



January 31, 2024

Office of the Regulator of Oil and Gas Operations (OROGO)
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Email: OROGO@gov.nt.ca

Sent Via Email

Attention: Pauline de Jong, Executive Director, OROGO

**Re: Colville Lake Suspended Wells Abandonment - Geology Updates for Tweed Lake M-47 (WID1476),
Tweed Lake A-67 (WID1555) and Bele O-35 (WID1600) Wells (OA-2021-003-SUN)**

Dear Pauline:

In response to the Compliance Notification received December 7, 2023. Please accept the information Suncor Energy Inc. (Suncor) has acquired for review and consideration of a change in compliance determination.

Context

Suncor suspended wells, Tweed Lake M-47 (WID1476), Tweed Lake A-67 (WID1555) and Bele O-35 (WID1600) Wells (OA-2021-003-SUN) have been observed by OROGO to require remedial isolation due to an uncemented interval within non-saline zones.

Background

In previous communications with OROGO, Suncor has proposed to “leave the surface casing in the current state”. In March 2021, OROGO noted that there was additional information required to demonstrate that:

- the existing uncemented casing intervals protect and isolate the non-saline groundwater;
- the depth of saline groundwater occurs below the formation containing open casing; and
- that exposed non-saline groundwater zones are naturally interconnected.

Regulatory Status

On December 7, 2023, Suncor received a “Compliance Notification: Assessment of Suspended Wells – Suncor Energy Inc.” letter. Suncor notes that information acquired by operators for the purpose of addressing areas of non-compliance must be reported to OROGO and may change the compliance determination once reviewed.

Suncor Energy Inc. Suspended Well Compliance Assessment – December 7, 2023

WID	Well Name	Risk Level	Downhole Barriers Compliant (Y/N)	Zonal Abandonment Complete (Y/N)	Well Inspection (Y/N)	Gas Migration Testing (Y/N)	OA Approved (Y/N)	ACW Approved (Y/N)	Observations	Abandonment Operations Deadline
1476	Tweed Lake M-47	II	Yes	No	Yes ¹	Yes	Yes	Yes	<p>Downhole Barriers: Zonal abandonment of Mount Clark perforations (1222.5 mKB) in 2015. Bridge Plug placed at 1187.8 mKB with 8m of cement on top. Total Depth 1418 mKB</p> <p>Last Well Inspection: August 10, 2019</p> <p>Note: Uncemented interval between 64mKB and 420 mKB requires remedial isolation.</p>	March 31, 2025 ²
1555	Tweed Lake A-67	II	Yes	No	Yes ¹	Yes	Yes	Yes	<p>Downhole Barriers: Zonal abandonment of Upper and Lower Mount Clark perforations in 1986. Bridge Plug placed at 1,260 mKB with 9.3m of cement on top. Total Depth 1347 mKB</p> <p>Last Well Inspection: August 11, 2019</p> <p>Note: Uncemented interval between 61.5mKB and 420 mKB requires remedial isolation.</p>	March 31, 2025 ²
1600	Bele O-35	II	Yes	No	Yes ¹	Yes	Yes	Yes	<p>Downhole Barriers: Suspended cased wellbore with no perforations completed in 1986. Total Depth 1384 mKB</p> <p>Last Well Inspection: August 10, 2019</p> <p>Note: Uncemented interval between 64mKB and 420 mKB requires remedial isolation.</p>	March 31, 2025 ²

Action Required

- As per section 5D of the Guidelines, the well must be inspected every five years or prior to abandonment of the well, whichever comes first.
- On December 19, 2022, OROGO extended the deadline for abandoning this well to March 31, 2025.

Observations corrections noted:

- Spelling of Bele O-35;
- Uncemented intervals:
 - Tweed Lake M-47 interval is between 64mKB and 370mKB.
 - Bele O-35 interval is between 63mKB and 625mKB.

Purpose of Submission

Suncor recently completed a detailed 3rd party geological review of the historical and new information for suspended wells A-67, M-47 and O-35. The intent of this geological review was to advance our geological knowledge of the wells, better understand the subsurface and address the OROGO information request.

Based on the geological assessments completed in 2020-2021 and recently in 2023, Suncor is proposing consideration of an abandonment plan that could eliminate the need for remedial cement in the non-isolated casing while remaining compliant with the Guidelines. The information presented herein is intended to demonstrate that the requirements to isolate and protect wellbore non-saline groundwater zones as defined in Section 6B of the Guidelines is already achieved in the current surface casing open interval state.

Geological Review

In October 2023, Suncor retained Sedimentary Geology Consultants (SGC) to complete a study on the geology of the carbonate formations in the vicinity of the wells M-47, A-67 and O-35. The purpose of this study was to evaluate the nature and distribution of the fractured carbonate interval, and how it may impact well abandonment strategies. Suncor originally reviewed the subsurface geology of the three wells of interest, this information was used as a framework for the recent review. New information included literature and a cuttings review. The SCG memorandum is provided in Attachment 1.

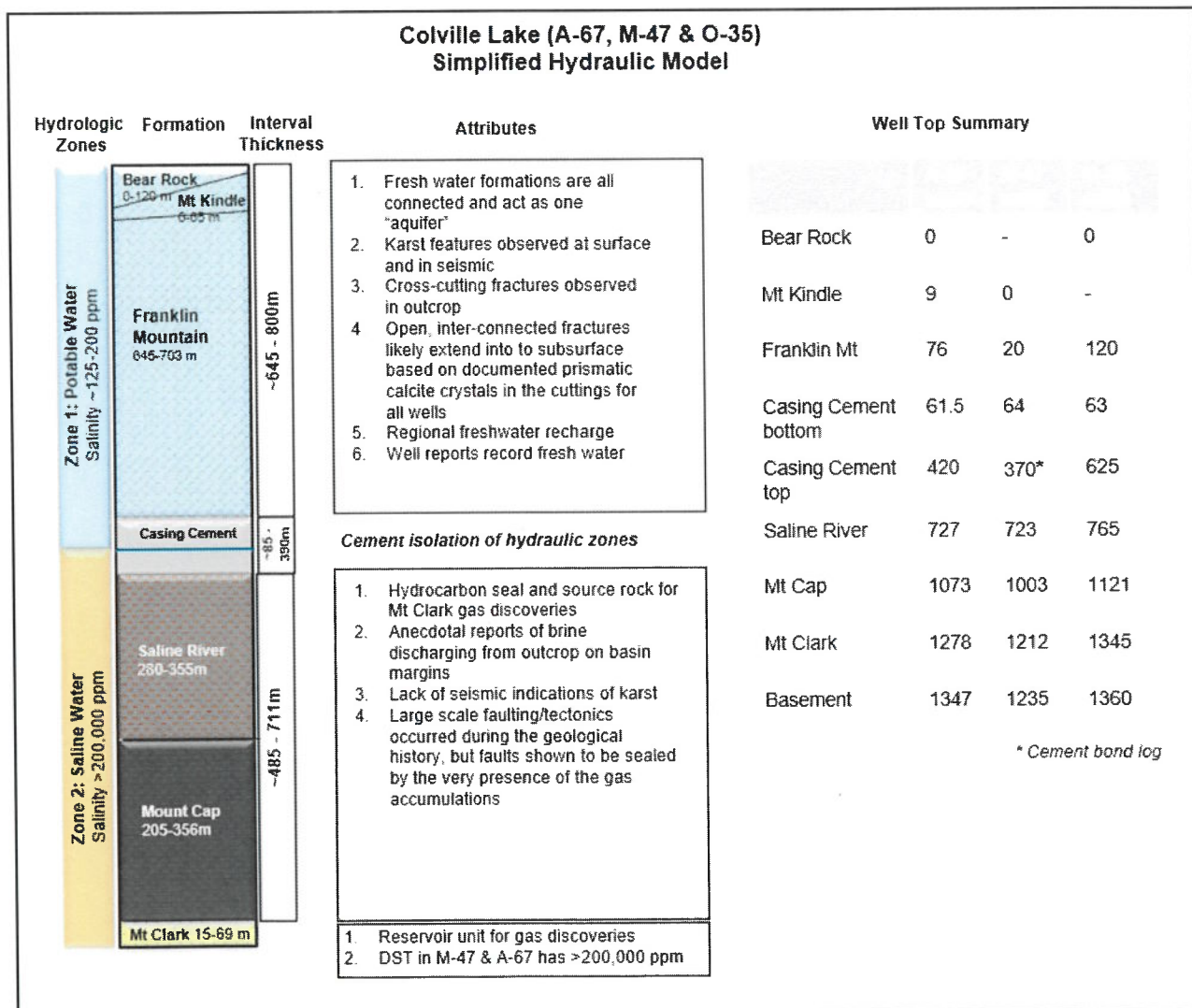
Based on the geology review completed, Suncor would like to recommend to OROGO that the wells can be safely abandoned without the use of remedial cement as the geological review supports:

- the existing uncemented casing intervals protect the non-saline groundwater;

- the depth of saline groundwater occurs below the formation containing open casing; and
- that exposed non-saline groundwater zones are naturally connected.

Based on the geology and geophysical reviews completed to date, Suncor believes there is strong evidence the freshwater-bearing section is kept separate from the saline water-bearing section within wellbores, there should be no cross contamination of the water reservoirs in the subsurface. The reviews also indicate that the potable water layers are in communication with each other making the need for remedial cement futile and low risk since the potable water layers above the open casing are isolated from any lower saline zones.

Simplified Hydraulic Model - Colville Lake Suspended Wells (Tweed Lake M-47, Tweed Lake A-67 and Bele O-35)



Summary

The information included within the attached technical memo demonstrates that the requirements to isolate and protect wellbore non-saline groundwater zones as defined in Section 6B of the Guidelines is already achieved in the current surface casing open interval state.

- The geological review of the Colville Lake area indicates that there is isolation between the upper freshwater groundwater supply formations and brine bearing units of the Saline River Formation and below.
- Water sample documentation in the wellbores is supported by the regional outcrop studies, stating that fresh and saline formations are isolated on a regional scale and through geological time.
- Natural fractures are interpreted to be connected through the entire Franklin Mountain Formation in the subsurface, and that all zones within are in natural communication with each other. The wellbore does not create a new pathway.

Closing

We trust that the response provided will satisfy your current requirements and provides suitable documentation for your records to consider updating the compliance determination to remove the requirement for remedial cement for the three suspended wells. If you have any further questions or concerns, please do not hesitate to contact the undersigned.

Thank you,

DocuSigned by:
Dara Schmidt
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Dara Schmidt
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DocuSigned by:
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ATTACHMENTS:

- 1) **SEDIMENTARY GEOLOGY CONSULTANTS MEMORANDUM**



ATTACHMENT 1

Colville Lake Suspended Wells Abandonment Geology Memorandum with Documentation Package

Well Name(s):

Tweed Lake M-47 (WID1475), Tweed Lake A-67 (WID1555), Bele O-35 (WID1600)

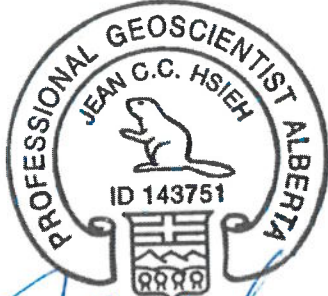
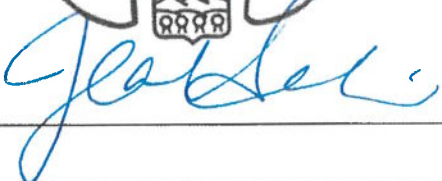
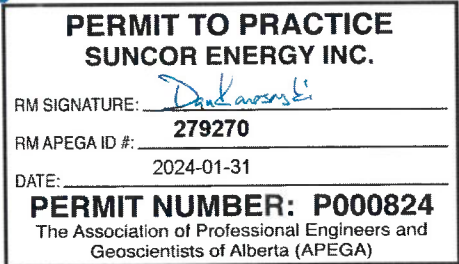
Prepared by: Jean C.C. Hsieh, P.Geo, Sedimentary Geology Consultants

Date: January 29, 2024



Professional Authentications:

The authors have made their best efforts in preparing this document according to existing Suncor policies and procedures, and industry practices. This document is based on the information available at the time when the work was carried out.

<p>Geologist</p> <p>Jean C.C. Hsieh, P.Geo. Carbonate Specialist, Sedimentary Geology Consultants</p>	 
<p>APEGA Responsible Member (Geology)</p> <p>Dan Karasinski, P.Geo. Sr Specialist Geoscience Advisor, Suncor</p>	

February 21, 2024:

NAPEG Responsible Member
(Geology)

Megan F. Boutin, P.Geo
Development Lead - Legacy Properties





Memorandum

Suncor Energy, Inc. (Suncor) requested a study from Sedimentary Geology Consultants on the geology of the carbonate formations (Mt Kindle and Franklin Mountain) in the vicinity of its wells (Tweed Lake M-47, Tweed Lake A-67, and Bele-O-35) near Colville Lake, NWT. The purpose of the study was to understand the nature and distribution of the fractured carbonate interval and how it may impact any well abandonment strategies. The study included a review of the subsurface geology summary from Suncor, a thorough and expanded literature search, a review of the original well files, and a study of the cuttings from the three key wells. This memorandum summarizes the results of the study.

Background and Regional Geology

The original review of the subsurface geology of the three wells of interest completed in 2020 and 2021 by Suncor was thorough. It provided a framework for the new understanding. The original study showed that the surface geological formations (Bear Rock, Mt Kindle, and Franklin Mountain) were composed of mainly dolomite with some beds of shale and limestone. There is also a significant amount of siliceous nodules contained within. These formations are also reported to be part of the aquifer in the region. Air photos and Google Earth show the region to be heavily karsted and it is likely the aquifer is recharged with fresh-water through the karsted terrain. The Suncor summary of outcrop geology was heavily reliant upon two major publications: *Hydrocarbon Pools of the Southeastern Great Slave Plain, Northwest Territories* by EP Janicki in 2003 and *A lithostratigraphic transect through the Cambro-Ordovician Franklin Mountain Formation in NTS 96D (Carcajou Canyon) and 96E (Norman Wells), Northwest Territories* by EC Turner in 2011. In order to better understand the regional geology, an updated and expanded literature search was performed. This resulted in additional studies to understand the geology.

In the Colville Lake area, the Phanerozoic sedimentary rocks are deposited upon Archean and Paleoproterozoic crystalline basement rocks of the Canadian shield during the breakup of the supercontinent Rodinia. As the shield broke apart, a basin formed allowing the deposition of sedimentary rocks. The Paleozoic strata were deposited in two major platform successions (Figure 1), the older Mackenzie-Peel platform of siliciclastics and carbonate (Cambrian through Silurian) and the younger Ellesmerian platform of mainly siliciclastics (Devonian to Carboniferous). These successions are overlain by the Mesozoic strata of the Cordilleran Foreland. Creation of the Mackenzie Mountains and Colville Hills (Figure 2) were associated with the development of the Canadian Cordillera during the late Cretaceous to Eocene times (Fallas et al., 2021). Some of the faults in the Colville Hills may have been reactivated Cambrian normal faults. Another good summary of the tectonic activity of the regions is found in Figure 3 from a report by Maclean et al., 2014.

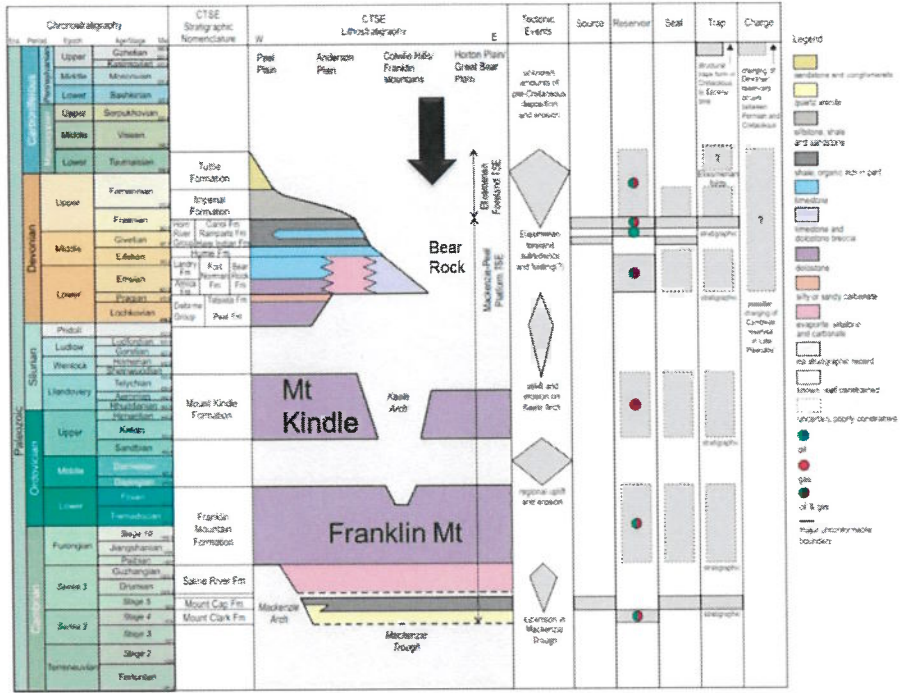
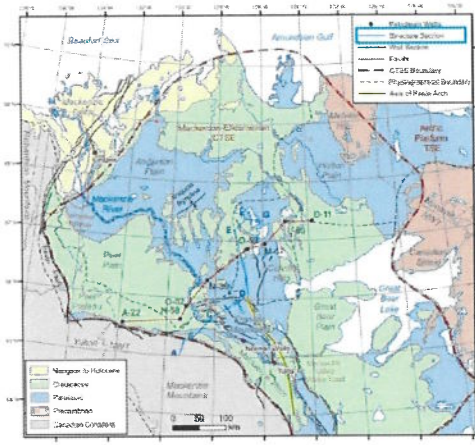


Figure 1. Stratigraphic relationship chart from Fallas et al., 2021.



Mackenzie–Peel Platform and Ellesmerian Foreland

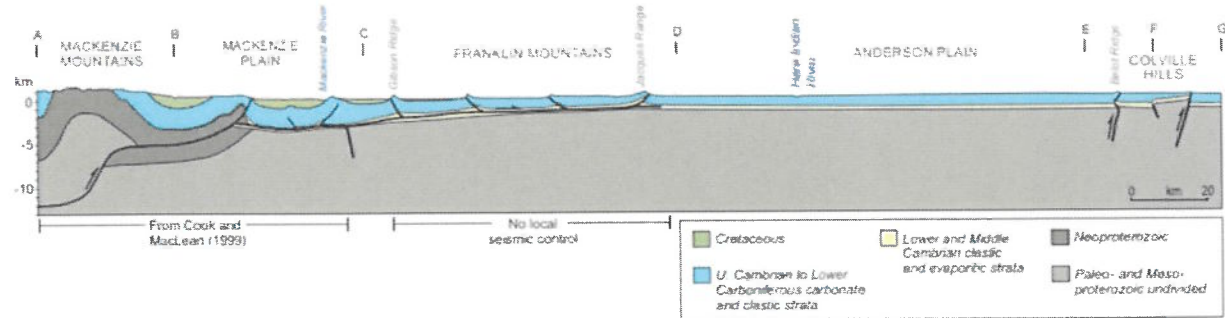


Figure 2. Location map and structural cross-section of the Mackenzie Mountains to Colville Hills from Fallas et al., 2021.

The Cambrian section is the hydrocarbon bearing interval in Suncor's Tweed Lake and Bele wells. Mt Clark Formation, rests on top of the Proterozoic. It represents the early basin fill during the transgression. It is a sandstone-rich interval with thin and discontinuous orthoquartzite and silicified siltstone. An example of the interval from Tweed Lake A-67 well is shown in Figure 4. As the basin deepened and expanded, the supply of coarse siliciclastic sediment declined. Mud and carbonate deposition started with occasional thin sands. This is the Mt Cap Formation which is interpreted to be deposition into a mostly low-energy, normal salinity, marine environment. The shales within this formation are the primary hydrocarbon source material for Cambrian sand reservoirs.

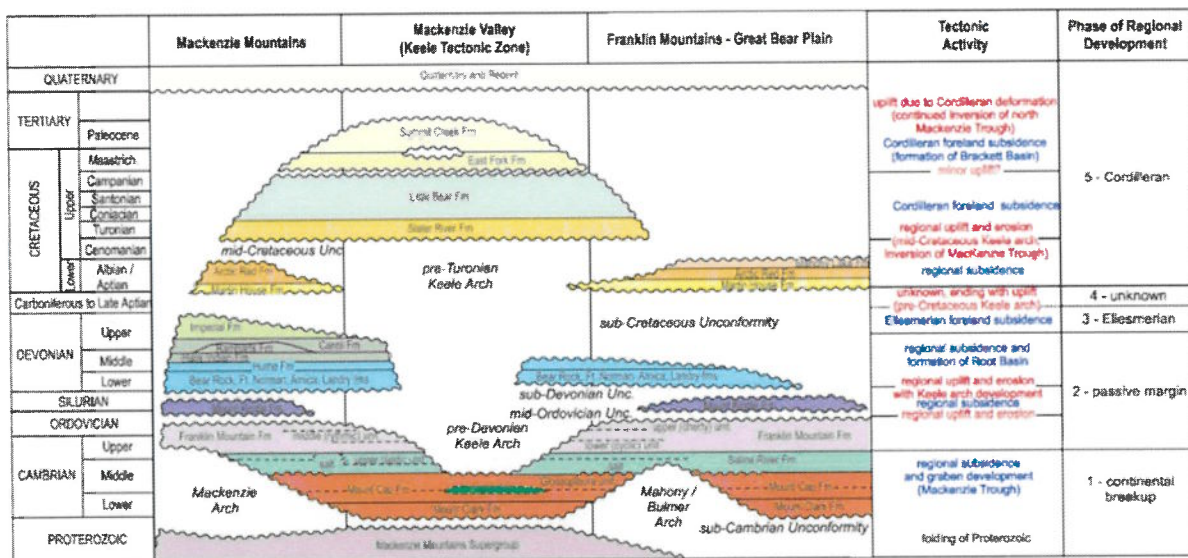


Figure 3. Stratigraphic column from Maclean et al., 2014 showing the major tectonic elements.

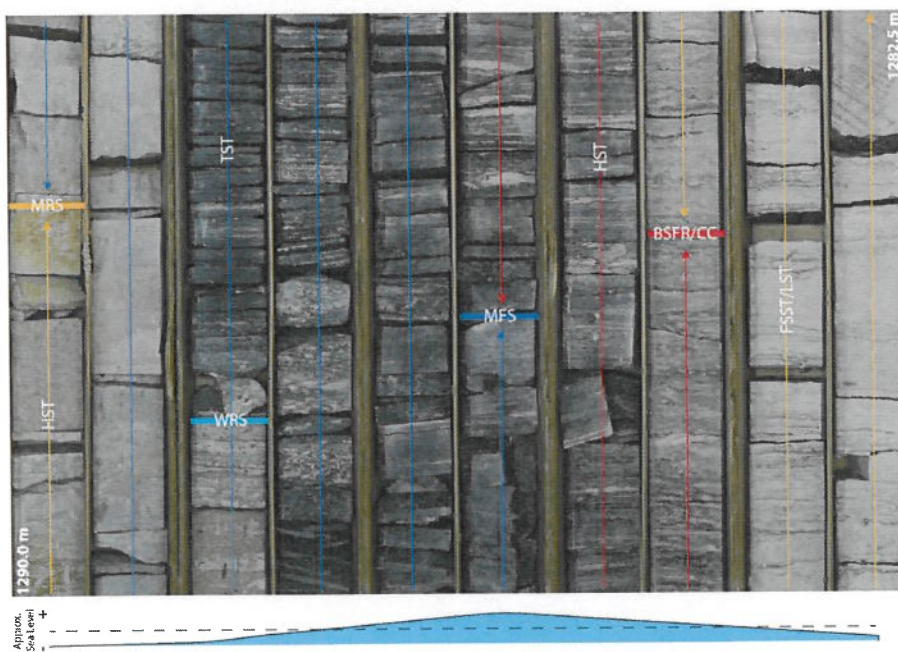


Figure 4. Sequence stratigraphic surfaces from Sequence 2 of the Mt Clark in Tweed Lake A-67 (From Sommers et al., 2020).

The uppermost Cambrian Formation is the Saline River Formation. This rests atop the Mt Cap and sometimes the Proterozoic. This boundary is a strong seismic reflection and is called Shale M. Saline River is considered the hydrocarbon seal for the Mt. Clark sandstones. It is usually divided into an upper and lower member. The upper "shale" member consists of red, pink, and green shale, dolomitic shale, gypsiferous and grey shale interbedded with light colored anhydrite and some anhydritic or gypsiferous dolomite. The lower "evaporite" member consists of white and orange-red halite and anhydrite with some argillaceous and dolomite thin beds depending on the location within the basin. During the deposition of the Saline River Formation in the Cambrian, the overall basin is restricted, allowing for a hypersaline environment and brines as pore fluid. At present, there have been reports (Hamilton, 1995) of brine discharging from the formation when it outcrops at surface. Most of the outcrops of the Saline River Basin occur near the edges of the basin where it has been uplifted as shown in Figure 5 in Hornaday River Canyon, along the coast of the Beaufort Sea. Here, there is little halite or anhydrite, but numerous salt casts also suggest the waters were more saturated with ions than seawater.

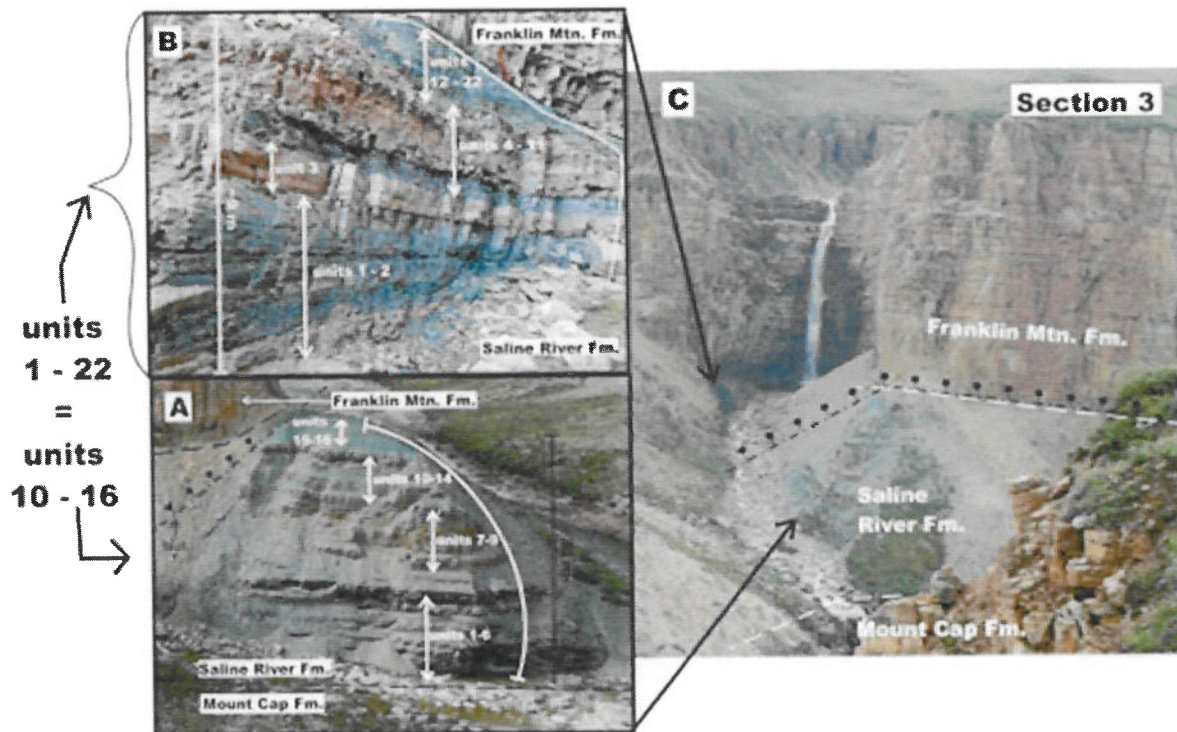


Figure 5. Saline River Formation in Hornaday River Canyon (from Bouchard and Turner, 2017).

Above the Saline River Formation is the Franklin Mountain Formation which is Late Cambrian to Early Ordovician in age. This consists of a series of dolomites and shales with some limestone and sandstone. Turner (2011) breaks up the Franklin Mountain into 3 units. Unit 1 consists of generally dusky-grey, planar bedded dolostones with sparse chert nodules, columnar stromatolites, and some orange-weathering argillaceous interlayers. Unit 2 consists of brownish, ooid dolopackstones with thin quartz silt interlayers and columnar stromatolites, and green argillaceous layers near the top. Unit 3 contains a succession of

oolitic, intraclastic and mechanically laminated dolomites with thin layers of bright green clay near the top, most likely due to volcanic ash.

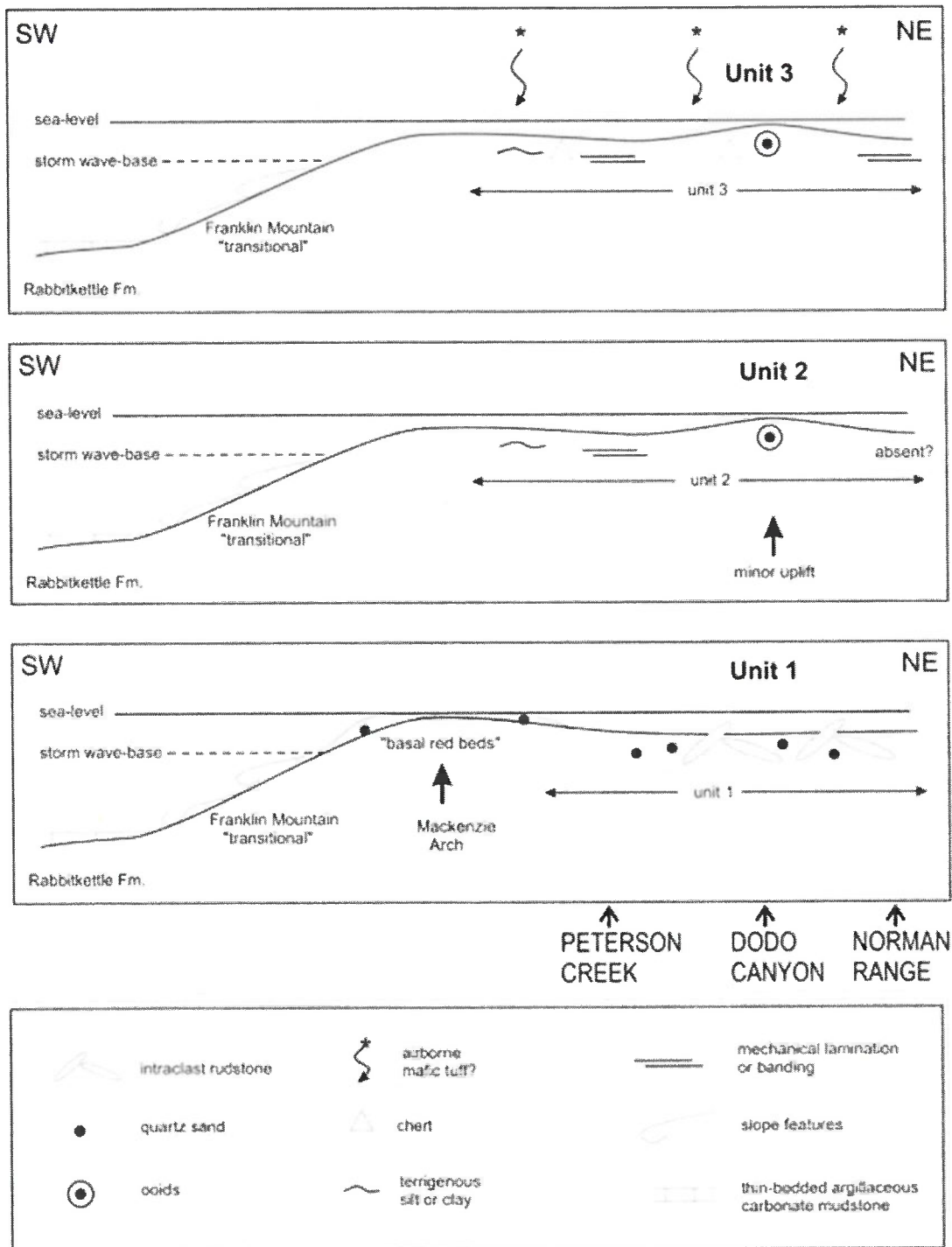


Figure 6. Depositional Models for the 3 units within the Franklin Mountain Formation. (Turner, 2011)

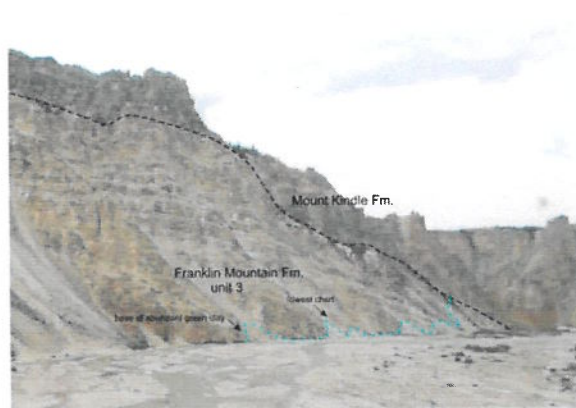
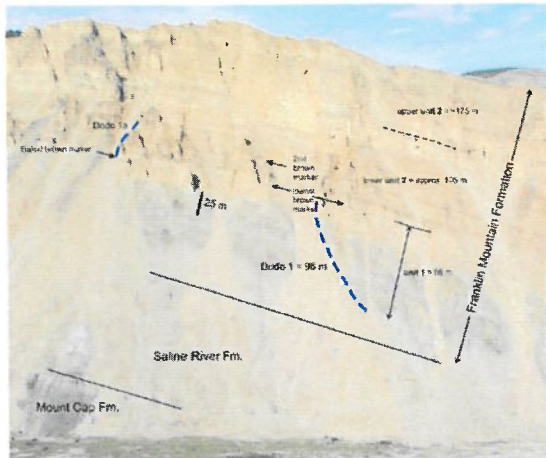


Figure 7. Outcrop sections showing the Mt Kindle, Franklin Mountain, and Saline River Formations in Dodo Canyon (Turner, 2011). Note the large fractures in the Franklin Mountain and Mt Kindle Formations.

Figure 6 shows the depositional environment interpretation for the three units. Unit 1 represents the flooding of the broad, flat area that was previously restricted. It is still low energy, relatively speaking and has normal marine conditions. During the deposition of Unit 2, the area became slightly differentiated with a restricted inner ramp, an outboard subtidal lagoonal area, and a central area of ooid shoals and inter-shoal muds. Higher order cycles are recorded in this interval. During deposition of Unit 3, further paleoenvironmental differentiation persisted with salinity-stressing in lagoonal areas and influxes of the bright green clay representing mafic tuffs.

Unconformably on top of the Franklin Mountain Formation is the Upper Ordovician to Silurian Mt Kindle Formation. This is a fossiliferous, medium to dark brownish grey, finely to medium crystalline thin to thick bedded dolomite that contains abundant chert (Norford and Macqueen, 1975). Silicified fossils (corals, brachiopods, and cephalopods), chert nodules and beds are common and vuggy porosity is well developed. Where it outcrops at the surface, karst pavements are common. Additionally, large scale fractures cut through both the Franklin Mountain and Mt Kindle Formations (Figure 7).

Finally, the youngest formation that was encountered in the wells is the Bear Rock Formation. This is a Middle Devonian unit which is equivalent to the Fort Norman Formation in the subsurface. It consists of an upper brecciated member and a lower evaporitic member. At the surface the evaporitic member is often completely dissolved to form surface karst. The breccia can form “spines” between the dissolved evaporite.

Karst and Fractures

As mentioned previously, the surface near the Colville Lake area is heavily karsted. The karst represents mainly the Bear Rock Formation as well as Mt Kindle Formation in places. Karst is a type of landscape where the dissolving of the bedrock has created sinkholes, sinking streams, caves, springs, and other characteristic features. Karst is associated with soluble rock types such as limestone, dolostone, marble and gypsum/anhydrite/halite.

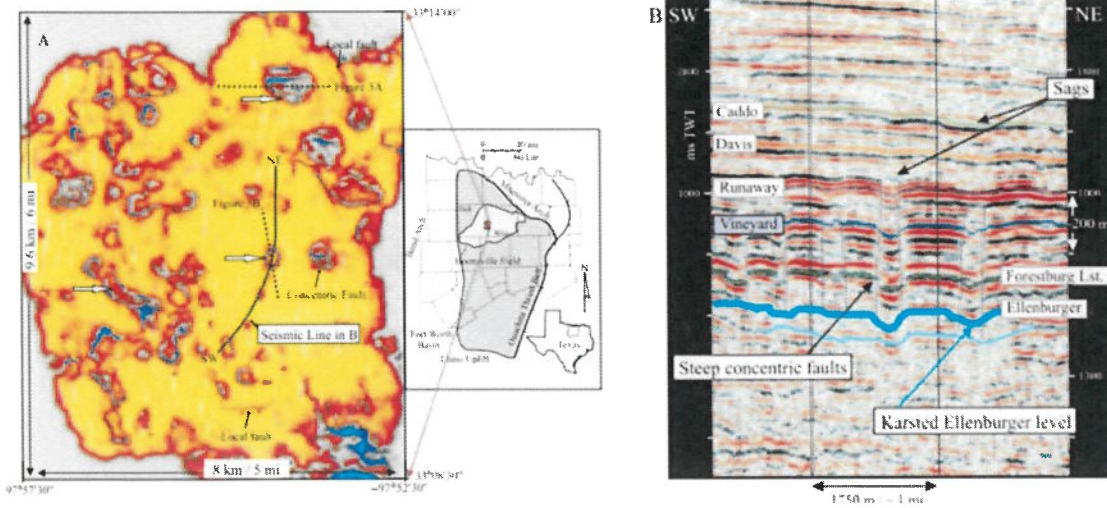


Figure 8. (A) Structurally smoothed attribute extraction from the Pennsylvanian middle Atokan Vineyard horizon. White arrows point out some of the "sinkhole" features. (B) Composite seismic section across several features at a depth of 760-1060 m (McDonnell et al., 2007).

In ancient rocks, any caves and other voids are usually buried by the "next sequence" of sediment. Thus, these voids generally collapse and leave breccias in their wake (Bellian, 2009). Some of these breccias and collapse features may be imaged on seismic, if they are large enough (>50 m). An example of subsurface karst imaged in seismic is shown in Figure 8. The images are from a study by McDonnell et al., 2007. The sinkhole features are clearly seen on the horizon slice and in a seismic section down at a depth of 760-1060 m. If we see similar features in the seismic data nearby the wells, then it is possible that the surface karsting reaches similar depths.

Figures 9 and 10 show the seismic sections through the 3 wells of interest. There are no obvious features that would indicate karst in below "surface" layers. There are large-scale faults in the area that compartmentalize the hydrocarbon reservoir, but these faults are sealing as the three wells found gas still within the reservoir. If the faults were open and flowing, the gas would have escaped since the Cambrian time. Thus, the hydrocarbon bearing system (Pre-Cambrian up to Saline River, represented by the Shale Marker (Shale M)) is most likely a closed system with no connection to the overlying interval.

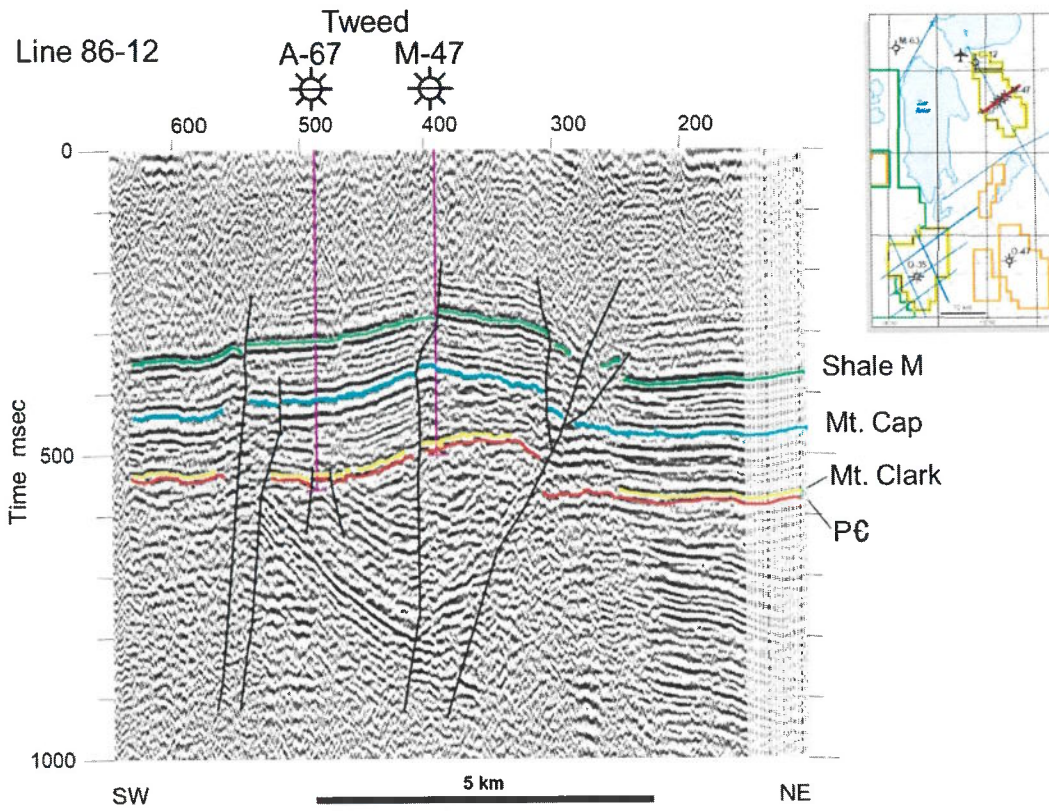


Figure 9. Seismic section through Tweed Lake A-67 and M-47. No obvious karsting features are present, as seen in Figure 8.

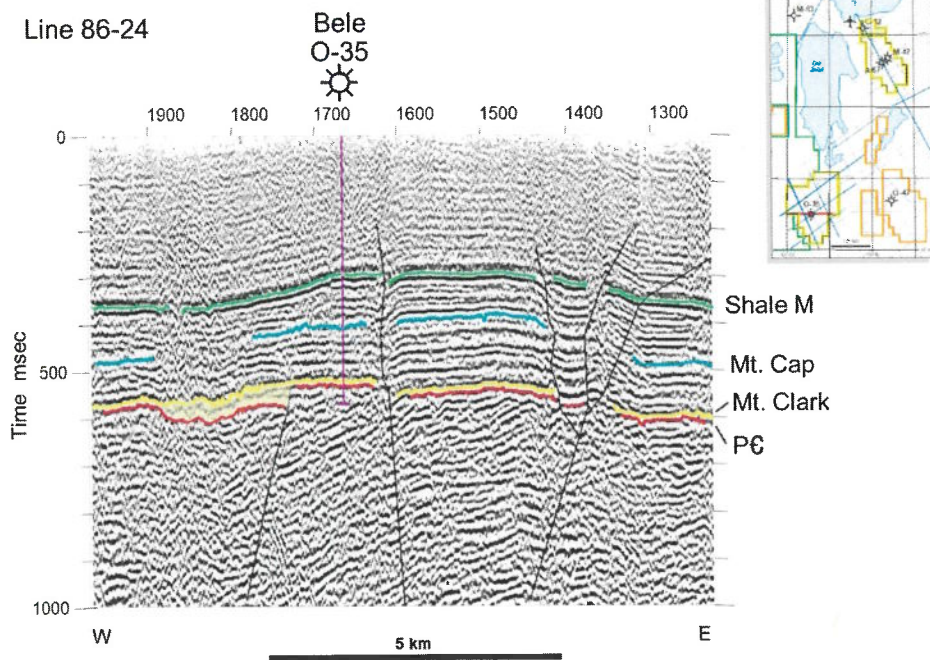


Figure 10. Seismic section through Bele O-35. No obvious karsting features are present, as seen in Figure 8.

As for the sections above the Cambrian hydrocarbon-bearing intervals and the Saline River sealing unit, i.e., the Franklin Mountain, Mt Kindle and Bear Rock Formation where present, it is highly likely that this interval is connected and part of the fresh-water aquifer system. As mentioned previously, Turner (2011) found large fractures through this Ordovician and Silurian section.

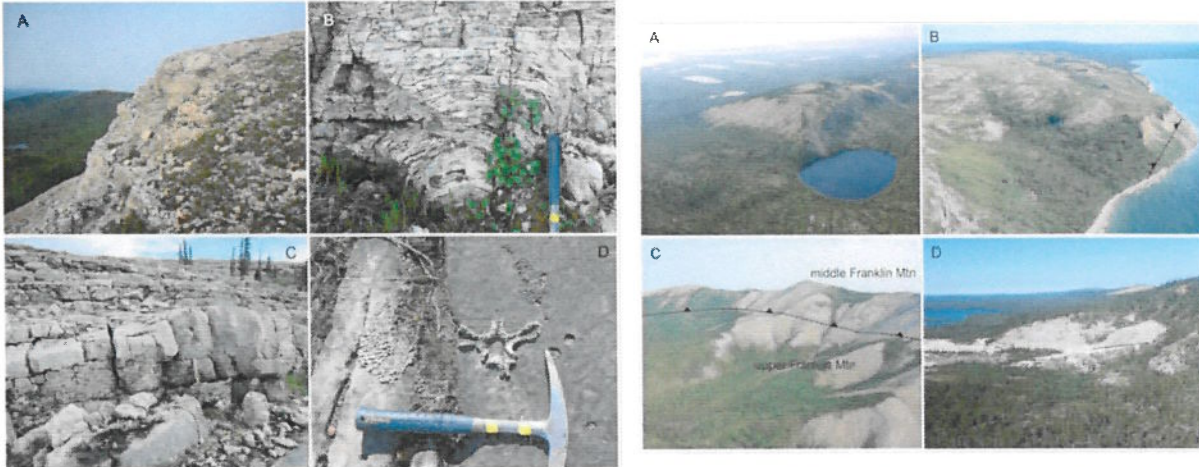


Figure 11. Outcrop images of Franklin Mountain and Mt Kindle Formations that are heavily fractured. Fallas et al. (2015) GEM 2 Mackenzie Project - Colville Hills bedrock mapping, stratigraphy, and related studies. Geological Survey of Canada Open File 7963.

In 2015, the Geological Survey of Canada had a project that included bedrock remapping of the Colville Lake area. The outcrops had heavy fracturing in Franklin Mountain and Mt Kindle Formations (Figure 11). The key to interconnected flow in the shallow subsurface, however, is keeping these fractures open under burial conditions. Fractures can be open due to present day stress conditions, such as opening mode fracture sets, or they can be open due to diagenetic conditions, e.g., partially cemented/sealed.

Laubach (2003) showed that opening-mode fractures can seal over time due to diagenesis. However, when porosity is preserved, i.e., diagenesis only partially seals the fracture, fluid can continue to flow. His study also showed that euhedral, prismatic cement crystals, whether they are quartz or calcite, are more likely to keep the fractures open. When the crystals grow, they start with a thick base along the fracture wall. As layers of the cement mineral grow, they become thinner towards the middle of the open space. If the fracture gets filled in completely, the crystals are no longer euhedral in shape, but are anhedral to subhedral. Thus, euhedral cement crystals in cuttings samples could be indicators of open fractures in the subsurface.

Cuttings Study

An examination of the cuttings was done over the interval of interest (surface down through the Saline River Formation). A brief description of the cuttings was provided for each sample as well as looking for evidence for (1) subsurface karsting as represented by vuggy porosity and dissolution features; (2) hydrothermal processes that could complicate flow as represented by saddle dolomite and other high temperature minerals; (3) fractures as represented by euhedral calcite or quartz crystals; (4) fresh water diagenesis which could impede flow as represented by authigenic clays lining carbonate pores.

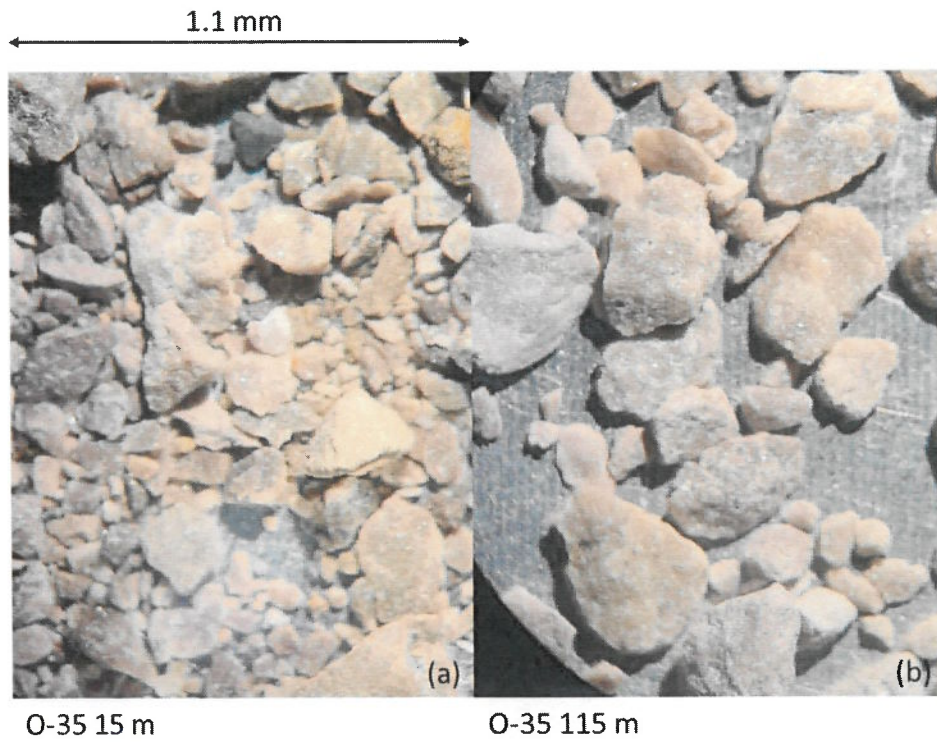


Figure 12. Cuttings samples from the Bear Rock Formation in well Bele O-35.

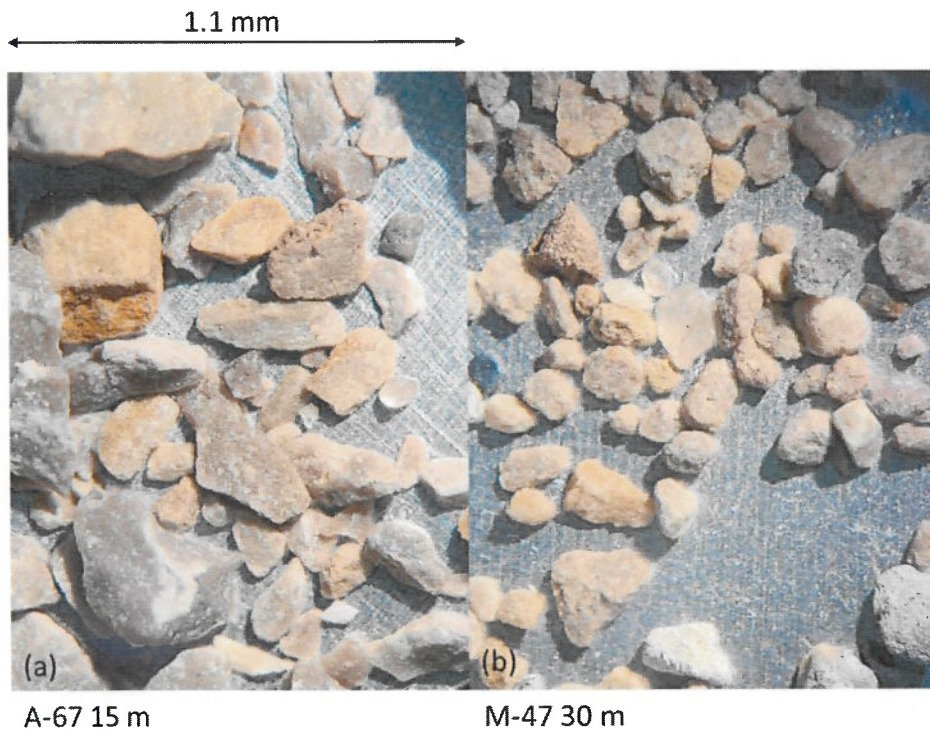


Figure 13. Cuttings samples from the Mt Kindle Formation in Tweed Lake A-67 and M-47 wells. Note the clear calcite crystals in the middle of (b).

The Bear Rock Formation was encountered only in the Bele O-35 well. These samples are composed of grey, medium crystalline dolomite which has some intercrystalline porosity (Figure 12). The cuttings from Mt Kindle Formation are honey-brown to grey in colour and are composed of fine to medium-crystalline dolomite with some evidence of vuggy porosity (Figure 13). There are also rare prismatic calcite crystals which are suggestive of fractures (Figure 13b).

Franklin Mountain Formation cuttings have more variation, most likely because the formation is thicker and there are more samples. However, they can be grouped into two main categories. The first group is composed of grey, medium crystalline dolomite with very little intercrystalline porosity (Figure 14). Depending on the stratigraphic position of the sample, there can be rare fragments of shale (green or grey). The second group is composed of grey to tan, fine crystalline dolomite with no intercrystalline porosity (Figure 15). These cuttings are also much smaller in size than the first group. There are often fragments of shale (grey mostly) in the samples. The variation in dolomite crystallinity size is likely to indicate variations in the original depositional facies, i.e., the grain vs mud content of the limestone. With a more detailed examination and study of the variability, a stratigraphic pattern related to cyclicity could be inferred.

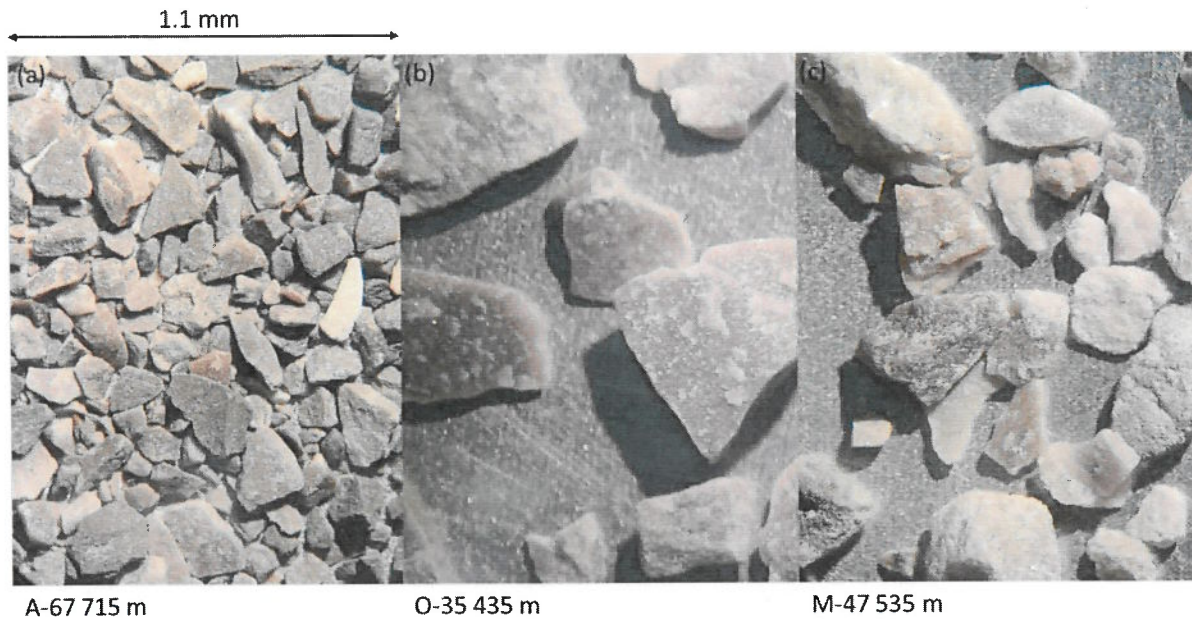


Figure 14. Cuttings samples from the Franklin Mountain Formation. These samples represent the first group of cuttings.

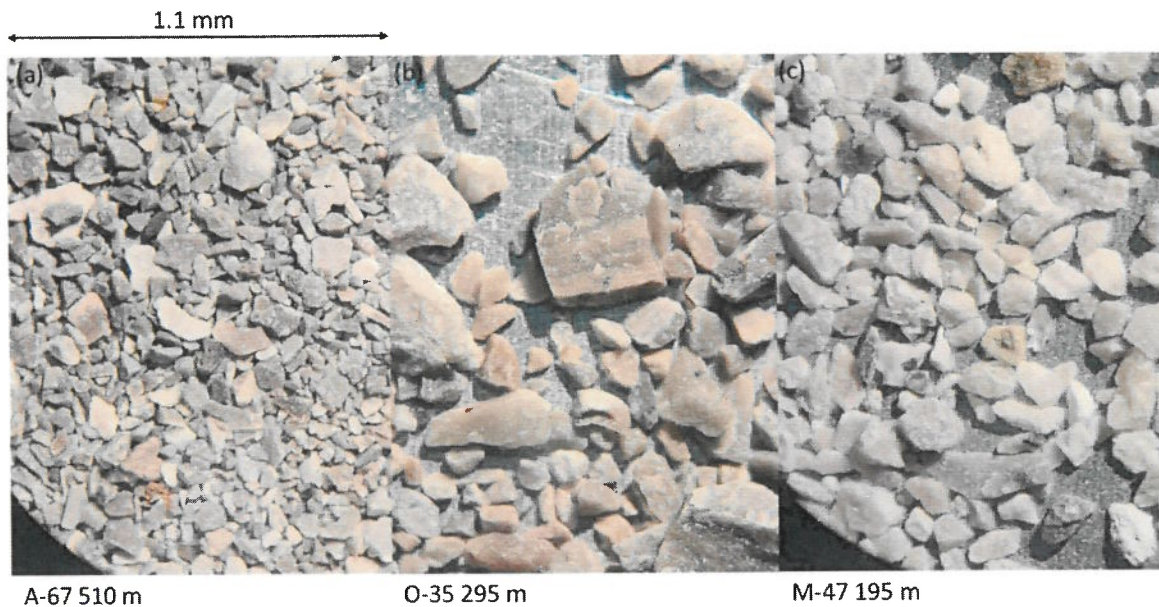


Figure 15. Cuttings samples from the Franklin Mountain Formation. These samples represent the second group of cuttings.

One common feature found while examining the cuttings samples is the presence of prismatic calcite. We see them in almost every formation and well (Figure 16). These crystals can be found individually or attached to the dolomite host rock. They can be very tiny, much less than 1 mm (Figure 16a) or several mm's in length. The presence of these crystals strongly suggests that there are fractures in the subsurface and that they are very likely to be partially open. Additionally, when the occurrence of prismatic calcite is compared with the occurrence of fractures as predicted by the petrophysical analysis and the intervals of lost circulation or water inflow, the concurrence is very good (Figure 17). This match gives confidence to the interpretation of fractures in the subsurface.

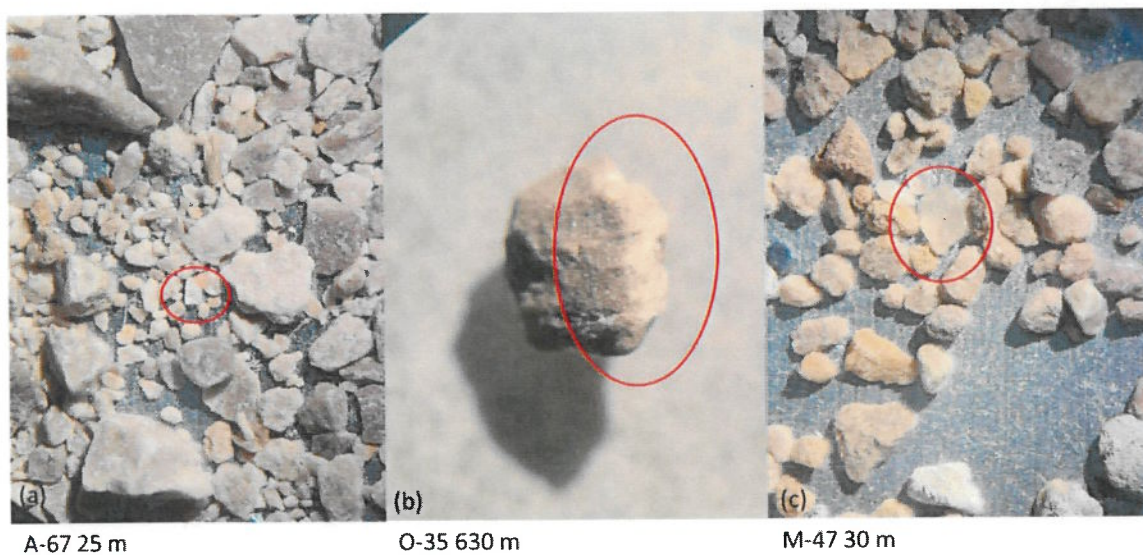


Figure 16. Prismatic calcite found in cuttings. (a) From Mt Kindle Formation (b) from Franklin Mountain Formation (c) from Mt Kindle Formation.

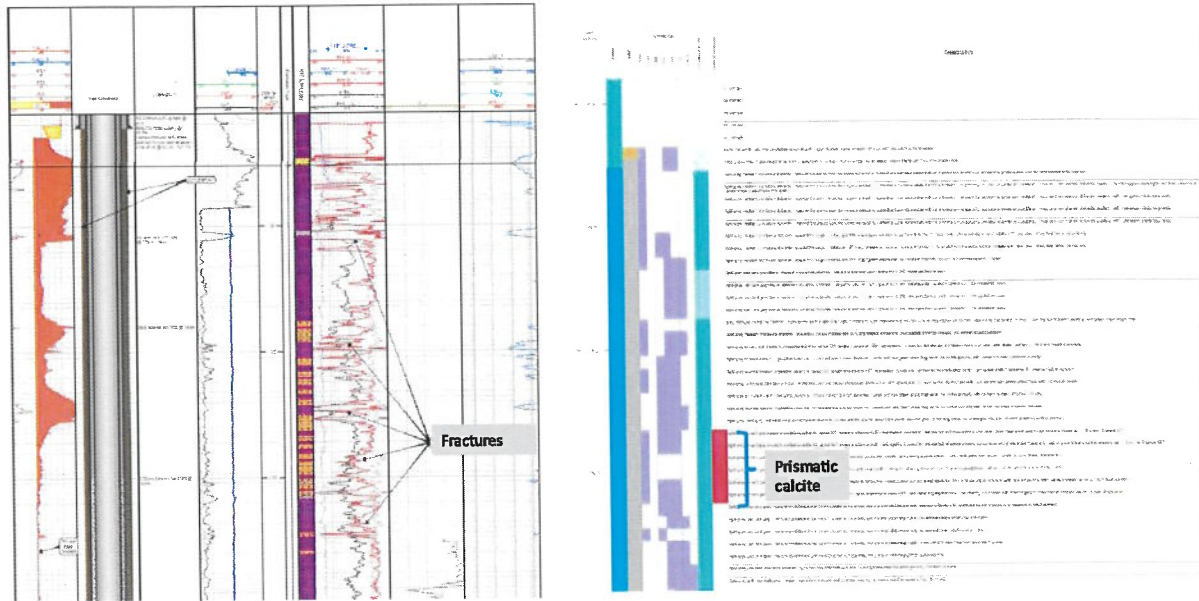


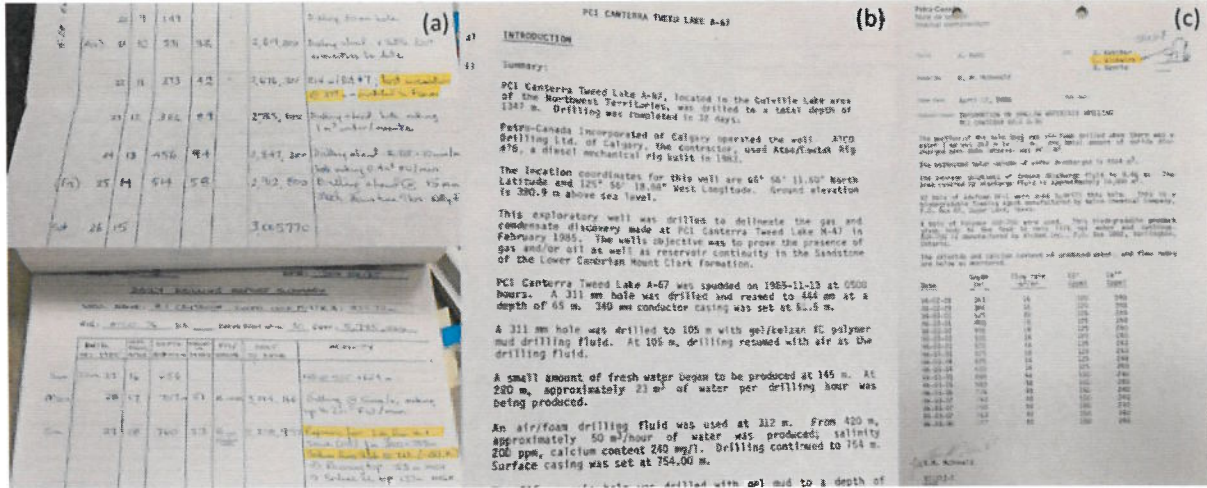
Figure 17. Petrophysical display on the left compared with the cuttings display on the right for Colville Lake A-67. Fractures are marked by black arrows on the petrophysical display while the interval of prismatic calcite is marked in the red bar.


The absence of abundant vuggy porosity or other dissolution products except just below the surface at Tweed Lake A-67 suggests that there is very little subsurface karsting. This was also supported by the seismic sections (Figures 9 and 10). No evidence of hydrothermal dolomite was found which is consistent with the interpretation that dolomitization occurred shortly after deposition (Turner, 2011). Finally, no explicit evidence of freshwater weathering was found. However, clay linings are difficult to preserve in cuttings after they have been washed.

Review of Original Well Files

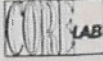
The original well files are all paper files. They were reviewed in order to find any information about the water that flowed into the wellbore and to find any information about pressures in the subsurface. Figure 18 shows the original documents from the well files that indicated that fresh water was flowing into the wellbore. No mention of water chemistry or salinity was found for the Tweed Lake M-47 well, other than the comment that fresh water (FW) was flowing into the wellbore. In the daily report summary of the Tweed Lake A-67 well, a salinity of 200 ppm and calcium content of 240 mg/L was mentioned, but no water chemistry report was found. Fresh-water contains less than 1000 mg/L total dissolved solids. For Bele O-35, a summary of water chemistry was provided (Figure 18c). In all cases, the salinity or calcium content was in the range of fresh water in the units above the Saline River Formation.

Below the Franklin Mountain Formation, no water flowed into the wellbore. Drill stem tests (DST) in the Mt Clark Formation in Bele O-35 showed that there was no water recovered, just condensate and drilling mud. However, in Tweed Lake M-47, during the DST 4 in the Mt Clark Formation, some water was recovered. The DST summary report mentions that this is likely to be formation water because the salinity was 240,000 ppm (Figure 19). Drill stem tests in Tweed Lake A-67 also recovered some water, which was also likely to be formation water as the salinity was in the order of 168,000+ Chloride (mg/L) (Figure 20).





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DST Chamber #302
CONTAINER IDENTIFY

66° 56' 11.60" NL
125° 56' 18.88" WL
LOCATION

Northwest Territories
FIELD OR AREA

DST #1
TEST TYPE & NO.

DST Chamber #302

70380-86-263
LABORATORY NUMBER

Petro-Canada Inc.
OPERATOR

PCI Canterra Tweed Lake A-67
WELL OR SAMPLE LOCATION NAME

Basal Sand Mt Clark
POOL OR ZONE

Lynes United Services
SAMPLER

TOOL: 250 ml Muddy Water, 25 ml Condensate
TEST RECOVERY

1290 - 1301
TEST INTERVALS OR PERFS

1985 12 17
DATE SAMPLED (Y/M/D)

4 of 8
PAGE

397.10 399.90
ARRECY (D) (D) ELEV

POINT OF SAMPLE
PUMPING FLOWING GAS LIFT SWAB

WATER m³/d OIL m³/d GAS m³/d

SEPARATOR RESERVOIR CONTAINER WHEN SAMPLED CONTAINER WHEN RECEIVED SEPARATOR

1986 02 04 1986 02 05
DATE RECEIVED (Y/M/D) DATE ANALYSED (Y/M/D)


LS
ANALYST

MUD FILTRATE ANALYSIS


Resistivity (Ohm-meters at 25°C) = 0.040

Chloride (mg/litre) = 169500

(a)



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DST Chamber #191
CONTAINER IDENTIFY

66° 56' 11.60" NL
125° 56' 18.88" WL
LOCATION

Northwest Territories
FIELD OR AREA

DST #2
TEST TYPE & NO.

DST Chamber #191

70380-86-263
LABORATORY NUMBER

Petro-Canada Inc.
OPERATOR

PCI Canterra Tweed Lake A-67
WELL OR SAMPLE LOCATION NAME

Mt Clark
POOL OR ZONE

Lynes United Services
SAMPLER

TOOL: 1500 ml Muddy Water
TEST RECOVERY

1278 - 1286
TEST INTERVALS OR PERFS

1985 12 20
DATE SAMPLED (Y/M/D)

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PAGE

397.10 399.90
ARRECY (D) (D) ELEV

POINT OF SAMPLE
PUMPING FLOWING GAS LIFT SWAB

WATER m³/d OIL m³/d GAS m³/d

SEPARATOR RESERVOIR CONTAINER WHEN SAMPLED CONTAINER WHEN RECEIVED SEPARATOR

1986 02 04 1986 02 05
DATE RECEIVED (Y/M/D) DATE ANALYSED (Y/M/D)

LS
ANALYST

MUD FILTRATE ANALYSIS

Resistivity (Ohm-meters at 25°C) = 0.040

Chloride (mg/litre) = 168047

(b)

Figure 20. Drill Stem Test water analysis for Tweed Lake A-67.



Summary

The regional geology and surface photos from Google Earth suggest that there is karst and fresh water in the surface formations (Bear Rock and Mt Kindle in places). Seismic imaging suggests that large scale karsting does not occur in these formations in the subsurface, at least not at seismic resolution of about 50 m and also does not occur in the section below (Franklin Mountain, Saline River, Mt Clark, and Mt Cap). Review of the daily drilling reports show that water flowed into the wellbore within the Franklin Mountain Formation. This water was reported as “fresh” in the daily reports with some salinity measurements to support that.

Outcrop geology shows many fractures in the Mt Kindle and Franklin Mountain Formations, some of which are quite long. Petrophysical analyses suggest that there are many fractures in the subsurface Mt Kindle and Franklin Mountain Formations. Cuttings analyses finds frequent occurrences of prismatic calcite crystals also suggesting that these formations are fractured and very likely partially open. Thus, it is highly likely that fresh water flows freely from the surface through to the Franklin Mountain Formation and flows freely within this formation.

The section below the Franklin Mountain Formation but above the Precambrian basement includes the Saline River, Mt Cap and Mt Clark Formations. Regional geology reports suggest that the formation water within the Saline River is hypersaline. There are reports of brines flowing out of Saline River outcrops (Hamilton, 1995). Most of the outcrops of the Saline River Basin occur near the edges of the basin where it has been uplifted, along the coast of the Beaufort Sea. Drill stem tests within the Mt Clark Formation show that any water that is present is highly likely to be saline based on the measured salinity values of greater than 150,000 ppm. Thus, it is fair to say that this lower section is saline does not have any freshwater present within it.

There is no evidence that the saline waters have ever mixed with the overlying fresh water through geological time. The Mt Clark sandstones produce natural gas in the present. Despite the large faults that are imaged in the seismic data (Figures 9 and 10), these hydrocarbon-bearing units have not leaked, not even during the tectonic activity during the Cordilleran orogeny, around 60 million years ago when the Colville Hills and Mackenzie Mountains were uplifted. The faults are sealing, and the Saline River Formation acts like a regional seal throughout the area in the subsurface.

Therefore, within the wellbore if the freshwater-bearing section is isolated from the saline water-bearing section, there should be no cross contamination of the water reservoirs in the subsurface.

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