

# **Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada\***

**Robert O. Potter<sup>1</sup> and Paul Harrington<sup>2</sup>**

Search and Discovery Article #40986 (2012)\*\*

Posted August 13, 2012

\*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

\*\*AAPG©2012 Serial rights given by author. For all other rights contact author directly.

<sup>1</sup>GeoChemTech Inc., Calgary, AB, Canada ([ropotter@geochemtech.com](mailto:ropotter@geochemtech.com))

<sup>2</sup>W.L. Gore & Associates, Inc., Newark, DE

## **Abstract**

Gas/condensate and oil has been discovered in the Cambrian sandstones reservoirs of the Mount Clark Formation in the Northwest Territories of Canada. The Mount Clark reservoir occurs at a depth of 1,000 to 1,400 m with net pays of 10 to 12 m. Subsequent deposition of the Saline River Formation resulted in a thick section of evaporates and salt up to 500 m thick.

It is estimated that the trend contains 84 structural prospects varying in area from 4 to 150 square kilometers. The undiscovered gas in place is estimate to be 5,791 Bcf contained in about 77 undiscovered fields (Natural Gas Potential in Canada 2001; Canadian Gas Potential Committee).

In the winter of 2007, a large surface Amplified Geochemical Imaging<sup>SM</sup> survey was conducted that included the Cambrian Tweed Lake pool as the geochemical model. Forty-eight modules were installed in the Tweed Lake area around two wells (M-47 and C-12) and along a northeast-southwest seismic line.

Once retrieved, all samples were analyzed by thermal desorption followed by gas chromatographic separation and mass selective detection. After signal to noise processing, statistical methods involving principle component analysis and discriminate analysis was applied to the data set to define the unique hydrocarbon signatures related to different hydrocarbon phases in the subsurface.

The geochemical model was developed using the M-47 and C-12 wells as the end-member set to collectively define their respective “gas/condensate-like” and “background-like” emanation signatures in two-way discriminant analysis.

The Tweed Lake C-12 dry well site defined the background in the Colville Hills area. This well is located ten kilometers from the Tweed Lake M-47 gas/condensate discovery well. Linear discriminant analysis was used to make a geochemical model of the gas/condensate.

The results for the Tweed lake M47 gas-like model in Colville Hills identified a geochemical feature at least 3.5 kilometers along the transect over the Tweed Lake field. The geochemical feature truncates along the transect 1.5 kilometers northeast of the Tweed Lake M-47 gas well and appears to closely correlate to the fault that defines the eastern edge of the Tweed Lake pool. Subordinate faults can be identified on the transect probability profile and the hydrocarbon signature of the gas condensate can be seen.

### **Selected References**

Northern Oil and Gas Directorate (Canada) (NOGD), 1995, Petroleum Exploration in Northern Canada: A guide to oil and gas exploration and potential: NOGC, 117 p.

Janicki, E.P., 2004, Hydrocarbon pools of the Colville Hills: (Canada) North West Territory (NWT) Open Report 2004-2006. Web accessed 23 July 2012. [http://gateway.nwtgeoscience.ca/browseB.php?MENU\\_ID=8&MENU\\_NAME=NTGO%20Publication&M\\_INDEX=7&LEVEL=1](http://gateway.nwtgeoscience.ca/browseB.php?MENU_ID=8&MENU_NAME=NTGO%20Publication&M_INDEX=7&LEVEL=1)

### **Website**

Canadian Gas Potential Committee (CGPC), 2001, Natural Gas Potential in Canada: A Report by the CGPC. ([cgpc@cadvision.com](mailto:cgpc@cadvision.com)).

# Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada

Robert O. Potter (Speaker), GeoChemTech Inc.  
&  
Paul Harrington, W. L. Gore & Associates, Inc.

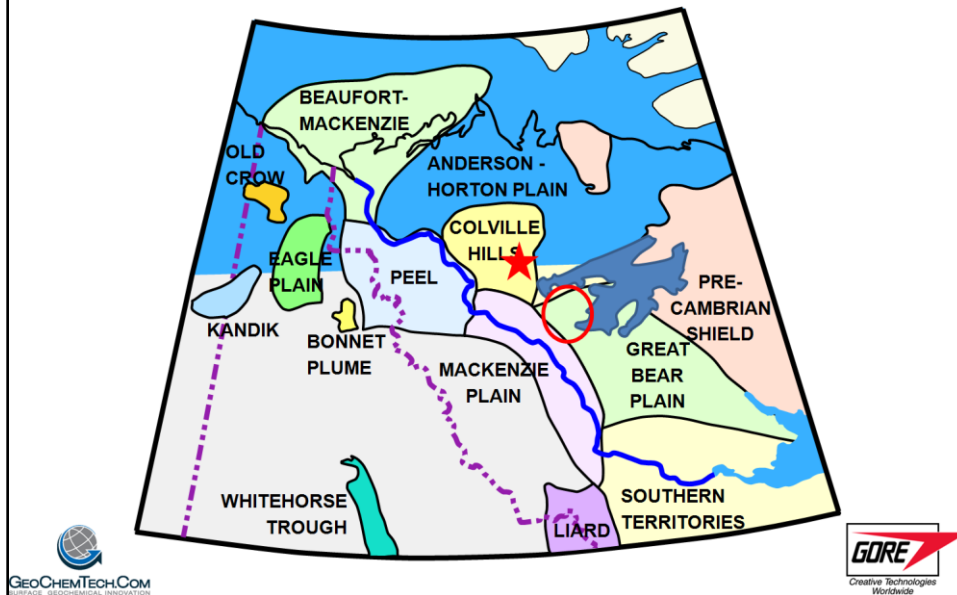


**GEOCHEMTECH.COM**  
SURFACE GEOCHEMICAL INNOVATION



Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

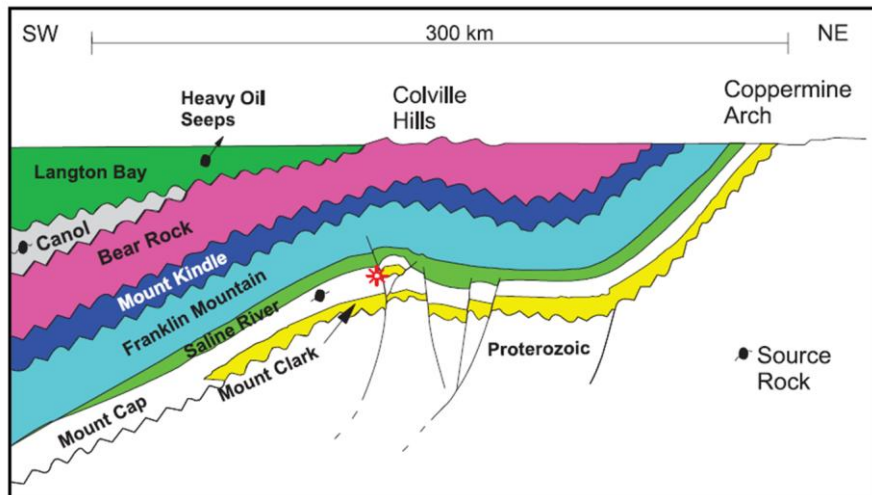
**SEDIMENTARY BASINS OF THE NORTHWEST & YUKON TERRITORIES, CANADA**



Presenter's notes: This slide shows the 13 sedimentary basins of the Northwest and Yukon Territories of Canada based on physiographic and geologic control. The Colville Hills area contains four Cambrian gas discoveries and one oil discovery with estimated reserves of plus 800 BCF. The RED circle indicates the location of the surface geochemical survey and the RED star indicates the relative location of the Tweed Lake Cambrian field.

Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

**SCHEMATIC SECTION, COLVILLE HILLS AREA**

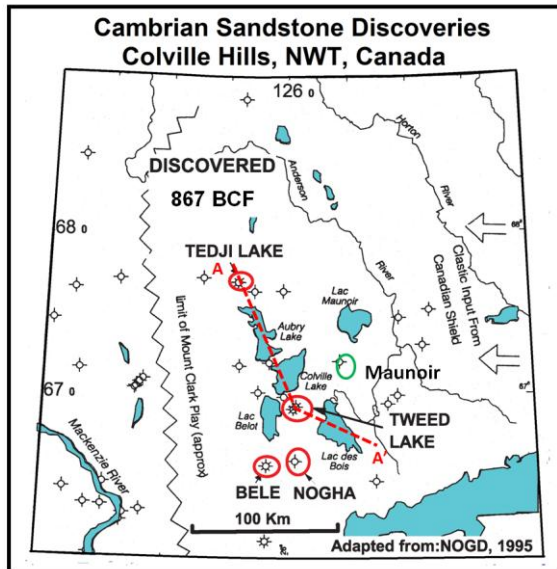


From NOGD, 1995

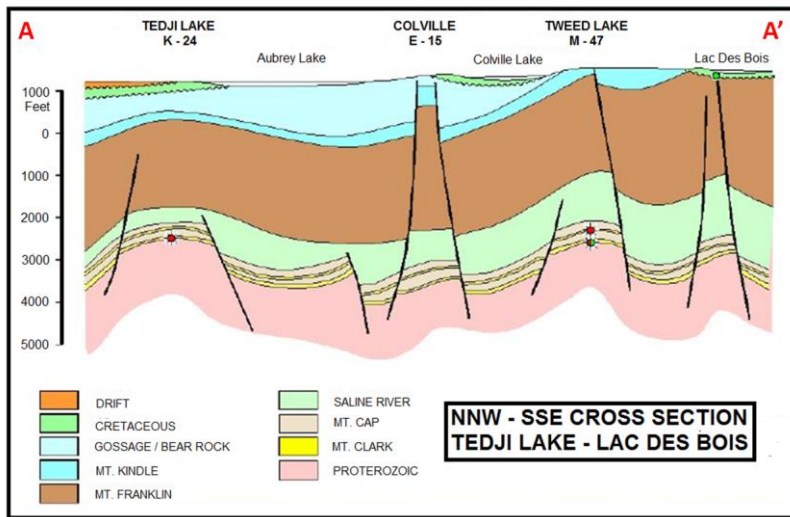


Presenter's notes: This schematic cross section shows the structural and stratigraphic setting of the Cambrian petroleum system of the Colville Hills area. Gas and oil is trapped in the sandstone reservoirs of the basal Cambrian Mount Clarke. The source rock is the Mount Cap shales but because of the presence of nitrogen in the gas, some believe that the meta-sediments of the Proterozoic may also be a source. Top and lateral seals for the play are considered to be of excellent quality due to the presence of the shales of the Mount Cap formation and thick evaporites in the Saline River formation. Trapping styles include flower structures, rollover anticlines in grabens, stratigraphic pinchouts and onlap traps against basement highs.

Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

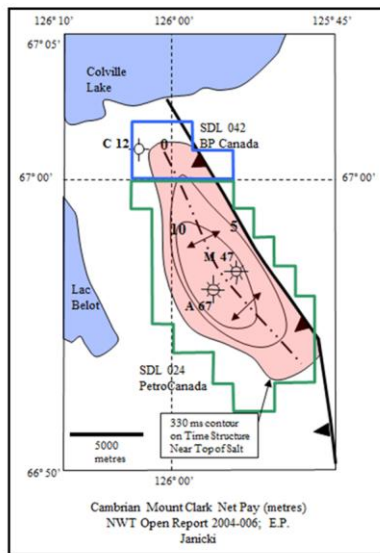


## Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada



Presenter's notes: This detailed cross section A – A' shows the structural relationship of gas zones within the Mount Clarke for the Tedji and Tweed Lake discoveries.

## Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada

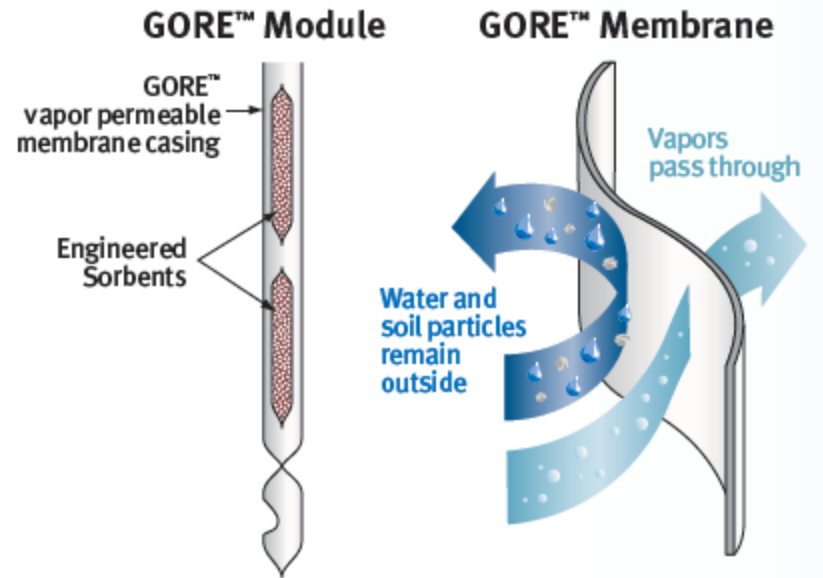


Presenter's notes: This slide is a simplified Mount Clarke net pay map of the Tweed Lake gas – condensate pool. The trap is a rollover anticline into a flower fault structure along the northeast side. The pool is defined by two gas wells (M 47 and A 67) and one abandoned well (C 12) and an extensive 2D seismic data set. The pool size is approximately 83 km<sup>2</sup> with estimated raw recoverable reserves of 355 BCF. (Drummond, 2009)



# Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada

## GORE® Amplified Geochemical Imaging<sup>SM</sup> Surveys



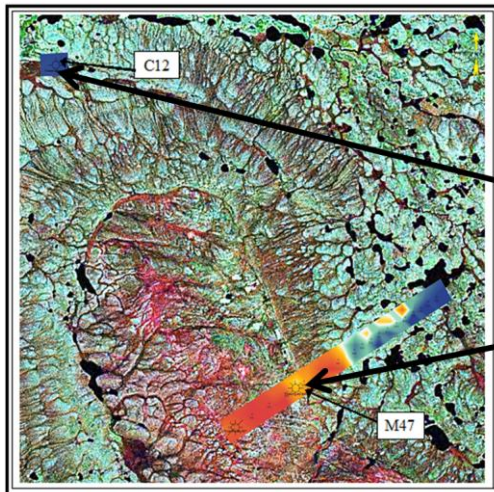
### LABORATORY PROCEDURES

1. Thermal Desorption
2. Gas Chromatograph
3. Mass Spectrometer



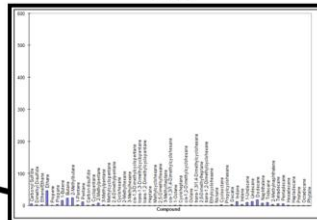
Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

**GOOGLE TOPOGRAPHIC IMAGE – TWEED LAKE**

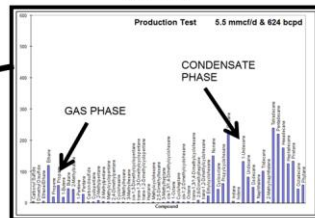


**MODEL WELL PROFILES**

**C-12**



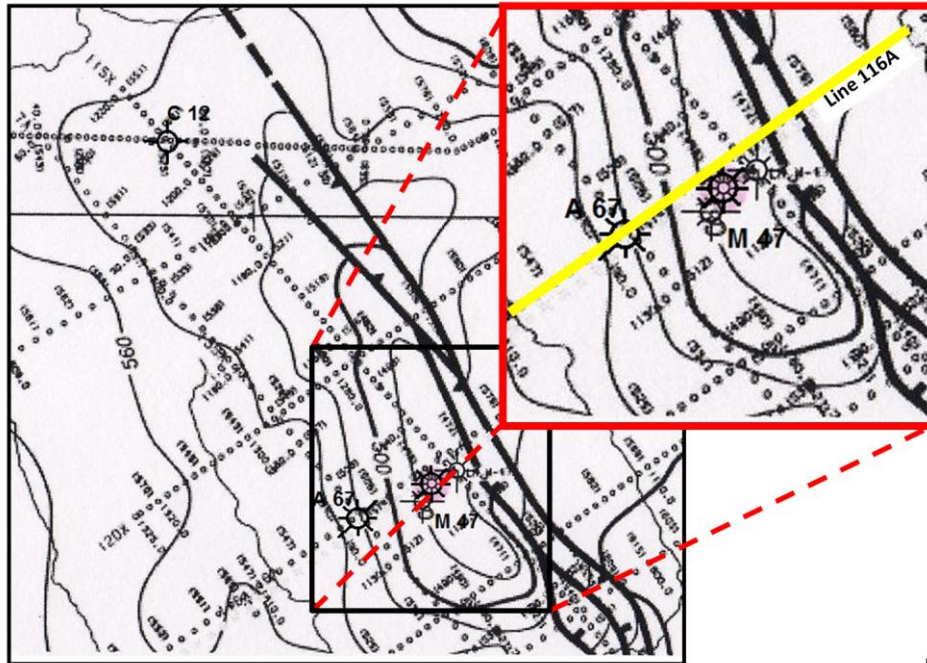
**M - 47**



Presenter's notes: This slide shows the design of the model survey on a Google Image showing the surface expression of the anticline and the geochemical profiles of the two model wells. The survey consisted of placing 15 modules around the M-47 discovery well and 13 modules around the C-12 abandoned well. A 3.5 km transect along seismic line 116A consisted of 18 modules at a spacing of 250 and 500 meters. The model well profiles consist of hydrocarbon compounds  $C_2$  to  $C_{20}$  along the horizontal axis and mass on a scale of 0 to 600 Ng on the vertical axis. The C-12 model well profile indicates very low levels of hydrocarbon compounds while the M-47 discovery well profile indicates levels of about 100 Ng in the gas phase and about 250 Ng in the liquid phase. It should be noted that the M-47 well tested 5.5 mmcf/d of gas and 624 bc/d. The orange/red portion of the transect indicates the gas-condensate signal as defined by M 47 while the blue portion indicates no hydrocarbon signal as defined by C-12. These signals are interpreted to be the result of microseepage from the reservoir.

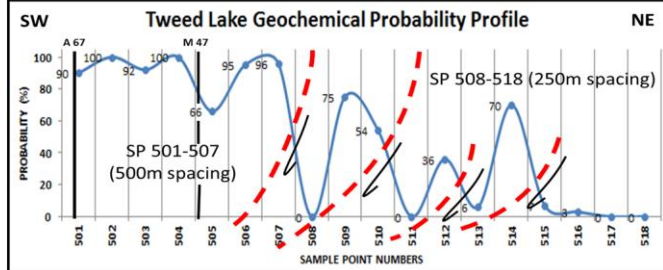
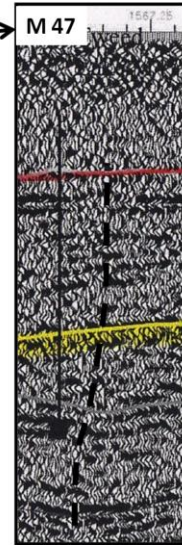
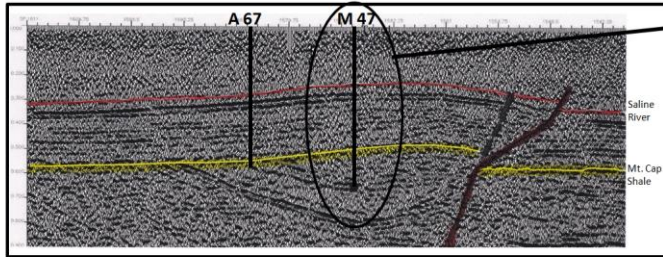
Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

**TWEED LAKE PROTEROZOIC TIME STRUCTURE**



Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

SEISMIC LINE 116A



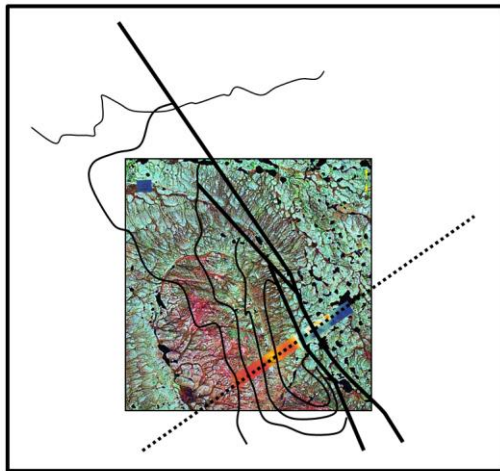
Presenter's notes: This slides correlates the interpretation of Line 116A and the profile of the chemical probabilities along the transect. The discoveries wells are indicated on both the seismic and geochemical probability section. Line 116A images the anticline structure that forms the Tweed Lake trap and interpreted flower structure. The seismic line does not image the flower structure in detail. The geochemical profile section plots the probability of hydrocarbons based on microseepage from the reservoir for the 18 modules placed along the transect. The geochemical profile section indicates a number of interest details:

1. Strong correlation between the 100% probabilities and the discovery wells
2. Numerous gas-bearing fault slices are implied by the geochemical signal before totally disappearing to the northeast. The updip fault complex that forms the trap is interpreted to consist of at least 4 separate faults.
3. A low probability of 66% at sample point 505 has been correlated to a disturbance in the seismic section that could be a fault within the pool.

This fault is supported by a surface lineament on the Google image. Because the fault could act as a barrier within the pool, it might impact production.

Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

**TWEED LAKE PROTEROZOIC TIME STRUCTURE**  
**WITH GORE® TRANSECT**

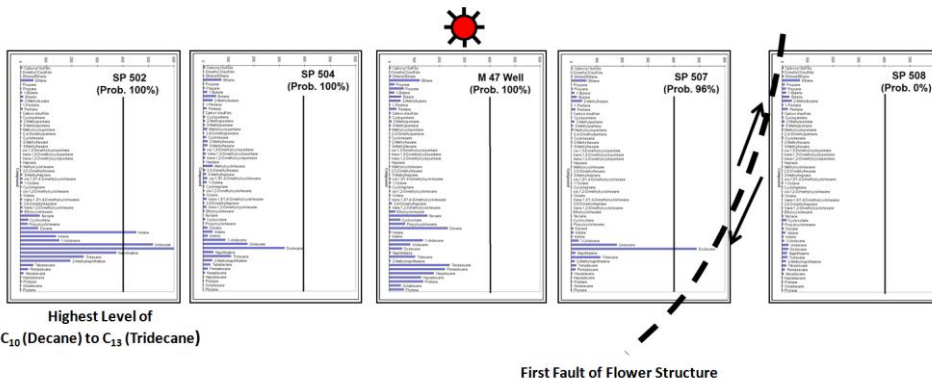


Presenter's notes: This slide shows the relationship between the geochemical transect shown earlier and the Proterozoic Time Structure Map projected on the Google image. The updip limit of the positive surface geochemical signal correlates to the first fault on the Proterozoic Time Structure map.



Surface Geochemical Imaging of the Tweed Lake Cambrian Field,  
Northwest Territories Canada

**TWEED LAKE, NWT, CANADA**  
**GEOCHEMICAL PROFILE CROSS-SECTION**



**Implies Variation of Condensate Concentration Across Field**



Presenter's notes: Another interpretation technique is to construct a geochemical cross section using the individual sample profiles. This section plots the compound profiles from four samples and the composite profile from the M47 well, indicate by the gas well symbol. The hydrocarbon compounds are plotted on the vertical scale and the mass with a scale of 0 to 600 Ng is plotted on the horizontal scale. For orientation, the vertical black lines indicate the 400 Ng level. The calculated probability for each sample is also noted on the charts. The first thing to note is the total disappearance of any indication of hydrocarbons across the first fault between samples 507 and 508, a distance of 250 meters. The second thing to note is the variation in strength of the C<sub>10</sub> (Decane) to C<sub>13</sub> (Tridecane) compounds in the lower portion of the charts. The strength of the signal implies variation in the concentration of condensate in the reservoir with the highest concentration indicate at the most downdip location – SAMPLE 502. This technique might be able to identify liquid concentrations in gas reservoirs.

## **CONCLUSIONS**

- 1. Certain currently available technologies can identify, measure and interpret microseepage anomalies resulting from reservoir hydrocarbons.**
- 2. Integration of the 3G's (geology, geophysics and geochemistry) can increase the knowledge available to the geoscientist for the ranking of prospects, identification of hydrocarbon phase and probably REDUCE RISK.**
- 3. Future innovation for our industry lies in the understanding of the 3M's (Migration, Macroseepage and Microseepage) of hydrocarbons.**



Presenter's notes: The Tweed Lake surface geochemical model has shown us that the updip fault complex could consist of three slides each containing hydrocarbon very similar to the pool, that there is a fault within the pool that could impact future production and that there is a variation in the concentration of condensate across the field implying potential sweet spots. With this presentation, I have tried to show what can be learned about a prospect with the integration of surface geochemistry, a direct hydrocarbon indicator, into the geological and geophysical interpretation.

# Surface Geochemical Imaging of the Tweed Lake Cambrian Field, Northwest Territories Canada

**When a distinguished...(geo)scientist states that something is POSSIBLE,  
he is almost certainly right.**

**When he states that something is IMPOSSIBLE, he is very probably  
wrong!**

- Adapted from Arthur C. Clark

