An overview of the hydrogeology of the Precambrian basement in Quebec and related mining problems

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Abstract : Groundwaters in the Precambrian basement are not used in large quantities in Québec, even though the basement underlies more than 90% of Quebec's surface area. Nevertheless, mining and hydroelectric power generation provide valuable data and study sites on hydrogeological, geomechanical and geochemical processes, and their interactions, around underground excavations. A decrease in permeability with depth and the occurrence of brines with high chloride content are also frequently observed in this environment.

INTRODUCTION

The principal interaction between groundwater and human activities in various geological environments, including the Precambrian basement, varies from one region of the World to the other (Gustafson and Krásný 1994). Mine drainage represents a characteristic hydrogeological problem in the Canadian Shield, particularly in Quebec (Charron 1967; Brown 1970; Rouleau et al. 1999a&b). Radioactive waste disposal (Farvolden et al. 1988) and hydroelectric power generation have also motivated local hydrogeological studies and observations in the bedrock of this region.

This presentation is an overview of the hydrogeology of the Precambrian basement in Quebec, describing a number of hydro-mechanical and hydro-chemical phenomena affecting mine drainage

GEOLOGY, HYDROLOGY AND CLIMATE

The Precambrian basement, which underlies more than 90% of Quebec (Fig.1), forms part of the Canadian Shield which is divided into geological provinces according to deformation style and age (Stockwell 1962).

Total annual precipitation ranges from about 1100 mm in the southern part of the Precambrian Shield to about 400 mm in the northern tip of Quebec (Lapointe 1977; Proulx *et al.* 1987). This decrease in precipitation, combined with the presence of more or less discontinuous permafrost over much of the area, results in considerably lower groundwater recharge at higher latitudes (Rouleau *et al.* 1999b).

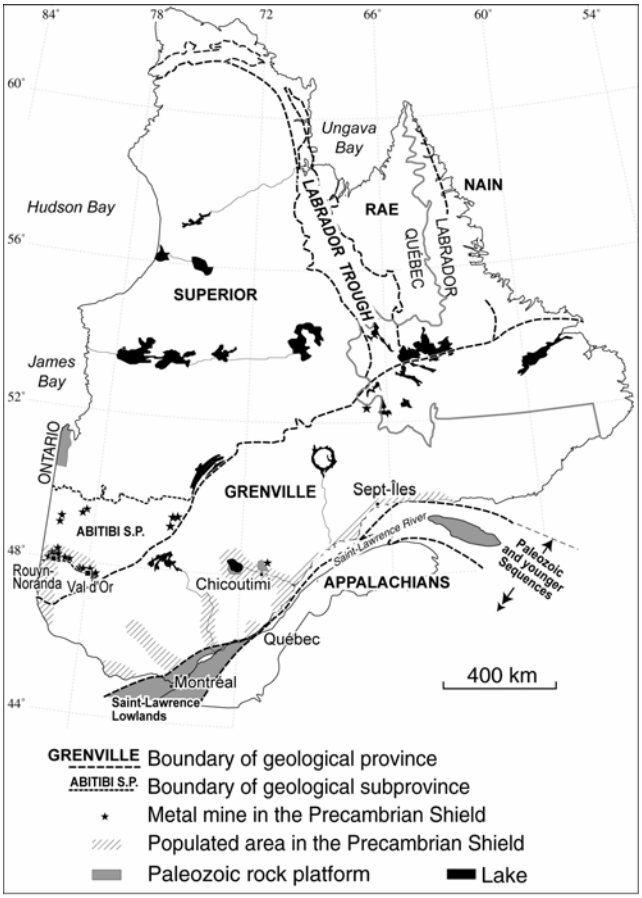

Fig.1 Map of the geological provinces in the Precambrian Shield in Quebec and Labrador, showing the location of mines

GROUNDWATER WITHDRAWAL

Local hydrogeological data are essentially restricted to the most populated areas of the Precambrian Shield in Quebec, which are located in the Grenville Province (Rivers *et al.* 1989) and in the Abitibi Subprovince of the Superior Province (Hock 1994). However, even in these areas groundwater is not used in large quantities because of the wide availability of surface water (i.e. lakes and streams). The groundwater is essentially drawn from permeable glacial and pro-glacial deposits, and is used by municipalities and industries. Mine drainage constitutes the main groundwater

withdrawal and is responsible for the characteristic hydrogeological problem in the crystalline basement formations in Quebec (Rouleau *et al.* 1999b). In the Abitibi geological Subprovince as an example, which covers about 90 000 km^2 of the Precambrian Shield, the total groundwater withdrawn from the 35 mines (in 1993) of that region amounts to about 57 000 m^3/day (MEFQ 1993). This is roughly equivalent to the groundwater withdrawn by the 150 000 inhabitants of this mining region for all other usages, including drinking water, pisciculture and other industries.

HYDRO-MECHANICAL AND HYDRO-GEOCHEMICAL PHENOMENA

Minor fractures and major structural discontinuities, such as faults and shear zones, clearly control groundwater inflow to a depth of about 300 m in the mines (Raven and Gale 1986). At greater depth, major structures alone generally constitute the groundwater conduits.

Excavation in a rock mass disturbs the geomechanical stress field, which in turn presumably affects the hydrogeological properties of the rock mass. However, field data on rock permeability around excavations suggest that other processes may also affect the hydrogeological properties of a rock mass around drained excavations, such as groundwater degassing and dissolution-precipitation along fracture planes (Rouleau *et al.* 1999a).

Many occurrences of brines and gases have been reported in the Canadian Shield (Fritz and Frape 1982; Guha and Kanwar 1987; Sherwood et al. 1988), including in the mines in Quebec. These brines are mostly encountered at a depth of 1000 m or more, and typically have high chloride content.

Groundwater drainage in mines often produces an important drawdown cone. The presence of air in this enlarged unsaturated volume of rock increases geochemical reactions affecting groundwater (Rouleau *et al.* 1999a**)**.

CONCLUSION

Mine drainage constitutes the main groundwater withdrawal and presents a characteristic hydrogeological problem in the Precambrian basement in Quebec. Mining and other underground excavations often have significant effect on the hydrogeological properties of a rock mass as well as on the groundwater quality and flow regime.

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