An area-based chemistry assessment of a shallow hydrocarbon-bearing formation in NW AB

Phil Richards
PR Enviroforensics

Remtech 2021
October 14, 2021

PR enviro forensics

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Fun with chemistry

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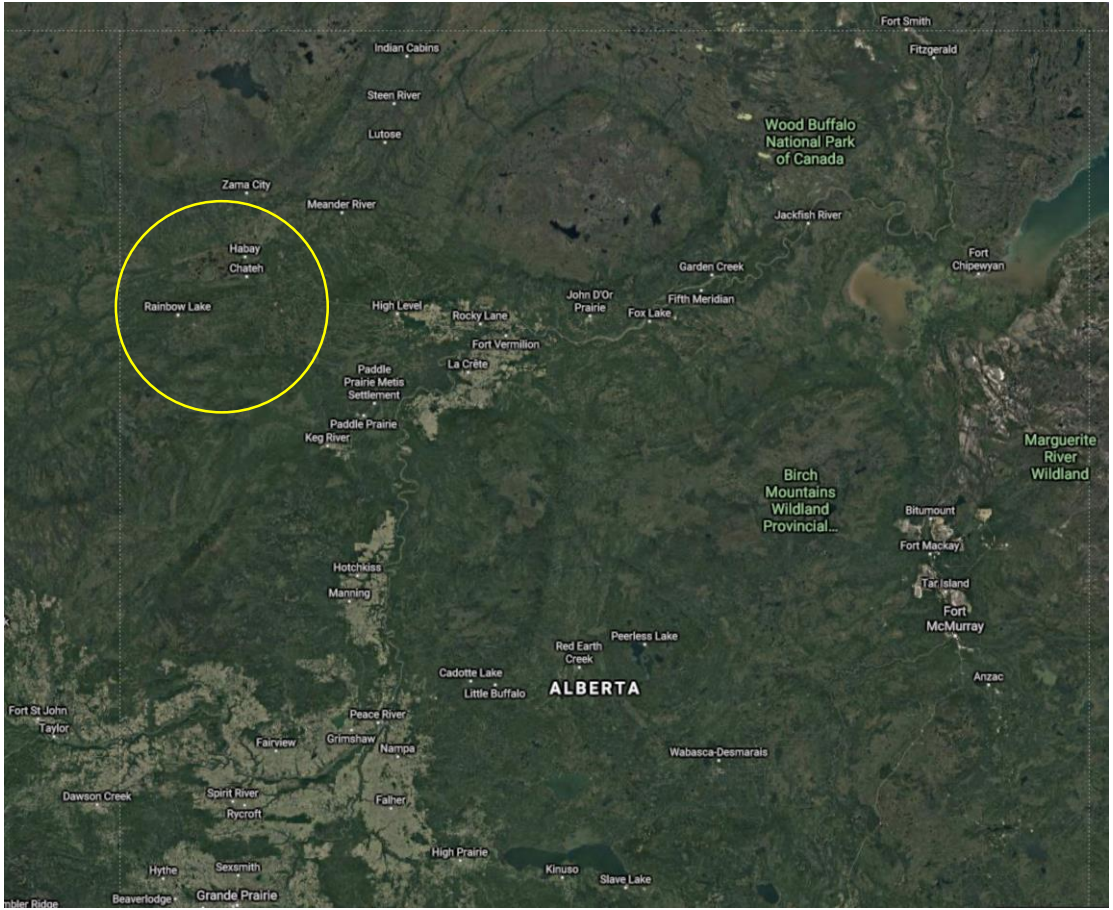
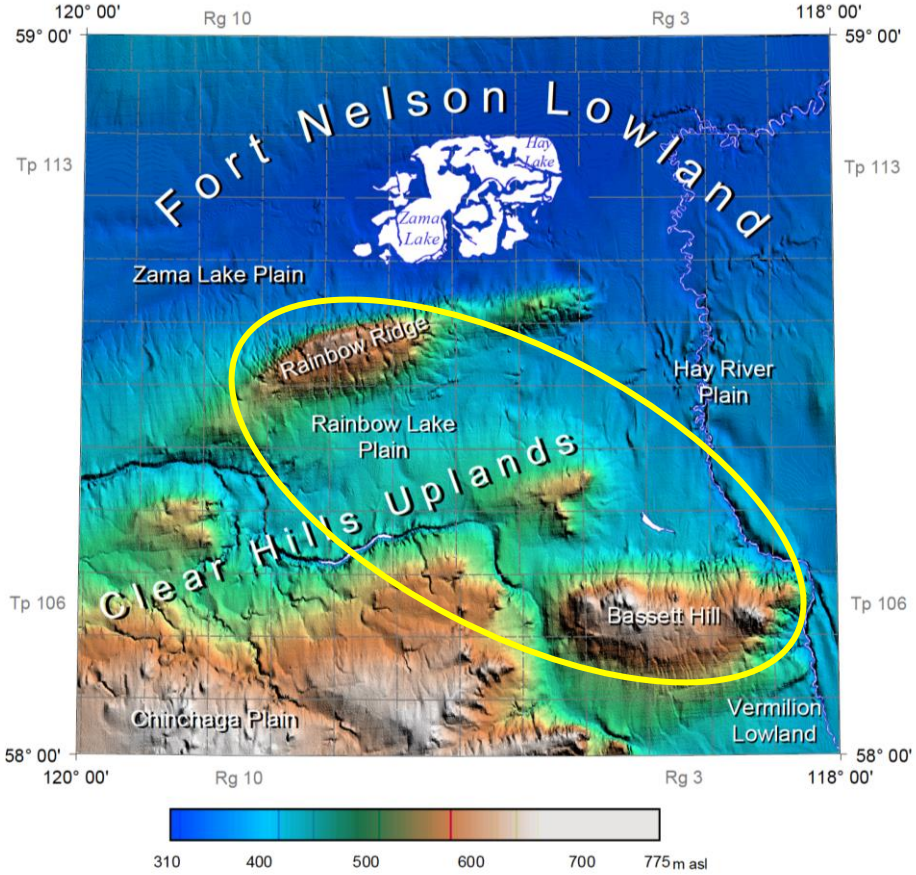

Fort Smith
Indian Cabins
Fitzgerald
Steen River
Wood Buffalo National Park of Canada
Lutose
Zama City
Meander River
Jackfish River
Habay
Chateh
Garden Creek
Fort Chipewyan
Rainbow Lake
High Level
John D'Or Prairie
Fifth Meridian
Rocky Lane
Fox Lake
Fort Vermilion
La Crête
Paddle Prairie Metis Settlement
Paddle Prairie
Keg River
Marguerite River Wildland
Birch Mountains Wildland Provincial...
Bitumount
Fort Mackay
Hotchkiss
Manning
Tar Island
Fort McMurray
Peerless Lake
Red Earth Creek
Cadotte Lake
Little Buffalo
ALBERTA
Anzac
Fort St John
Taylor
Peace River
Fairview
Grimshaw
Nampa
Wabasca-Desmarais
Dawson Creek
Spirit River
Rycroft
Falher
High Prairie
Hythe
Sexsmith
Kinuso
Slave Lake
Beaverlodge
Grande Prairie



Bedrock topography of Zama Lake Area, AGS, 2005.

Sites generally in upland areas south of Zama Lake.

- Rainbow Ridge
- Rainbow Lake Plain
- Bassett Hill

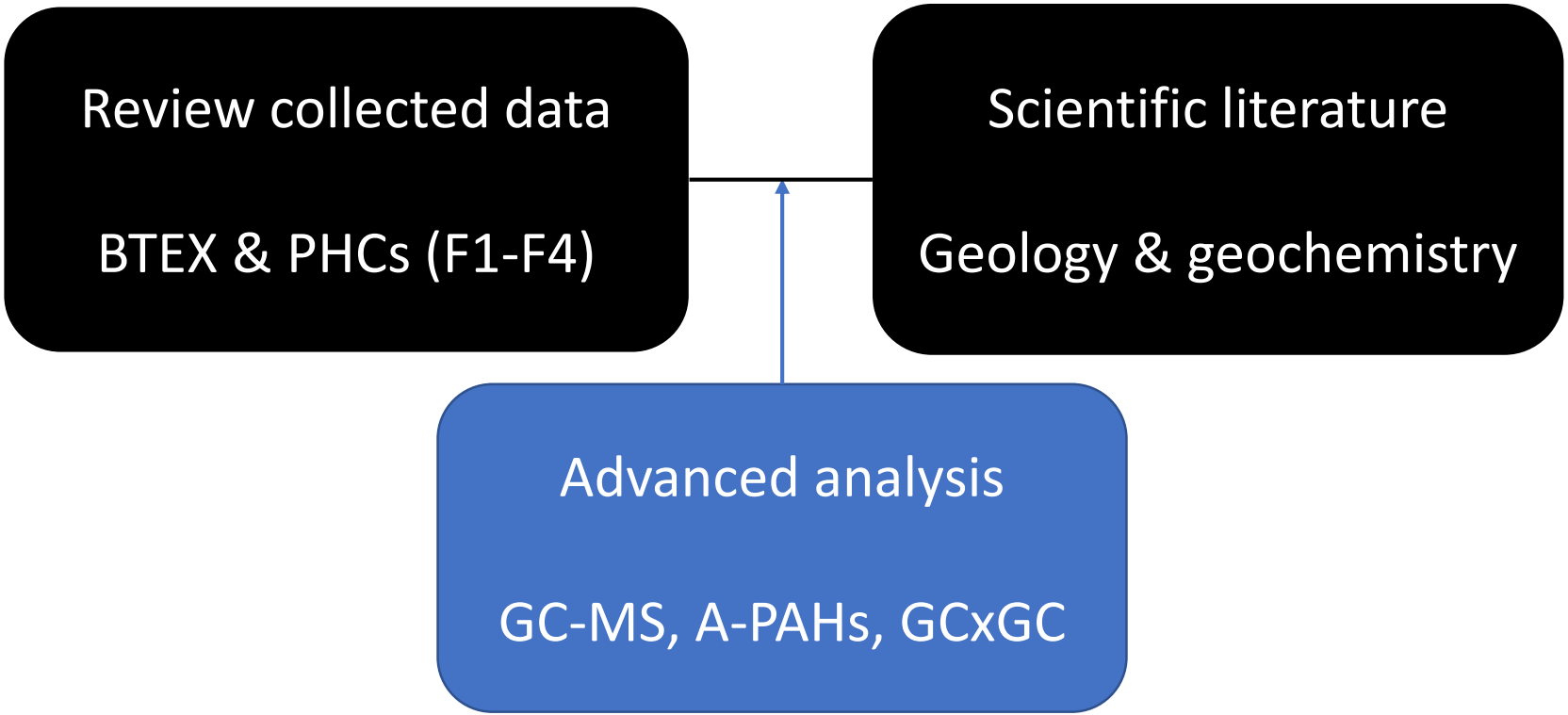
The Puzzle

Started with a chat about a single site that presented odd data during intrusive Phase II work.
Quickly became a conversation about multiple sites presenting odd chemistry.

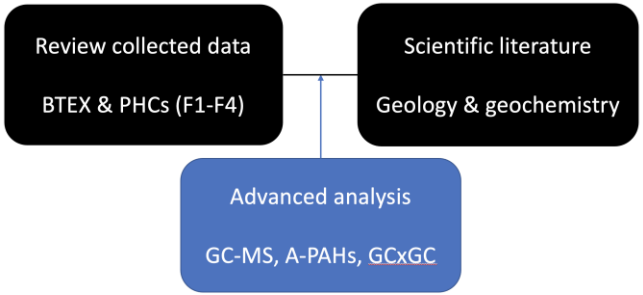
75-100 km between locations.

Observe - Full-range hydrocarbons in all boreholes to >20m.
Expect - Gas, condensate, maybe diesel, kerosene, motor oil.

Overview

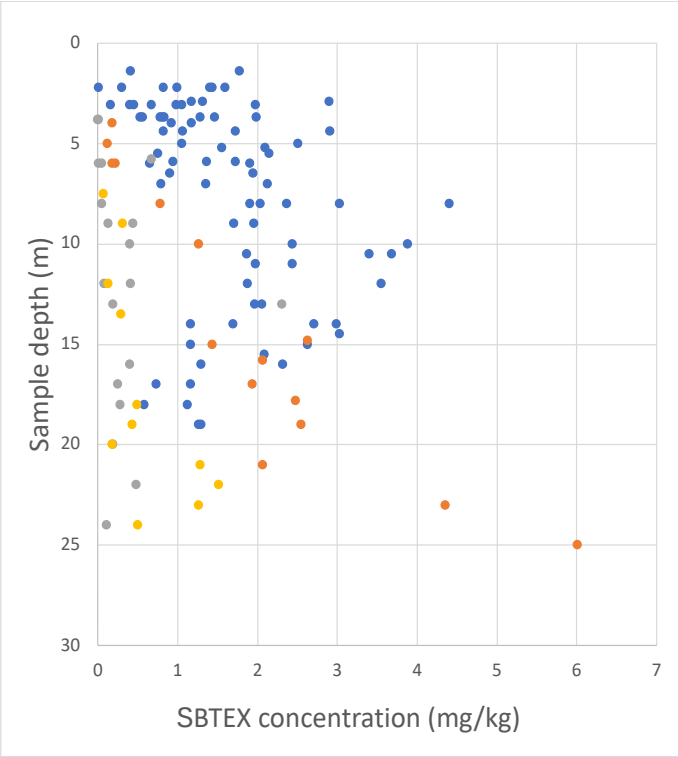

Review collected data
BTEX & PHCs (F1-F4)
Scientific literature
Geology & geochemistry
Advanced analysis
GC-MS, A-PAHs, GCxGC

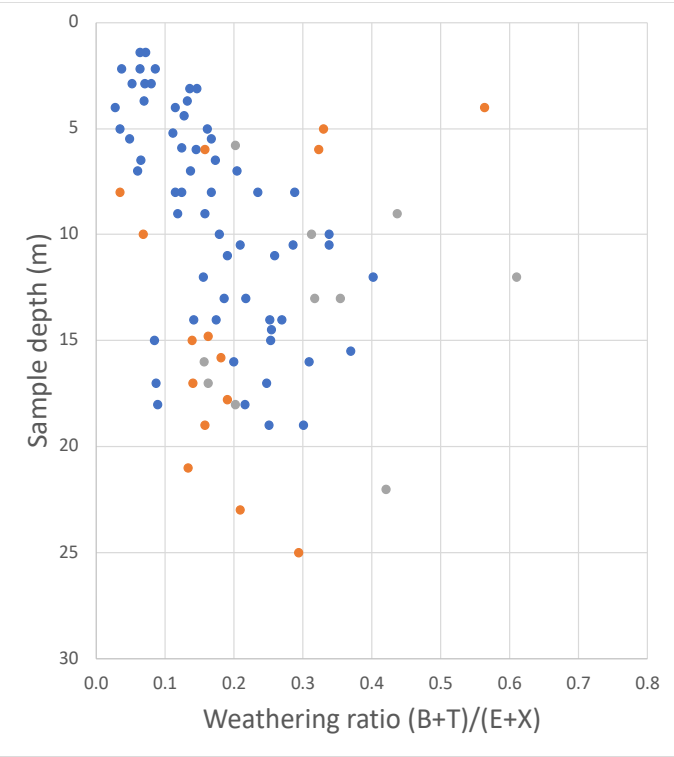
Standard analytical data



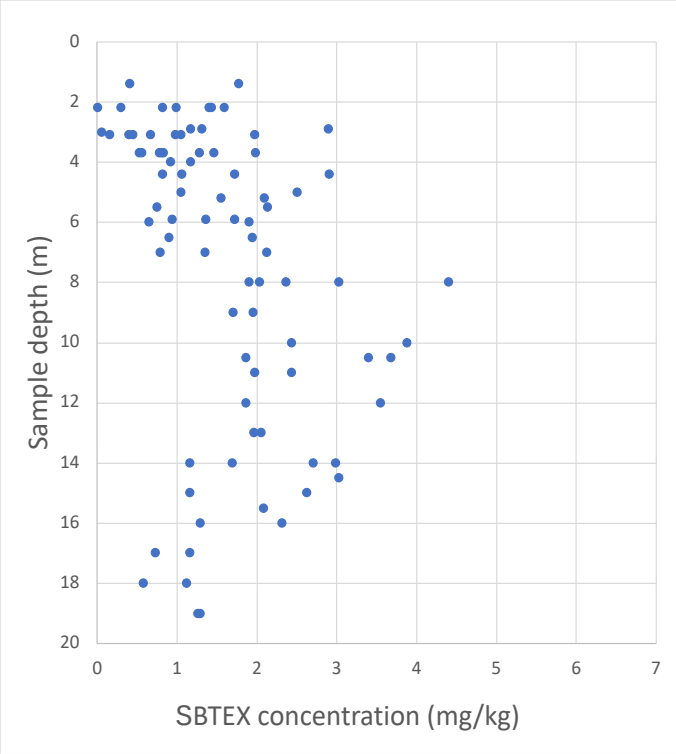
BTEX and PHCs (plus chroms)

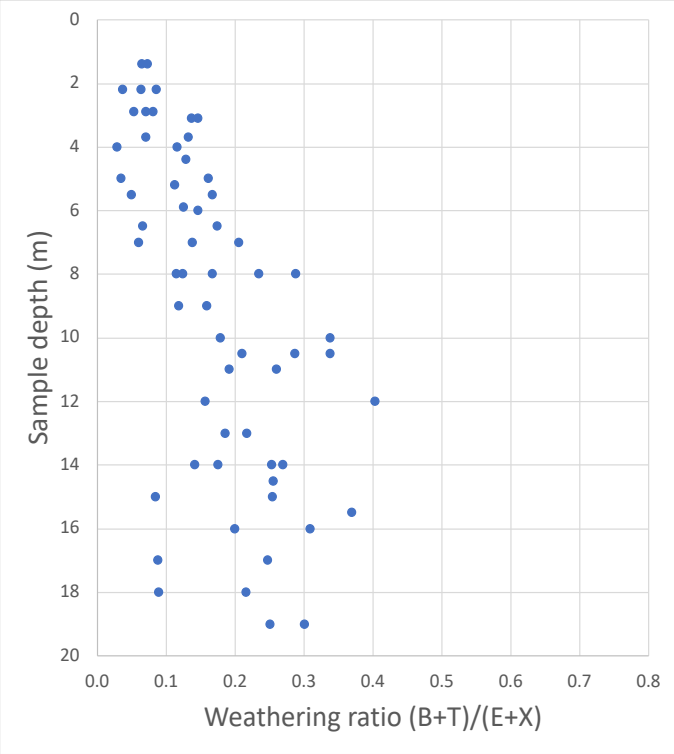
BTEX – all sites



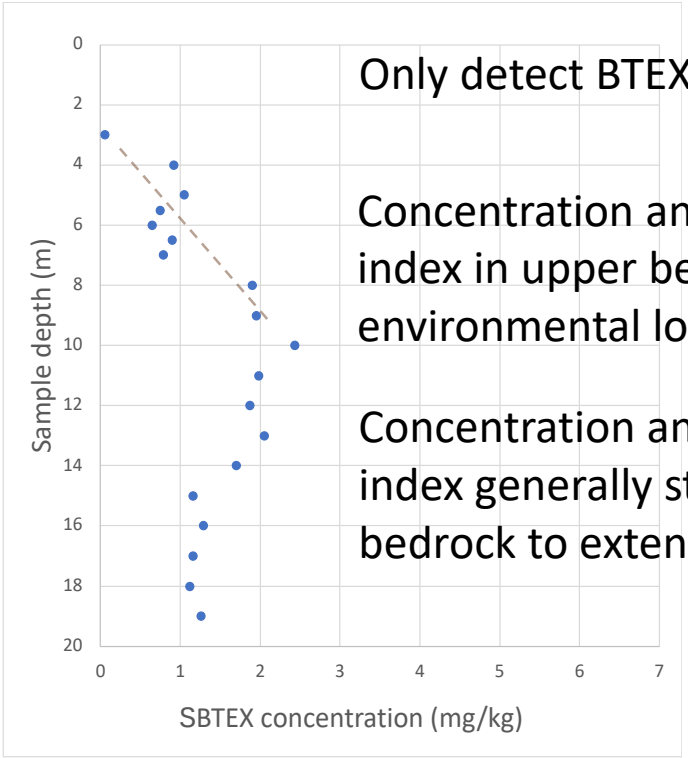


BTEX – one site, all boreholes





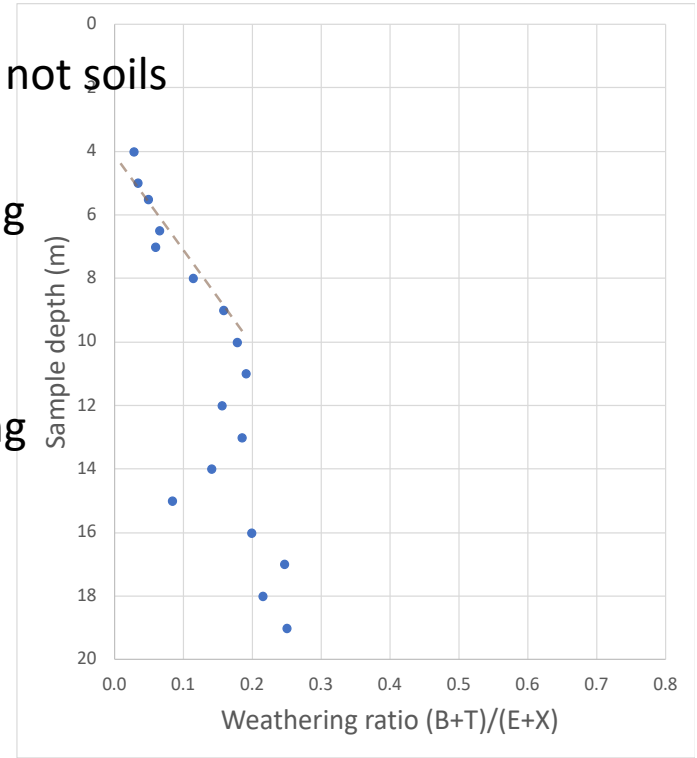
BTEX – one site, one borehole



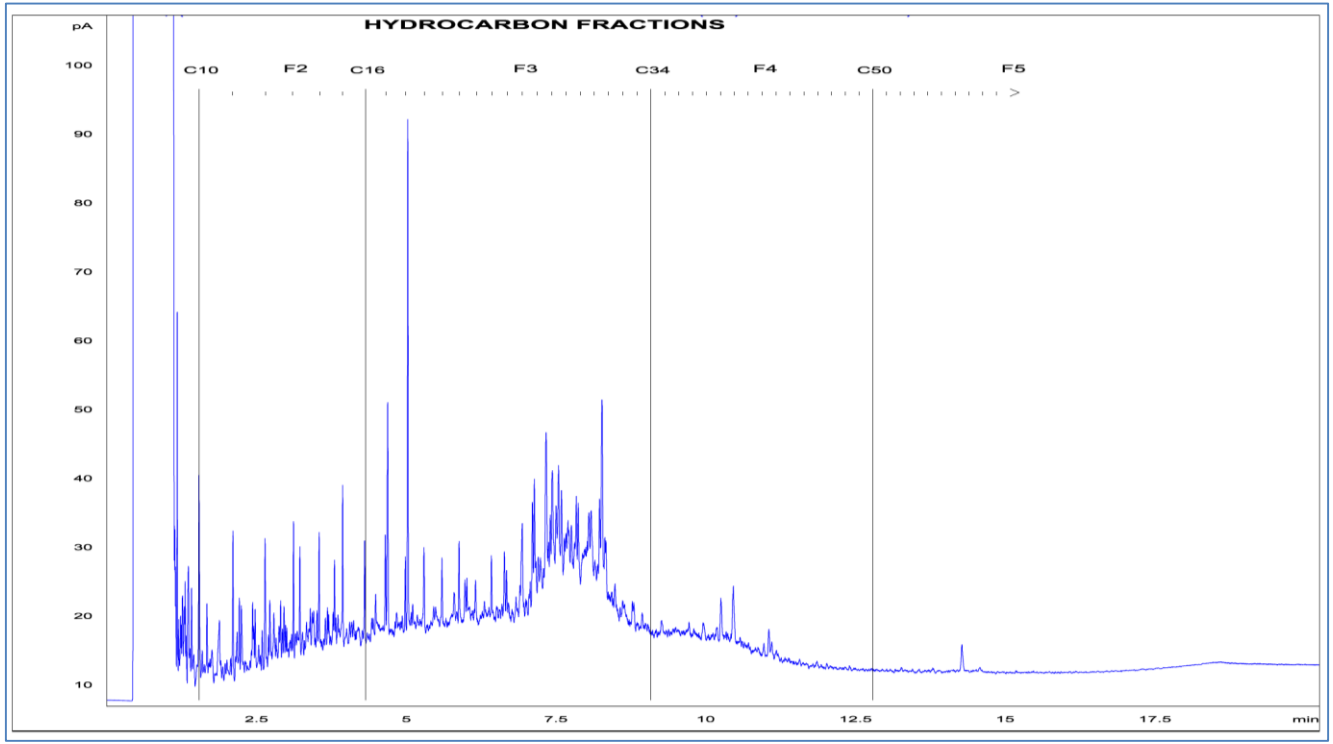
Only detect BTEX in bedrock, not soils

Concentration and weathering index in upper bedrock show environmental losses

Concentration and weathering index generally stable within bedrock to extent of drilling

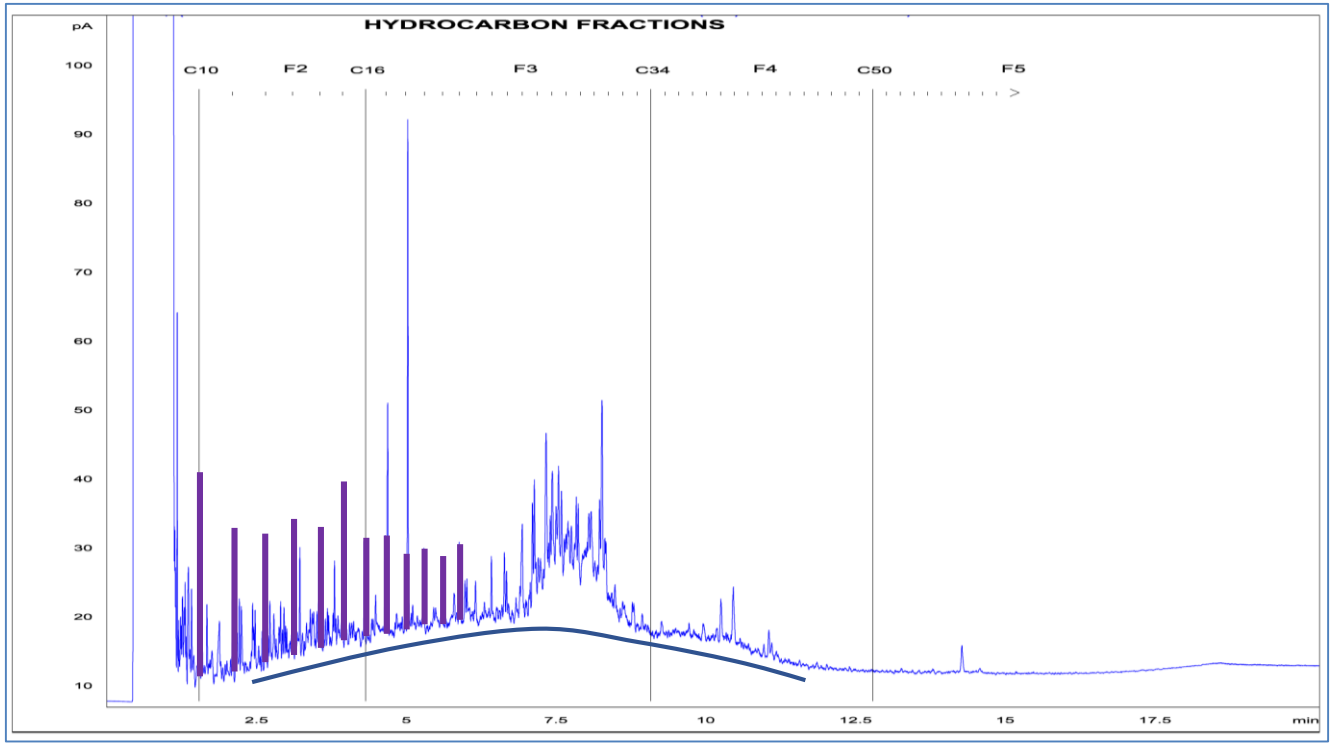


PHCs



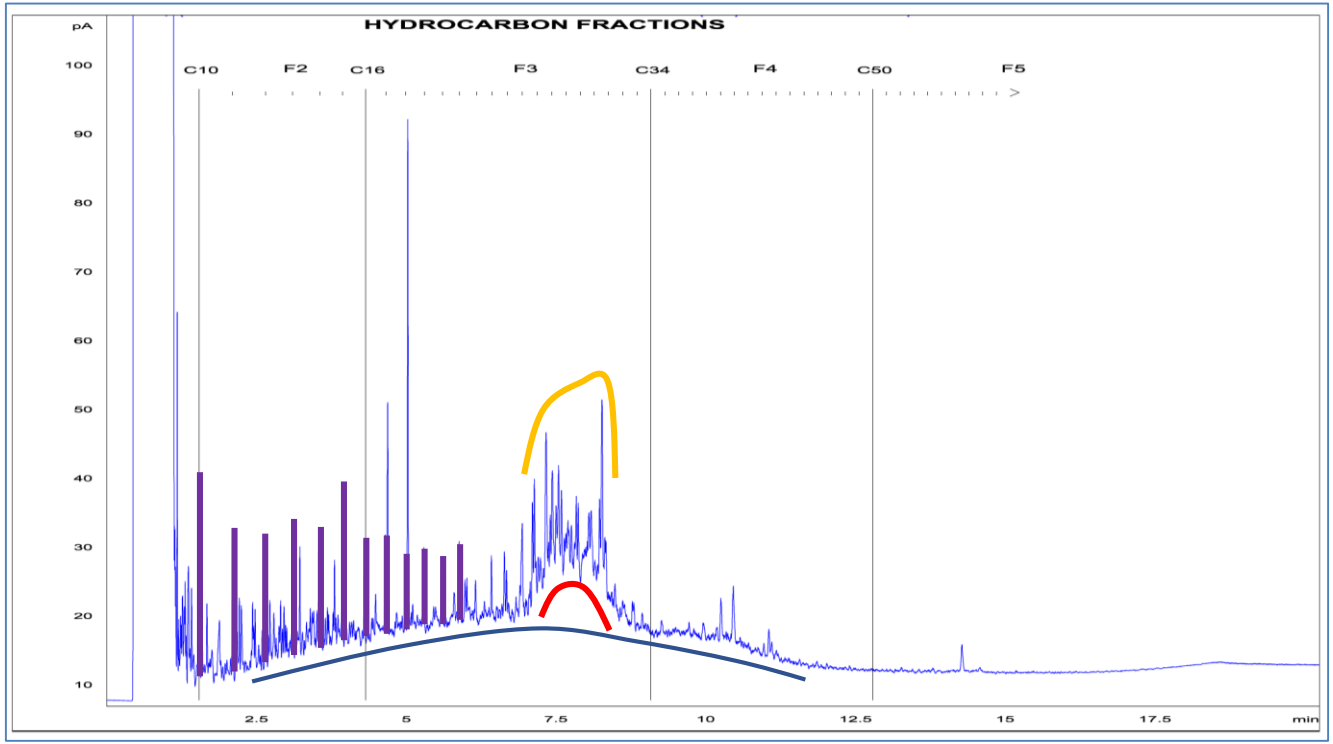
Very comparable chromatogram features in results across each site and between sites.

PHCs



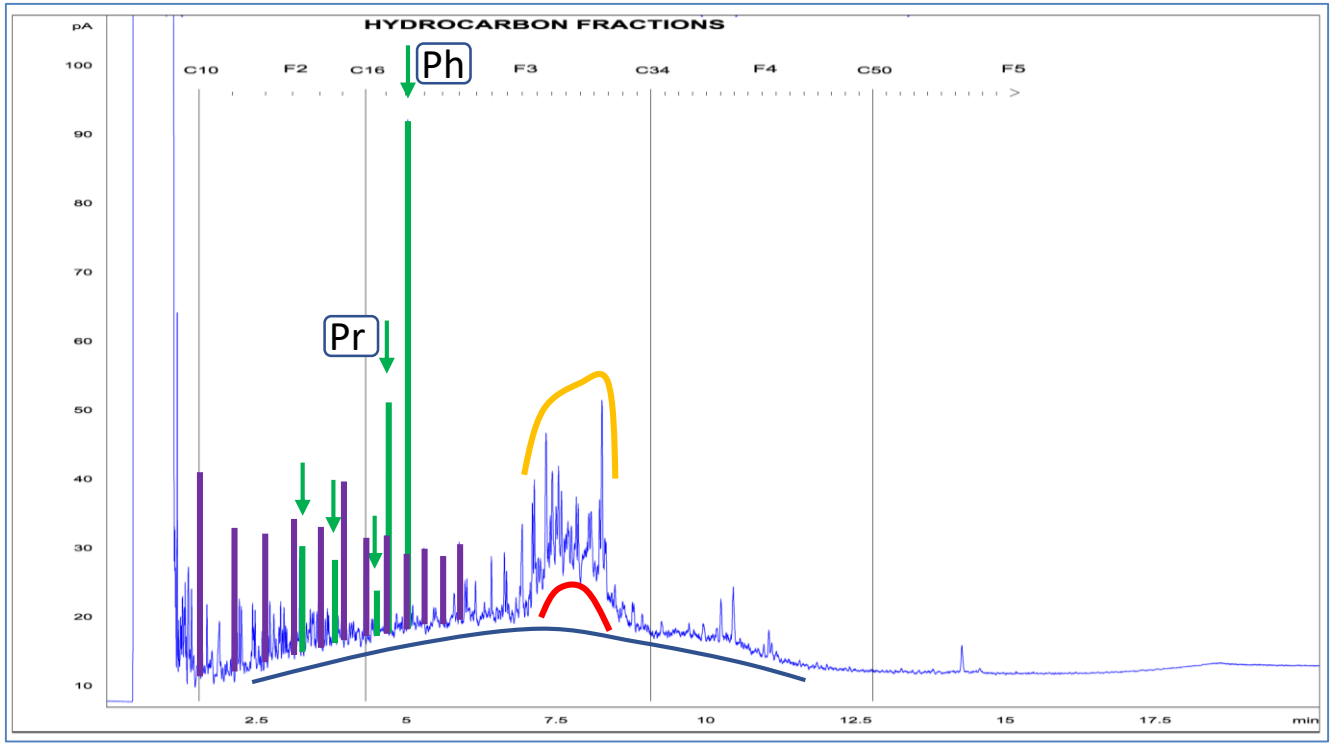
Wide-ranging UCM and observable alkanes

PHCs



Notable secondary UCM in F3b range, sterols prominent - immature

PHCs



Isoprenoids – particularly pristane and phytane – immature, anoxic

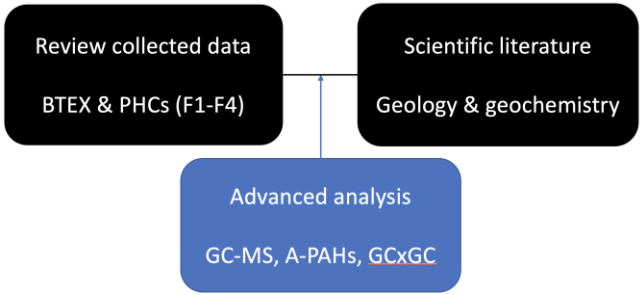
BTEX and PHC Summary

- Non-detect in soils, only encountered in shallow bedrock,
- Concentration profile generally steady to extent of drilling (>20m),
- Same profile at all sites and all depths,

- Confirms that bedrock is source. But what is it?

- Immature source,
- Anoxic deposition,

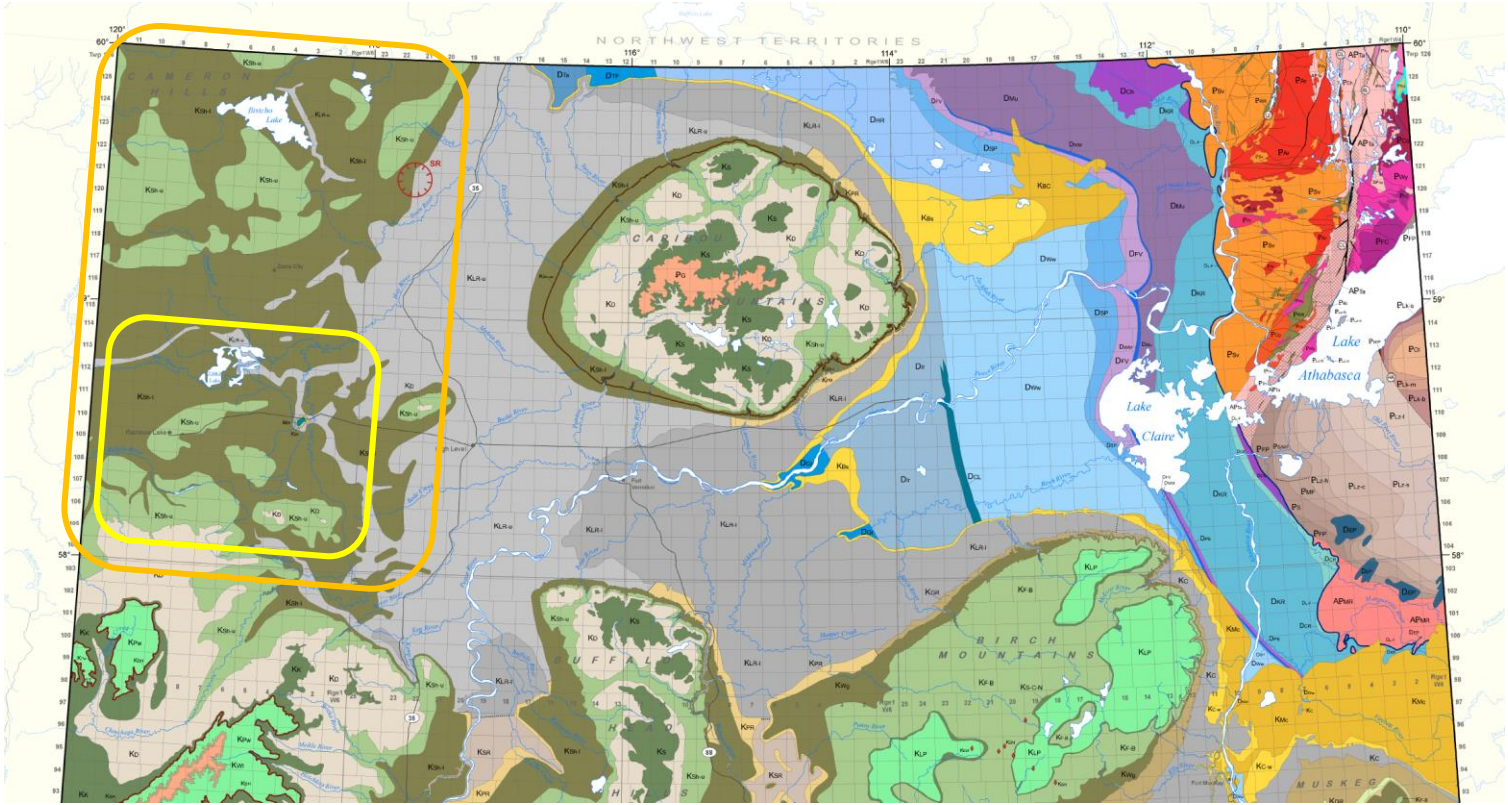
Geology and geochemistry



- Literature review of geology,
  - Identify formation(s) of interest,

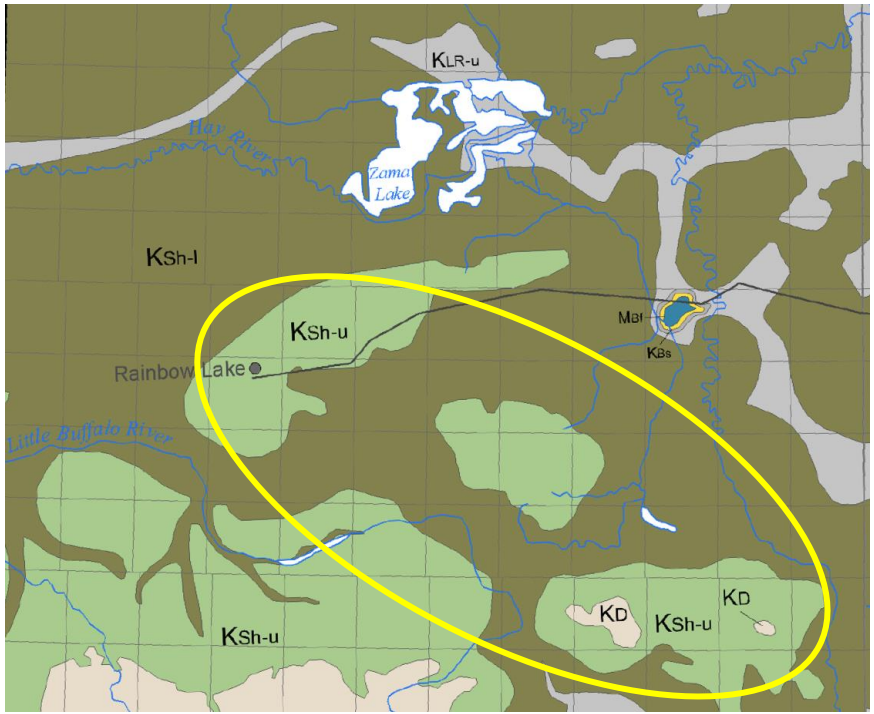
- Literature review for bedrock chemistry,
  - What should be expected and compared with the assessment data,

The surficial bedrock geology – **Shaftesbury Formation** across NW AB



Bedrock geology of Alberta: Alberta geological survey map 600

Upper and lower formations at specific areas, but otherwise covers the entire area



- Rainbow Ridge
- Rainbow Lake Plain
- Bassett Hill

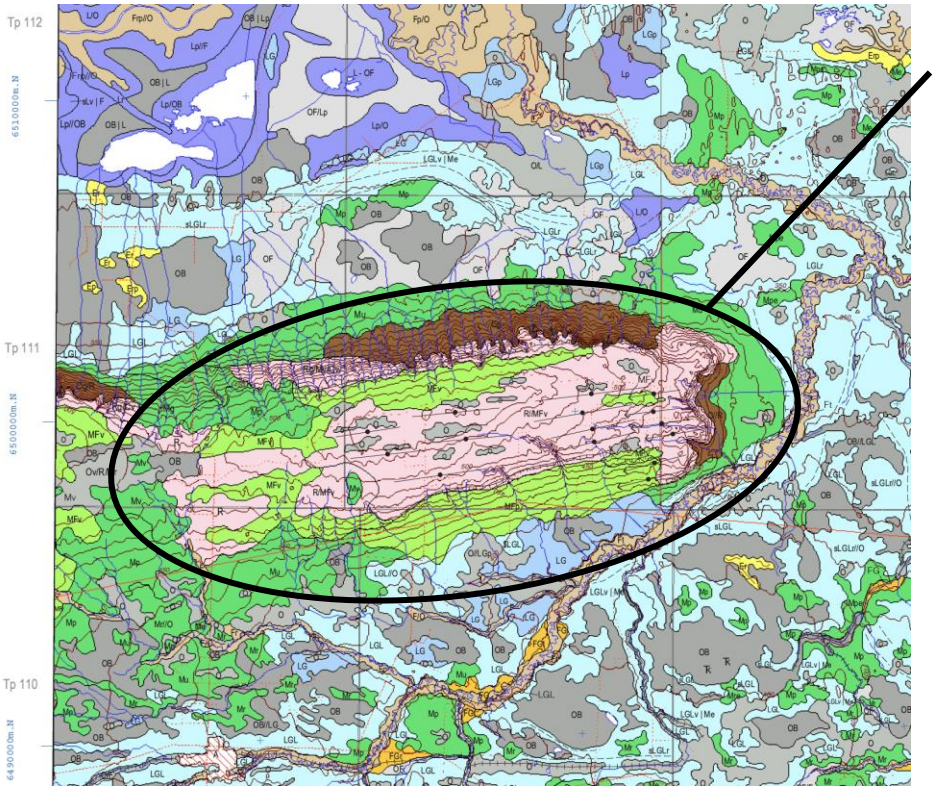
Bedrock geology of Alberta: Alberta geological survey map 600

The drift over bedrock

1:100 000 drift maps are available for the area:

- Two from Alberta Geological Society,
- Two from Geological Survey of Canada

- 1:250 000 surficial geology maps summarizes this data (*Map 329 Drift Thickness of Zama Lake Area, Alberta (NTS 84L)*)



Example partial of map showing Rainbow Ridge

The areas of interest are described as bedrock outcrops and veneer over bedrock,

Veneer = ‘<2m’ i.e. well within the range of intrusive investigations.

The literature summary of geochemistry isn't extensive but it is there.

ORGANIC-RICH, RADIOACTIVE MARINE SHALE: A CASE STUDY OF A SHALLOW-WATER CONDENSED SECTION, CRETACEOUS SHAFTESBURY FORMATION, ALBERTA, CANADA[1]

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QUATERNARY GEOLOGY OF THE ZAMA CITY AREA, NORTHWESTERN ALBERTA

by

Christopher J. Kowalchuk
B.Sc., Simon Fraser University, 2003

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

An anoxic event at the Albian–Cenomanian boundary: the Fish Scale Marker Bed, northern Alberta, Canada

Dale A. Leckie[a], Chaitanya Singh[b], John Bloch[a], Mark Wilson[c] and John Wall[a]
[a]*Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, 3303- 33 St. NW., Calgary, Alta. T2L 2A7, Canada*
[b]*Alberta Geological Survey, Alberta Research Council, P.O. Box 8330, Postal Station F, Edmonton, Alta. T6H5X2, Canada*
[c]*Department of Zoology, University of Alberta, Edmonton, Alta. T6G 2E9, Canada*
(Received March 5, 1991; revised and accepted September 26, 1991)

Light volatile liquid and gas shale reservoir potential of the Cretaceous Shaftesbury Formation in northeastern British Columbia, Canada

Gareth R. L. Chalmers and R. Marc Bustin

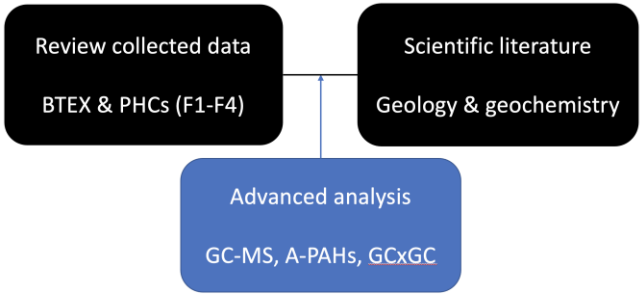
Geochemistry Summary

- High organic content shales,
- Not generally accessible for extraction in AB, but produces gas and oil in BC.
- Largely deposited in anoxic environment,
- Immature hydrocarbons,

Geology and Geochemistry Summary

- Surficial bedrock called the Shaftesbury Formation,
- Likely encountered in intrusive investigations,
- Surficial bedrock contains hydrocarbons,
- Anoxic and Immature,

Advanced Chemistry

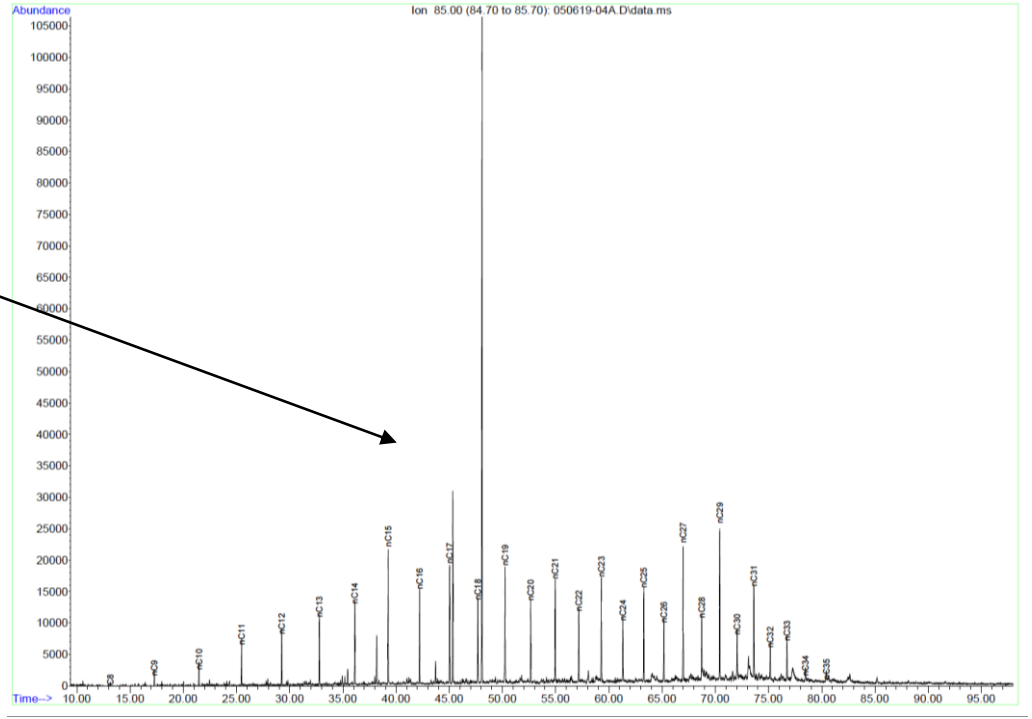


Make the connection between the standard analytical chemistry and the literature geochemistry of the bedrock formation.

- GC-MS characteristics,
- A-PAHs,
- GCxGC-TOFMS

Alkanes, and branched alkanes

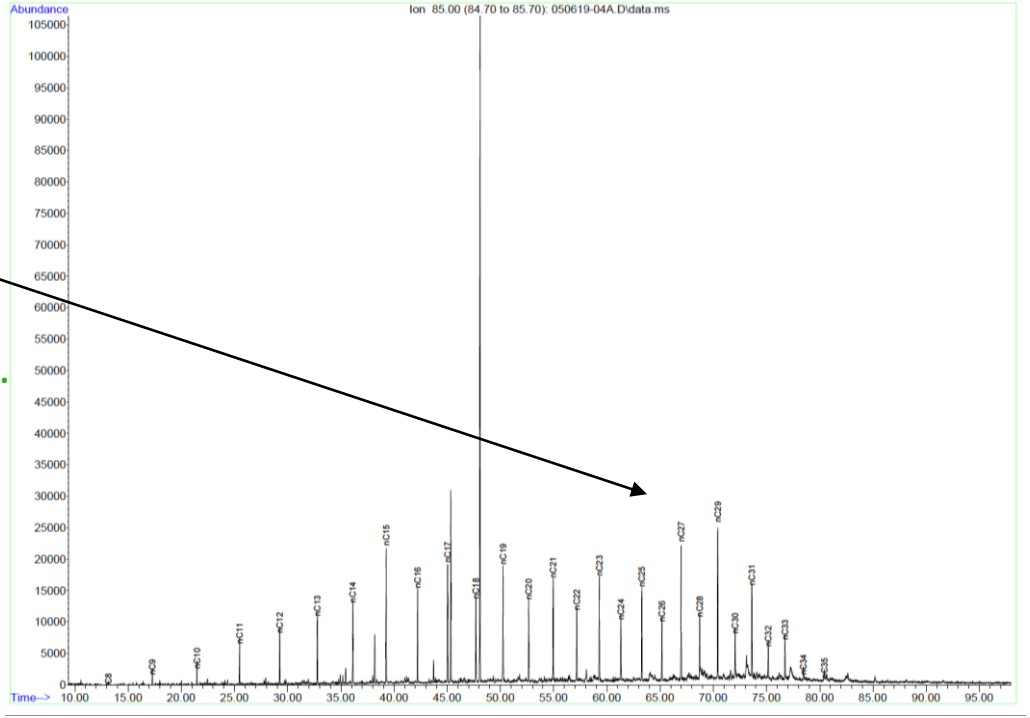
wide-ranging oil alkane profile
(>C35)



Alkanes, and branched alkanes

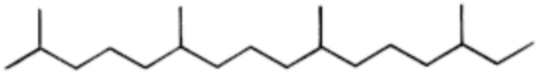
plant hydrocarbon signature
(odd > even alkanes)

Alkanes still contain source characteristics.

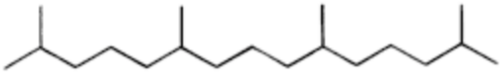


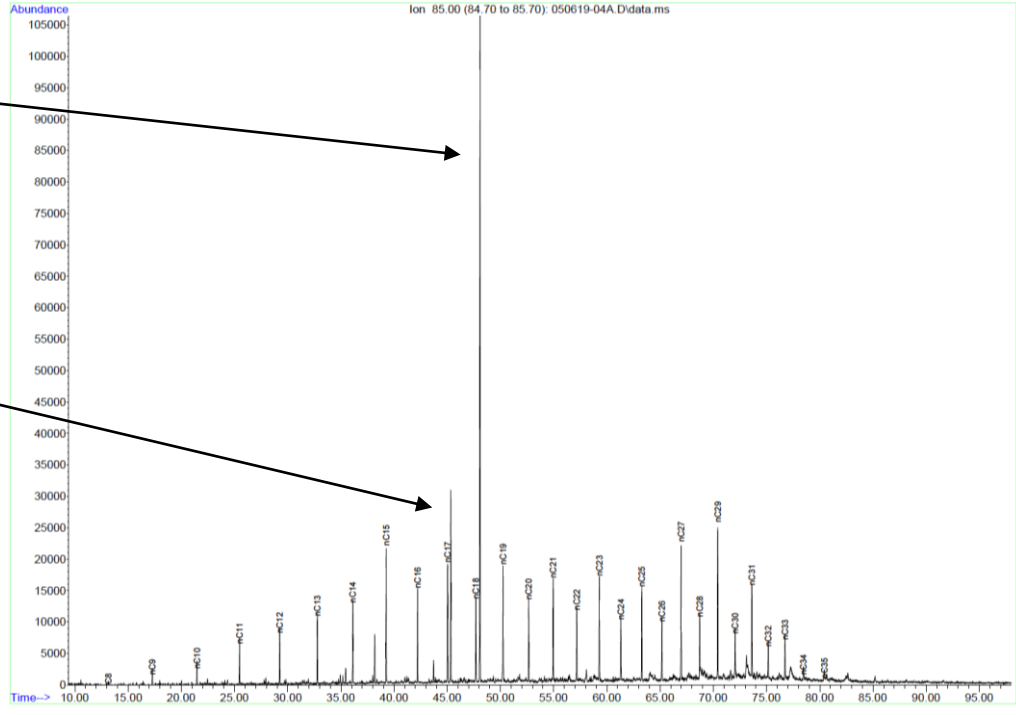
Alkanes, and branched alkanes

phytane



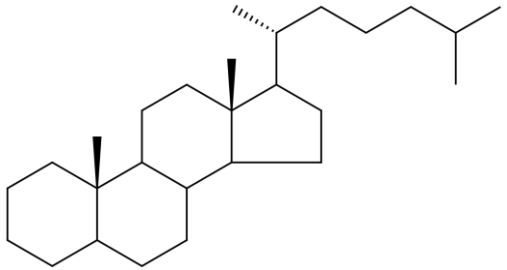
pristane





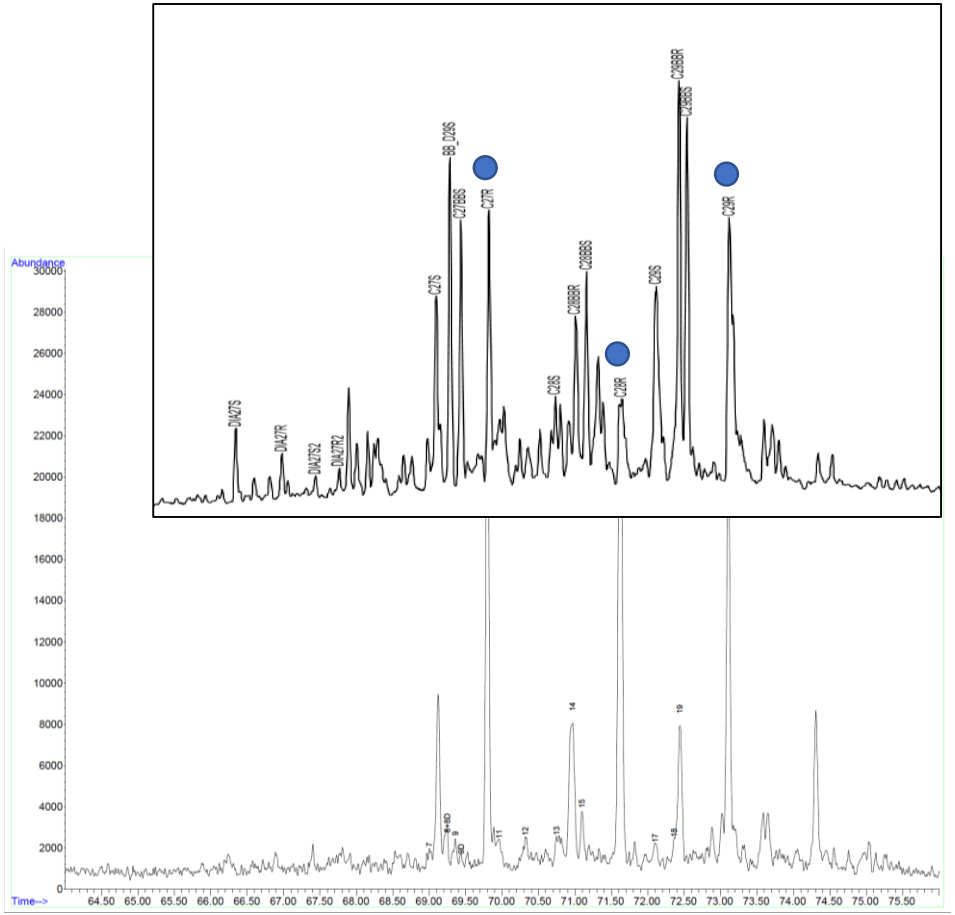
Low Pr/Ph ratio indicative of anoxic source.

Biomarkers (steranes)

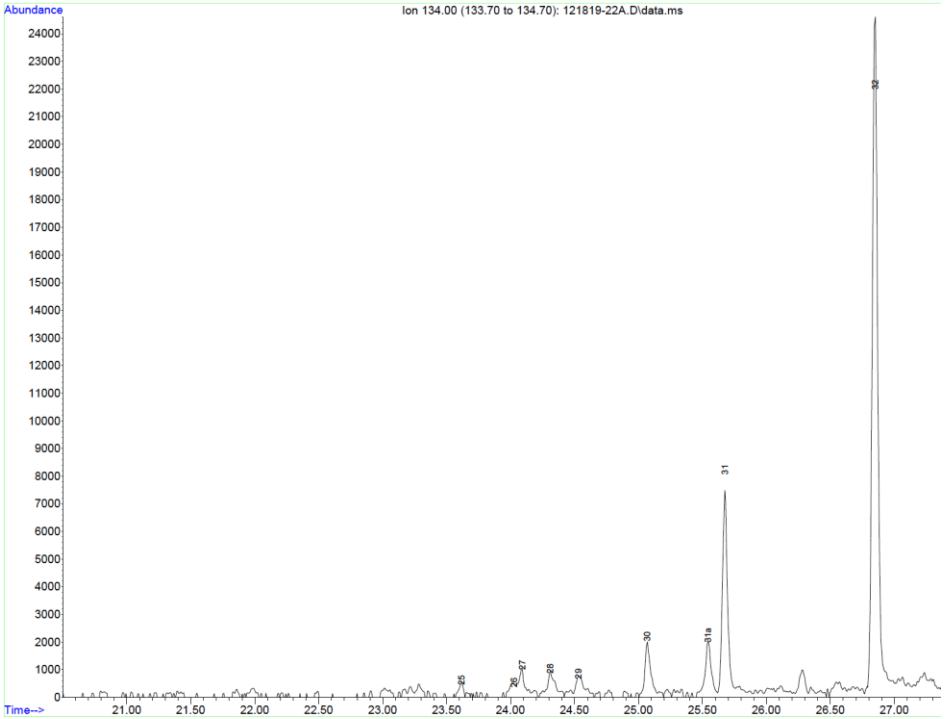


Cholestane structure

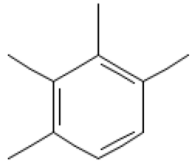
Steranes are dominated by
14α, 17α-(20R) cholestane isomers.
Indicative of an immature source.



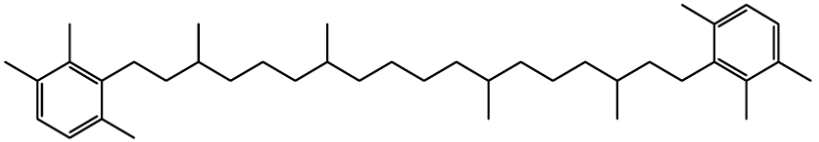
Biomarkers (C4-benzenes)



Non-thermodynamic composition with very high 1,2,3,4-TMB content.



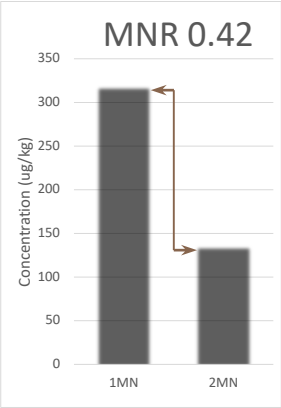
Likely derived from aromatic carotenoids, literature sources linked to green sulfur bacteria from anoxic marine settings.



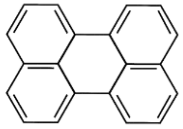
A-PAHs

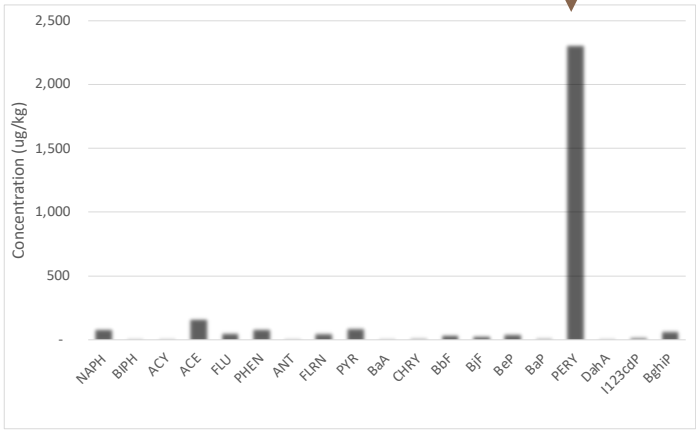
MNR indicates immature source.

Substantial concentration of perylene - immature.



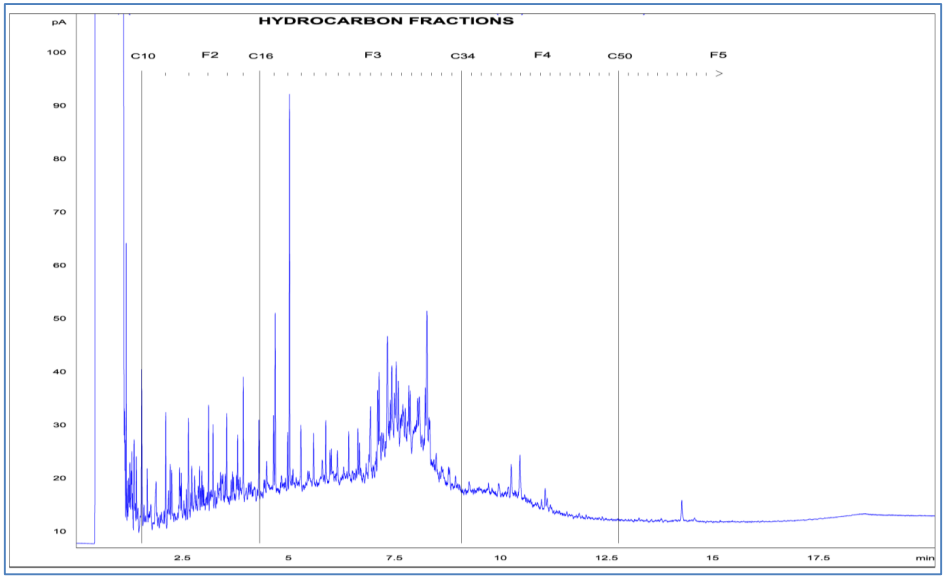
perylene





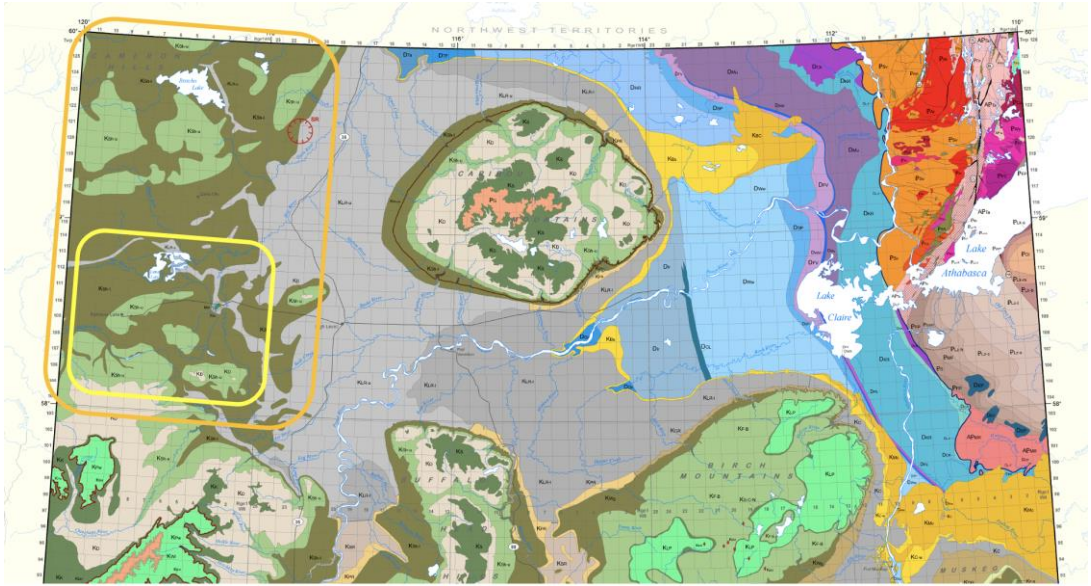
Summary

- BTEX and PHCs from multiple sites across Rainbow Ridge, Rainbow Lake Plain and Bassett Hill are related.



Summary

- Extent of Shaftesbury Formation describes the area of potential interference with Phase II investigations.



Thanks for Listening