv.qc.ca/public/Geologie/Sigeom_Internet_FICHIERS/license.pdf

Groundwater: Quebec Water Wells

Layers:

Quebec Water wells

Description:
Water well data are created and maintained by the Web Mapping Service and can be accessed through the Groundwater Information Network (GIN) http://gw-info.net/

This Web Mapping Service distributes data through as a series of databases across Canada. The data is accessed through a mediation system that converts stored in local formats and structures into a standard format called GWML. The service is currently distributing data from British Columbia, Alberta, Manitoba, Ontario, Québec and Nova-Scotia.

Credits:
Groundwater Information Network (2012) *Water Wells and Aquifers of Canada*. Available at: http://ngwd-bdnes.cits.nrcan.gc.ca/service/api_ngwds:gin/en/wmc/aquifermap.html (Accessed: 12 July, 2012)

Use limitation:
Data can be freely accessed by the public.

Exploration and Analysis: Exploration wells and 2D seismic data

Layers:

Exploration wells
2D seismic data

Description:
Onshore exploration data for the province of Quebec. Data can be ordered via Ministère des Ressources naturelles et de la Faune (MRNF):

http://sigpeg.mrnf.gouv.qc.ca/gpg/classes/igpg?langue=A

Credits:
Direction de Géologie Québec, Ministère des Ressources naturelles, Québec.

Use Limitations:
See, terms of use and information about data at:
ftp://ftp.mrnf.gouv.qc.ca/public/Geologie/Sigeom_Internet_FICHIERS/license.pdf

Exploration and Analysis: Exploration Permits

Layers:

Production licences

Exploration permits

Description:
Location maps of current license areas by geological region. Downloaded from:

http://www.mrn.gouv.qc.ca/energie/petrole-gaz/petrole-gaz-potentiel.jsp (May 15, 2012)

Credits:
Direction de Géologie Québec, Ministère des Ressources naturelles, Québec.

Use Limitations:
See, terms of use and information about data at:
ftp://ftp.mrnf.gouv.qc.ca/public/Geologie/Sigeom_Internet_FICHIERS/license.pdf

Exploration and Analysis: Utica Shale well based synthesis

Layers:

- Logs overburden
- Logs bedrock
- Gas petro shows overburden
- Gas shows water wells
- Water shows bedrock
- Water analyses bedrock

Description:
The Hydrogeologic synthesis of the Utica Shale (Séjourné et al., 2012) can be downloaded from the Évaluation Environnementale Stratégique sur le Gaz de Schiste website (French only):

http://ees-gazdeschiste.gouv.qc.ca/documentation/

The original data interpreted in the hydrogeologic synthesis were collected and are maintained by the Ministère du Développement durable, Environnement, Faune et Parcs, Québec.

Credits :
Institut National de la Recherche Scientifique Centre Eau Terre Environnement in collaboration with the Ministère du Développement durable, Environnement, Faune et Parcs, Québec

Séjourné, S, Malet, X et Lefebvre, R. 2012. Synthèse hydrogéologique du Shale d'Utica et des unités sus-jacentes (Lorraine, Queenston et dépôts meubles). Institut National de la Recherche Scientifique Centre Eau Terre Environnement, Rapport de recherche I292, 97p.

Use limitation:
The following report was submitted to the Comité de l'évaluation environnementale stratégique sur le gaz de schiste. Several technical studies were conducted at the request of the committee and will be released to the public as they become available.

Consequently, the report and accompanying annexe contain data that may have been updated after they were published by the author.

Exploration and Analysis: Utica Shale and Trenton Group: Extent of depth and thickness analysis

Layers:

Extent of depth and thickness analysis

Description:
Outline of the Utica Shale and Trenton Group analysis. The layer was created to facilitate access to the hyperlinked depth and thickness figures from report number DV 2012-04.

Credits:
V. Brake, GSC-Québec

Use Limitations:
Data are not subject to use limitations

Exploration and Analysis: Utica Shale and Trenton Group: Depth and thickness analysis

Layers:

Depth to top of Utica Shale
Depth to top of Trenton Group
Thickness of Utica Shale
Thickness of Lower Utica Shale
Thickness of Upper Utica Shale

Description:
Downloaded from the SIGEOM website of the Quebec Ministry of Natural Resources (from report number DV 2012-04):
http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_index?l=a&entt=LG

Processed with:

- Oasis Montaj
- ArcGIS 9.3 (for page layout only)

Reference (source of data):
Thériault, R. (2012). Caractérisation du Shale d'Utica et du Groupe de Lorraine, Basses-Terres du Saint-Laurent – Partie 2 : Interprétation géologique. Ministère des Ressources naturelles et de la Faune, Québec ; DV 2012-04, 80 p.

Credits :
Direction de Géologie Québec, Ministère des Ressources naturelles, Québec.

Use limitation:
See, terms of use and information about data at:
ftp://ftp.mrnf.gouv.qc.ca/public/Geologie/Sigeom_Internet_FICHIERS/license.pdf

Exploration and Analysis: Utica Shale: Extent of Utica Rock-eval analysis

Layers:

Extent of Utica Rock-eval analysis

Description:
Outline of the Utica Shale Rock-eval analysis. The layer was created to facilitate access to the hyperlinked Rock-eval figures from report number DV 2012-03.

Credits:
V. Brake, GSC-Québec

Use Limitations:
Data are not subject to use limitations

Exploration and Analysis: Utica Shale: Rock-eval geochemical data

Layers:

Total organic carbon (TOC) – Lower Utica Shale
Total organic carbon (TOC) – Upper Utica Shale
Tmax – Lower Utica Shale
Tmax – Upper Utica Shale
Hydrogen Index (HI) – Lower Utica Shale
Hydrogen Index (HI) – Upper Utica Shale
Production Index (PI) – Lower Utica Shale
Production Index (PI) – Upper Utica Shale

Description:
Downloaded from the SIGEOM website of the Ministère des Ressources naturelles, Québec (from report number DV 2012-03):
http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_index?l=a&entt=LG

Processed with:

- Oasis Montaj
- ArcGIS 9.3 (for page layout only)

Reference (source of data):

Thériault, R. (2012). Caractérisation du Shale d'Utica et du Groupe de Lorraine, Basses-Terres du Saint-Laurent – Partie 1 : Compilation des données. Ministère des Ressources naturelles et de la Faune, Québec ; DV 2012-03, 212 p.

Credits:
Direction de Géologie Québec, Ministère des Ressources naturelles, Québec.

Use limitation:
See, terms of use and information about data at:
ftp://ftp.mrnf.gouv.qc.ca/public/Geologie/Sigeom_Internet_FICHIERS/license.pdf

Geophysics:

Aeromagnetic Compilation

Layers:

1st Vertical Derivative (200m)
Residual Total Field (200m)

Description:
First Vertical Derivative, Total Residual Magnetic Field, downloaded from: Geoscience Data Repository: http://gdr.nrcan.gc.ca/aeromag/index_e.php.

Processed with:

- Oasis Montaj 7.3, viewer, for GeoSoft (.grd) conversion to ".flt" format
- Arc GIS 10.0, for conversion from ".flt" to GRID

Total Residual Magnetic Field, downloaded from: Geoscience Data Repository: http://gdr.nrcan.gc.ca/aeromag/index_e.php.

Processed with:

- Global Mapper 13.0 to create hillshade from geosoft (.grd) original file.

Credits :
Government of Canada, Natural Resources Canada, Earth Sciences Sector

Use limitation:
See, terms of use and information about data at: http://gdr.nrcan.gc.ca/aeromag/index_e.php.

Gravity Compilation

Layers:

Bouger
Horizontal Gradient
1^{st} Vertical Derivative

Description:
Gravity anomaly, Bouguer, Horizontal Gradient and First Vertical Derivative downloaded from: Geoscience Data Repository: http://gdr.nrcan.gc.ca/aeromag/index_e.php.

Processed with:

- Oasis Montaj 7.3, viewer, for GeoSoft (.grd) conversion to ".flt" format
- Arc GIS 10.0, for conversion from ".flt" to GRID

Credits :
Government of Canada, Natural Resources Canada, Earth Sciences Sector

Use limitation:
See, terms of use and information about data at: http://gdr.nrcan.gc.ca/aeromag/index_e.php.

Digital Elevation Model (DEM):

Layers:
DEM

Description:
Canadian Digital Elevation Model, used in PERD shale gas projects. 2013

Canadian Digital Elevation Model, from GeoBase website. Original files (.dem) were transformed to ESRI grids format.

http://www.geobase.ca/geobase/en/data/cded/index.html

Credits:
Laboratoire de Cartographie Numérique et Photogrammétrie, 2013 for processing. Geobase for original dataset.

Use limitation:
Data are subject to the GeoGratis Licence Agreement for Unrestricted Use of Digital Data:

http://geogratis.cgdi.gc.ca/geogratis/en/licence.jsp

Hillshade of Digital Elevation Model:

Layers:

HSD_DEM

Description:
Hillshade derived from Canadian Digital Elevation Model, used in PERD shale gas projects. 2013

Canadian Digital Elevation Model, from GeoBase website. Original files (.dem) were transformed to ESRI grids format.

http://www.geobase.ca/geobase/en/data/cded/index.html

Credits:
Laboratoire de Cartographie Numérique et Photogrammétrie, 2013 for DEM processing. Hillshade created by V. Brake

Use limitation:
Data are subject to the GeoGratis Licence Agreement for Unrestricted Use of Digital Data:

http://geogratis.cgdi.gc.ca/geogratis/en/licence.jsp