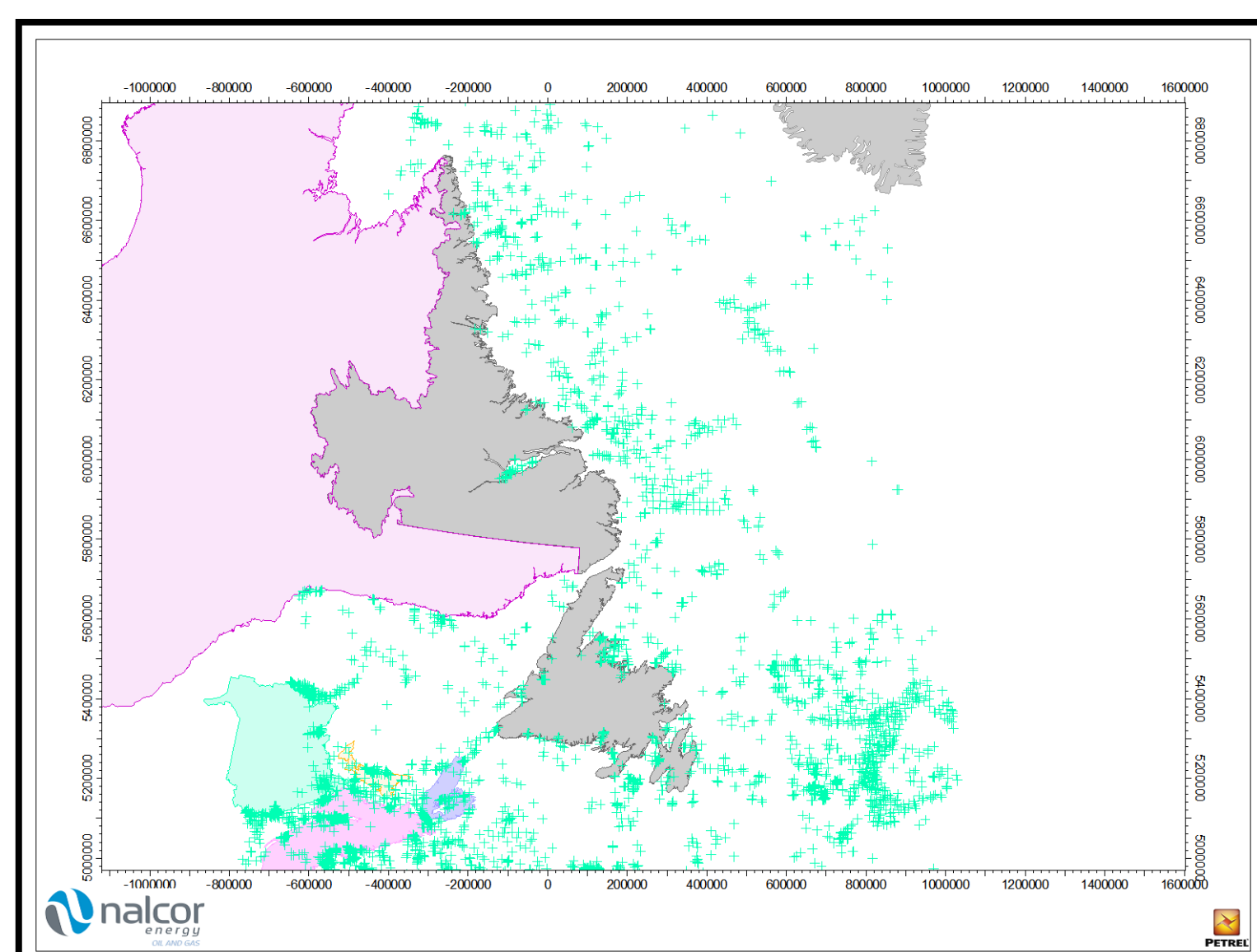


# Analysis of Preserved Ocean Floor Cores for Hydrocarbons East Coast of Newfoundland and Labrador

## Overview

- An extensive library of ocean seabed core samples exist for the east coast of Canada collected over a period from 1965 to present
- These are stored at the Geological Survey of Canada at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia.
- 170 cores were selected by Nalcor Energy Oil and Gas as a pilot program to perform geochemical sampling from areas off the coast of Newfoundland and Labrador.
- Objective was to determine if there are indications of petroleum hydrocarbons on any of the cores.
- Amplified Geochemical Imaging<sup>SM</sup> technology was utilized to geochemically sample the cores for the presence of hydrocarbons at nanogram ( $10^{-9}$ ) levels.

## Location of Cores Collected Offshore Eastern Canada (1965 to 2011)



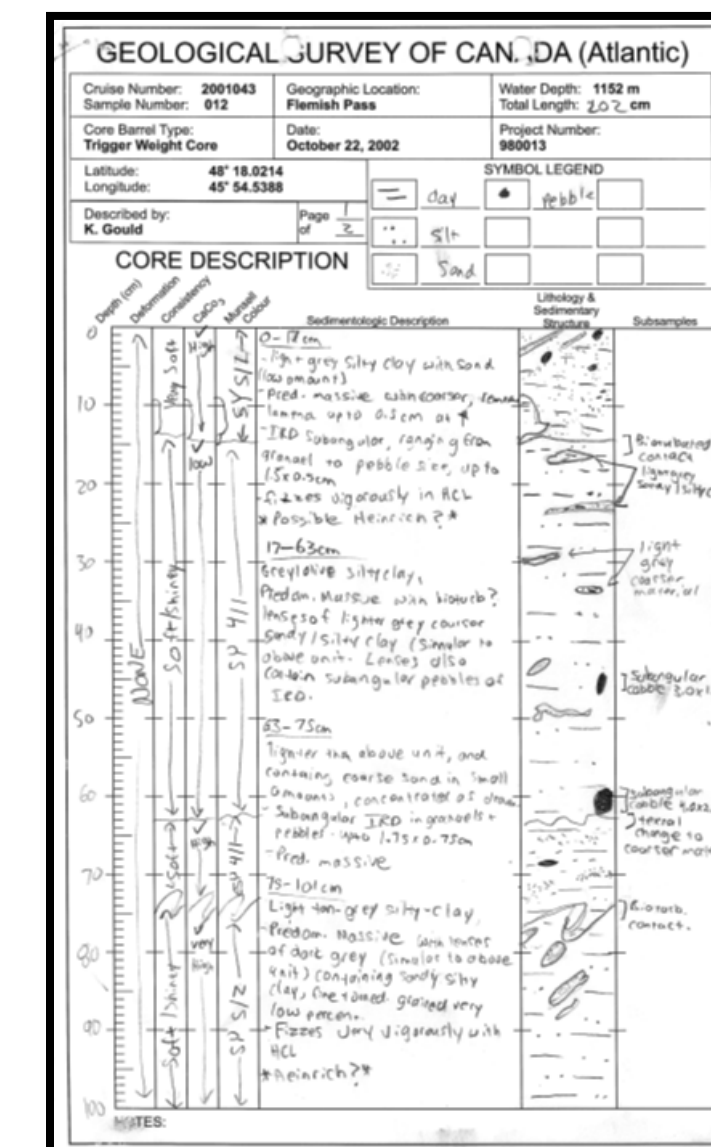
## BIO Storage Facility for Cores



## Split Cores, Labeled and Sealed for Preservation



## Detailed Core Descriptions



## Analysis of Preserved Ocean Floor Cores

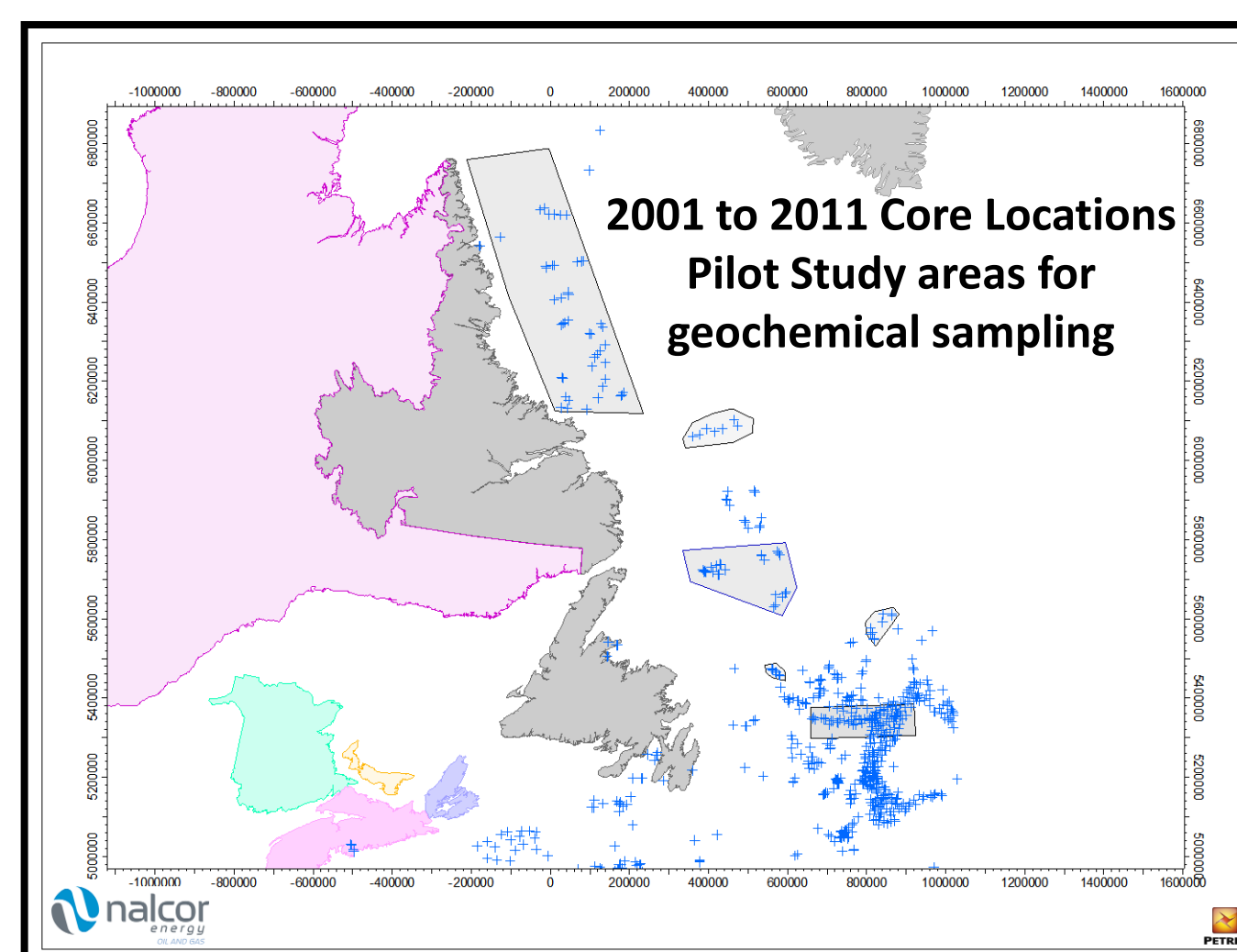
- Sampling is performed by experienced technician in a similar way to fresh offshore cores
- Exposure of approximately 60cc of core sediment to a Gore® module
- Analysis of module using Thermal desorption/gas chromatography/mass spectrometry
- Detection of hydrocarbons in nanograms for both microseepage and macroseepage signals in the  $C^2$  to  $C^{20}$  range.
- Statistical data processing to identify gas phase or liquid phase from background

## Core Sampling Bedford Institute of Oceanography



- Cores were accessed by personnel from the Geological Survey of Canada
- GORE contracted Peregrine Ventures to conduct core subcrop sampling
- 170 Cores were sampled over a 7 day period

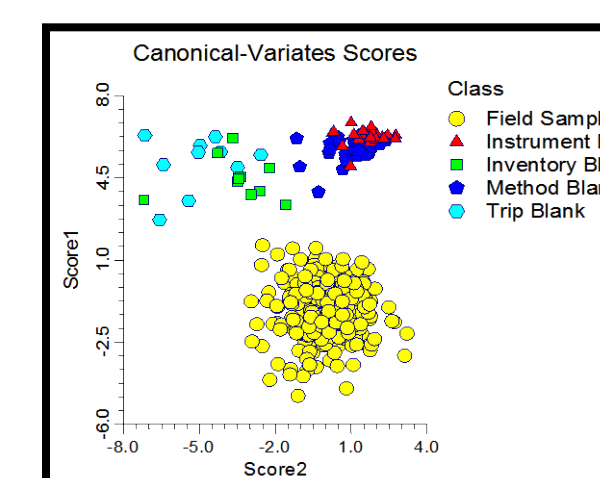
## 2001 -2011 Core Locations



## Analysis Gore Laboratory



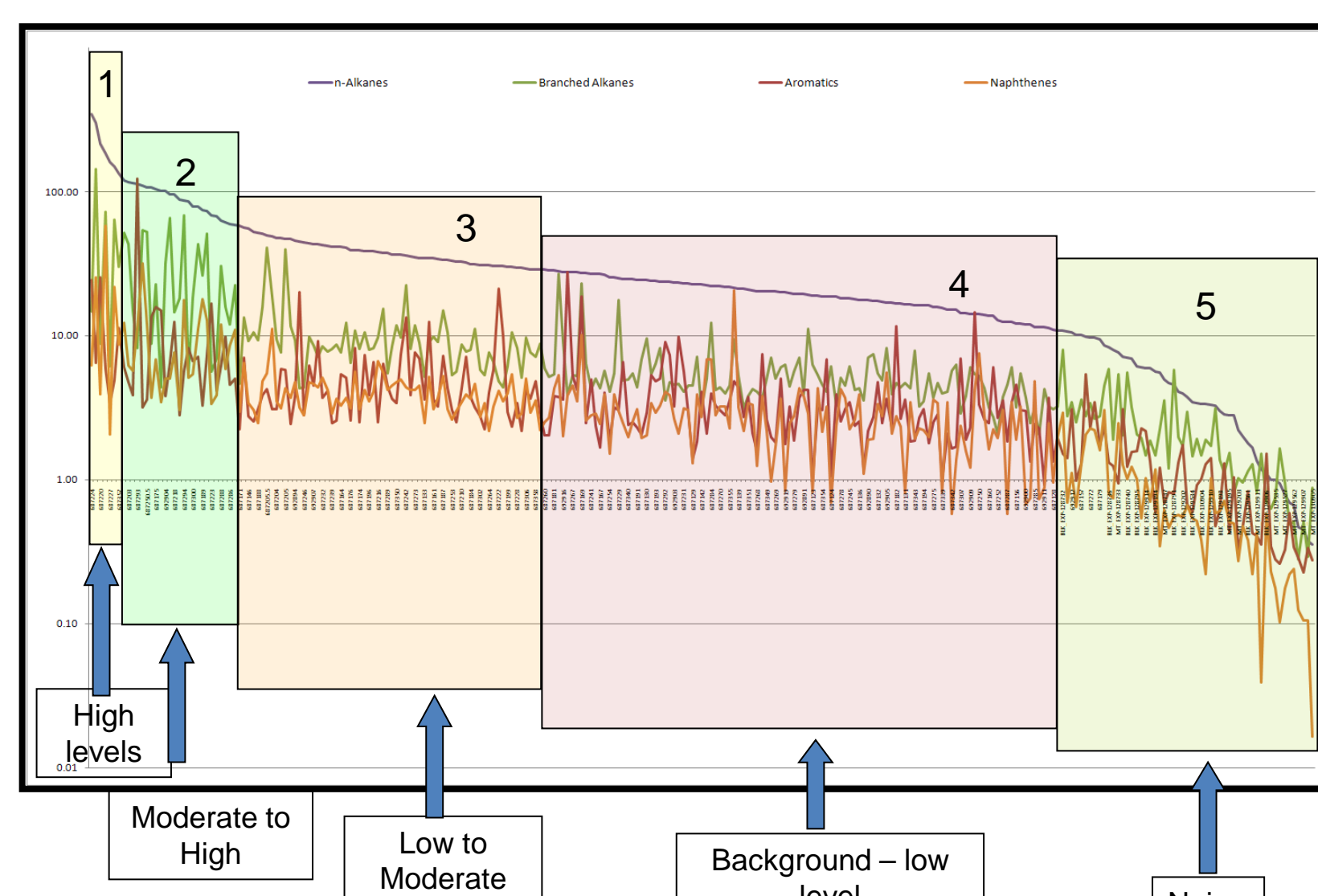
- 20 day exposure period
- TD/GC/MS analysis in controlled laboratory
- Rich mass data set
- [80+ compounds,  $C_2$  thru  $C_{20}$ ]



## Analytical Compound List by Compound Class: $C_2$ – $C_{20}$

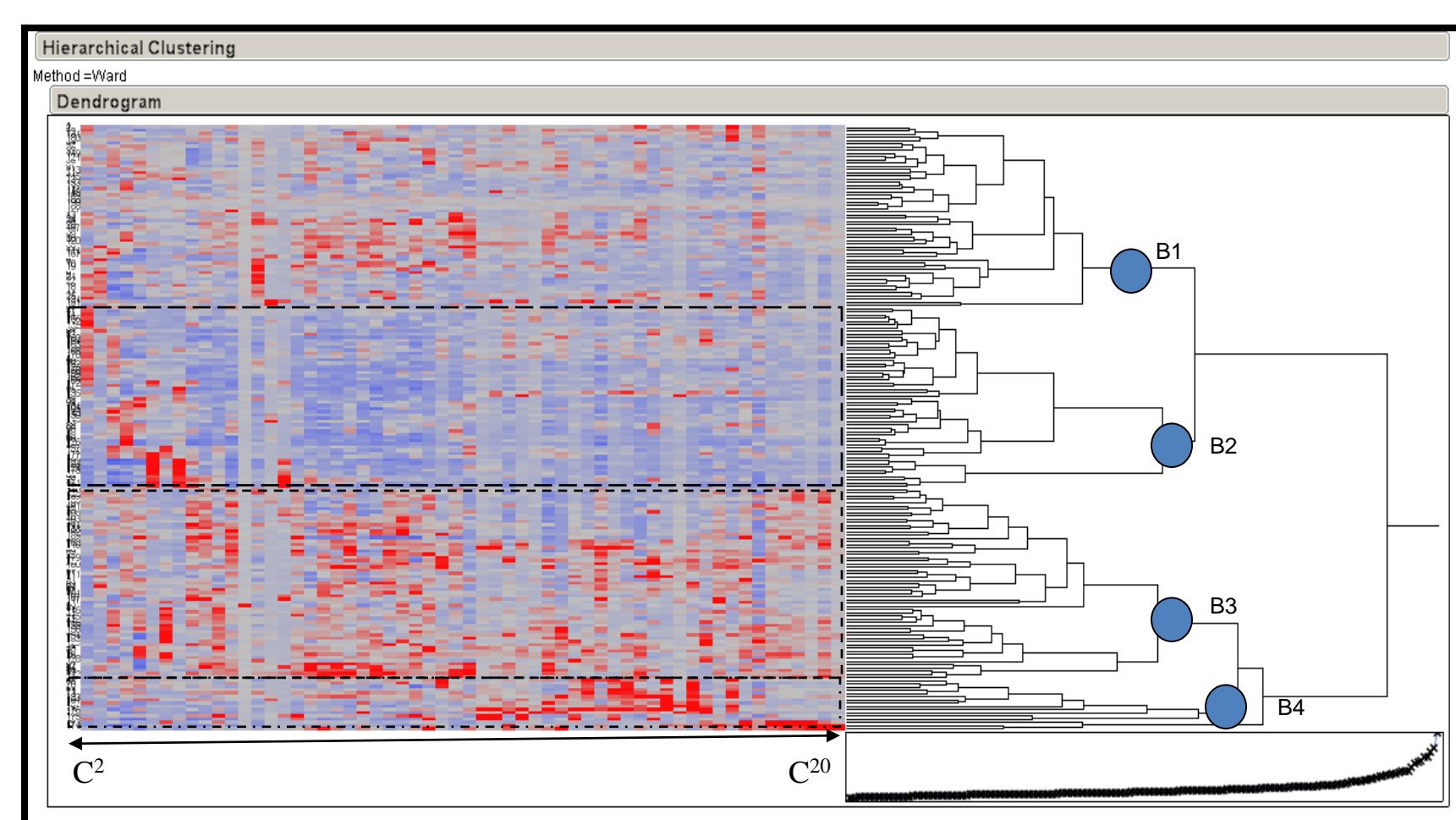
Typical Petroleum Constituents Hydrocarbon number in ( )			
Normal Alkanes	Iso-alkanes	Cyclic Alkanes	Aromatics and PAH*
Ethane (2) Propane (3) Butane (4) Pentane (5) Hexane (6) Heptane (7) Octane (8) Nonane (9) Decane (10) Undecane (11) Dodecane (12) Tridecane (13) Tetradecane (14) Pentadecane (15) Hexadecane (16) Heptadecane (17) Octadecane (18)	2-Methylbutane (5) 2-Methylpentane (6) 3-Methylpentane (6) 2,4-Dimethylpentane (7) 2-Methylhexane (7) 3-Methylhexane (7) 2,5-Dimethylhexane (8) 3-Methylheptane (8) 2,6-Dimethylheptane (9) Pristane (19) Phytane (20)	Cyclopentane (5) Methylcyclopentane (6) Cyclohexane (6) cis-1,3-Dimethylcyclopentane (7) trans-1,3-Dimethylcyclopentane (7) trans-1,2-Dimethylcyclopentane (7) Methylcyclohexane (7) Cycloheptane (7) cis-1,3,4-Dimethylcyclohexane (8) cis-1,2-Dimethylcyclohexane (8) trans-1,3,1,4-Dimethylcyclohexane (8) Ethylcyclohexane (8) Cyclooctane (8) Propylcyclohexane (9)	Benzene (6) Toluene (7) Ethylbenzene (8) m,p-Xylenes (8) o-Xylene (8) Propylbenzene (9) 1-Ethyl-2/3-methylbenzene (9) 1,3,5-Trimethylbenzene (9) 1-Ethyl-4-methylbenzene (9) 1,2,4-Trimethylbenzene (9) Indane (9) Indene (9) Butylbenzene (10) 1,2,4,5-Tetramethylbenzene (10) Naphthalene (10) 2-Methylnaphthalene (11)
Byproduct / Alteration and Other Compounds			
Alkenes	Aldehydes	Biogenic	NSO* and Other Compounds
Ethene (2) Propene (3) 1-Butene (4) 1-Pentene (5) 1-Hexene (6) 1-Heptene (7) 1-Octene (8) 1-Nonene (9) 1-Decene (10) 1-Undecene (11)	Octanal (8) Nonanal (9) Decanal (10)	alpha-Pinene beta-Pinene Camphor Caryophyllene	Furan 2-Methylfuran Carbon Disulfide Benzofuran Benzothiazole Acenaphthylene

## Summed a-alkanes



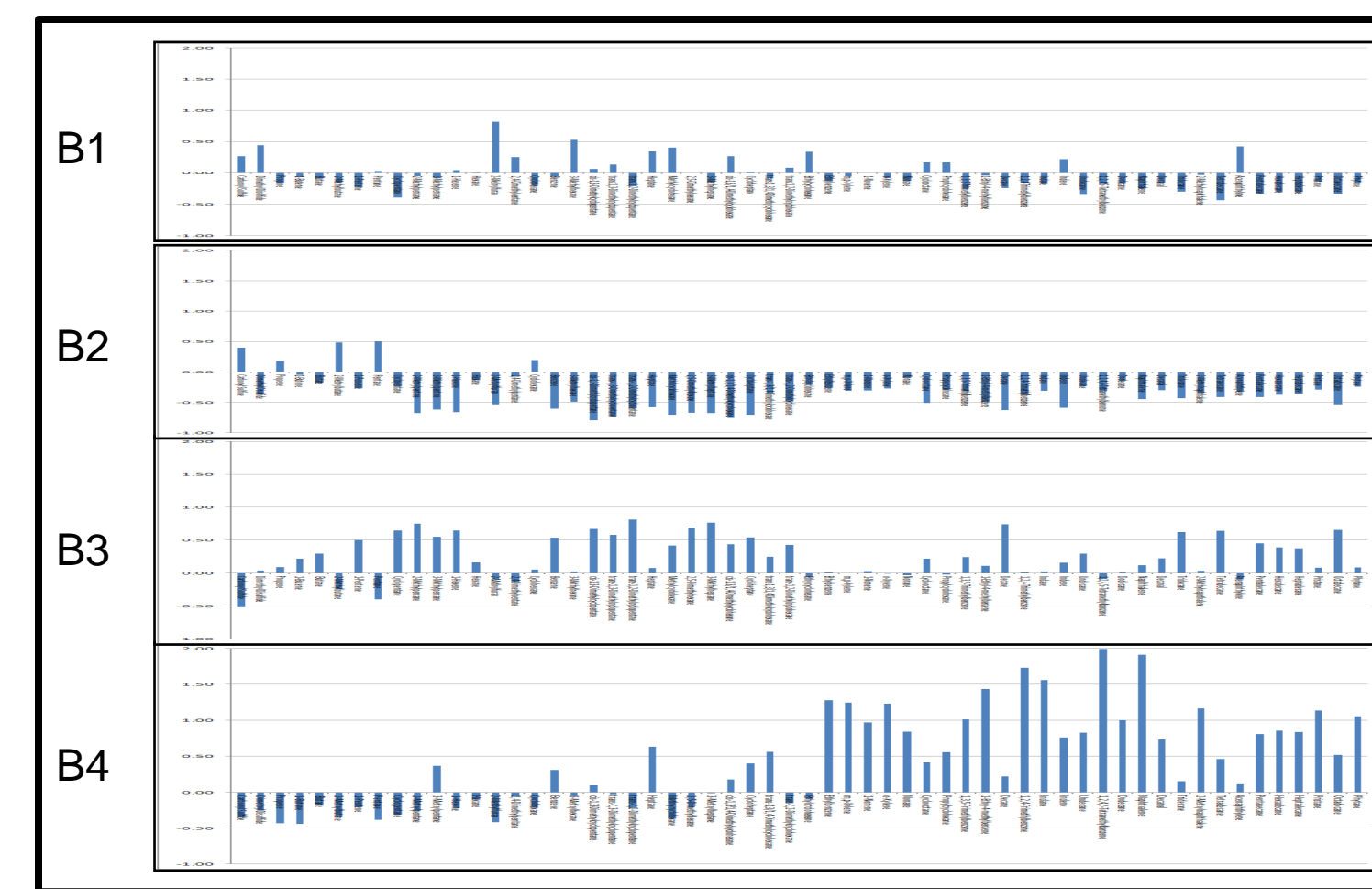
High levels have summed n-alkanes > 115 ng. Moderate to high are 55 – 115, low to moderate are 30 – 55, background – low levels are between 12 and 30, and Noise levels are less than 12 ng.

## Hierarchical Cluster Analysis of the Data Set

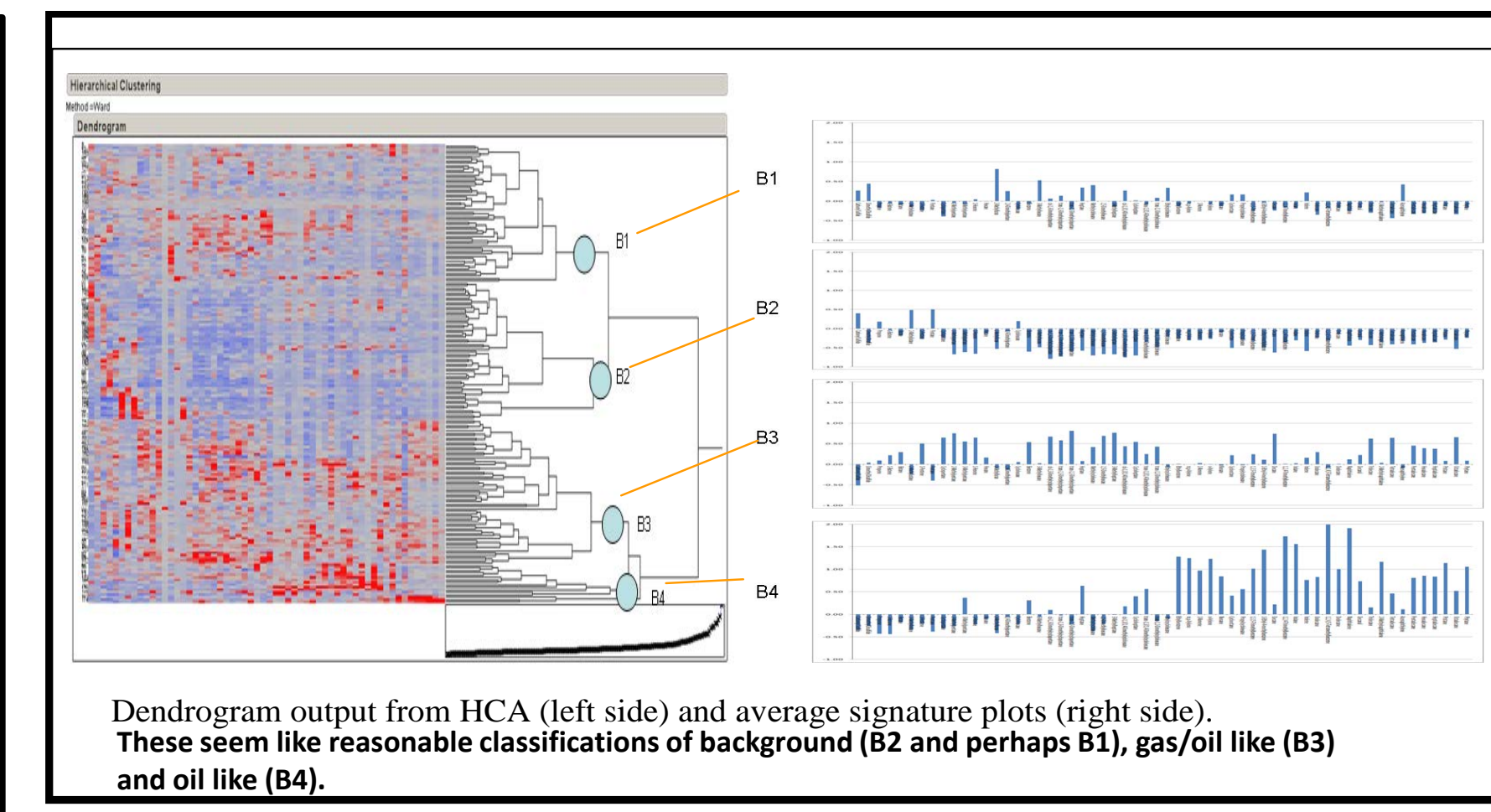


This HCA output has identified 4 primary groups and their average signatures are on the following slide.

## Hydrocarbon Signatures from Cluster

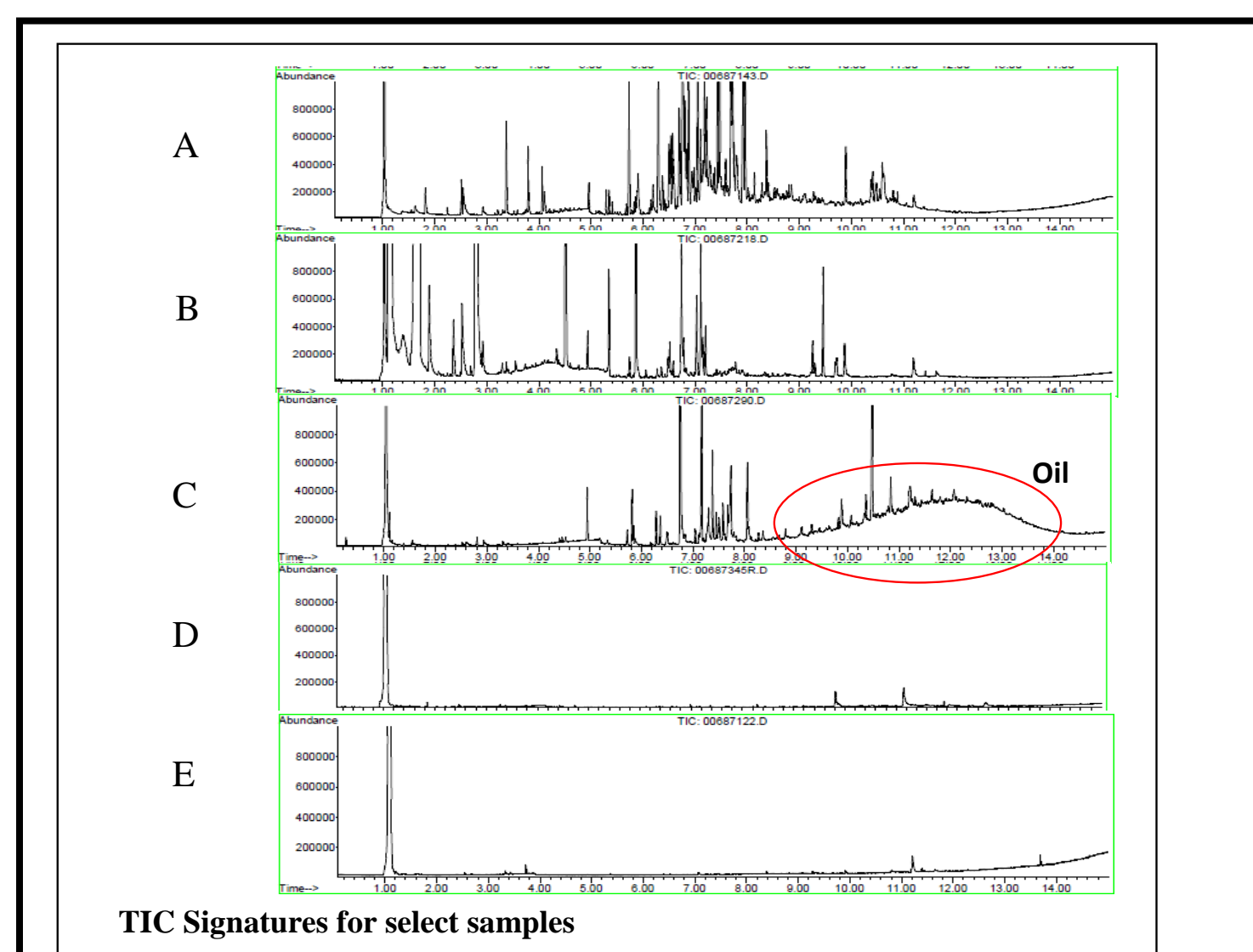


## Cluster Groups and Hydrocarbon Signatures



Dendrogram output from HCA (left side) and average signature plots (right side). These seem like reasonable classifications of background (B2 and perhaps B1), gas/oil like (B3) and oil like (B4).

## Total Ion Chromatograms of Select Sample Groups



## Conclusions of Preserved Ocean Floor Core

- Cores that have been collected and stored properly could have valuable geochemical signal even after years in storage
- Well preserved cores are usually:
  - Sealed and encased in plastic or some other material to retain core integrity and moisture
  - Refrigerated or Frozen Cores are desirable
  - Cores should be stored in a clean environment away from volatile organics
- Hydrocarbon signal has been detected on Well Preserved cores as old as 10 years, in this case back to 2001
- The results can provide information on hydrocarbon potential and phase in underexplored areas
- The encouraging results from the pilot study have lead to the planning of a larger more comprehensive follow on study

## Acknowledgements

- Nalcor Energy Oil and Gas
  - Geological Survey of Canada
  - GeoChemTech Inc.
  - Peregrine Ventures Inc.
- Prepared by  
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