Volume estimate of granular deposits and groundwater reserves of the Abitibi-Témiscamingue eskers, Québec

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INTRODUCTION

The contribution of Quaternary studies to the economic geology of Nordic countries was convincingly demonstrated in several papers published in a special number of the journal Striae (1986). These document the expansion of the granular materials extraction industry in Scandinavian countries and stress the need for effective management of the resource to protect groundwater reserves and accommodate salinization problems. With numerous large eskers laid out for the most part in a subaqueous environment, the Abitibi-Témiscamingue region has a glacial legacy similar to that of several areas in Scandinavia and consequently from the same level of salinization problems. Esker-based activity relies on a wide variety of activities, ranging from sand and gravel extraction, recreation, and locally control high-quality groundwater reserves. Several municipalities have their supply of drinking water from wells located in nearby eskers. However, the region lacks at this time a basic information to properly manage the resource. Based on the distribution of eskers shown from surface geological maps, this study presents the first regional quantitative estimate of the Abitibi-Témiscamingue granular resources and their groundwater potential.

SEDDIMENTATION ENVIRONMENTS OF ABITIBI ESKERS

The accuracy of the methods used to estimate the volume and the aquifer potential of eskers is closely related to the sedimentation environment of eskers. The depth of proglacial lake Barlow-Ogivey was a major controlling factor of the sedimentation process. Clay (or) sedimentation occurs in water depths exceeding 50 to 60 m (Veillette, 1986).

Maximal depth of Barlow-Ogivey submergence

A model was derived from empirical measurements of the maximal depth reached by the glacial lake to produce a map showing variations in the depth of proglacial lake water over the region. This model was created by visual analysis in ArcGIS 9.1 with maximal depth (200 elevation points) compiled by Veillette (unpublished data). The model uses the same tilt as a submergence (Veillette, 1986).

Types of sedimentation environments

Veillette et al. (2006) subdivided the eskers of the region into four broad types according to their sedimentation environments:

- **Type A**: The esker lies above or outside the area submerged by proglacial water.
- **Type B**: The esker was submergence but lies at a depth located inside the level of deep submergence (veins) or is buried by fine-grained deposits.
- **Type C**: The esker lies within the deep water basin and is uplifted by four-grained deposits.
- **Type D**: The esker is merely or totally buried by fine-grained deposits.

**Figure 1.** Sedimentation environments and maximum depth of proglacial lake Barlow-Ogivey in the study area.

APPARENT VOLUME OF GRANULAR DEPOSITS

The volume of granular deposits was estimated using 6DIF methods. A DEM (digital elevation model) was generated by tap to raster in ArcGIS 9.3 for each esker from a 1:20 000 topographic map (Figure 2). The apparent granular mass of the esker, which is the cross section (median length) that stands above the coarse fraction (sand, silt or peat as detached on surficial geology maps) (reference) was measured (Figure 3). It follows that this volume represents a minimum value since it does not allow for the buried base parts of eskers that may extend below the confining depths. Field observations and drilling show that only submergence eskers extend below the outcropping proglacially. The apparent volume of eskers is the volume estimated by Veillette et al. (2006) for the study area.

**Figure 2.** A conceptual model for esker formation in deep glaciallacustrine waters.

AQUIFER POTENTIAL OF ABITIBI ESKERS

The presence of an aquifer in an esker is closely related to its sedimentation environment and site-specific conditions such as the bedrock topography below the esker. Springs and seepage areas on eskers are outside the sedimentation environment. These parameters were used to assess the aquifer potential of esker segments, according to the classification outlined below (1) for unfavorable conditions, (2) and (3) for favorable conditions. The integration of these parameters produces four different levels of aquifer potential (Figure 6).

**Figure 6.** Aquifer potential in deepest part of the glaciallacustrine basin.

**Figure 7.** Apparent volume of granular material in an esker segment.

Sedimentation environments

- **Type A**: The esker is entirely located above the level of deep submergence. It is therefore considered a maximum volume reservoir.
- **Type B**: The esker is partly located above the level of deep submergence. It is therefore considered a minimum volume reservoir.
- **Type C**: The esker is entirely located below the level of deep submergence. It is therefore considered a minimum volume reservoir.
- **Type D**: The esker is partly located below the level of deep submergence. It is therefore considered a minimum volume reservoir.

**Figure 3.** Eiker segment boundary (red) as it appears in surficial geology map, DEM study and the apparent volume of granular material in an esker segment.

**Figure 4.** Example of apparent section (green) calculated to estimate the apparent volume of granular material in an esker segment.

**Figure 5.** Height of eskers and maximum depth of proglacial lake Barlow-Ogivey in the study area.

CONCLUSION

The different methods presented constitute the first regional conservative estimate for the volume of granular deposits and the aquifer potential of eskers in the region. This study shows the great variations in volume, grain size and aquifer potential that can be encountered in eskers. The aquifer potential in eskers are classified into four segments possessing different physical properties and groundwater conditions. Potential groundwater resources are highlighted in the study area. These results will be useful for further planning and further investigations of segments showing favorable conditions for the retention of groundwater.