

Unique Geochemical Methods for Regional On-shore Petroleum Exploration in the Mackenzie Delta, Northwest Territories, Canada*

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Abstract

A regional geochemical orientation survey was conducted over the Tuk Tertiary oil field, Tuk Cretaceous gas field and the Mayogiak Devonian oil field located in the Mackenzie Delta of the Northwest Territories, Canada. The orientation survey was performed to determine which, if any, of four analytical methods tested on lake sediments and soil cores would provide the most coherent surface expression of the oil & gas fields in a regional survey. Effective geochemical methods could then be used to focus more cost-prohibitive seismic surveys and drilling over on-shore parts of the Mackenzie Delta.

Lake sediment and soil core samples were collected at 1 km intervals on 2-km spaced lines over an approximate area of 150 square kilometers. The samples were analyzed for C1-C6 alkane hydrocarbons using headspace, acid and pulverization extraction methods and for aromatic hydrocarbons by fluorescence analysis. Anomaly thresholds for the hydrocarbon data were selected from probability plots and the variables were plotted as proportional symbols on a topographic background.

The headspace, acid-extraction, pulverization and fluorescence analysis of soil cores revealed hydrocarbon anomalies over and adjacent to the oil and gas fields. More specifically, the C2+ alkane concentrations, wet gas ratios (C3/C1) and 3-ring aromatics are anomalous over and near the Tuk oil & gas fields. Thermogenic (C2+) headspace hydrocarbons are also anomalous in lake sediments over the Tuk and Mayogiak fields, but the methane is erratic probably because of its biogenic origin.

The main conclusion from the geochemical orientation study over the Tuk and Mayogiak fields is that hydrocarbon analysis of 2-meter deep soil cores provides statistically significant thermogenic hydrocarbon anomalies over oil and gas fields, even at 1 km sample intervals. Thermogenic headspace hydrocarbons are also anomalous in lake sediments over the fields. Regional surveys in the Mackenzie Delta should therefore involve the collection of 2-meter deep soil cores and/or lake sediments at approximately 1 km sample intervals. The samples should be analyzed for headspace C1-C6 alkanes and solvent-extractable aromatics (fluorescence method) to search for oil & gas reservoirs because these methods are less expensive than the acid and pulverization extraction techniques. The hydrocarbon data should be evaluated in probability plots to establish thresholds between anomalous and background populations.

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Outline

- **Objectives**
 - **Sample collection and analysis**
 - **Alkane anomalies in soil cores, and lake sediments**
 - **Aromatic anomalies in soil cores**
 - **Alkane anomalies in shot-hole sediments**
 - **Conclusions and recommendations**

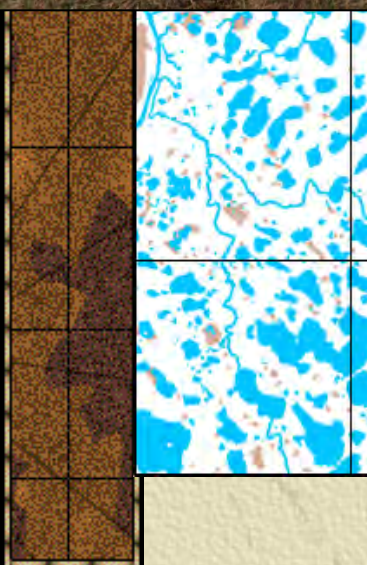
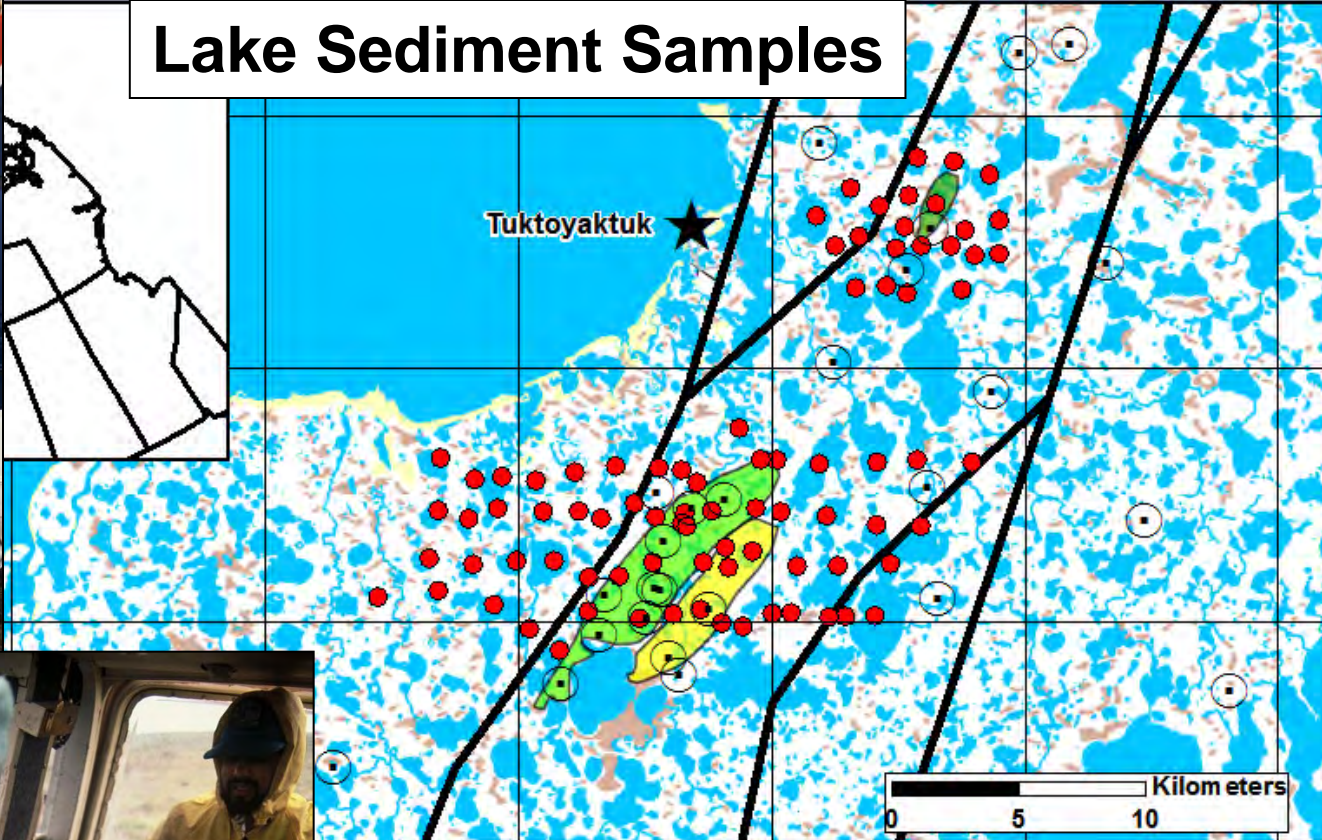
Objectives

- *Determine if hydrocarbons can migrate through thick permafrost.*
- *Find optimal geochemical methods for regional exploration in the Mackenzie Delta.*

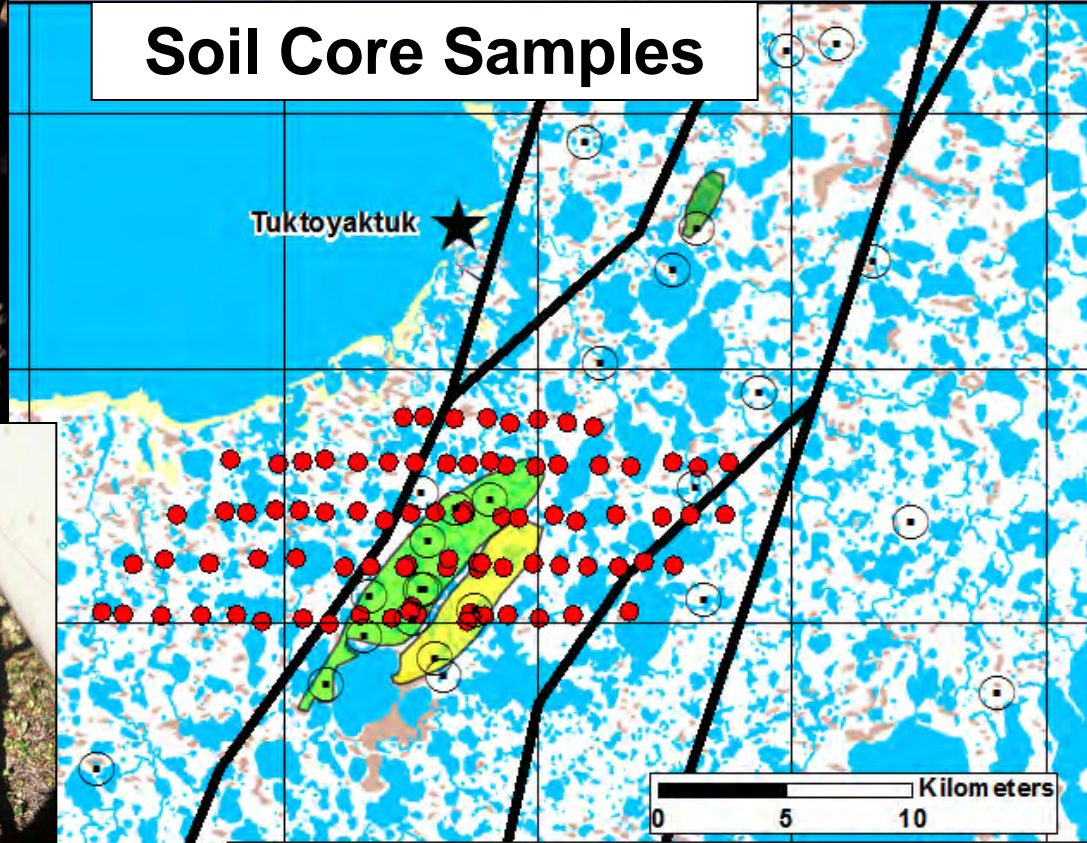
Glaciated Terrain in Mackenzie Delta



Lake Sediment Samples



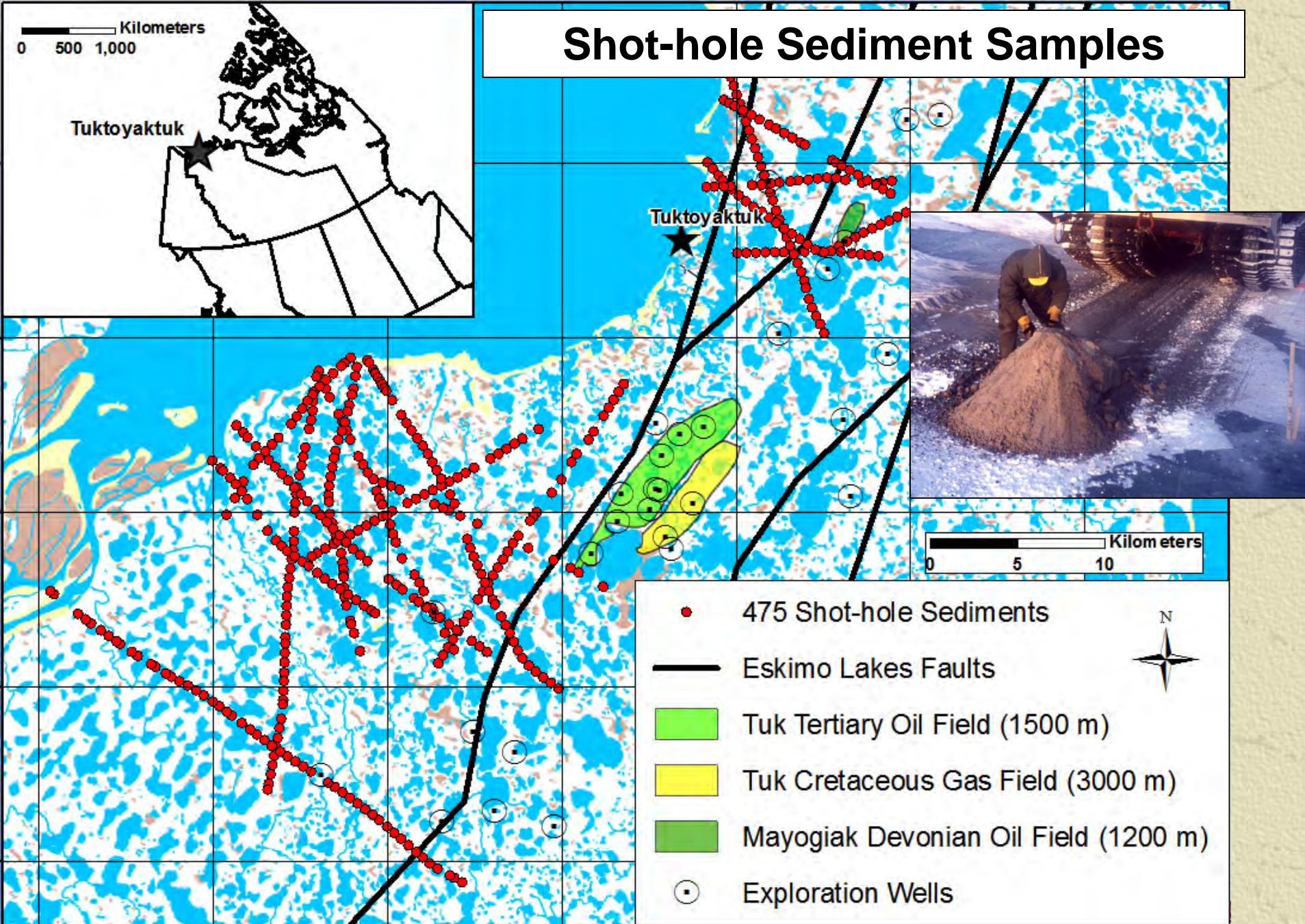
Soil Core Samples



- 90 Soil Cores
- Eskimo Lakes Faults
- Tuk Tertiary Oil Field (1500 m)
- Tuk Cretaceous Gas Field (3000 m)
- Mayogiak Devonian Oil Field (1200 m)
- Exploration Wells



Shot-hole Sediment Samples

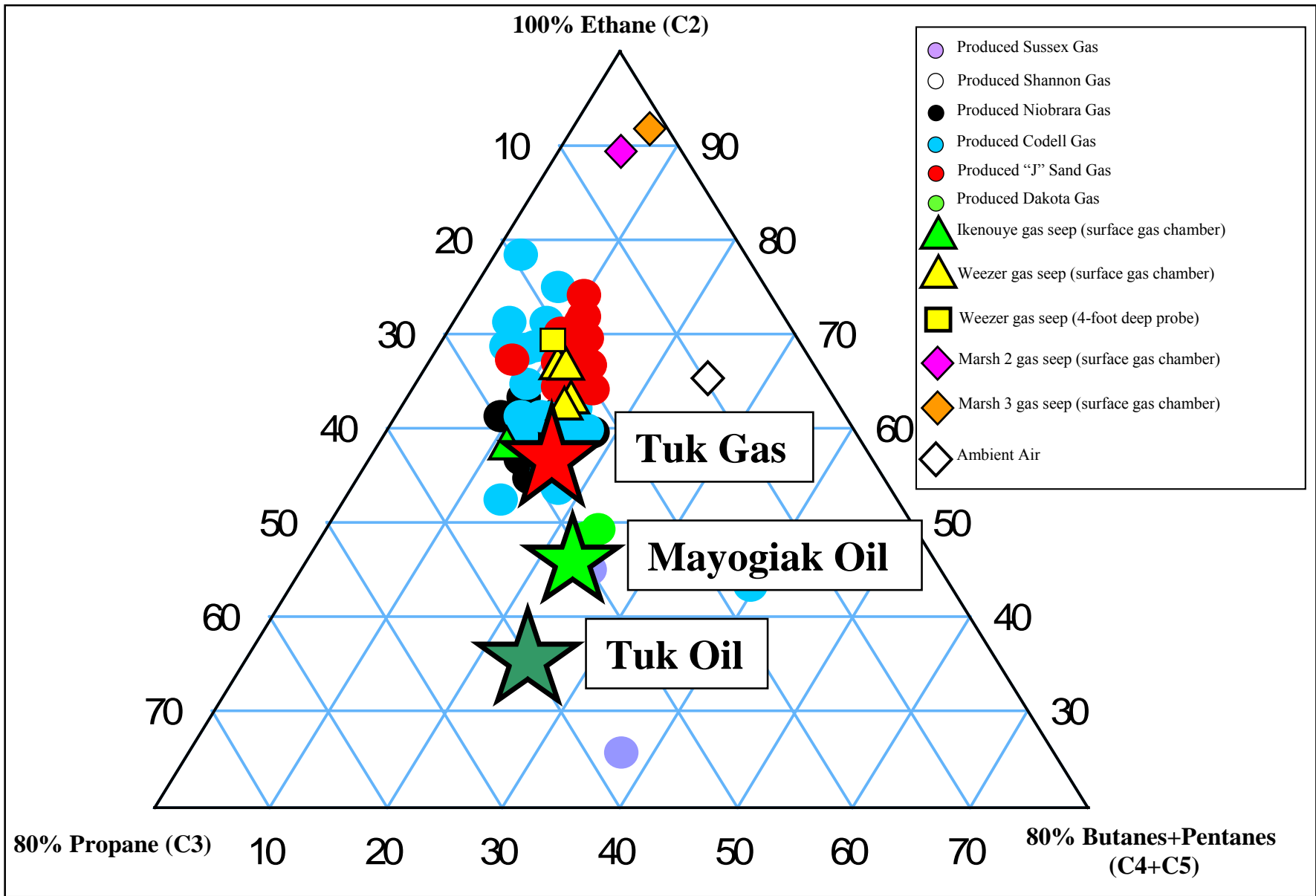


Analysis

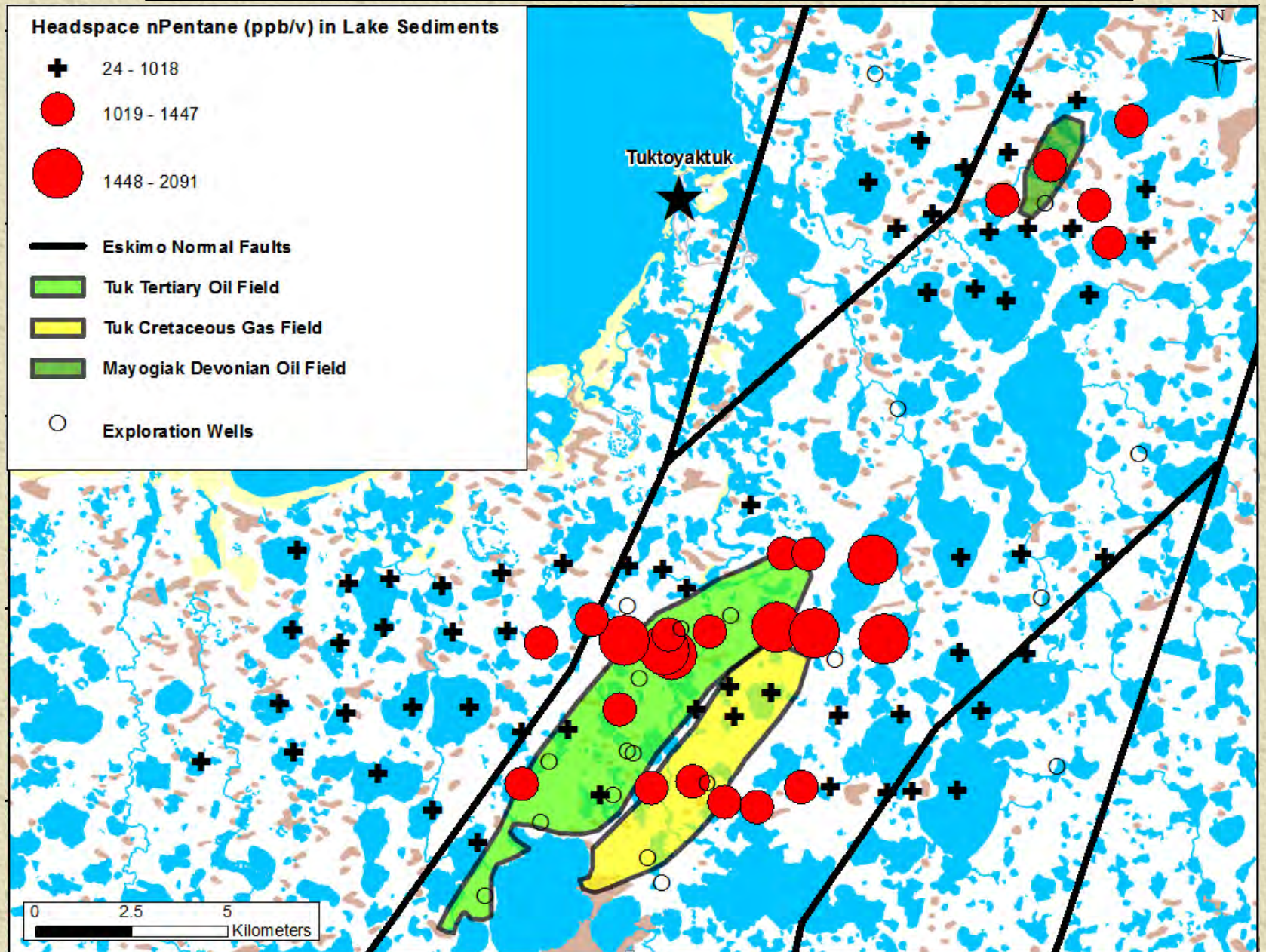
- **Acid-Extractable Gas (C1-C6 Alkanes)**
 - **Headspace Gas (C1-C6 Alkanes)**
 - **Blender Gas (C1-C6 Alkanes)**
- **Fluorescence (C6-C36 Aromatics)**



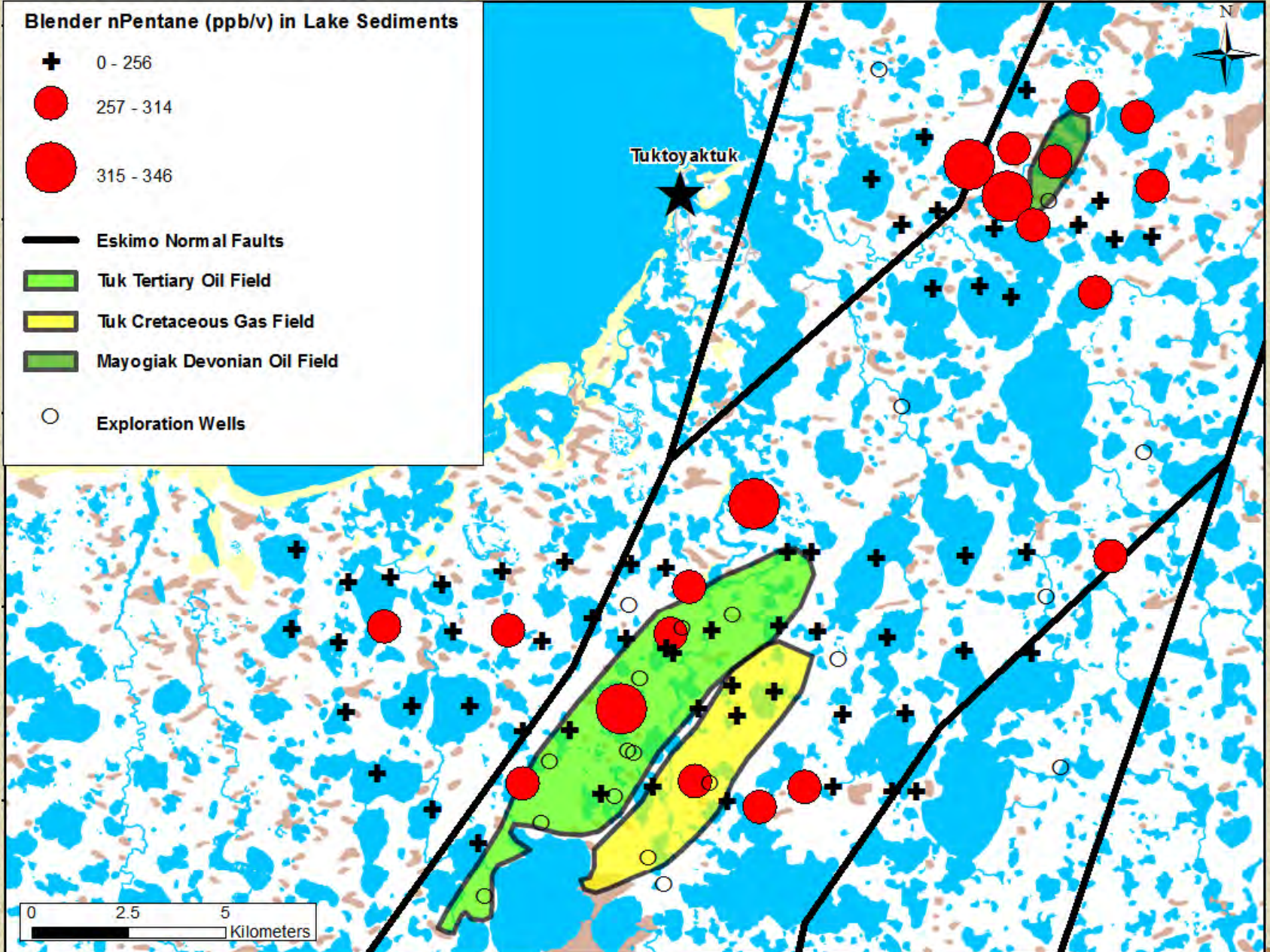
DST Gas Composition (Tuk and Mayogiak)



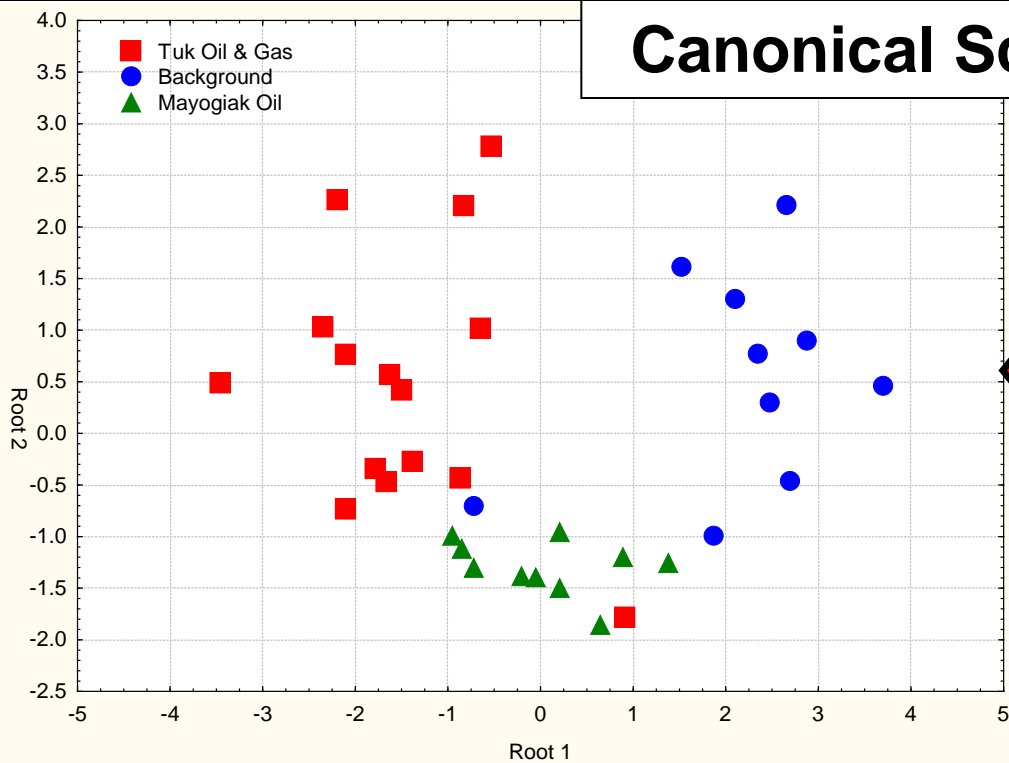
Headspace nPentane (Lake Sediments)



Blender nPentane (Lake Sediments)

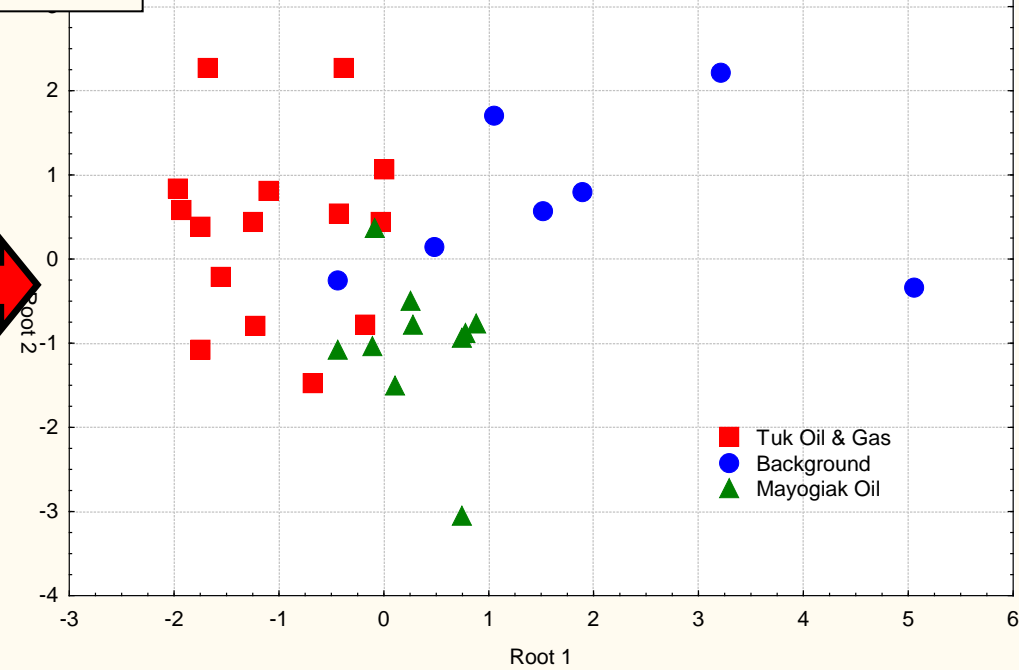


Canonical Score Plots (Lake Sediments)

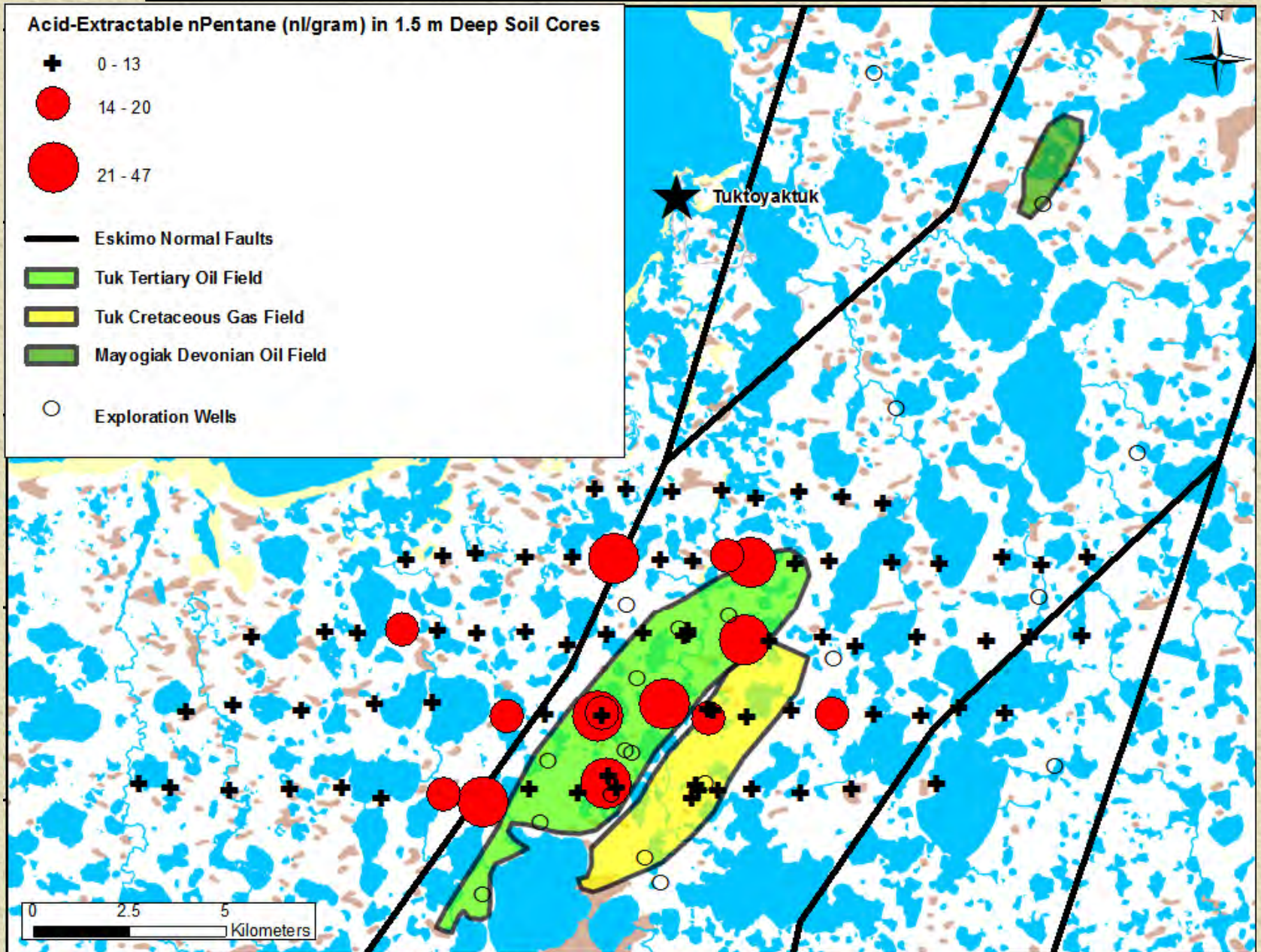


Headspace Gas

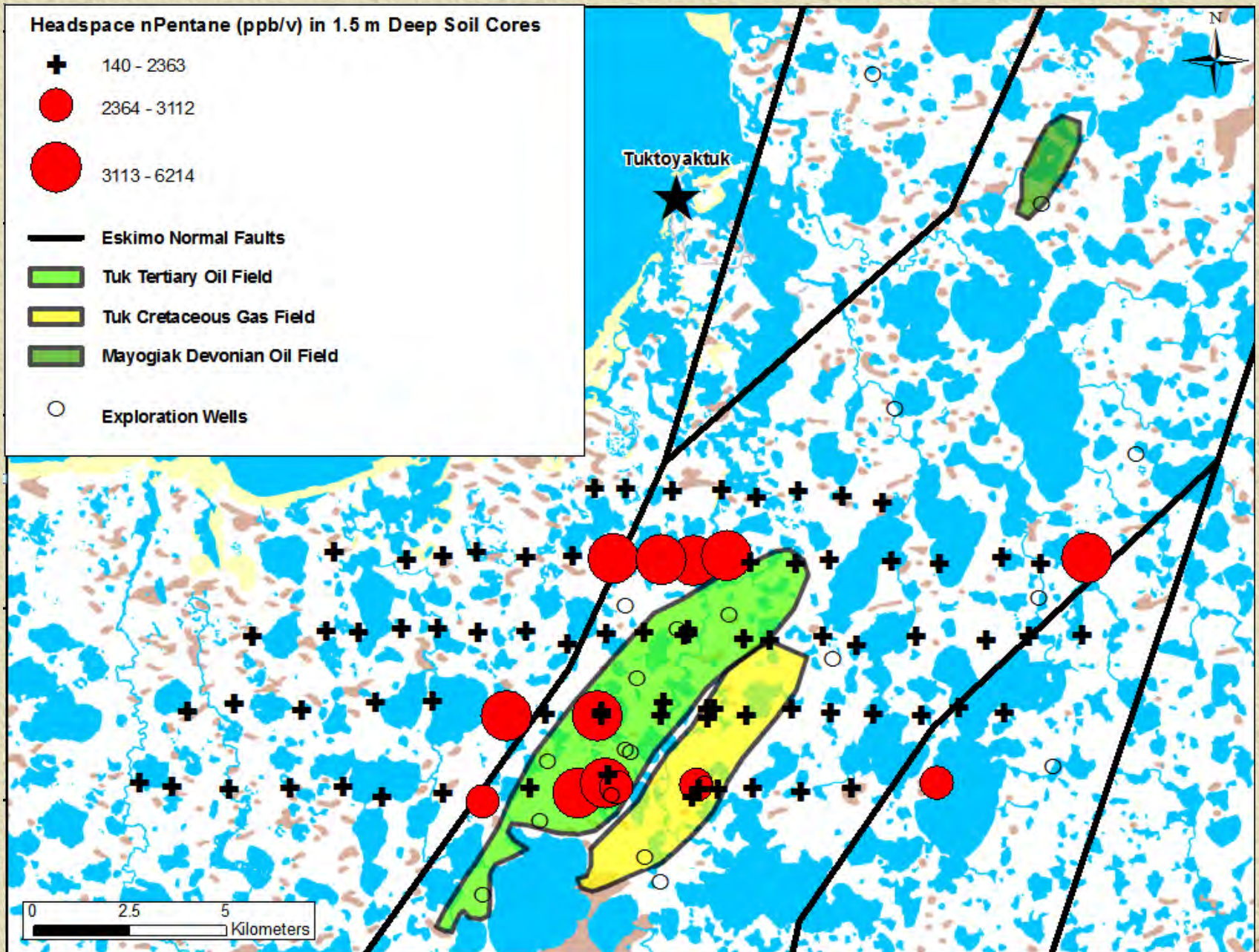
Blender Gas



Acid-Extractable nPentane (Soil Cores)



Headspace nPentane (Soil Cores)

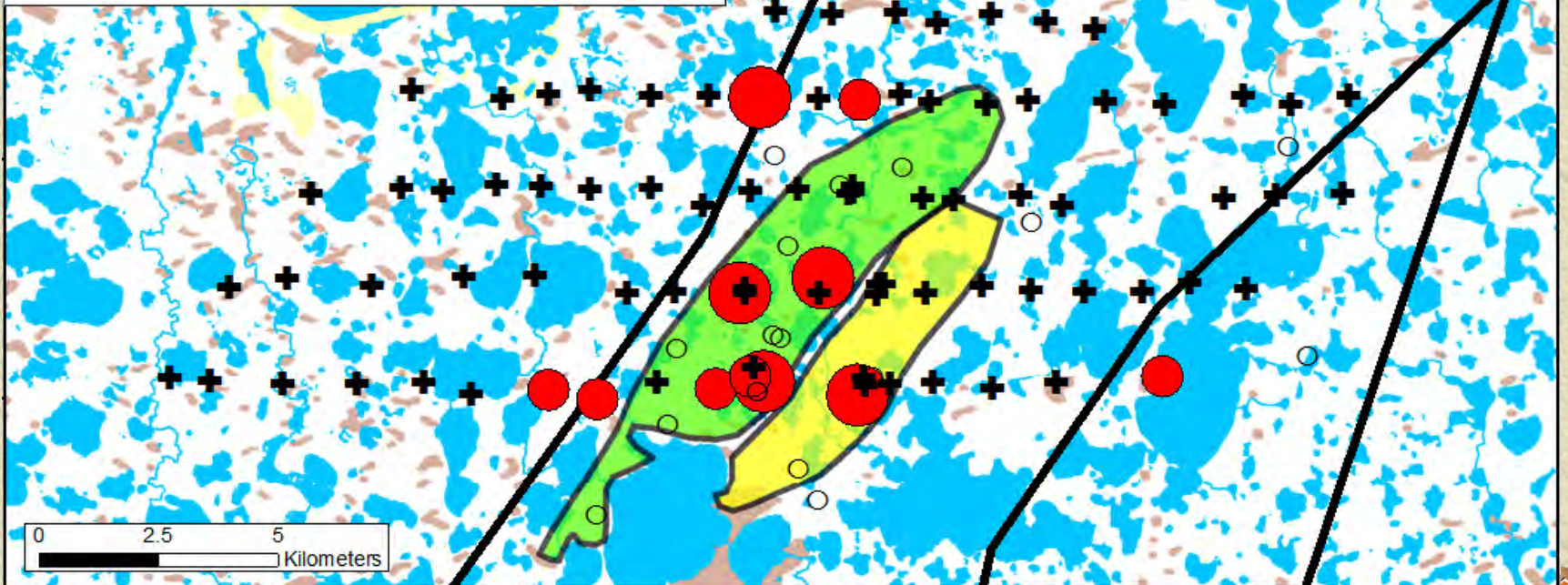


Blender nPentane (Soil Cores)

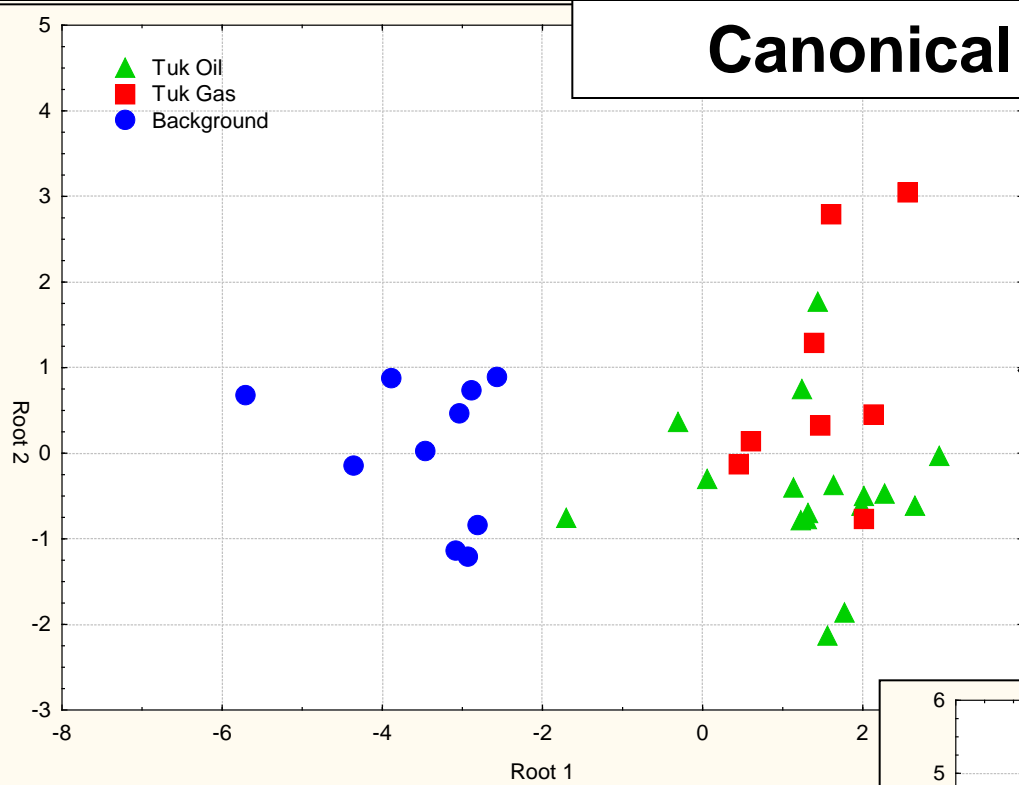
Blender nPentane (ppb/v) in 1.5 m Deep Soil Cores

- ✚ 44 - 522
- 523 - 953
- 954 - 1506

- Eskimo Normal Faults
- Tuk Tertiary Oil Field
- Tuk Cretaceous Gas Field
- Mayogiak Devonian Oil Field
- Exploration Wells

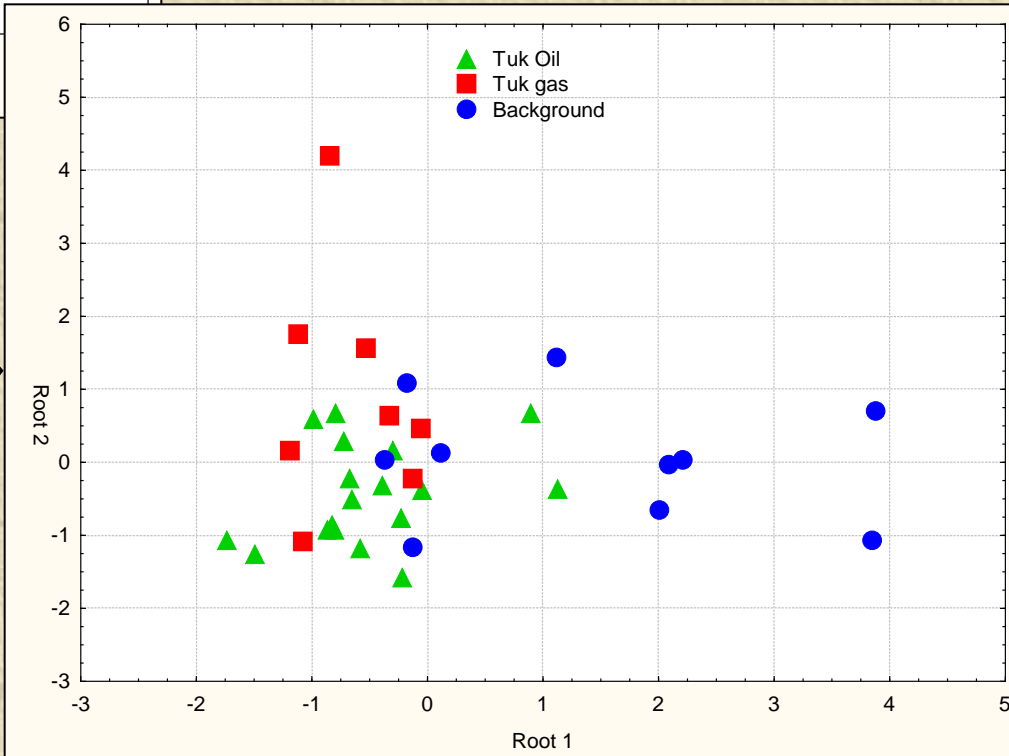


Canonical Score Plots (Soil Cores)

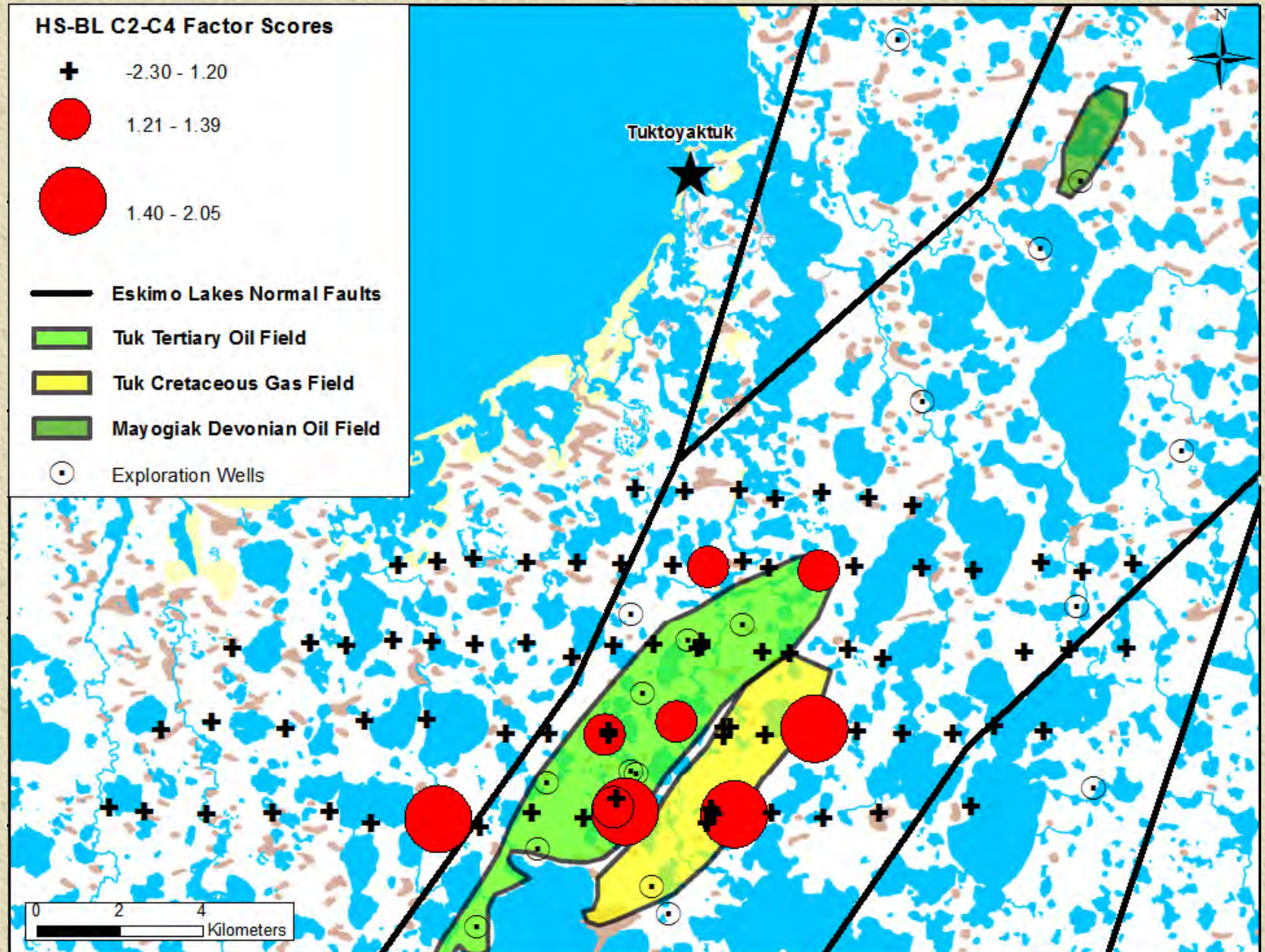


Acid-extractable Gas

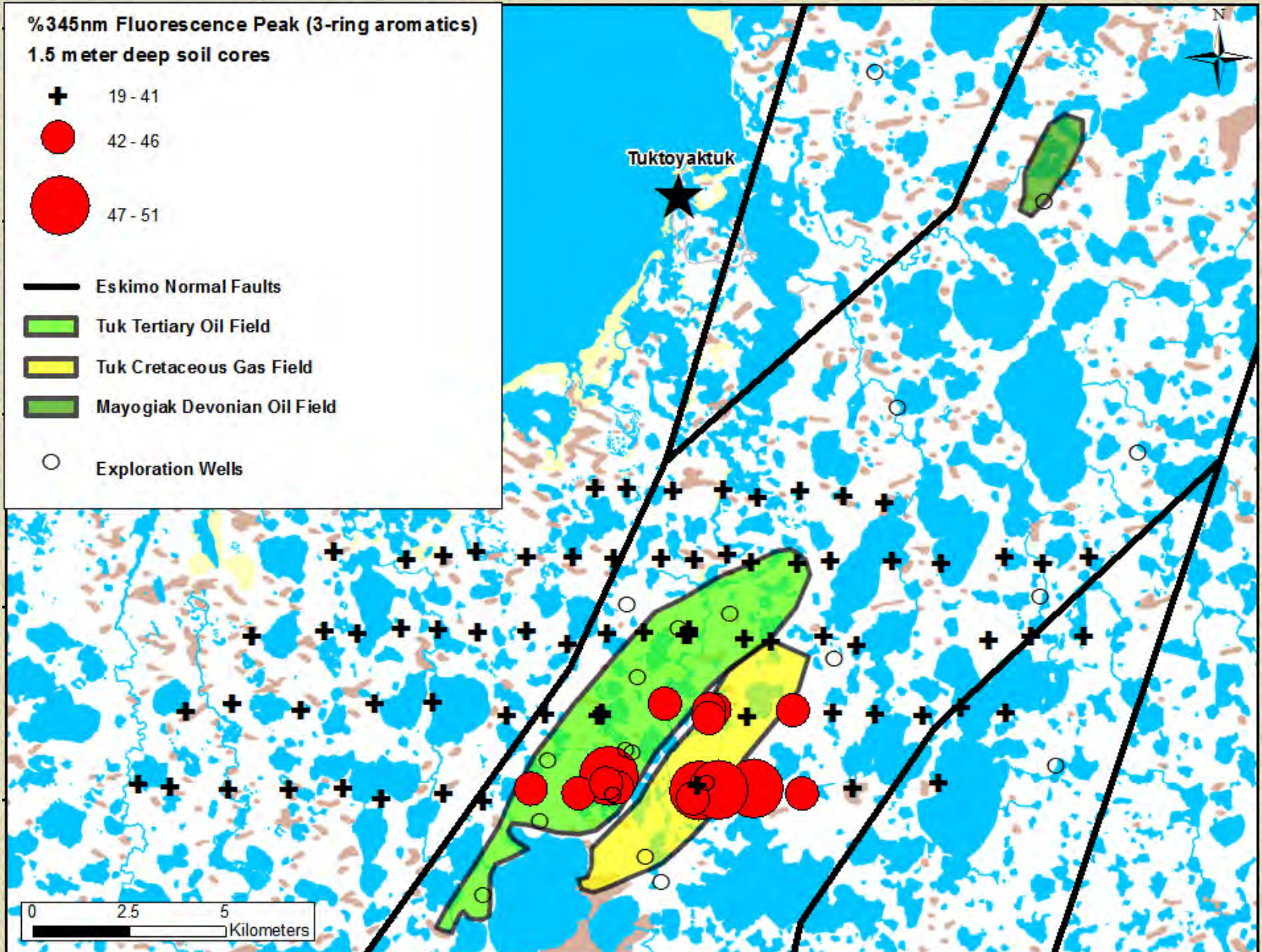
Headspace Gas



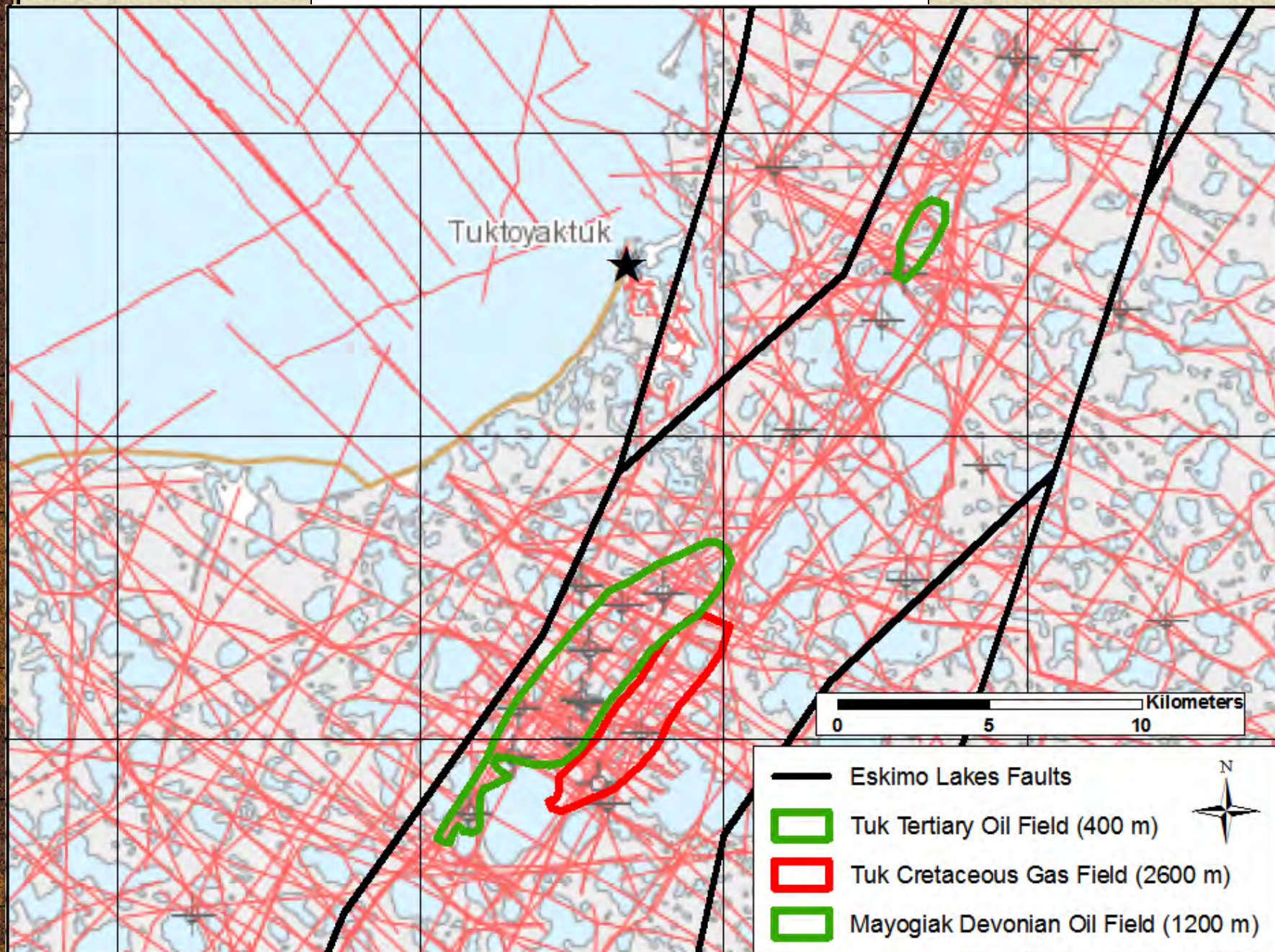
Correlation of Headspace and Blender C2-C3-C4 Gas



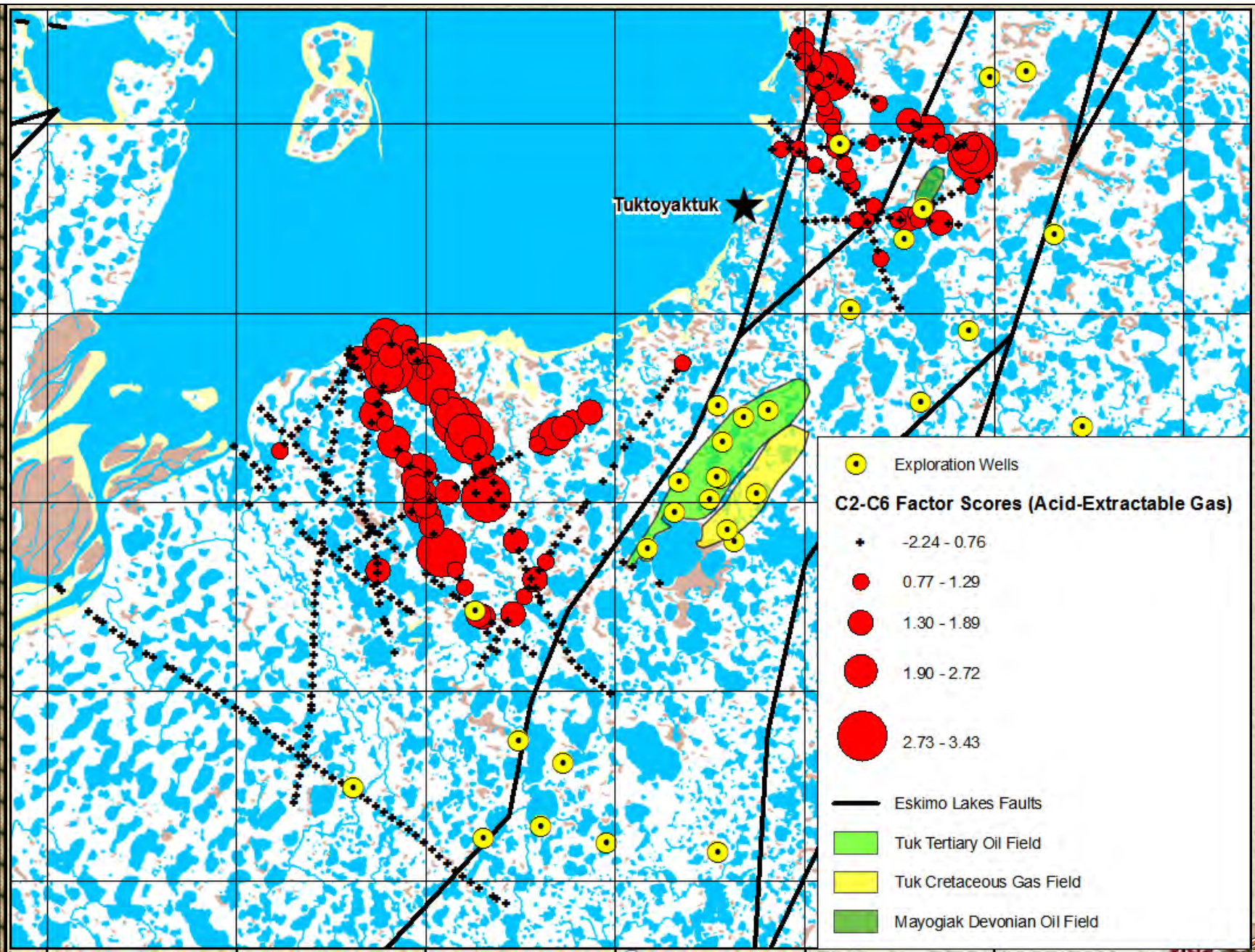
Fluorescence Anomalies (%345nm Peak – 3-ring aromatics)



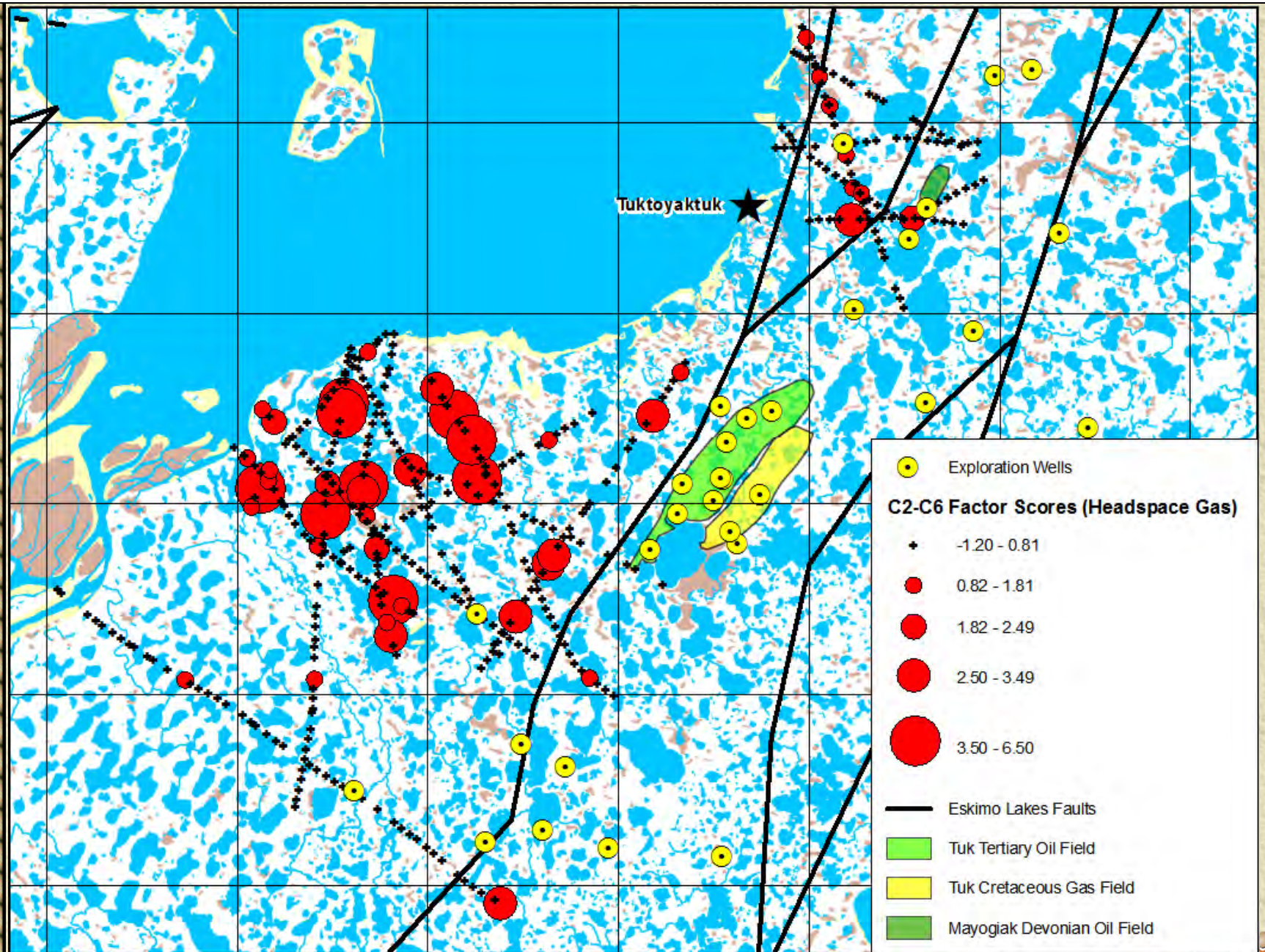
Structural Lineaments



Acid-extractable C2-C6 Factor Scores (Shot-hole Sediments)



Acid-extractable C2-C6 Factor Scores (Shot-hole Sediments)



Conclusions and Recommendations

- *All sample media and analytical methods provide indications of oil & gas fields.*
- *Headspace gas in lake sediments and acid-extractable gas and aromatics in soil cores and shot-hole sediments are optimal.*
- *Headspace/blender gas and acid-extractable gas have different mineralogical sources in soils and shot-holes.*
- *Hydrocarbon anomalies are correlated with higher lineament density.*
- *C2-C6 anomalies in shot-holes west and north of Tuk warrant follow-up.*