Updated Devonian Hydrostratigraphy in Northeast Alberta

John Wozniewicz
Golder Associates Ltd., Calgary, Alberta, Canada
John_Wozniwicz@golder.com
Dr. Wayne Savigny
BGC Engineering Inc., Vancouver, BC, Canada
Dr. Frank Stoakes
Stoakes Consulting Group Ltd., Calgary, Alberta, Canada
Robert Mahood
Shell Canada Energy, Calgary, Alberta, Canada
Matthijs Verhoef
Shell Canada Energy, Calgary, Alberta Canada

KEY WORDS - hydrostratigraphy, karst, data integration

ABSTRACT
Information from six new boreholes drilled in 2011 on the Shell Muskeg River Mine (MRM) lease has led to an update of the Devonian hydrostratigraphy in NE Alberta. This information together with ongoing studies will provide a foundation for assessing the degree of hydraulic isolation of saline Devonian aquifers from future open pit mining operations in the surface mineable oil sands area.

Historically, the primary regional Devonian aquifer in the area of MRM was considered to be the Keg River Formation, which is predominantly dolomite. It has informally been subdivided into a “Lower Thin-Bedded Member” (ramp) and more areally restricted “Upper Massive Member” (reef/bank).

Recent data for the Keg River ramp section suggest aquitard hydraulic properties, whereas aquifers have been identified within the overlying Prairie Evaporite Formation. The Prairie Evaporite Formation comprises a lower “intact” unit of interbedded dololaminites and anhydrite with an overlying unit comprising anhydrite together with a chaotic mixture of laminated dolomudstones and shaly beds that are often brecciated. The upper section is referred to informally as the “collapsed” Prairie Evaporite resulting from the interstratal dissolution of the halite beds. Where present, the dololaminites lap up against the flanks of Keg River reefs/banks with a relatively thin “collapsed” section overlying the top of the reefs/banks. Lost circulation during drilling and zones of enhanced hydraulic conductivity (>1 x 10^{-06} m/s) from core analyses are associated with laterally extensive dololaminites (on scale of 1 – 10’s kms) and more local zones in various stages of dedolomitization and solution collapse.

Overlying the Prairie Evaporite Formation to the sub-Cretaceous unconformity are predominantly interbedded calcareous shales and limestones. Historically, the intervening units were considered a regional aquitard with the exception of local scale aquifers confined within formations. This conceptualization was consistent with operations experience in the surface mineable oil sands area up to 2008.

The presence of vertical pathways or “hydraulic windows” through these units was predicted in the early 1970’s. These include collapse chimneys, faults and fractures, most associated with collapse of the Prairie Evaporite Formation due to halite dissolution. The first actual encounters occurred in 2008 and characterization is ongoing.

In summary, the Devonian units underlying the surface mineable oil sands area become relevant, in terms of the potential for saline water inflow, when a vertical pathway hydraulically connects the underlying saline Devonian aquifers with the top of the Devonian surface. The presence and geologic controls for these conditions are being evaluated by the integration of both static and dynamic data sets. Work that is still ongoing includes: a review of 2D seismic surveys, integration of aeromagnetic and resistivity survey data with other complementary data sets; drilling of inclined boreholes to target vertical pathways of interest; superimposing dynamic data from a network of monitoring wells maintained by multiple operators on the geophysical and geological data sets; and, forensics of mine and aquifer water quality data. This integrated approach will provide an improved understanding of the Devonian hydrogeology and allow for improved risk management related to groundwater in the surface mineable oil sands area and other geohazard exposures.