Spring Water Characteristics; Anne & Sandy Cross Conservation Area

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Abstract

Fresh water is critical for society. In southern Alberta, rapid growth in water demand, along with the regulatory decision to stop issuing licenses for surface-water, has led to increased demand for groundwater. Calgary's population recently surpassed a million and continues to rapidly expand placing further strains on the local fresh water supply. It is critical to improve our understanding of both the local surface and ground water. The Anne and Sandy Cross Conservation Area (ASCCA), southwest of Calgary, has 22 natural springs which form some of the headwaters for the Bow River Watershed, an important source of surface-water for the City of Calgary and her surrounding communities. While it is the Tertiary Paskapoo sandstones that form most of the aquifers in southern Alberta, it is the overlying Wisconsinan glacial till that has a strong influence on groundwater geochemistry. Here it is predicted that these spring water chemistries should be lower in total dissolved solids (TDS) and higher in Ca-HCO_3 reflecting the overlying Cordilleran glacial till that contains mostly Paleozoic carbonates and Cambrian quartzites. Groundwater east of Calgary typically contains higher TDS due to oxidized pyrite from the overlying Laurentian glacial tills composed primarily of igneous and metamorphic clasts from the Hudson Bay region of the Canadian Shield (Grasby et al., 2010).

Introduction

The Anne and Sandy Cross Conservation is a vast area of 4,800 acres of land located southwest of Calgary, Alberta. The conservation area is of vital importance in preserving all aspects of nature and wildlife, but also plays a key role in research and education (www.crossconservation.org). With minimal geological analysis having been done in the Anne and Sandy Cross Conservation area, it would be of great benefit to study the areas outcrops, springs, seismic and well data in order to determine the geologic history of the region. This study hopes to use seismic and well data previously collected as well as detailed field study to determine the origin of the glacial till in the area, identify the prominent bedrock lithology, and to understand the development and origin of the 22 springs that are located on the property.

Methods

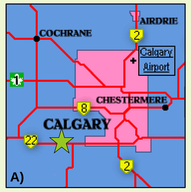
Rock data was collected during April-August 2014 using the following methods:

- Site accessed on foot. Every outcrop was visited, samples were collected and photographs were taken.
- Outcrop descriptions were recorded and included lithologies, colour, sorting, grain size, fabric/layering, structures, and strike and dip.
- GPS coordinates were obtained for each outcrop.
- Samples are in the process of being made into thin sections for further petrographic analysis.
- Glacial till samples collected by participating elementary school students from Calgary Board of Education Schools (table 1, figures 3,4).

Water data will be collected early November 2014 using the following methods:

- Multiple samples will be collected for each of the 22 springs on site.
- Water samples will be collected as close to the mouth of the spring as possible.
- Samples will be collected in clean sealable bottles. Bottles will be free of any contaminants such as dirt and dust. They will be sealed immediately after collection.
- Preservation of the samples may be required.
- Samples will be transported in a cooler and delivered to a lab as soon after collection as possible (ie. Next business day).

Following data collection, water samples will be sent for chemical analysis to confirm the geochemistry. This data, along with information previously collected will be used to form a conclusion on the geology and spring characteristics of this area.



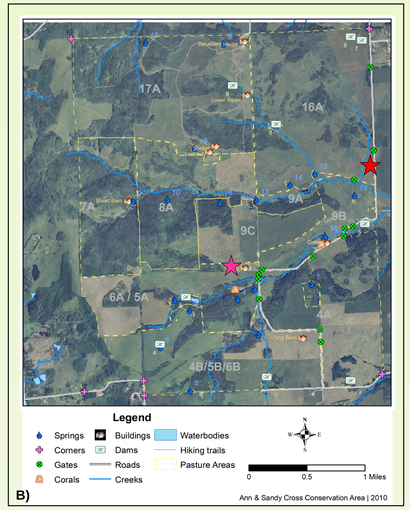


Figure 1. A) Map of Calgary and surrounding area. Green star represents location of Anne & Sandy Cross Conservation area. Image modified from: http://hirsche.com/location.html

B) Map of Anne & Sandy Cross Conservation area. Red star shows location of roadside outcrop (figure 2). Pink star is location of glacial till collection by participating elementary school students (figures 3,4).

Local Geology

The prominent geology within the Anne and Sandy Cross Conservation Area includes the Paskapoo sandstone and glacial till deposits.

The Paskapoo Sandstone is middle to upper Paleocene in age and is the youngest known deposit in the Western Canadian Sedimentary Basin (Grasby et al., 2008). It extends 65,000 km^2 and covers approximately 10% of Alberta (Grasby et al., 2008). The Paskapoo Formation generally thins towards the east and unconformably overlies the Scollard Formation representing a hiatus of 1-2.5 million years (Grasby et al., 2008). It is divided into 3 members: Hayes, Lacombe, and Dalehurst (Grasby et al., 2008).

The Hayes member is the oldest and consists of medium-grained channel sandstone aquifer bodies, minor and discontinuous mudstone layers (10-30%) and sandstones (70-90%) (Grasby et al., 2008). This member is characterized by conglomeratic lags, trough cross-bedding, minor ripples, and roots and plant fragments (Hamblin, 2004).

Overlying the Hayes member is the Lacombe member which consists of interbedded siltstone and mudstone, some fine-grained sandstone and argillaceous coals (Hamblin, 2004). It is overlain by the Dalehurst member which consists of interbedded fine-grained sandstones, siltstones and mudstones and some thick coal seams. The siltstones contain plant fragments and pedogenic structures (Hamblin, 2004).

Glacial till within the region is thought to have originated from two major ice sheets which have rocks characteristic of their source areas. During the Pleistocene, the plains were covered by a continental ice sheet (Grasby et al., 2010). Near Calgary, the westward moving ice from the Laurentide met the eastward-moving ice from the Cordilleran "along a roughly defined N-S boundary through central Alberta" (Fulton, 1995). The Cordilleran ice sheet is dominated by carbonates and quartzite whereas the Laurentide ice sheet is characterized by granite and gneissic pebbles (Grasby et al., 2010).

Figure 2. Road side outcrop of the Paskapoo Formation. Photo credit: S. Weckman.

Figure 3.. Participating elementary students collecting glacial till samples. Photo credit: K. Boggs.

Figure 4. Participating elementary students recording observations. Photo credit: K. Boggs.

Hydrogeology

The Paskapoo sandstone is the most significant source of groundwater within the Canadian Prairies with approximately 64,000 water wells which accounts for nearly one third of all groundwater wells in Alberta (Grasby et al., 2008). The piezometric surface of the aquifer follows surface topography and interpreted as "shallow groundwater system dominated by local scale flow" (Toth, 1962) and that recharge to the aquifer "occurs over a majority of the aquifer area" (Grasby et al., 2008).

The bulk water geochemistry is variable across the aquifer and ranges from Ca-Mg-HCO_3 to Na-HCO_3 to Na-SO_4 waters (Grasby et al., 2008). Total dissolved solids (TDS) also range throughout the aquifer. The lowest TDS are found in the western portion (<450mg/L) whereas the highest TDS can be found in the SE portion (>750mg/L and up to 1500 mg/L) (Grasby et al., 2008).

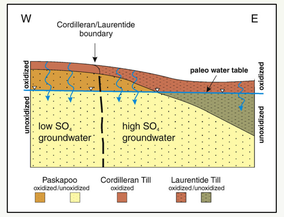


Figure 5. Diagrammatic representation of effect till has on groundwater near the boundary of the Cordilleran and Laurentide ice sheets. Modified from Grasby et al., 2010.

In recent discussions, fracture distribution has been determined as a major implication of water flow through the Paskapoo aquifer. A correlation has been made between higher hydraulic conductivity with fracture systems in the Paskapoo sandstones. Two major implications arise from this correlation including: 1) a fracture flow system overprints the matrix flow in northeast-southwest direction; 2) the high fracture density increases flow in highly-fractured beds, whereas porous flow is dominated in thicker, less fractured sandstone channel bodies. (Grasby et al., 2008).

High sulphide concentrations within the bedrock aquifers in the western plains is recognized as a source for concern (Grasby et al., 2010). Limited work has been completed to determine the source of sulphate however it is theorized to be either of natural (glacial till) or anthropogenic origin (from the large sour gas industry in the region) (Grasby et al., 2010).

Preliminary Data

Rock data collected during the summer of 2014 has revealed that the Cross Conservation area consists prominently of the Paskapoo Sandstone and is dominated by NE dipping beds. In general, two units were observed: an upper cross-bedded unit and a lower massive basal unit. The upper unit consists of well-sorted, very fine-grained lithic arenites that are poorly consolidated. They are medium brown on the fresh surface and dark brown on the weathered surface. This unit commonly displays cross-bedding. The lower unit is a well-sorted, very fine-grained lithic arenite similar to the upper unit however it has massive bedding and is cream to light beige in colour. In lesser abundance are light beige siltstone beds.

Paleocurrent data shows a wide scatter which is typical for fluvial deposits (Grasby et al., 2008). Most paleocurrent measurements were oriented in a northwest direction. Most data falls between 240 and 310º. See figure 6 below.

Till Composition	Frequency
Cambrian Gog Quartzite	33%
Tertiary Paskapoo Sandstone	30%
Devonian/Mississippian Limestone	28%
Devonian/MississippianDolostone	9%

Table 1. Glacial till pebble lithologies collected by participating Calgary Board of Education grade 3/4 Students. The presence of quartzite and carbonate (and the lack of granitoid and gneiss) pebbles confirms that these tills are from the Cordilleran Ice Sheet.

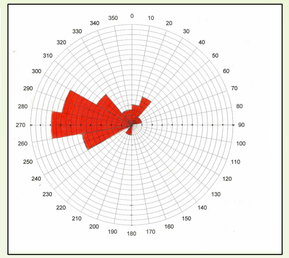


Figure 6. Rose diagram showing paleocurrent directions of outcrops within the Cross Conservation area.

Discussion

As minimal data has been compiled at this time, it is difficult to display any results from the study area. Rock samples that have been collected are being processed and made into thin sections to allow for petrographic analysis to determine complete rock composition. Spring water samples are anticipated to be collected early November 2014.

Based on background research, the authors anticipate that the spring water will be characteristic of the overlying till. Geochemical analysis will provide information on total dissolved solids and ionic components within the water. Of particular interest are the concentrations of bicarbonate (HCO_3) and sulphate (SO_4) within the spring waters.

It can be theorized that if the groundwater contains high levels of bicarbonate (Ca-Mg-HCO_3) the overlying glacial till originated from the Cordillera ice sheet. Based on preliminary till collection and categorization, it is suspected that much of the overlying till originated from the Cordilleran ice sheet as it is prominently carbonate materials (not igneous such as granites as would be expected from the Laurentide). This suggests that the groundwater should contain high levels of bicarbonate and low levels of total dissolved solids because no Laurentide tills were located on the property. High Na-SO_4 levels in the groundwater may indicate an anthropogenic origin of these waters (such as sour gas industry).

Conclusion

Further research will need to be conducted to come to a firm conclusion on the relationship between bedrock, overlying glacial till and characteristics of spring water in the Anne & Sandy Cross Conservation area. Preliminary data suggests that the spring water should have high levels of bicarbonate within it as the overlying glacial till appears to have originated from the Cordilleran ice sheet. Further sample collection and geochemical analysis will be conducted in November 2014.