ENERGY-FORENSICS

# Heli Source Ltd.

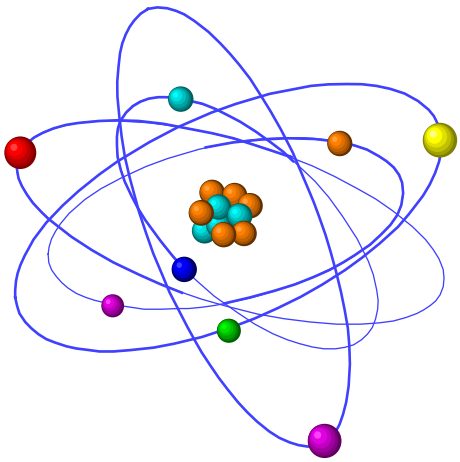
**Work Order-Ref #: 22323**

# Vapor Intrusion Assessment (VIA)

# Surface Casing Vent (SCV) Flow Test

## Cameron Hills M-74

**September 16, 2022**

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**FORENSIC SOLUTIONS FOR ENERGY CHALLENGES**

## 1.0 Vapor Intrusions Assessment (VIA) Summary

**Operating Company:** Not Provided
**Well Name:** M-74
**UWI:** M-74-60-10-117-15

**License Number:** 2063
**Test Date** September 16, 2022
**GCHEM Project Number** 22323

### 1.1 Production Casing Assessment Summary Table

| | | | |
|---|---|---|---|
| **Combustible Gas ($CH_4$) ([%LEL])** | nm | | |
| **Hydrogen Sulphide ($H_2S$) Gas (ppm v/v)** | nm | | |
| **PC Flow Rate ($m^3$/day)** | nm | | |
| **P-T Date Logger Installed** | nm | | |
| **P-T Data Logger Removed** | nm | | |
| **P-T Data Logger Test Duration** | nm | | |
| **MAX Pressure (kPa)** | nm | | |
| **Gas Spls. Collection-Measurement** | **Total Collected** | **Analysis Requested*** | **Classification**** |
| **PC Samples (Total)** | 0 | | |
| **PC Combustible Gas Class. Level-1 (Chemical)** | | NA | NA |
| **PC Combustible Gas Class. Level-2 ($\delta^{13}C$)** | | NA | NA |
| **PC Combustible Gas Class. Level-3 ($\delta D$)** | | NA | NA |
| **PC Combustible Gas Class. Level-4 ($^{14}C$)** | | NA | NA |

### 1.2 Surface Casing Vent Flow (SCVF) Assessment Summary Table

| | | | |
|---|---|---|---|
| **SCV Ten-Minute Bubble Test Result** | PASS | | |
| **SCV Flow Rate ($m^3$/day)** | 0 | | |
| **SCV Pressure-Temp Logger Installed** | NA | | |
| **SCV Pressure-Temp Data Logger Removed** | NA | | |
| **SCV Shut-In Time (hrs)** | NA | | |
| **SCV MAX-Recorded Build Up Pressure (kPa)** | NA | | |
| **SCV Stabilized Build-up Pressure (kPa):** | NA | | |
| **SCV Stabilized Build-up Time (hours)** | NA | | |
| **SCV Standpipe Max $CH_4$ Content (ppm v/v):** | 1862 | | |
| **SCV Standpipe Max $H_2S$ Content** | <1 | | |
| **SCV Gas Spls. Collection-Measurement** | **Total Collected** | **Analysis Requested*** | **Classification**** |
| **SCV Samples (Total)** | 1 | | |
| **SCV Combustible Gas Class. Level-1 (Chemical)** | | 1 | NON-IMPACTED |
| **SCV Combustible Gas Class. Level-2 ($\delta^{13}C$)** | | NA | NA |
| **SCV Combustible Gas Class. Level-3 ($\delta D$)** | | NA | NA |
| **SCV Combustible Gas Class. Level-4 ($^{14}C$)** | | NA | NA |

## 1.3 Soils Outside Casing (AGM) Assessment Summary Tables

### A) Non-Intrusive $CH_4$ Surface Soil Scan (PMD) (Figure-1 and Table-1)

| | |
|---|---|
| **Well Casing Surface $CH_4$ Test Sites** | 28 |
| **MAX Surface $CH_4$ Reading** | 1 ppm v/v |
| **MAX $H_2S$ Well Soil Reading (ppm v/v)** | <1 |
| **Number of Background Sites** | 1 |
| **MAX Background $CH_4$ (ppm v/v)** | 1 |
| **Max $H_2S$ BKG Soil Reading (ppm v/v)** | <1 |
| | |
| **Surface $CH_4$-PMD Gas Classification** | NON-IMPACTED |

### B) Non-Intrusive Surface Enclosed Soil Vapor FLUX Chamber Test

| | | | |
|---|---|---|---|
| **Surface SV-FC $CH_4$ Test Sites** | nm | | |
| **MAX SV-FC $CH_4$ Reading** | nm | | |
| | | | |
| **SV-FC Gas Spls. Collection-Measurement** | **Total Collected** | **Analysis Requested*** | **Test Site** |
| **SV-FC Samples (Total)** | 0 | | |
| **SV-FC &Sites Requested for Level-1 Analysis** | | NA | NA |
| **Combustible Gas Classification Level-1 (Chem.)** | | NA | |
| **SV-FC &Sites Requested for Level-2 Analysis** | | NA | NA |
| **Combustible Gas Classification Level-2 ($\delta^{13}C$)** | | NA | |
| **SV-FC &Sites Requested for Level-3 Analysis** | | NA | NA |
| **Combustible Gas Classification Level-3 ($\delta D$)** | | NA | |
| **SV-FC &Sites Requested for Level-4 Analysis** | | NA | NA |
| **Combustible Gas Classification Level-4 ($^{14}C$)** | | NA | |

### C) Intrusive Auger Test Holes with Soil Vapor Probes (Figure 2 and Table 2)

| | | | |
|---|---|---|---|
| **Number Soil Vapor Probe (SVP) Test Sites** | 16 | | |
| **MAX SVP $CH_4$ Reading (ppm v/v)** | 398 | | |
| **Max $H_2S$ SVP Field Reading (ppm v/v)** | <1 | | |
| **Number SVP BKG Test Sites** | 1 | | |
| **MAX SVP $CH_4$ BKG Test Sites (ppm v/v)** | 1 | | |
| | | | |
| **SVPs Gas Spl. Collection & Measurement** | **Total Collected** | **Analysis Requested*** | **Test Site** |
| **Soil Vapor Probes (SVPs) AGM (Total)** | 4 | | |
| **SVP &Sites Requested for Level-1 Analysis** | | 4 | N5, E3, S5 & W5 |
| **Combustible Gas Classification Level-1 (Chem.)** | | Elevated Combustible Gases | |
| **SVP &Sites Requested for Level-2 Analysis** | | 1 | N5, W5 |
| **Combustible Gas Classification Level-2 ($\delta^{13}C$)** | | Fractionated, unrepresentative | |
| **SVP &Sites Requested for Level-3 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-3 ($\delta D$)** | | NA | |
| **SVP &Sites Requested for Level-4 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-4 ($^{14}C$)** | | NA | |

| BKG Gas Spl. Collection-Measurement | Total Collected | Analysis Requested* | Test Site |
|---|---|---|---|
| **BKG Soil Vapor Probe (SVPs) (Total)** | 1 | | |
| **BKG &Sites Requested for Level-1 Analysis** | | 1 | BKG N35 |
| **Combustible Gas Classification Level-1 (Chem.)** | | BASELINE | |
| **BKG &Sites Requested for Level-2 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-2 ($\delta^{13}C$)** | | NA | |
| **BKG &Sites Requested for Level-3 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-3 ($\delta D$)** | | NA | |
| **BKG &Sites Requested for Level-4 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-4 ($^{14}C$)** | | NA | |

**** Sample selection for chemical and isotope analysis (geochemical analytical suite) selected by client/operator.***

## 1.4 Interpreted Source of Migrating Gases

| Sample Point | Geologic Formation | Depth Range | Source Depth |
|---|---|---|---|
| Soil gases are fractionated or indicate degassing (see notes below). This well is not impacted by SCVF or gas migration at the time of this investigation. | | | |

## 3.0 Vapor Intrusion and Surface Casing Vent Flow Testing and Sampling Comments

**Assessment-Collection Date: September 16, 2022**

1) The Surface Casing Vent passed the ten-minute bubble test (no observable flow) and 1862 ppm v/v methane was measured.
2) A surface combustible gas scan was performed near the wellbore using a Sensit Portable Methane Detector (PMD). All readings were low, (1 ppm v/v methane) compared to background (1 ppm v/v) established 35m north from the wellbore (Figure 1, Table 1).
3) An intrusive soil gas migration test was then performed by drilling test holes and inserting Soil Vapor Probes (SVPs). Combustible gas readings in the SVPs 5m from the wellbore were elevated (up to 398 ppm v/v at S5), compared to the background probe (1 ppm v/v methane) installed approximately 35m north of the wellbore to establish background levels in the area and for comparison to other samples collected during this investigation (Figure 2, Table 2).
4) Four soil gas samples from SVPs (N5, E3, S5 & W5) and gases from background (BKG N35) were collected, contained, and preserved for geochemical analysis and characterization, classification, geologic origin (source) and depth measured from the KB (Table 3).
5) Light alkane levels are elevated in soil gas taken 5m from the wellbore. Migrating thermogenic natural gases typically follow the light alkane distribution of C1>>C2>C3>nC4>nC5. Soil gases collected at N5 and S5 are methane deficient and contain elevated propane contents. W5 is also methane deficient. These gases may be present in the soils from the degradation and weathering of hydrocarbon contamination. Alternatively, the gases may be present as a result of a historic subsurface release and at present the soils / subsurface have not degassed to atmosphere.
6) Stable carbon isotope analysis of soil gases from N5 indicate the gases originate from a deep thermogenic source. This sample is methane deficient. Methane content should be normally one to two orders of magnitude greater than the C2+ light alkane gas content. In this case methane is lower indicating that the soils may be degassing. Lighter molecules such as methane will degas first and faster than heavier molecules and therefore contain the concentration pattern in the N5 soil gas sample (C1<C2<C3).
7) Stable carbon isotope analysis of soil gases from W5 indicate this gas sample is severely fractionated, likely by bacterial processes in the near surface, and is not representative of any pristine natural gas source.
8) This well does not contain evidence of SCV flow or active gas migration at the time of this investigation.


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**Figure 1. AGM Non-Intrusive Surface PMD**

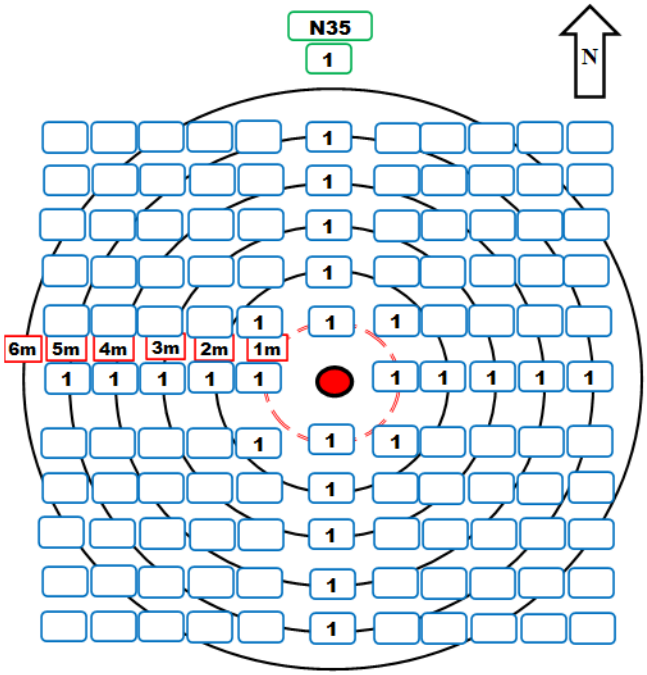


**Figure 1A. Non-Intrusive $CH_4$ Surface Well Casing Detail VIEW**

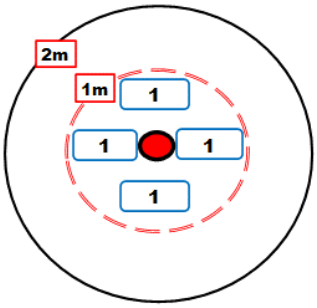


**Table 1. AGM Non-Intrusive Surface PMD**

**WELL CASING (AGM) Non-Intrusive Surface PMD ($CH_4$) Soil Scan**

| Test Site (m) | PMD $CH_4$ (ppm v/v) | (% Vol) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (% Vol) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (% Vol) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (% Vol) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N.5 | 1 | | E.5 | 1 | | S.5 | 1 | | W.5 | 1 | |
| N1 | 1 | | E1 | 1 | | S1 | 1 | | W1 | 1 | |
| N2 | 1 | | E2 | 1 | | S2 | 1 | | W2 | 1 | |
| N3 | 1 | | E3 | 1 | | S3 | 1 | | W3 | 1 | |
| N4 | 1 | | E4 | 1 | | S4 | 1 | | W4 | 1 | |
| N5 | 1 | | E5 | 1 | | S5 | 1 | | W5 | 1 | |
| N5-E1 | | | E5-S1 | | | S5-W1 | | | W5-N1 | | |
| N4-E1 | | | E5-S2 | | | S4-W1 | | | W5-N2 | | |
| N3-E1 | | | E5-S3 | | | S3-W1 | | | W5-N3 | | |
| N2-E1 | | | E5-S4 | | | S2-W1 | | | W5-N4 | | |
| N1-E1 | 1 | | E5-S5 | | | S1-W1 | 1 | | W5-N5 | | |
| N1-E2 | | | E4-S5 | | | S1-W2 | | | W4-N5 | | |
| N2-E2 | | | E4-S4 | | | S2-W2 | | | W4-N4 | | |
| N3-E2 | | | E4-S3 | | | S3-W2 | | | W4-N3 | | |
| N4-E2 | | | E4-S2 | | | S4-W2 | | | W4-N2 | | |
| N5-E2 | | | E4-S1 | | | S5-W2 | | | W4-N1 | | |
| N5-E3 | | | E3-S1 | | | S5-W3 | | | W3-N1 | | |
| N4-E3 | | | E3-S2 | | | S4-W3 | | | W3-N2 | | |
| N3-E3 | | | E3-S3 | | | S3-W3 | | | W3-N3 | | |
| N2-E3 | | | E3-S4 | | | S2-W3 | | | W3-N4 | | |
| N1-E3 | | | E3-S5 | | | S1-W3 | | | W3-N5 | | |
| N1-E4 | | | E2-S5 | | | S1-W4 | | | W2-N5 | | |
| N2-E4 | | | E2-S4 | | | S2-W4 | | | W2-N4 | | |
| N3-E4 | | | E2-S3 | | | S3-W4 | | | W2-N3 | | |
| N4-E4 | | | E2-S2 | | | S4-W4 | | | W2-N2 | | |
| N5-E4 | | | E2-S1 | | | S5-W4 | | | W2-N1 | | |
| N5-E5 | | | E1-S1 | 1 | | S5-W5 | | | W1-N1 | 1 | |
| N4-E5 | | | E1-S2 | | | S4-W5 | | | W1-N2 | | |
| N3-E5 | | | E1-S3 | | | S3-W5 | | | W1-N3 | | |
| N2-E5 | | | E1-S4 | | | S2-W5 | | | W1-N4 | | |
| N1-E5 | | | E1-S5 | | | S1-W5 | | | W1-N5 | | |

**BACKGROUND Non-Intrusive Surface PMD ($CH_4$) Soil Scan**

| Test Site (m) | PMD $CH_4$ (ppm v/v) | (%) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (%) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (%) | Test Site (m) | PMD $CH_4$ (ppm v/v) | (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N35 | 1 | | | | | | | | | | |

**Figure 2. AGM Intrusive SVPs-**

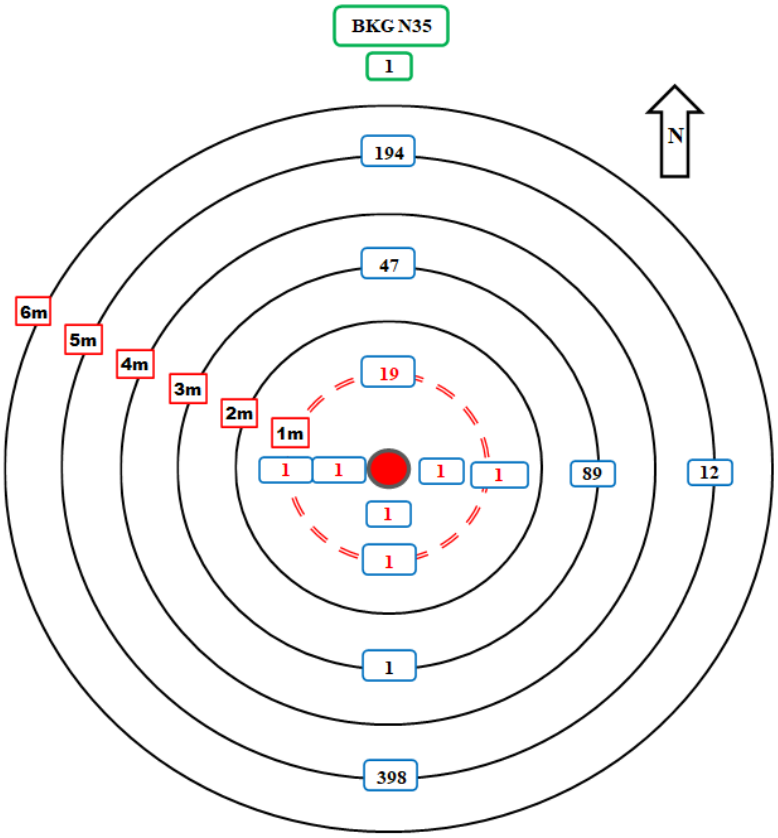


**Table 2. AGM Intrusive SVPs**

**Intrusive AGM -Test Hole-Install Soil Vapor Probes (SVPs) ATM-Isolated**

| Test Site (m) | Soil Vapor Probes IR-$CH_4$ (ppm v/v) | (%LEL) | $H_2S$ (ppm v/v) | Soil Parameters Type | Moist. (1-5) | HC-CONT (Y-N) | Gas Sample (Y-N) |
|---|---|---|---|---|---|---|---|
| N0.5 | 22 | | <1.0 | Grvl | 3 | No | No |
| N1 | 19 | | <1.0 | Grvl | 3 | No | No |
| N3 | 47 | | <1.0 | Spongy | 3 | No | No |
| N5 | 194 | | <1.0 | Spongy | 3 | No | Yes |
| E0.5 | 1 | | <1.0 | Grvl | 3 | No | No |
| E1 | 1 | | <1.0 | Grvl | 3 | No | No |
| E3 | 89 | | <1.0 | Spongy | 3 | No | Yes |
| E5 | 12 | | <1.0 | Spongy | 3 | No | No |
| S0.5 | 1 | | <1.0 | Grvl | 3 | No | No |
| S1 | 1 | | <1.0 | Grvl | 3 | No | No |
| S3 | 1 | | <1.0 | Spongy | 3 | No | No |
| S5 | 398 | | <1.0 | Spongy | 3 | No | Yes |
| W0.5 | 1 | | <1.0 | Grvl | 3 | No | No |
| W1 | 1 | | <1.0 | Grvl | 3 | No | No |
| W3 | 1 | | <1.0 | Spongy | 3 | No | No |
| W5 | 109 | | <1.0 | Spongy | 3 | No | Yes |

| Test Site (m) | Soil Vapor Probes IR-$CH_4$ (ppm v/v) | (% Vol) | $H_2S$ (ppm v/v) | Soil Parameters Type | Moist. (1-5) | HC-CONT (Y-N) | Gas Sample (Y-N) |
|---|---|---|---|---|---|---|---|
| BKG N35 | 1 | | <1.0 | | 3 | No | Yes |

**Table 3: High resolution molecular compositions of gas samples collected as part of the VIA Heli Source M-74.**

| Sample Point / Date Collected / Gas Component | SCV Sept. 16-22 ppm v/v | N5 Sept. 16-22 ppm v/v | E3 Sept. 16-22 ppm v/v | S5 Sept. 16-22 ppm v/v | W5 Sept. 16-22 ppm v/v | BKG Sept. 16-22 ppm v/v |
|---|---|---|---|---|---|---|
| Neon | 19.52 | 18.22 | 20.62 | 19.44 | 19.76 | 19.56 |
| Hydrogen | 512.2 | 493.1 | 609.2 | 357.9 | 675.9 | 576.4 |
| Helium | 3.02 | 2.87 | 2.77 | 7.46 | 3.16 | 8.70 |
| Nitrogen | 777115 | 773904 | 774800 | 778442 | 774287 | 775887 |
| Oxygen | 221446 | 222851 | 221916 | 217817 | 222343 | 222959 |
| Carbon Dioxide | 794.9 | 1726 | 2578 | 3091 | 2359 | 533.9 |
| Methane | 99.00 | 154.9 | 73.49 | 249.0 | 241.3 | 15.14 |
| Ethane | 0.59 | 227.3 | <0.01 | 2.28 | 44.09 | <0.01 |
| Ethene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Propane | 0.64 | 284.5 | <0.01 | 3.95 | 11.69 | <0.01 |
| Propene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| iso-Butane | 0.30 | 66.97 | <0.01 | 1.20 | 1.30 | <0.01 |
| n-Butane | 0.89 | 153.7 | <0.01 | 2.94 | 6.36 | <0.01 |
| iso-Pentane | 0.82 | 60.29 | <0.01 | 1.66 | 1.01 | <0.01 |
| n-Pentane | 1.32 | 47.47 | <0.01 | 1.61 | 2.24 | <0.01 |
| C6+ | 5.55 | 10.16 | 0.27 | 2.54 | 3.72 | 0.56 |
| | | | | | | |
| C1 Index (C1/ΣC2+) | 28.69 | 0.22 | N/A | 23.10 | 3.75 | N/A |
| C2 Index (C2/ΣC3+) | 0.21 | 0.47 | N/A | 0.27 | 2.17 | N/A |
| C3 Index (C3/ΣC4+) | 0.29 | 1.41 | N/A | 0.87 | 1.36 | N/A |
| C4 Index (C4/C5) | 0.67 | 3.24 | N/A | 1.83 | 2.85 | N/A |
| ΣC2+ | 3.45 | 713.0 | N/A | 10.78 | 64.38 | N/A |
| ATM Ratio (N2/O2) | 3.51 | 3.47 | 3.49 | 3.57 | 3.48 | 3.48 |
| Vol % CO2 of TG | 0.08 | 0.17 | 0.26 | 0.31 | 0.24 | 0.05 |
| Vol % Lt. Alk. of TG | 0.01 | 0.10 | 0.01 | 0.03 | 0.03 | 0.00 |
| Vol % Lt. Alk. CH4 | 95.59 | 15.56 | 100.0 | 94.81 | 78.35 | 100.0 |
| Vol % Lt. Alk. C2+ | 4.41 | 84.44 | 0.00 | 5.19 | 21.65 | 0.00 |
| Vol % C2+ of TG | 0.00 | 0.07 | 0.00 | 0.00 | 0.01 | 0.00 |
| | | | | | | |
| **Stable Carbon Isotope Compositions (‰ VPDB)** | | | | | | |
| d13C CH4 | nm | nm | nm | nm | nm | nm |
| d13C C2H6 | nm | nm | nm | nm | nm | nm |
| d13C C2H4 | nm | nm | nm | nm | nm | nm |
| d13C C3H8 | nm | nm | nm | nm | nm | nm |
| d13C C3H6 | nm | nm | nm | nm | nm | nm |
| d13C i-C4H10 | nm | nm | nm | nm | nm | nm |
| d13C n-C4H10 | nm | nm | nm | nm | nm | nm |
| d13C i-C5H12 | nm | nm | nm | nm | nm | nm |
| d13C n-C5H12 | nm | nm | nm | nm | nm | nm |
| d13C CO2 | nm | nm | nm | nm | nm | nm |
| | | | | | | |
| **Stable Hydrogen Isotopic Compositions (‰ VSMOW)** | | | | | | |
| dD H2 | nm | nm | nm | nm | nm | nm |
| dD CH4 | nm | nm | nm | nm | nm | nm |
| dD C2H6 | nm | nm | nm | nm | nm | nm |
| dD C3H8 | nm | nm | nm | nm | nm | nm |
| dD i-C4H10 | nm | nm | nm | nm | nm | nm |
| dD n-C4H10 | nm | nm | nm | nm | nm | nm |
| | | | | | | |
| 14C Concentration (pMC) | nm | nm | nm | nm | nm | nm |

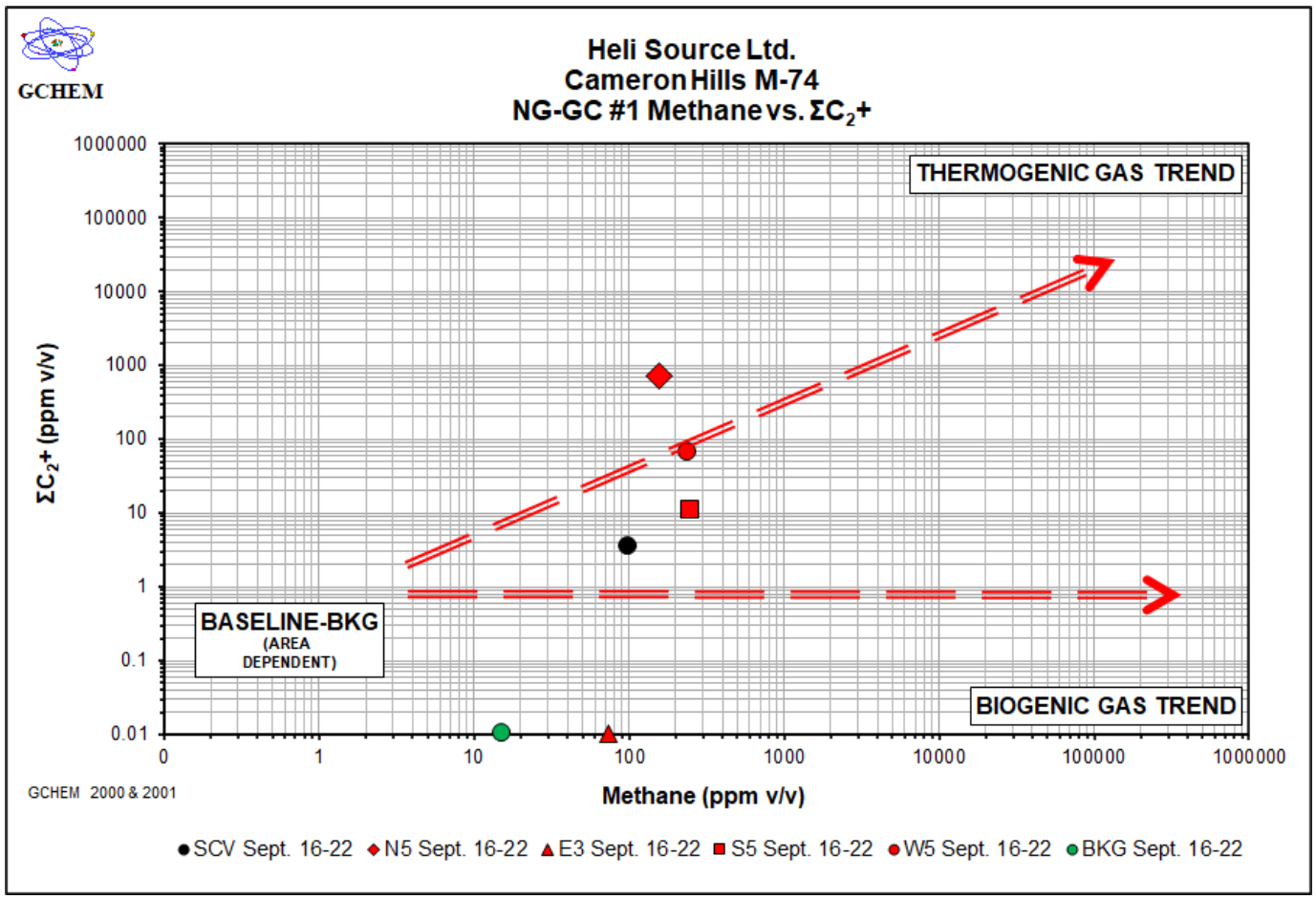


**Figure 3: ΣC2+ vs Methane.**Combustible gases detected in soils and SCVs at a wellhead may result from several origins. Natural gases indicative of SCVF or AGM are thermogenic in origin (natural gas in deep reservoirs), contain high methane and $C_2$+ contents and plot in the Upper RH Quadrant. Low natural gas levels in background, off lease areas are naturally present in soils, vary from region to region and plot in the Lower LH Quadrant. Biogenic gases (swamp-gas) are produced by bacteria, are comprised of predominantly methane and plot in Lower RH Quadrant. Samples plotting in the Lower LH and RH do not contain SCVF or AGM and would not require down-hole remediation

**NG-GC-1 Comments**

1) Natural gases in the soils 5m form the wellbore contain elevated levels of C2+ gases.

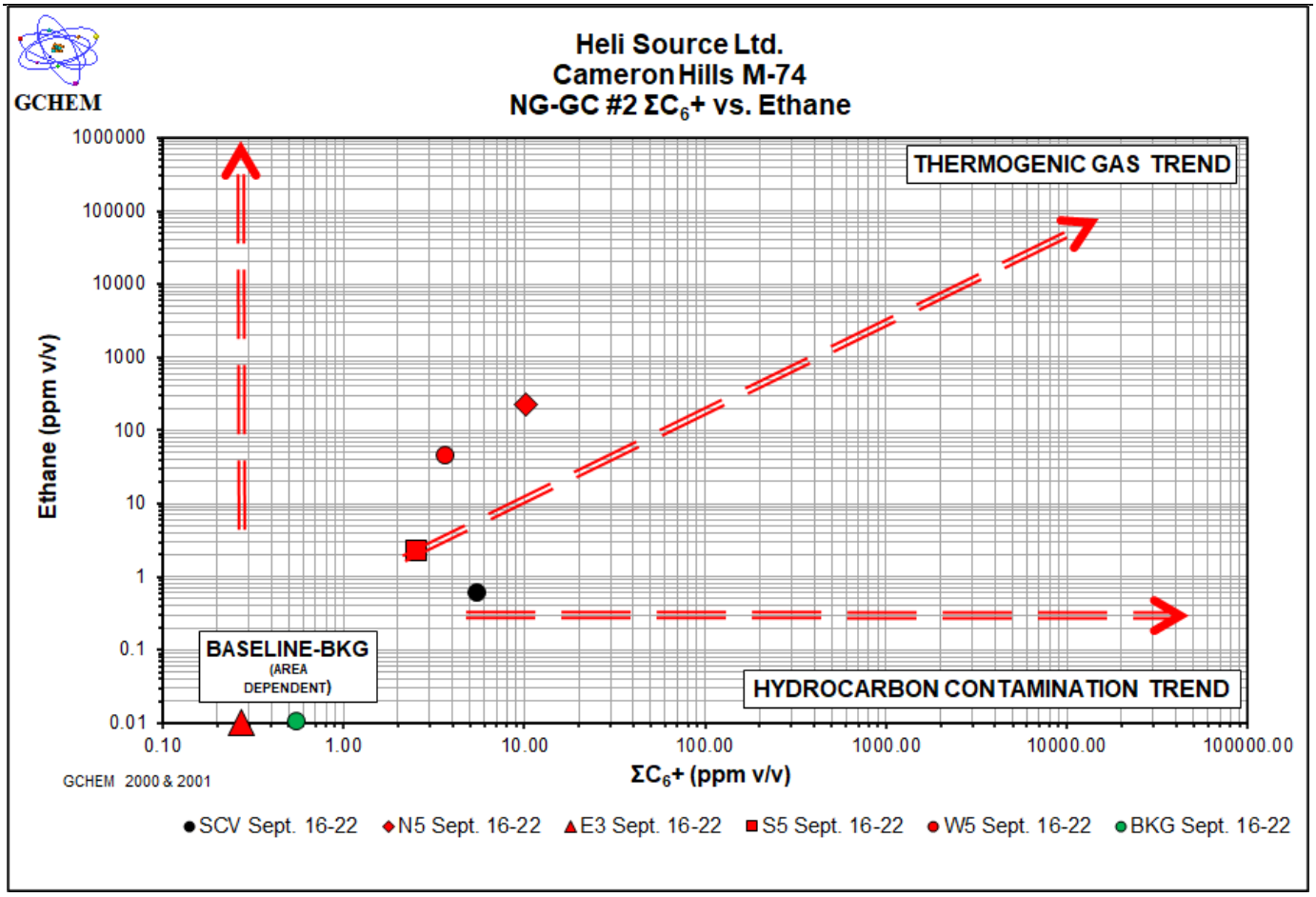


**Figure 4: $\Sigma C_6+$ vs Ethane.** $C_6+$ gases are relatively large molecules that do not readily or easily migrate in large quantities from depth upwards through subsurface fractures or micro-fractures to surface. Contamination by oil spills, fuels, and solvents is indicated by soil vapor samples that have high contents of $C_6+$ compounds and plot in the Lower RH Quadrant**.** Samples plotting in the Lower LH and RH Quadrants do not contain evidence of either SCVF or AGM and would not require downhole repair operations.

**NG-GC-2 Comments**

1) $C_6+$ contents of the soil gas samples 5m from the wellbore are elevated to background readings.

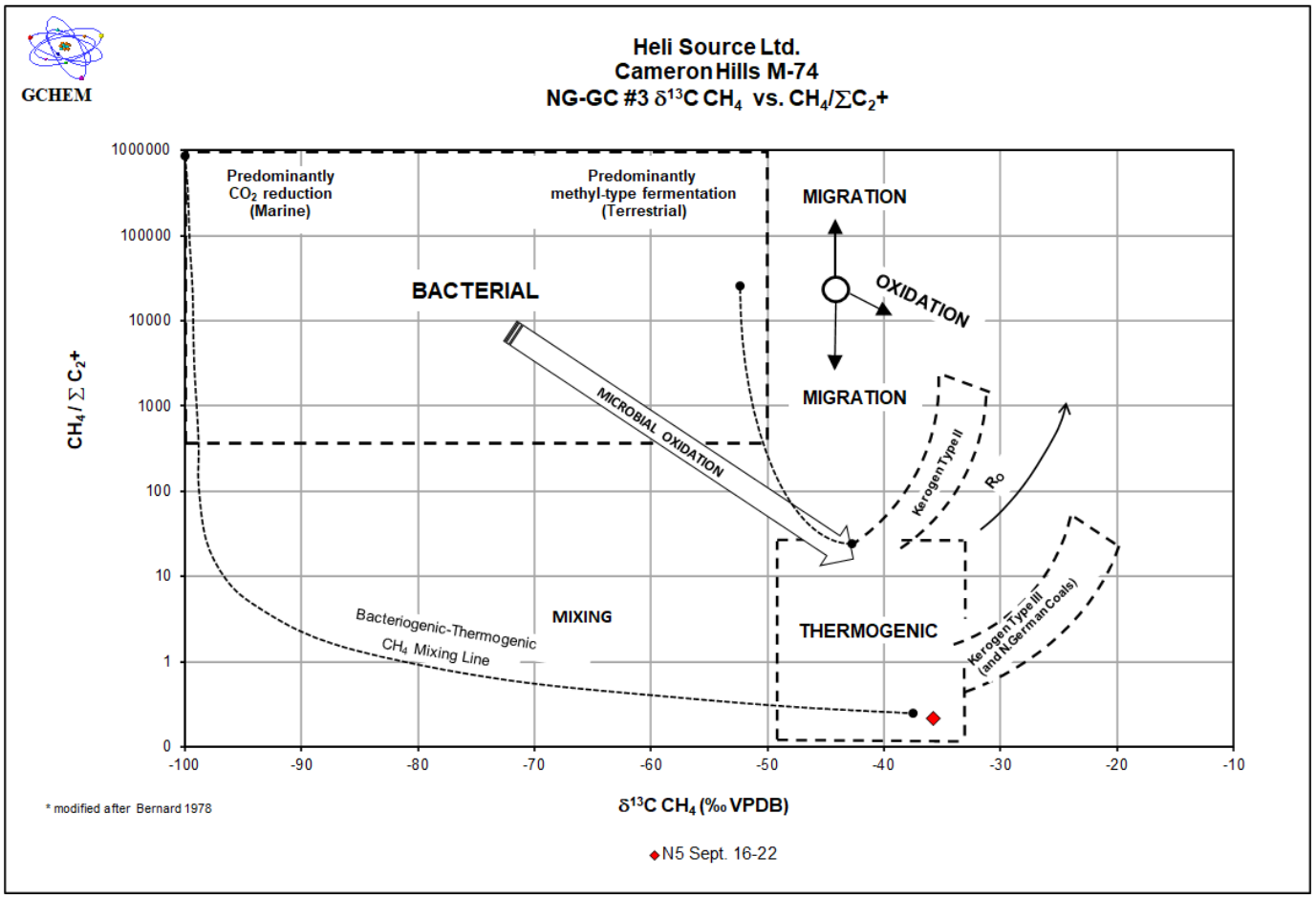


**Figure-3. NG-GC #3 $CH_4$ / $\Sigma C_{2+}$ vs. $\delta^{13}C$ $CH_4$.** Thermogenic methane or methane generated by abiotic processes such as the thermal degradation of organic matter at high temperature and pressure (thermogenesis) contains enriched (less negative) $\delta^{13}C$ values ranging from -50 to -20‰ VPDB and methane relative to $C_{2+}$ gas contents (gas wetness) less than 100. Methane gas can be generated by biotic processes such as the degradation of organic matter via $CO_2$ reduction or fermentation reactions generating biogenic methane. It should be noted that as a normal part of soil respiration, methane may be generated or destroyed by variable biotic pathways. Biogenic methane gas may be oxidized by bacteria resulting in an 'isotopic enriching effect' (i.e. $\delta^{13}C$ values become less negative as a result of oxidizing bacteria in soils that preferentially consume $^{12}C$ over $^{13}C$, leaving the remaining gas enriched in $^{13}C$). Since biogenic oxidization decreases the ratio between $^{12}C$ and $^{13}C$, it may result in enriched $\delta^{13}C$ $CH_4$ values that overlap with the MIXING or THERMOGENIC-GAS TREND. Biogenic methane may therefore contain $\delta^{13}C$ values greater than -50‰ VPDB (GCHEM Internal RD).

**NG-GC-3 Comments**

1) Methane in the soil gas is a mixture of primarily bacterial gases with a smaller contribution of gases from thermogenic sources.
2) This is consistent with natural gases originating from the Upper Colorado Group in this area.

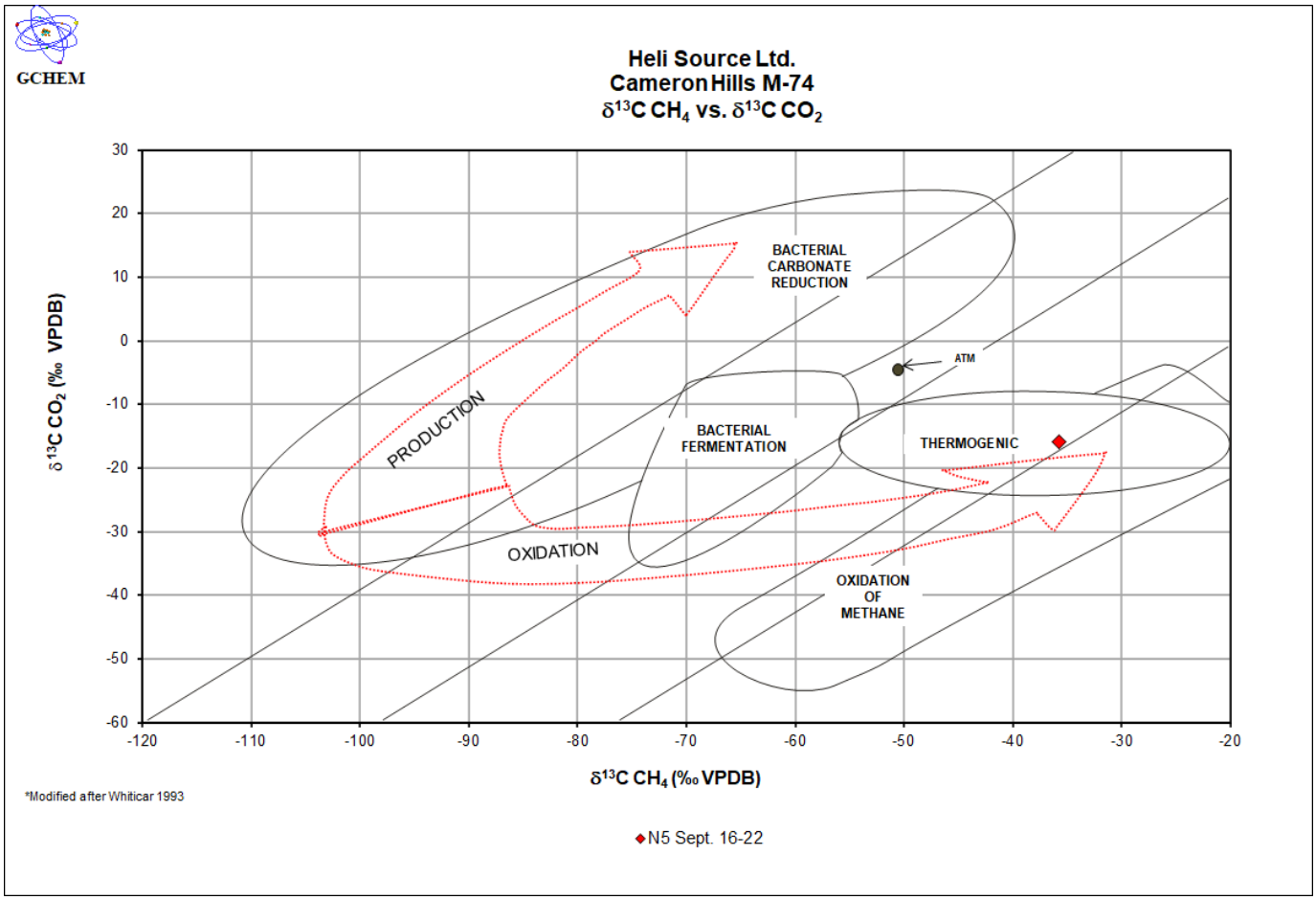


**FIGURE-4: NG-GC #4 $\delta^{13}C$ $CO_2$ vs. $\delta^{13}C$ $CH_4$.** Thermogenic methane or methane generated by abiotic processes such as the degradation of organic matter at high temperature and pressure contains enriched (less negative) $\delta^{13}C$ values ranging from -55 to -20‰ VPDB (or higher) and $\delta^{13}C$ $CO_2$ values in the range of -25 to 4‰ VPDB. Methane gas may be generated by biotic processes such as the degradation of organic matter via $CO_2$ reduction or fermentation reactions generating biogenic methane. Biogenic methane may contain $\delta^{13}C$ values greater than -40‰ VPDB due to biogenic oxidation processes (GCHEM, in prep).

**NG-GC-4 Comments**

1) Methane and carbon dioxide in soil gas sample N5 is conistent with a thermogenic natural gas origin.

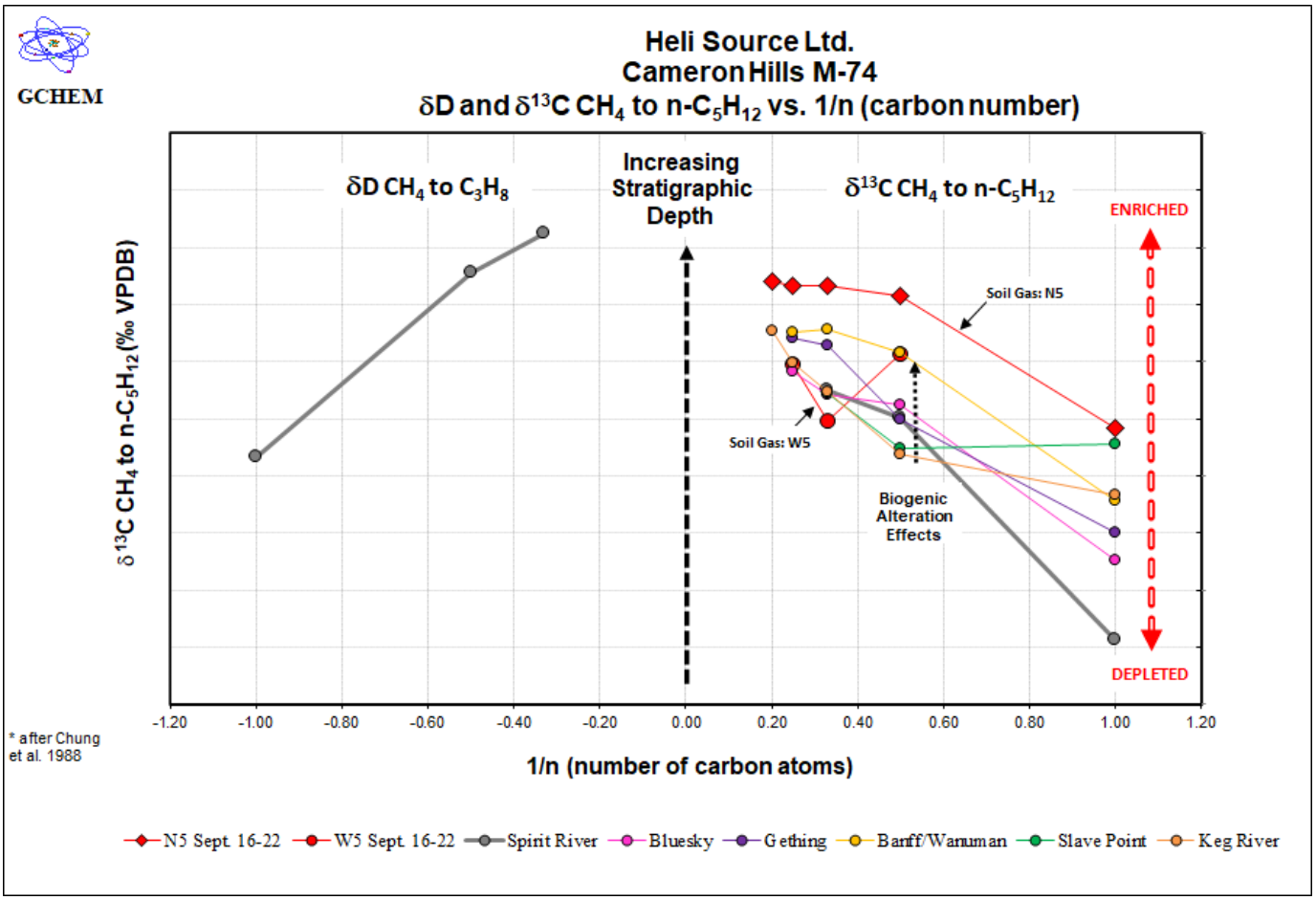


**Figure-5. $\delta^{13}C$ $CH_4$ to n-$C_4H_{10}$ vs. 1/n (Modified CHUNG Plot):** Once gases have been identified as related to SCVF or AGM the geological source may be identified. As molecular and carbon isotope compositions change systematically with increased depth, discrete geological intervals are shown to have unique isotopic characteristics. Thermogenic gases collected at surface in soils or SCV's may be compared to this template of subsurface gas compositions (Natural Gas Isotope Logs –NGILs) and their geologic source is identified. Best results are achieved when NGILs, for correlation, are established in the immediate area.

## Chung Plot Diagram Comments

1) Natural gas in the soils at N5 is isotopically similar to natural gas originating from a deep thermogenic source.
2) Soil gases collected at W5 are severely fractionated and not representative of any naturally occurring gas in Western Canada.