GEOLOGY

UNIVERSITY OF CALGARY

GROUNDWATER CONNECTION FACT SHEET SERIES

Why is geology important in groundwater research?

Geological formations are three-dimensional features below the surface of the ground consisting of similar rock types, lithological patterns (e.g., the sequence of rock types and thicknesses) and formations. The rock materials within these formations have two important physical properties with respect to hydrology; the porosity and hydraulic conductivity. The volume of pore spaces between grain particles and rocks (porosity) and their size and connectivity (hydraulic conductivity) determine groundwater flow and storage within the aquifers.

How is geology mapped?

Boreholes are generally drilled for water well construction or oil and gas extraction and exploration. When a borehole is drilled, the driller will record the type and thickness of rock material found. These geological logs provide a small "snapshot" of the subsurface at a single geographic location. It is through these multiple borehole logs within a region that researchers begin to understand the spatial structure of the region and the sub-surface geology. In particular the borehole data can allow researchers to begin to identify the location of the Paskapoo formation in Alberta. In Rocky View County, as of 2008, there were approximately ten-thousand boreholes that had been drilled (Alberta Geological Survey, unpublished data).

Ten-thousand boreholes in Rocky View County is equivalent to approximately two and a half boreholes per square kilometer. Given the complexity of the Paskapoo Formation (see below for explanation), this is a very low density. Research has also found that the sandstone channels within the Paskapoo vary greatly in terms of thickness and width, ranging between 15 and 300 meters (Gibling, 2006). In addition, the location accuracy for these boreholes varies between boreholes located within meters of the true location (measured using the GPS technology), versus those located within hundreds of meters of their true location (e.g., wells registered at the closest quarter section of the Alberta Township Survey system). Therefore it is difficult to fully understand the complexities of the Paskapoo Formation by only assessing the borehole data.

POROSITY:

- **It is the relative fraction of the spaces between solid grains or minerals that can be occupied by water.**

HYDRAULIC CONDUCTIVITY

- **It is a coefficient that relates groundwater flow rate through sediments and rocks to the slope of the water table.**

PERMEABILITY

- **The ability of a material to allow the passage of liquid through it.**

BOREHOLE

- **A narrow hole made in the ground, generally drilled to locate water or oil.**

What is the Paskapoo Formation?

The Paskapoo Formation is one of the most important aquifers in Alberta, extending eastward from the foothills of the Rocky Mountains and extending north and south along the Edmonton–Calgary corridor (Hamblin, 2004). Therefore, the Paskapoo Formation is the predominant bedrock formation in Rocky View County and is where the majority of groundwater is extracted from.

How was the Paskapoo formed?

The Paskapoo Formation was deposited as soft sediments approximately 60-65 million years ago and subsequently became the rock formation over a long time (Hamblin, 2004). One of the typical depositional environments of the Paskapoo is referred to as an anastomosing river system (Hamblin 2004; Grasby et al. 2008; Burns et al. 2010). An anastomosing river system is characterized by a series of stream channels, which vary in depth and sinuosity and are divided by stable vegetated islands (Smith & Putnam, 1980). This type of system results in three distinct types of depositional features: (1) **the stream channels**; (2) **crevasse splays**; and (3) **inter-channel wetlands** (Smith and Putnam 1980).

THREE FEATURES:

1. *Stream Channel*
2. *Crevasse Splay*
3. *Inter-channel wetland*

These three features can be distinguished by the type of original material deposited.

(1) Stream channels are generally composed of coarse grained materials (sands and gravels)

(2) Crevasse splays are composed of thin layers of coarse grained material and are formed when the channel banks are breached during high flow events.

(3) Inter-channel wetlands are composed of a wider distribution of sediment size, ranging from clays to sands (Grasby et al. 2010; Burns et al. 2010a).

The type of deposit determines whether groundwater can flow and be stored within the rocks that formed from the material. For the purpose of groundwater research, it also determines the location and extent of aquifers that can be used by humans and animals. The Paskapoo has ancient **stream channels** characterized by fractured **sandstone**, which were formed from sand (Figure 1 – green box). Much like the original stream, these sandstone channels meander through the subsurface. The **crevasse splays** are also characterized by **sandstone**, but are more localized and discontinuous compared to the **sandstone channels**. The **inter-wetland/ floodplain** deposits (Figure 1 – red box) characterize the majority of the Paskapoo formation and are mainly composed of **shale** (formed from clay sediments) and **mudstones** (formed by a variable sediment sizes) (Burns et al. 2010).

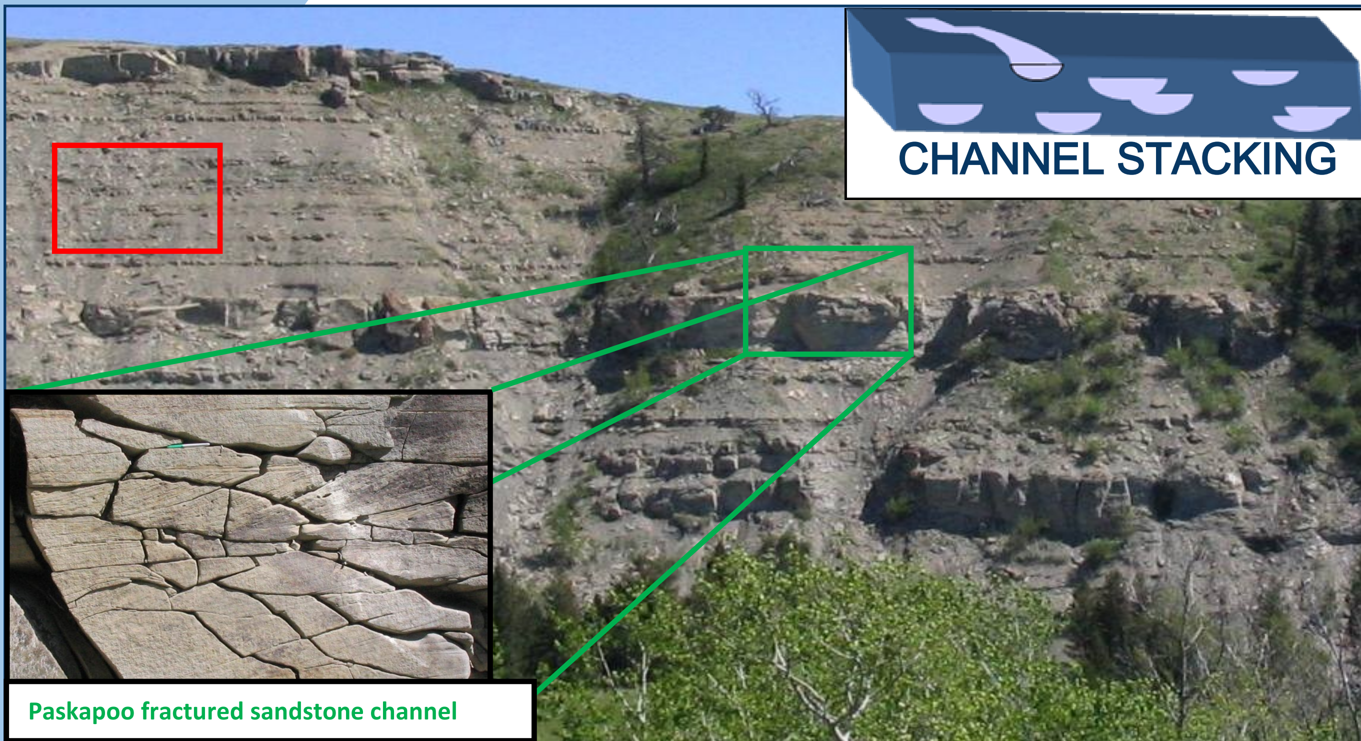

Figure 1: Paskapoo Outcrop. Examples of the overbank / wetland deposits are located within the red square and examples of the sandstone channel units correspond with the green square.

What makes the Paskapoo aquifer difficult to study?

The Paskapoo was formed through ancient fluvial systems. As vertical accumulation occurred over time, the sandstone channels appear to stack on top of each other. However, due to the fluvial system, variability within channel location occurs as the channel migrated and flow regimes shifted. Therefore, channels do not simply build up directly on top of each other, but rather are offset from one another (Figure 1). These differences in depositional processes have resulted in the Paskapoo formation being heterogeneous, with each component having different hydraulic properties. The sandstone layers act as aquifers due to their highly fractured rock, along with greater pore spaces relative to surrounding overbank mudstone deposits allowing for: (1) groundwater storage and (2) groundwater flow. Since the sandstone layers are stacked meandering channels, it can be difficult to determine the location, size and dimensions of these aquifers. In addition, it is not really understood how the sandstone units are connected; however, it is predicted that the distribution and connectivity of the sandstone channels and splays vary with depth (Hamblin 2004; Grasby et al. 2008; Burns et al. 2010).

REFERENCES

Burns, E. R., L. R. Bentley, M. Hayashi, S. E. Grasby, A. P. Hamblin, D. G. Smith, and P. R. J. Wozniak. (2010). Hydrogeological implications of paleo-fluvial architecture for the Paskapoo Formation, SW Alberta, Canada: a stochastic analysis, Hydrog18: 1375 – 1390.

Gilblin, M.R. (2006). Width and thickness of fluvial channel bodies and valley fills in the geological record: A literature compilation and classification. *Journal of Sedimentary Research*, 76, 731-770

Grasby, S.E., Chen, Z., Hamblin, A.P., Woznlak, P.R.J., & Sweet, A.R. (2008). Regional characterization of the Paskapoo bedrock aquifer system, southern Alberta. *Canadian Journal of Earth Science,* 45, 1501-1516

Grasby, S.E., Osborn, J., Chen, Z., & Wozniak, P.R.J. (2010). Influence of till provenance on regional groundwater geochemistry. *Chemical Geology,* 273, 225-237

Hamblin, A.P. (2004). Paskapoo=Porcupine Hills Formations in Western Alberta: Synthesis of Regional Geology and Resource Potential. *Geological Survey of Canada*, Open File 4679

Smith, D.G., Putnam, P.E. (1980). Anastomosed river deposits: Modern and ancient examples in Alberta, Canada. *Canadian Journal of Earth Science*, 17, 1396-1406

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