Oak Ridges Moraine, Project Overview

Introduction

Groundwater is a strategic natural resource in Canada. It is vital to the well-being and health of about 7 million Canadians who rely on groundwater for daily water supply. However, there are regional disparities in supply, demand and water quality such that some areas have excess water whereas others have shortages or water quality limitations. Groundwater is also essential to the viability of our environment and growth of the Canadian economy, particularly the agricultural sector. Groundwater likewise has important economic significance to a range of urban activities.

Fig 1: *Thematic mapper image of the Greater Toronto Area showing a distinction between urbanized areas, Metro Toronto, and agricultural lands with field patterns. The ORM is marked by an east-west strip of forest cover from east of Aurora to east of Lake Scugog.*

The Canadian Geoscience Council (1993) recently concluded that current Canadian efforts in groundwater inventory, protection and research are fragmented and inadequate. There is a deficient geological framework and knowledge base in groundwater studies at a national scale. For example, the Brown report, the most recent national synthesis of Groundwater in Canada, was published by the Geological Survey of Canada (GSC) in 1967. On the other hand, the United States Geological Survey (USGS) has carried out comprehensive groundwater programs in the US over the last 25 years under their Regional Aquifer System Analysis (RASA) program (Sun and Johnston, 1994). Programs like RASA have made use of improved regional methods (e.g. hydrogeochemistry) and groundwater modelling routines to advance understanding. In Canada, reinvestment in groundwater research is overdue, particularly at the regional scale. Hence the GSC, in collaboration with provincial and municipal partners, has re-initiated regional groundwater studies in several areas of the country, including the ORM (Fig. 1). An immediate emphasis is on providing a regional three-dimensional hydrogeological framework in support of resource evaluation. This focus should complement and provide a regional context for site and local scale investigations

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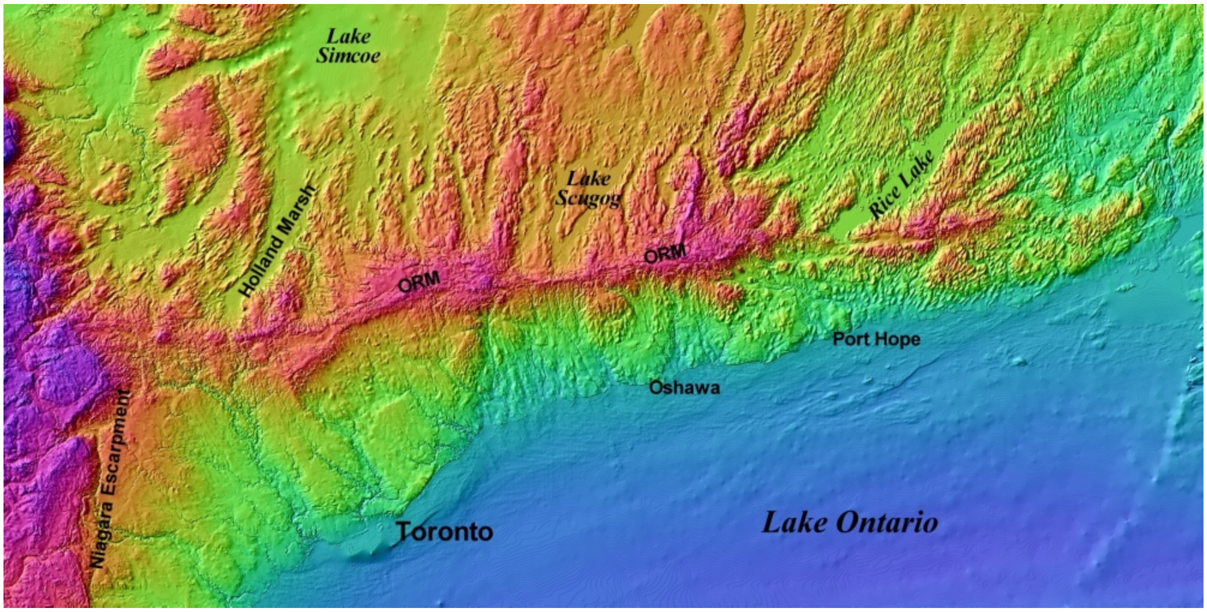

Fig 2: *Digital Elevation Model (DEM) of the GTA. East-west higher terrain, ORM, separates stream flow north to Lake Simcoe and south to Lake Ontario (Kenny et al., 1999).*

Regional hydrogeological mapping

Groundwater supply is one issue of interest in present hydrogeological studies in the ORM-GTA. As in many parts of Canada in the last 50 years, groundwater development has relied heavily on water well drillers (Cherry et al., 1988) and their reported records as a fundamental source of water resource information (e.g. Russell, et al., 1998). Domestic wells are completed to the required depth on a residential property by a driller familiar with the aquifer potential in the local area. Municipal supplies have expanded in a similar site-specific manner. In a few cases, groundwater resource evaluations were carried out by groundwater professionals prior to the installation of production wells. To date, the well-drilling approach has been reasonably successful in providing domestic and municipal water supply. However, this methodology and the lack of investment in water resource evaluation has yielded limited hydrostratigraphic data or accumulated knowledge regarding further groundwater resource development in the ORM region (e.g. Sharpe et al., 1996).

As a result of relying on the well-drilling approach to aquifer delineation, there is a weak geological framework for addressing a range of hydrogeological topics and related land use planning issues. Further, there is considerable difficulty in developing groundwater understanding in areas with complex subsurface glacial deposits, such as the ORM, because aquifers and aquitards have varied regional extents and geometry, and, sedimentary facies can change rapidly. Consequently, groundwater flowpaths are poorly known in these glacial stratigraphies where sediments are up to 200 m thick. Hence, 3-D geological mapping is needed to identify the geological controls on groundwater flow. This knowledge, combined with aquifer-specific hydraulic monitoring, will allow a better evaluation of aquifer connectivity, capacity and protection.

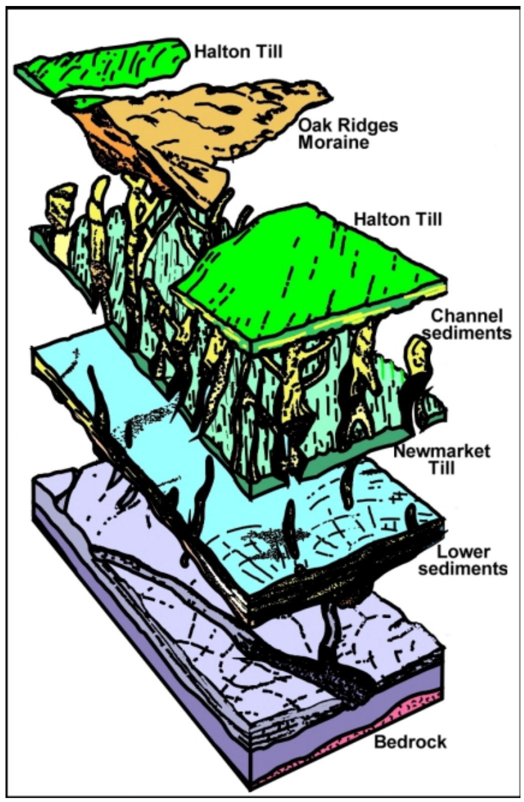

Fig 3: *Geological model of the ORM area. Oldest to youngest units are: i) bedrock; ii) lower sediments; iii) Newmarket Till; iv) channel sediments; v) Oak Ridges Moraine sediments, and; vi) Halton Till.*

Groundwater studies in the Oak Ridges Moraine

The present study of the ORM is one of the first regional studies of a moraine in southern Ontario (Fig. 2) and Canada that has focused on understanding the 3-D geological structure in support of regional hydrogeological mapping. Central to this effort is the development of a conceptual geological model of the ORM region (Fig. 3). Regional geological methods have been applied to complement hydrogeological methods used at the site-specific scale (Fig. 4). These methods include basin analysis techniques such as sediment mapping (e.g. Sharpe et al., 1997), reflection seismic surveys (Pugin et al., 1999), continuous deep drilling, borehole geophysics and remote sensing, geostatistical analysis (Desbarats et al., 1998), subwatershed-scale stream baseflow gauging and geochemistry surveys (Hinton, et al., 1998; Dyke, 1999), and, collation of archival data. Data synthesis and analysis have been completed in a relational database (Russell et al., 1996) that allows GIS integration in 3-dimensions. Such reservoir identification and characterization techniques are common in the oil and gas industry.

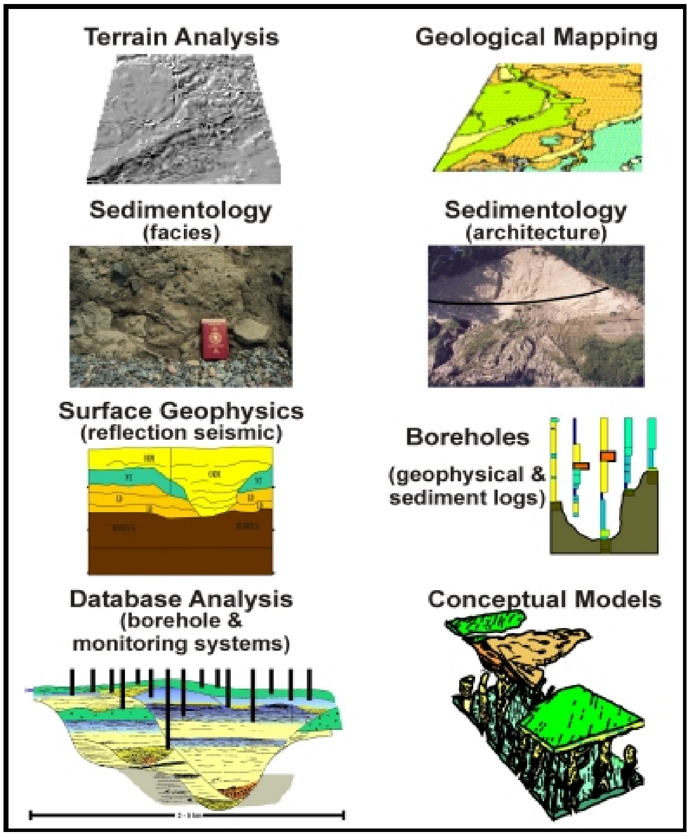

Fig 4: Regional 3-D hydrostratigraphic methods emphasize the role of geology, geophysics and data integration in advancing hydrogeological understanding.

Hydrostratigraphic data in the GTA can be organized into major sediment packages depicted in a 3-D regional geologic framework that highlights six principal stratigraphic elements. From oldest to youngest these are: i) bedrock; ii) lower sediments; iii) Newmarket Till; iv) channel sediments; v) Oak Ridges Moraine sediments, and; vi) Halton Till. Lower, channel and ORM sediments form significant aquifers, whereas Newmarket and Halton Till generally form aquitards. Bedrock acts locally as an aquifer or an aquitard.

The geological model is being used to develop a stratigraphic and hydrostratigraphic framework for the region. Of particular interest are the channel and moraine sediments of the ORM area, which form a principal aquifer system. Moraine and channel landforms and sediments are genetically related as defined by evolving sedimentary models (e.g. Gilbert, 1997; Barnett, et al., 1998; Russell, et al., 1998). The sedimentary models draw upon recent progress in documenting the role of subglacial meltwater floods in glaciated terrain in southern Ontario (e.g. Shaw and Gilbert, 1990; Brennand and Shaw, 1994; Barnett et al., 1998). This development of stratigraphic and sedimentary models is necessary to derive the most accurate 3-D hydrostatigraphic understanding in preparation for hydrogeological modelling. In turn, these methods are necessary to address a range of water resource management issues from across the country, particulary those facing rapidly-expanding urban areas such as the ORM-GTA.

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