Hydrogeology of the Potsdam Sandstone Aquifer and Springs in the Chateaugay Area, Northern New York

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ABSTRACT

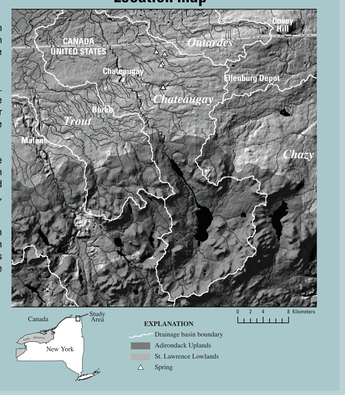
The Potsdam sandstone of Cambrian age forms a transboundary aquifer that extends from northern New York into southern Quebec. The Potsdam sandstone is a gradational sequence of arkose, subarkose, and orthoquartzite that unconformably overlies Precambrian metamorphic bedrock. In the Chateaugay area, thick till overlies the Potsdam sandstone except in the east where the till is discontinuous. A network of Pleistocene ice-marginal channels have been cut into the till, and along the Chateaugay River, a deep bedrock gorge has been carved by post-glacial erosion.

A series of major springs discharge adjacent to tributaries of the Chateaugay River at rates ranging from 1000 to more than 5000 liters per minute. The springs are used for municipal, bottled-water, and fish-hatchery supply. Wells in the Chateaugay area penetrate subhorizontal bedrock fracture zones with hydraulic heads that generally decrease with depth. Wells that intercept shallow fractures near the top of bedrock display shallow water levels, while wells that intercept deep fractures show deep water levels. Cascading water and downward flow are common in wells that penetrate both shallow and deep fracture zones.

Hydrogeologic investigations near Ellenburg Depot, New York and Covey Hill in southernmost Quebec confirm the presence of areally extensive fractured zones related to bedding in the Potsdam sandstone aquifer. These observations, and those from the Chateaugay area, are consistent with a conceptual model of the Chateaugay springs and bedrock gorge being points of discharge for a gently dipping series of bedding-related fractured zones. The major recharge areas for the springs probably are in the east where till cover is discontinuous. The abandoned ice-marginal channels, where cut to bedrock, may serve as focused points of recharge.

Simulated recharge areas for the Chateaugay springs estimated with a regional ground-water flow model extend in a southeast-east direction with their size proportional to the discharge of the springs. Simulated recharge areas for existing and proposed wells for water-bottling plants in southern Quebec (northwest and northeast of the Chateaugay springs) extend across the border into New York. The configuration of the actual recharge areas will be different than that simulated because recharge is largely limited to areas of discontinuous till and much of the flow is through areally extensive fractured zones.

Location map



ACKNOWLEDGEMENTS

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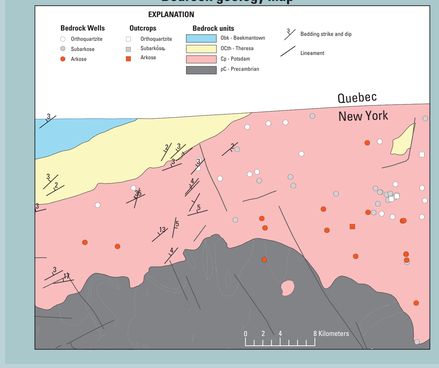
BEDROCK GEOLOGY

The Potsdam sandstone unconformably overlies Precambrian metamorphic rocks and underlies the dolomitic sandstones and sandy dolostones of the Theresa Formation. The Potsdam sandstone irregularly grades upward from a heterogeneous feldspathic and argillaceous rock to a homogeneous, quartz-rich and matrix-poor rock. The Adirondacks, except for a few outliers within the uplands, mark the southern extent of the Potsdam sandstone. In general, bedding in the Potsdam sandstone gently dips to the northwest west of the Chambly Arch and to the northeast east of the Arch.

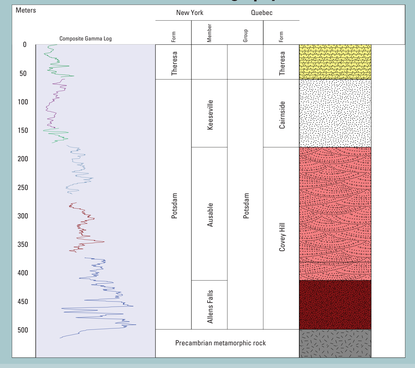
A composite of gamma logs from selected wells in northern New York and southern Quebec reflects the upward decrease in feldspathic and argillaceous content in the Potsdam sandstone. The Potsdam consists of three lithostratigraphic units -- the Allens Falls, Ausable and Keeseville members. The Covey Hill and Cairnside Formations of the Potsdam Group in Quebec are lithologically and stratigraphically equivalent, respectively, to the Allen Falls and Ausable members and the Keeseville member in New York.

Contacts for the Potsdam and younger stratigraphic units on the current geologic maps for New York and Quebec do not match across the New York – Quebec border. The discrepancies may be partly explained by the gradational nature of the contacts between the Potsdam units and the overlying Theresa Formation, differences in the unit classification between investigators, general lack of recognized stratigraphic markers within the Potsdam and Theresa, and insufficient outcrops. However, in the 1960s, USGS and GSC geologists mapped folds and faults at and west of Covey Hill, which implies that some offsets may be structurally related.

Bedrock geology map



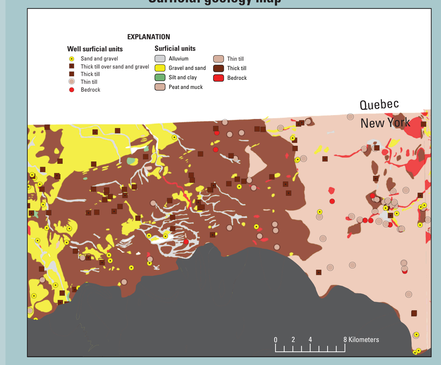
Bedrock stratigraphy



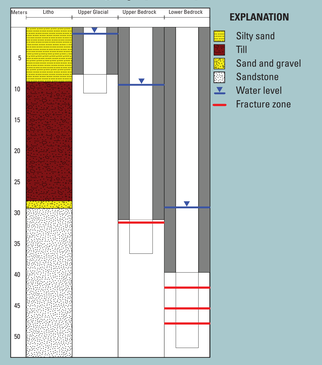
SURFICIAL GEOLOGY

Till; fluvial, deltaic, and beach sand and gravel; and lacustrine and marine silt and clay of Pleistocene age discontinuously overlie the Potsdam sandstone. Till is the most widespread glacial-drift deposit in the study area. Fifteen to more than 50 m of till typically overlie the sandstone from just east of the Chateaugay River to its drainage divide with the Salmon River in the west. The till thins along a bedrock high to the east-northeast, and near the Chateaugay River's eastern drainage divides with the English and Chazy Rivers. Scattered thin beds of sand and gravel are present in the till, most commonly near the contact with the underlying bedrock. A network of ice-marginal channels, diagonal to the present-day topographic slope, are cut into 8 m or more of till and, and toward the east, into or close to bedrock. Deltaic sands graded to a series of glacial lake levels locally overlie the till. Post-glacial erosion has carved a deep bedrock gorge along the Chateaugay River through the till and from 15 to 30 m into the underlying sandstone.

Surficial geology map



Glacial stratigraphy and hydraulic heads



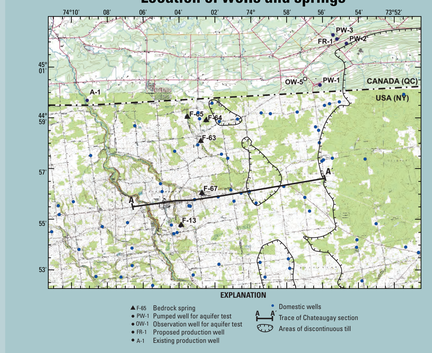
HYDROGEOLOGY

A series of major springs, which are used for municipal, bottled-water, and fish-hatchery supply, discharge from 1000 to over 5000 l/min adjacent to several tributaries east of the Chateaugay River. The springs are characterized by consistent flow rates and temperatures (46-49 deg F) and low-dissolved solids (less than 200 mg/L). A water-quality analysis from spring F-64 had low chloride, sodium, potassium, and sulfate concentrations. Calcium and magnesium concentrations were moderate, which is consistent with the presence of dolomitic cement in the upper Potsdam sandstone. Trace metals, pesticides and herbicides and volatile and semi-volatile compounds were all non-detect. The nitrate concentration, 2.7 mg/L, was what might be expected from water that has been minimally impacted by agricultural fertilizers. The concentration of radon, which was 540 pCi/L, exceeded the proposed USEPA MCL but was less than the proposed AMCL.

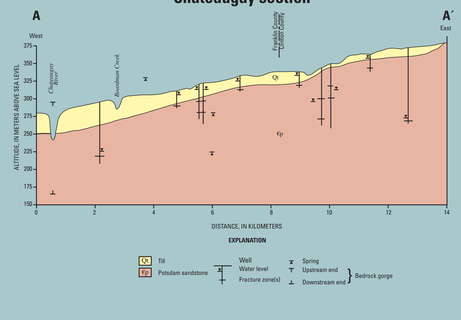
Hydraulic-head gradients in the Potsdam sandstone aquifer commonly are downward with laterally extensive series of subhorizontal flow zones serving as drains for the ground-water flow system. Domestic wells completed in shallow, fractured bedrock have water levels less than 10 m from land surface, while wells tapping deeper fractures typically have water levels of more than 30 m below land surface. Drillers report zones of lost circulation in many deep wells. Cascading water is common in wells that penetrate both shallow and deep flow zones. The ambient flowmeter log of a deep well east of Chateaugay, which had a composite water level of 35 m below land surface, delineated downward flow to a low-hydraulic head fractured zone at 84 m below land surface.

The presence of areally extensive bedding-related fractured zones in the Potsdam sandstone aquifer is indicated by hydrogeologic investigations in the Ellenburg Depot area to the east and the Covey Hill area in southernmost Quebec. These observations and those from the Chateaugay area are consistent with a conceptual model of the Chateaugay springs and bedrock gorge being points of discharge for a gently dipping series of transmissive fractured zones. The major recharge areas for the springs would likely be upgradient in a southeast direction where the till cover is thin or absent. The abandoned channels, where cut into or close to bedrock, may serve as focused points of recharge.

Location of wells and springs



Chateaugay section



Within the F-63 spring house, about 2000 l/min issues from thin-bedded, ripple-marked and jointed orthoquartzite.

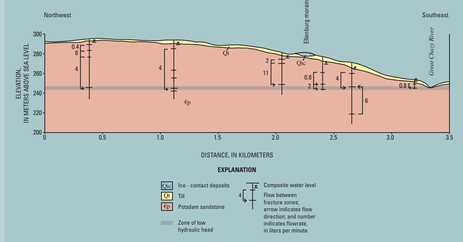
High Falls in bedrock gorge of Chateaugay River

Waterfall along unnamed tributary to Hinchinbrook Brook downstream of spring F-63. With additional spring discharge, the flow is over 4000 l/min.

Ellenburg Depot

At Ellenburg Depot, a laterally extensive fractured zone in the Potsdam sandstone was penetrated by 8 wells drilled along a 600 m long transect from an upland recharge area to the North Branch Chazy River discharge area. Ambient flowmeter measurements in the open-hole wells indicated downward flows at rates greater than 4 l/min from shallow fractures to the deep zone. Core and geophysical log analysis suggests that the deep zone consists of a series of subhorizontal fractures associated with thin coarser grained beds that are present within thicker bedded and well-cemented orthoquartzite.

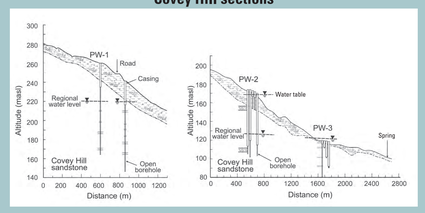
Ellenburg Depot section



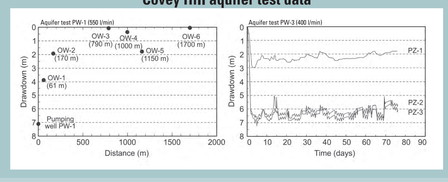
Covey Hill

At Covey Hill, shallow piezometers and a deep open-hole well had head differences of nearly 40 m. In a 3-day aquifer test, which resulted in 7 m of drawdown in the pumped well, an observation located more than 1000 m away had almost 2 m of drawdown. Drawdown in shallow and deep piezometers completed in individual bedding fracture zones and located 1.5 m from a pumped well had a difference in drawdown of about 4 m.

Covey Hill sections



Covey Hill aquifer test data



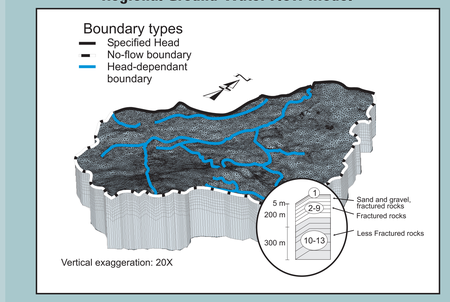
SIMULATED RECHARGE AREAS TO SPRINGS AND WELLS

The regional ground-water flow model developed as part the investigation of the Chateauguay River Basin by the Geological Survey of Canada and Quebec Ministry of the Environment was used to provide a preliminary estimate of the recharge areas to springs and wells in the Chateaugay area. The transboundary model, which was built using the finite-element model code FeFlow with 13 layers and 18,600 nodes, covers an area of 2850 km2 extending from the Adirondacks to the St. Lawrence River.

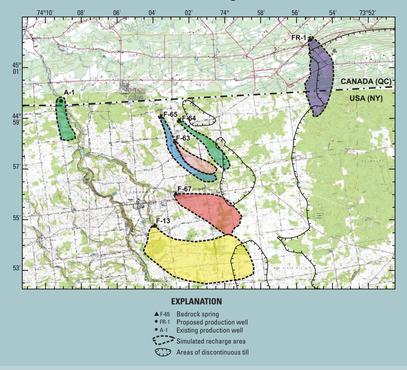
Simulated recharge areas for the Chateaugay springs extend in a southeast-east direction with their size proportional to the discharge of the springs. Simulated recharge areas for existing and proposed wells for water-bottling plants in southern Quebec (northwest and northeast of the Chateaugay springs) extend across the border into New York.

The regional ground-water flow model does not incorporate the detailed subsurface information recently collected from well logs in the Chateaugay area, and recharge areas simulated with the model should only serve as a general guide for further investigation. The configuration of the actual recharge areas will be different than that simulated because recharge is largely limited to areas of discontinuous till and much of the flow is through areally extensive fractured zones.

Regional Ground-Water Flow Model



Simulated recharge areas



BATTLE OF CHÂTEAUGUAY

With a force of over 4,000 regulars and some militia, Major General Wade Hampton advances up the Chateauguay River towards Chateauguay (and ultimately to meet with Wilkinson's Army for an assault on Montreal.). He encounters a force of French Canadian Militia, Voltigeurs, Canadian Fencibles and their Native Allies behind a number of quickly built defensive works. He divides his force with one wing to cross the river and take the French Canadian Militia from behind. The battle is won by the militia who hold off the American attack from the front and rear. Discouraged by his army's effort, Hampton withdraws to Four Corners and then Plattsburgh, refusing to join Wilkinson's Army for the attack on Montreal.

It was from Chateauguay, New York that **General Hampton invaded Canada**, only to be **humiliatingly defeated** by a greatly inferior force, and **shamefully** driven back to his encampments. After his **criminal withdrawal** of his army from Chateauguay to Plattsburgh in the autumn of 1813, in practical desertion of General Wilkinson, with whom it had been planned that he should operate against Montreal, other smaller bodies of troops occupied Chateauguay from time to time (a detachment from General Wilkinson's army under Colonel Bissell comprising one of them) until evacuation in February, 1814, when the British poured in for a day or two - proceeding east as far as Marble river, and seizing a good deal of private property as well as military stores that had been abandoned by the Americans. **Not a little of the private belongings so taken was rum.**

From History of Chateauguay, New York by Frederick Seaver (1918)