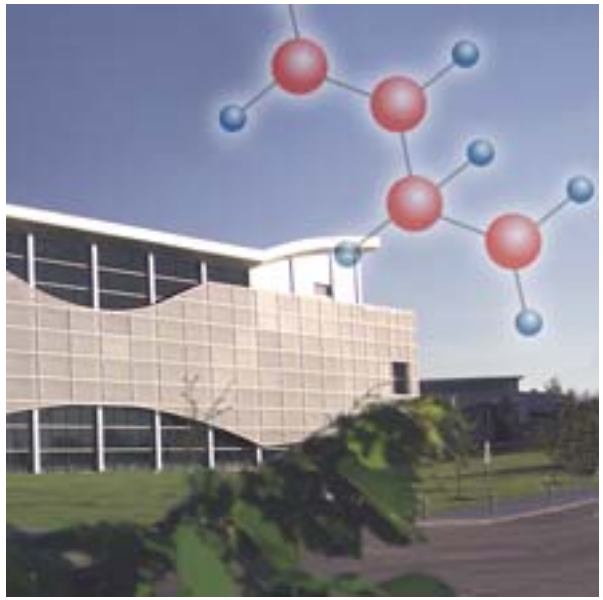




Hydrocarbon Delineation in Muskeg: Distinguishing Biogenic from Petrogenic Sources

ESSA Remediation Technologies Symposium

October, 2006

Presented by: Craig Harris

UMA | AECOM

Outline of Presentation

- Introduction and Challenges in Muskeg Environments
- Clients Objectives and Analytical Approach
- Soil Physical-Chemical Characteristics (Box Plots)
- GC-FID and GC-MS Chromatograms
- *Approach to Establish *True* Biogenic Source
- Recommended Analytical Program and Corrections for Biogenic Input

Introduction & Objective

Upstream emulsion flow line rupture releasing a saline, sour crude into a low lying muskeg setting in NE British Columbia.

Containment and Recovery

Conductivity Survey with Soil Investigations

Regulatory Agencies

– Challenging Environments
  - Access challenges
  - Analytical challenges

– Client Objectives
  - Distinguish and quantify biogenic influences
  - Analytical program to facilitate delineation

Analytical Approach

Primary analytical methods -

- GC-FID analysis of hexane/acetone extract (EPH)
  - Fraction quantified: C_{10}-C_{19} and C_{19}-C_{32}
- GC-FID analysis of silica gel EPH extract
- GC-MS Open Characterization
  - Carbon Preference Index (CPI)
  - Unresolved Complex Mixture (UCM)

Considered, but not used -

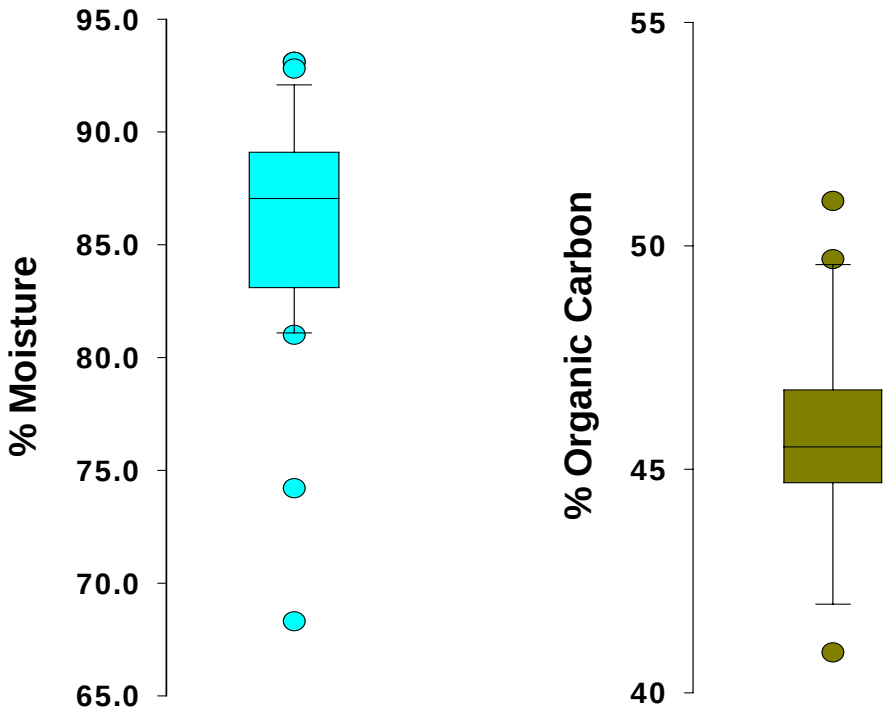
- Aromatic vs. Aliphatic Fractionation
- GC-MS Library
- Isotopic Ratios and Biomarkers

Supporting Literature – CPI/UCM

Studies on Distribution and Origin of Hydrocarbons in Estuary Sediment.

- J. Colombo et al. (1989)
  - Use of *n*-alkane (CPI) and PAH distribution indexes in Rio de La Plata Estuary, Argentina.
- V. Choiseul et al. (1998)
  - Use of UCM and CPI to study the distribution of hydrocarbons in the Liffey Estuary, South – West Irish Coast
- K. Tran et al.
  - Use of *n*-alkane ratios (CPI), UCM and various PAH ratios to determine petrogenic from biogenic sources off San Diego, USA

Peat Soil – High Moisture and Organic Carbon



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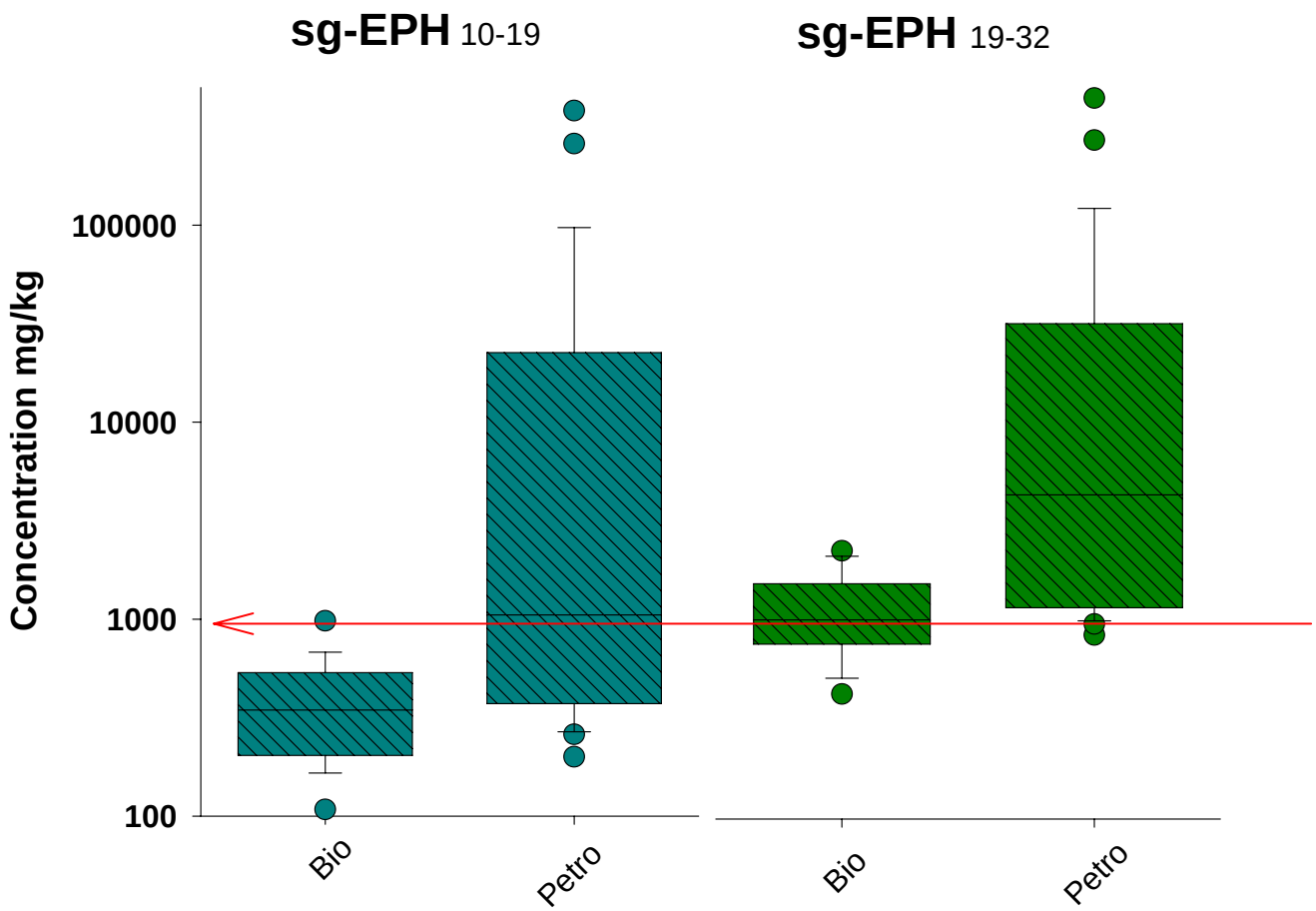
Silica Gel Extractable Petroleum Hydrocarbons



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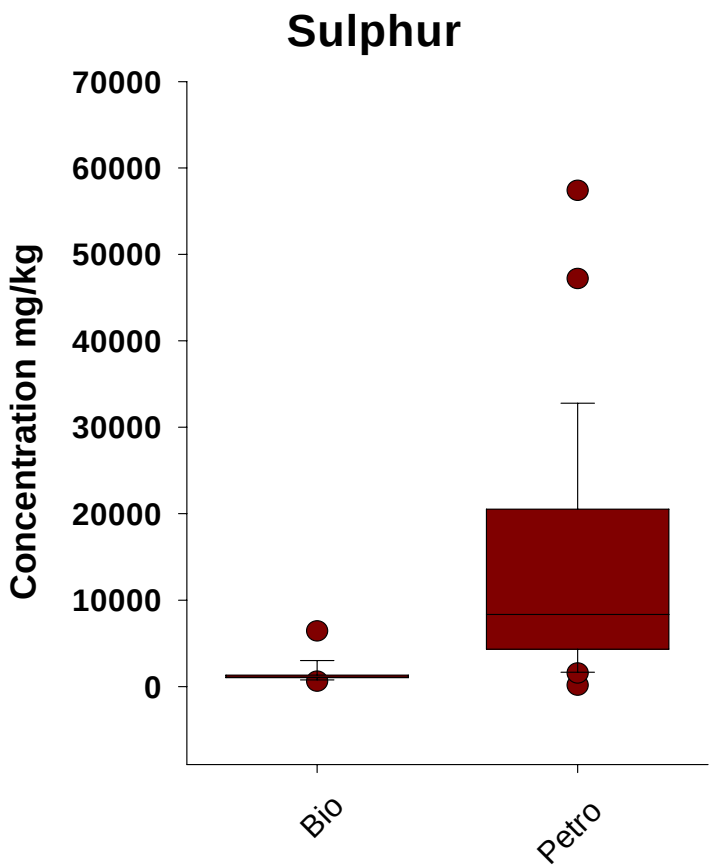
Sulphur Concentration



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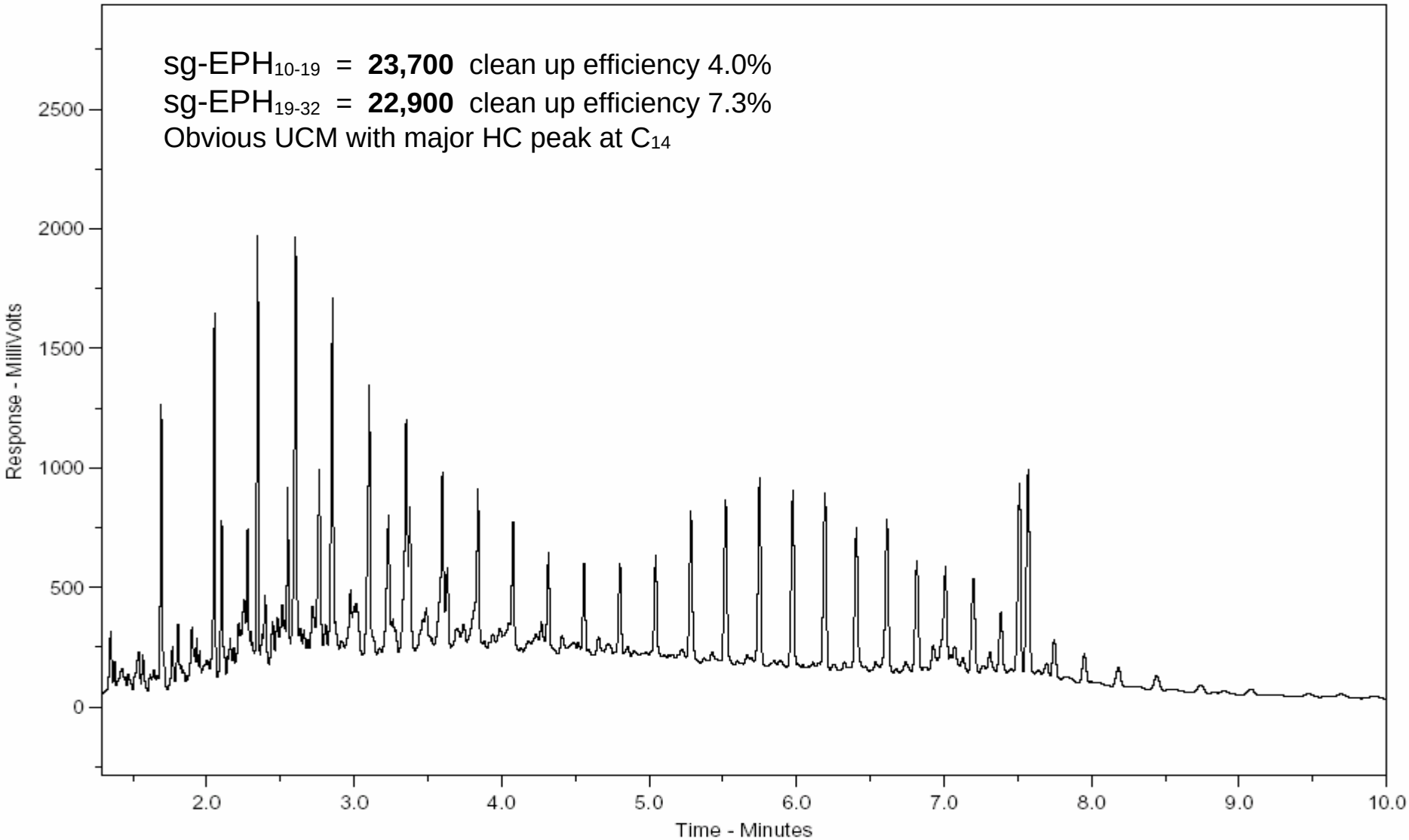
GC-FID Chromatogram for Petrogenic Source



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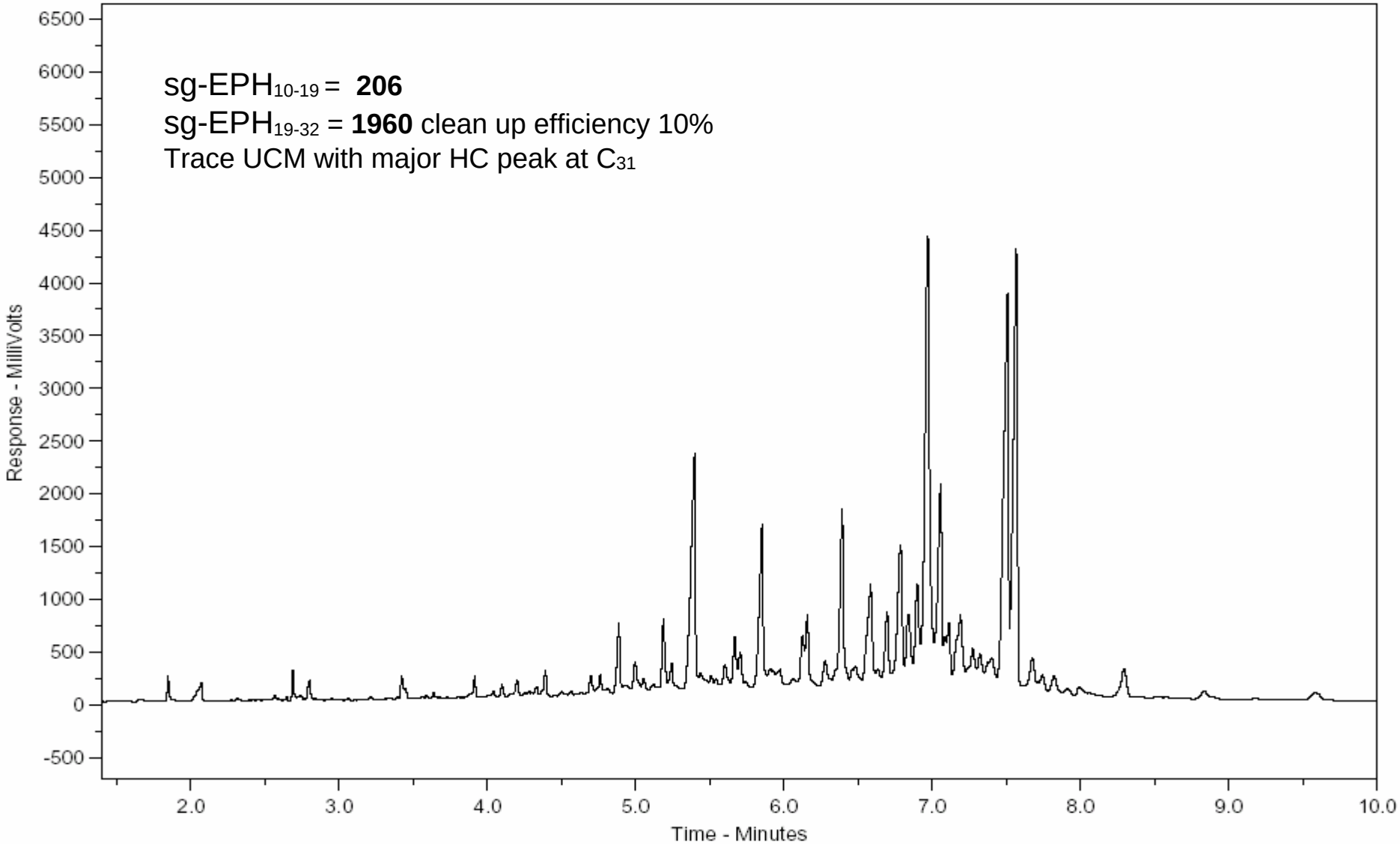
GC-FID Chromatogram for Biogenic Sample



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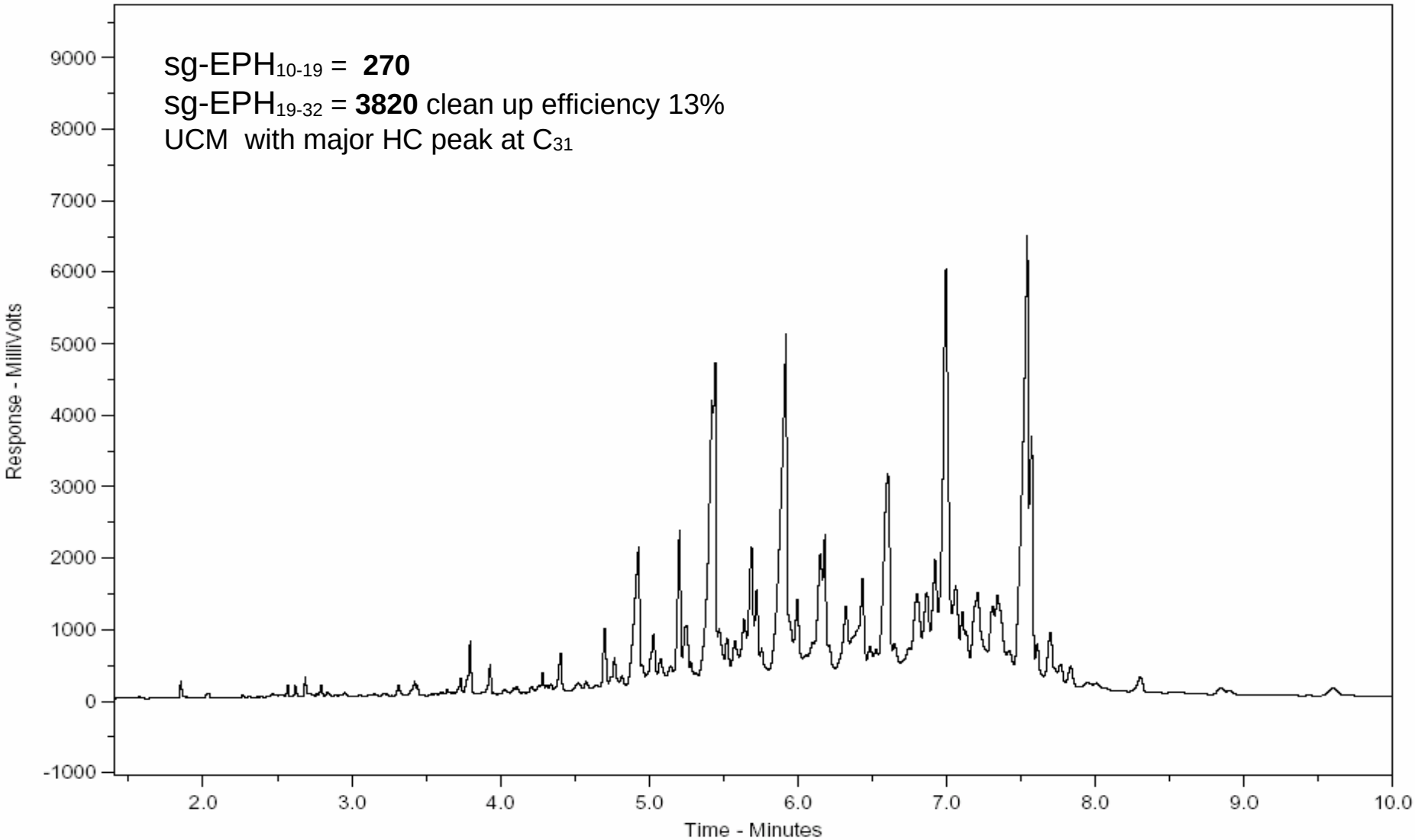
GC FID Chromatogram for Biogenic -Petrogenic Mix



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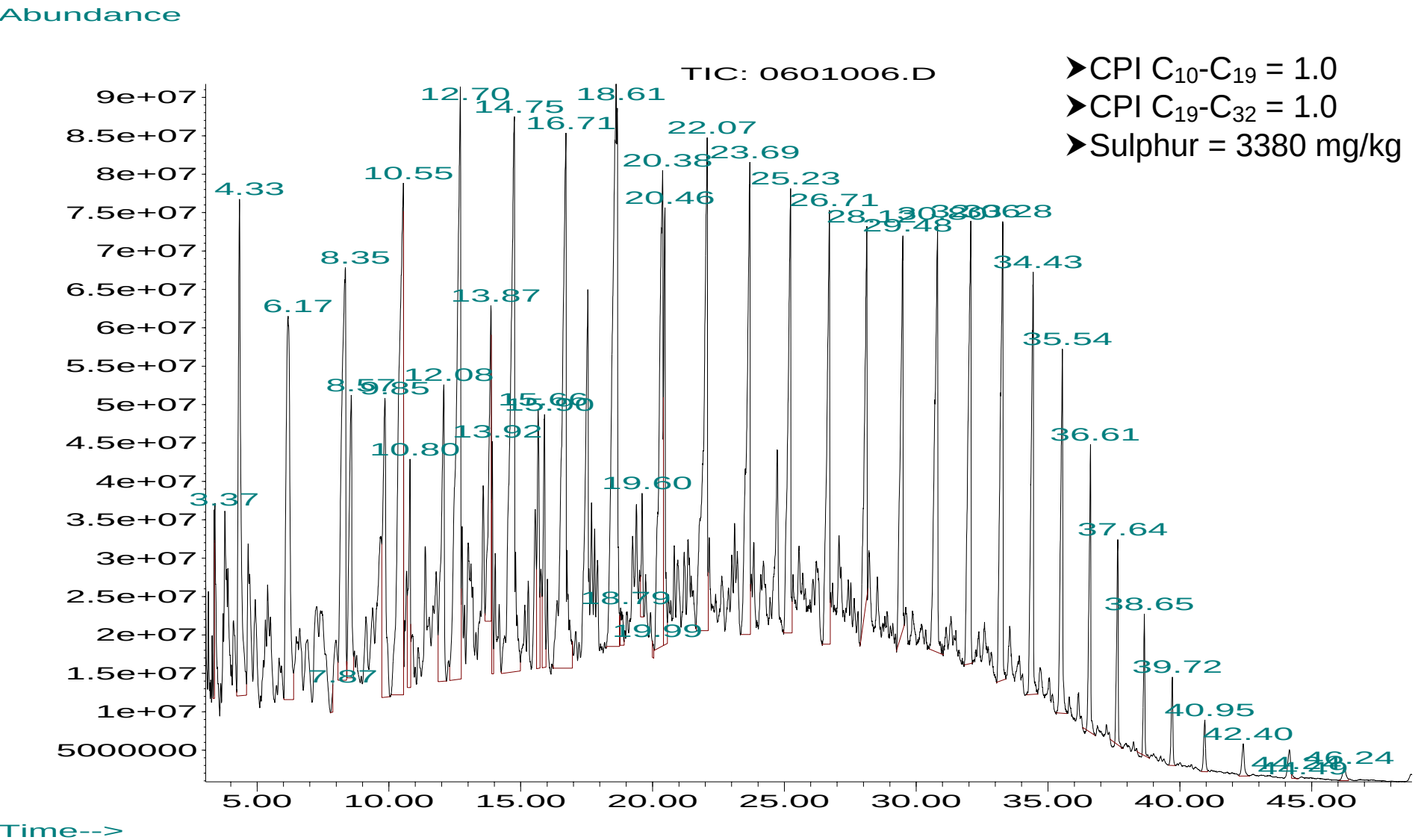
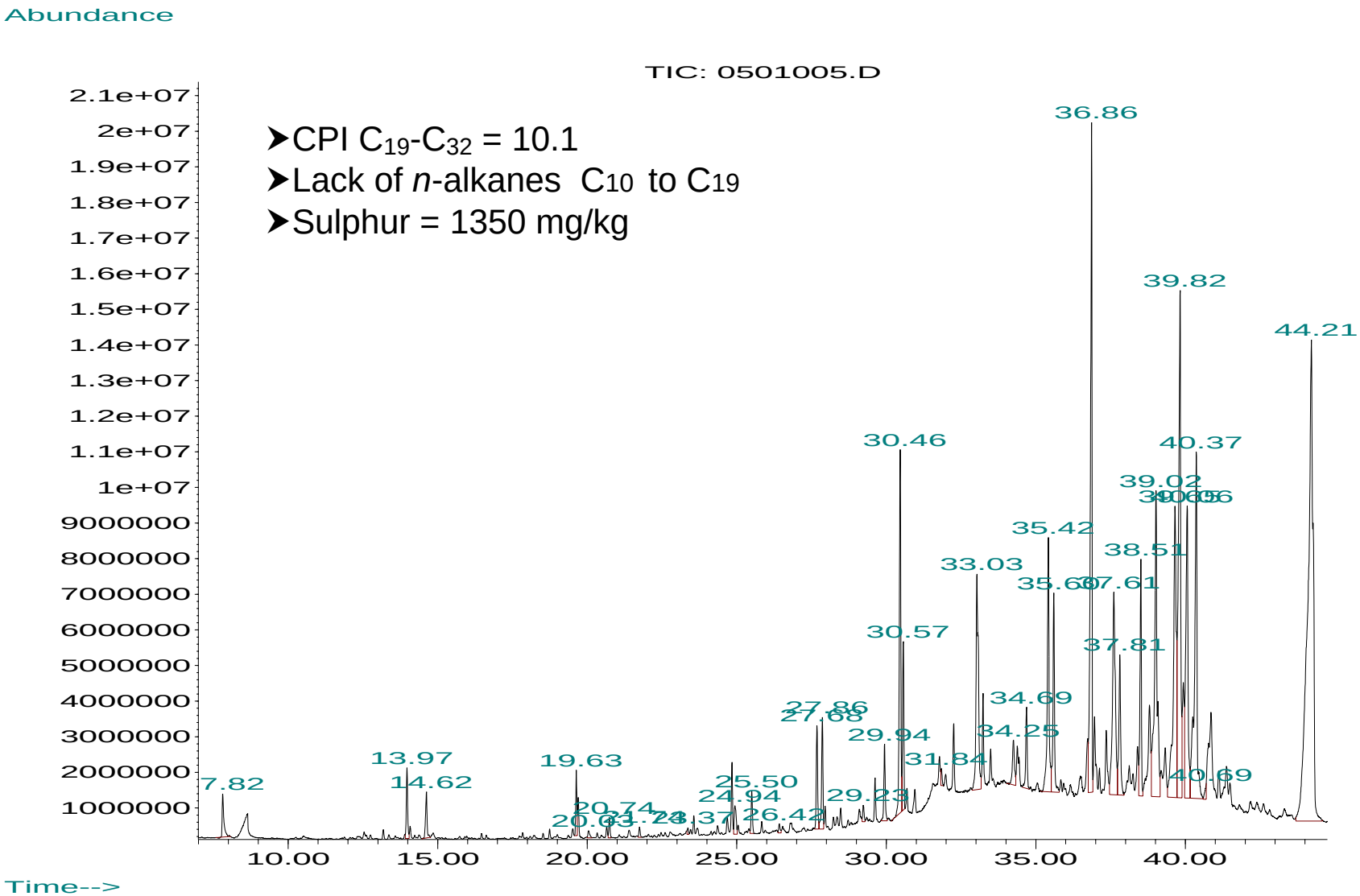
GCMS Total Ion Chromatogram: Petrogenic Source



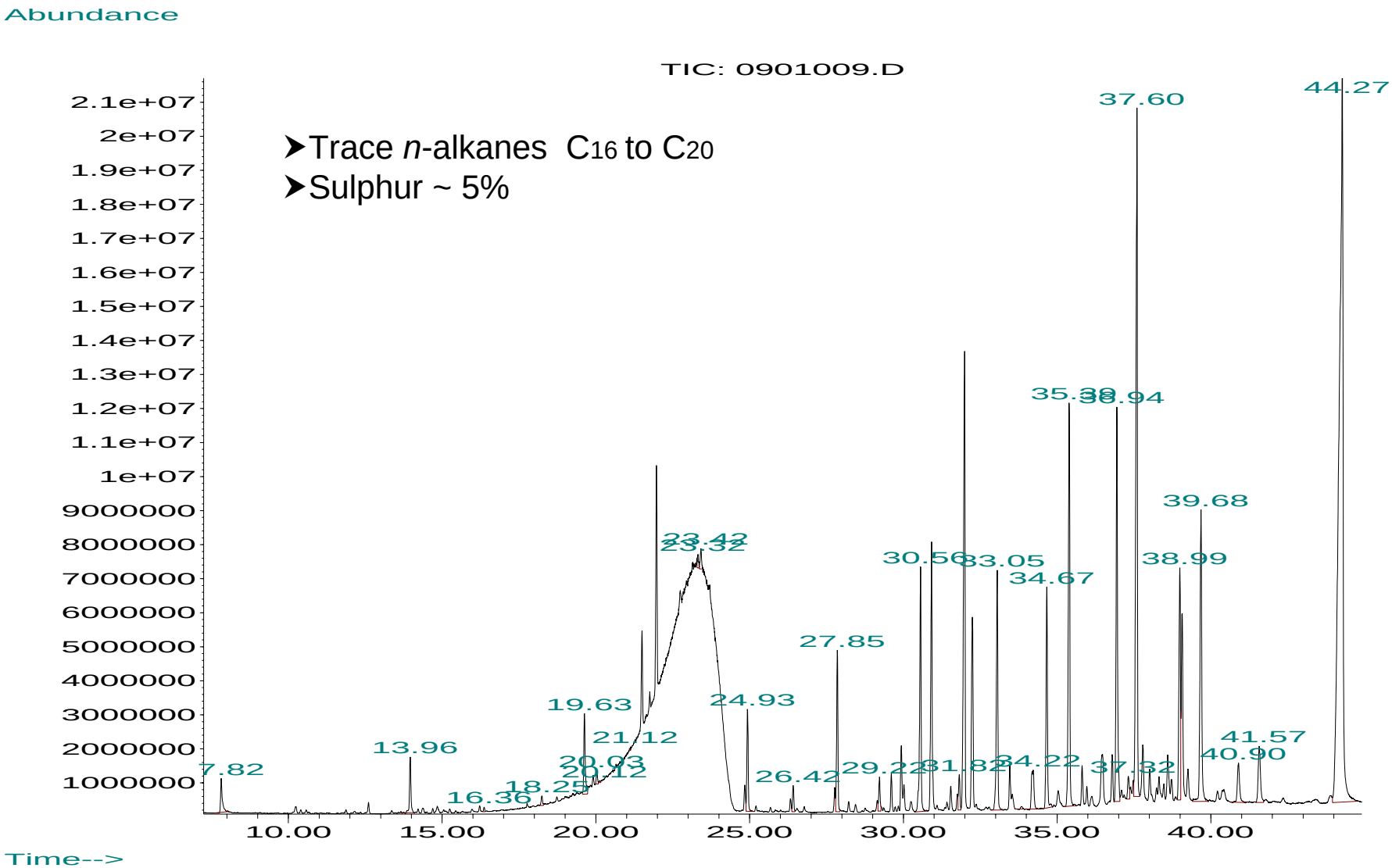
- CPI C_{10}-C_{19} = 1.0
- CPI C_{19}-C_{32} = 1.0
- Sulphur = 3380 mg/kg

GCMS Total Ion Chromatogram: Biogenic Sample



- CPI C_{19}-C_{32} = 10.1
- Lack of *n*-alkanes C_{10} to C_{19}
- Sulphur = 1350 mg/kg

GCMS Total Ion Chromatogram: Biogenic-Petrogenic Mix



- Trace *n*-alkanes C_{16} to C_{20}
- Sulphur ~ 5%

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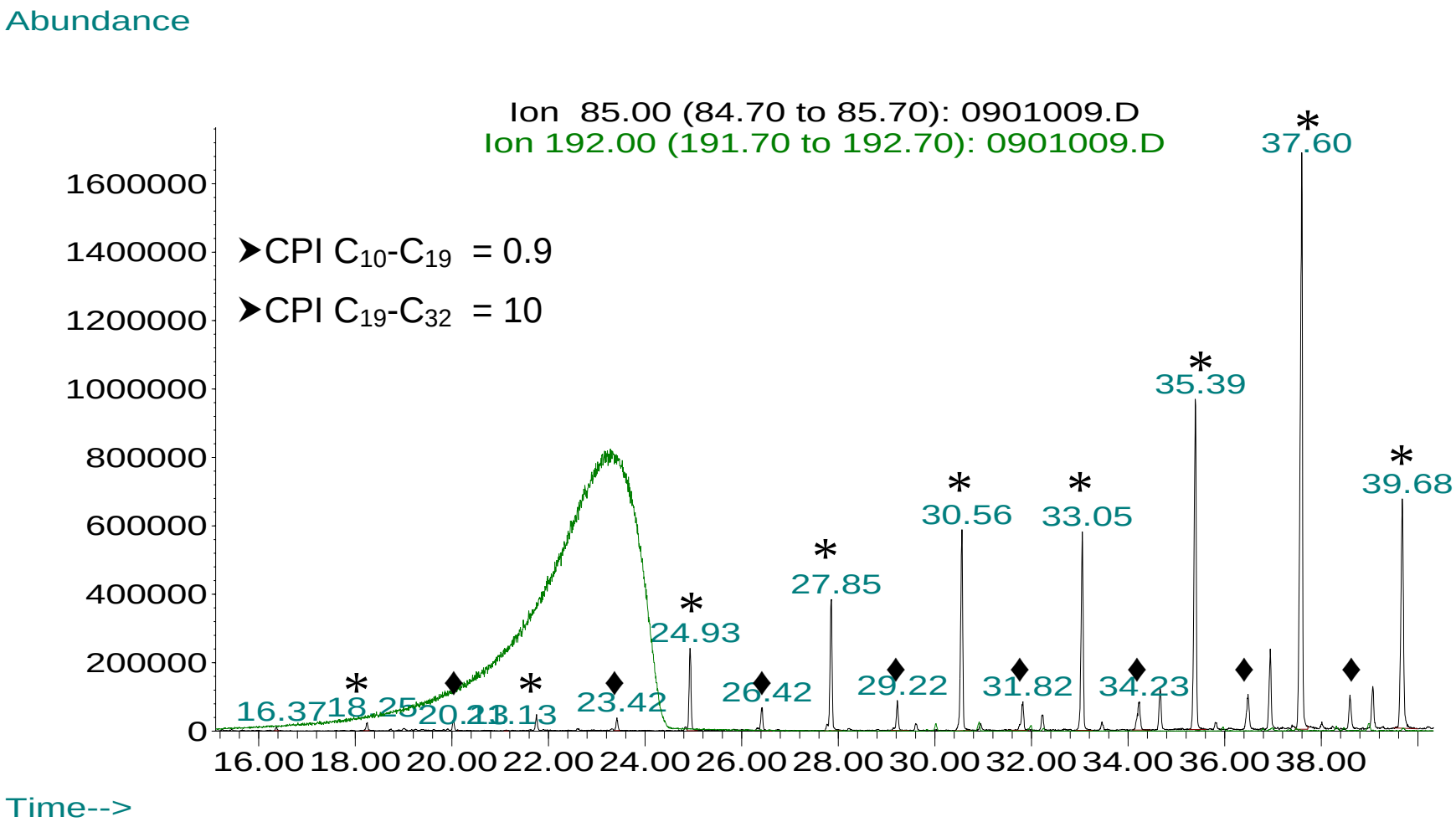
GC-MS Scan Alkanes + Sulphur: Petrogenic-Biogenic Mix



*= odd carbon # n-alkanes ♦= even carbon # n-alkanes

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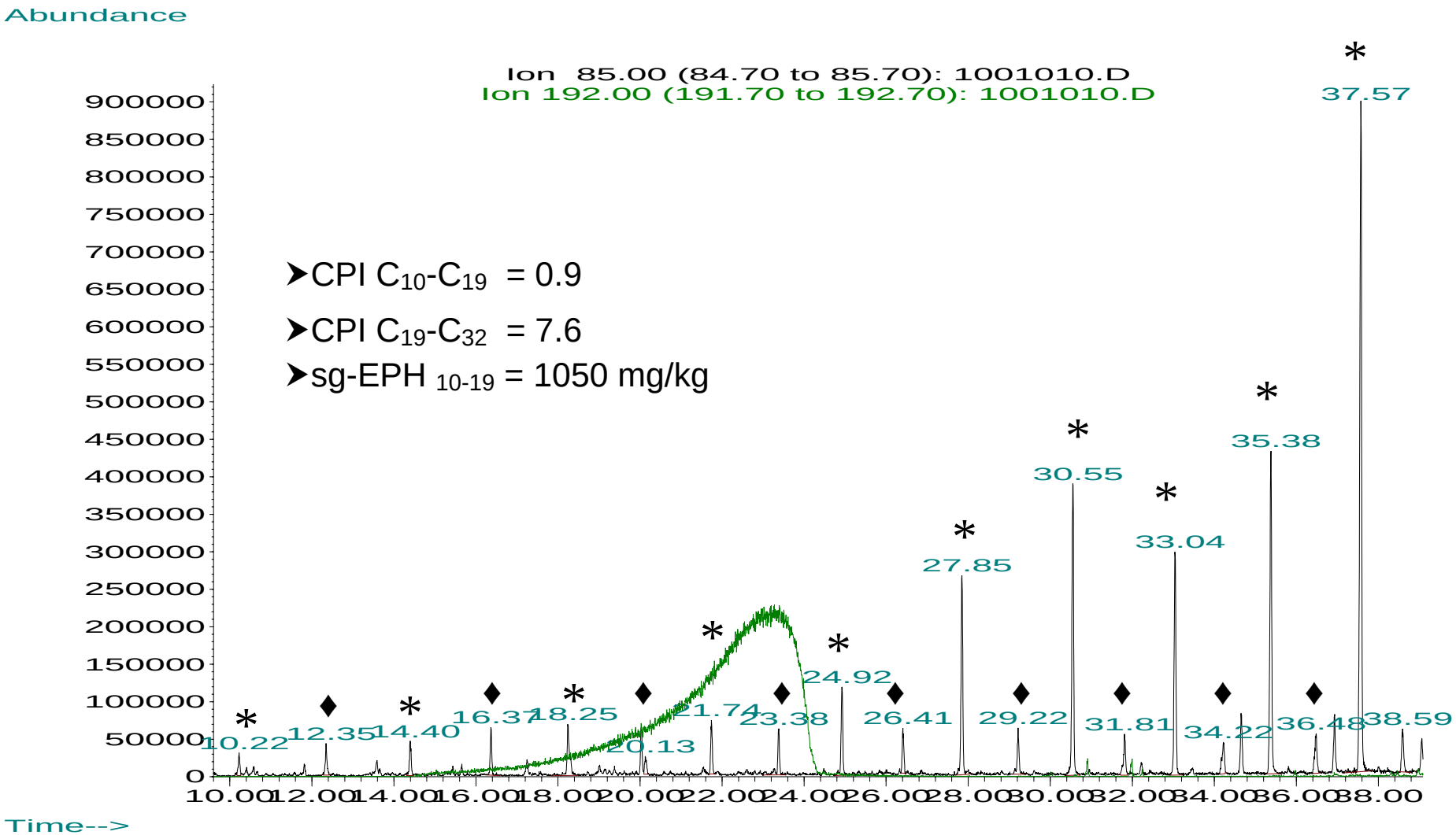
Petrogenic-Biogenic Mix Second Example



- CPI C_{10}-C_{19} = 0.9
- CPI C_{19}-C_{32} = 7.6
- sg-EPH $_{10\text{-}19}$ = 1050 mg/kg

* = odd carbon # n-alkanes ♦ = even carbon # n-alkanes

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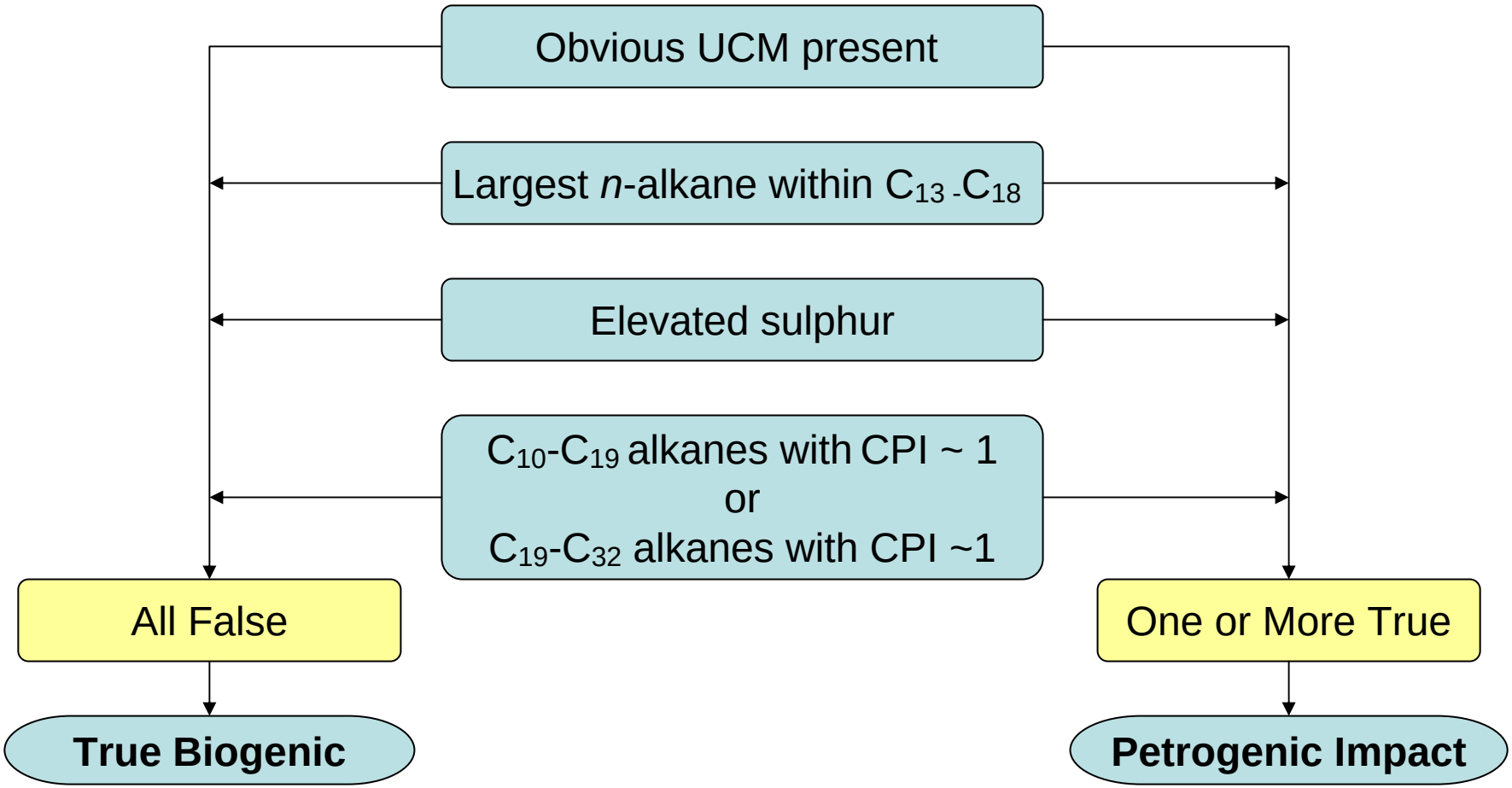
Determination of "*True Biogenic*" Samples



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Analytical Program and Definition of "*Contaminated Peat*"

Analytical Program

- Organic Carbon
- Silica Gel EPH_{10-19} and EPH_{19-32}
- Total Sulphur

Determination of "*Contaminated Peat*"

- sg-EPH_{10-19} compared to BC CSR uncorrected
  - **[1000 mg/kg]**
- sg-EPH_{19-32} compared to BC CSR with correction
  - **[2400 mg/kg]** assumes biogenic contribution ~ 1400 mg/kg
- Total sulphur compared to mean from biogenic data
  - **[1500 mg/kg]**

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