April 4, 2024

Troy Charpentier
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Baton Rouge, Louisiana 70802

***Chemical Fingerprint of 7B Cavern Oil – February 2024***
***Westlake Sulphur Dome Study***

Dear Mr. Charpentier,

NewFields is pleased to provide you with this report of chemical fingerprinting results for an oil collected from the 7B cavern well in February 2024 as part of the on-going investigation of the Westlake US 2 LLC (Westlake) salt dome caverns in the Sulphur Mines oil field, Calcasieu Parish, Louisiana (the Site).

This study follows 11 earlier chemical fingerprinting studies at the Site (**Table 1**). These earlier studies included five oils from the 7B cavern well (collected between January and October 2023), 13 local crude oil samples collected from nine Yellow Rock wells and the Yellow Rock tank battery, and eight surface oils/sheens. Among other conclusions, these earlier studies showed:

- The 7B cavern oils are chemically distinct from the locally produced (Yellow Rock) crude oils studied, which varied only slightly among themselves.
- All surface oils/sheens studied that contained oil are local crude oils and are chemically distinct from 7B cavern oils.
- There was no change in composition of the 7B cavern oil between January and October 2023, indicating no local crude oil(s) had or was presently entering Cavern 7.

The present study expands upon the latter of these earlier conclusions as it reports on the character of a new sample of 7B cavern oil collected in February 2024.

***Samples***
**Table 2** provides an inventory of samples included in this study – along with those previously studied for ease of reference. The newly studied 7B cavern oil sample was collected on February 7, 2024 by personnel from ERM. The sample was sent to NewFields' alliance laboratory, Alpha Analytical (Mansfield, Massachusetts, USA) on Feb. 7th and arrived safely on Feb. 12, 2024. A copy of the chain-of-custody document received with the shipment is found in **Attachment 1**.

***Objectives***
The objective of the current study was to determine if the character of the oil within the 7B cavern on February 7, 2024 has remained as it was in January, March, May, June and October 2023, or possibly has changed in a manner that suggests locally produced crude oil has or may have entered the cavern.

***Methods***

This objective was pursued using specific chemical fingerprinting and interpretation methods based on the CEN oil spill identification protocol[1], as were described in the original study's report.[2] The chemical fingerprinting analyses performed herein remain unchanged from the previous reports (Table 1).

For this study, the 7B cavern oil collected February 7, 2024 was prepared and analyzed in duplicate. In addition, and as first described in the study of May 2023 oils,[3] this study also included the (re-)analysis of the cavern 7B oil collected in January 2023, that was adopted as a *site-specific reference oil*. This oil is being re-analyzed for quality control with each "batch" of samples analyzed from the Sulphur Dome site to assess the long-term precision of diagnostic ratios (DRs) used in the quantitative (statistical) comparison of samples from the site. An expanded discussion of this topic was provided earlier.[4] Based on the new results of the duplicate pair and site-specific reference oil reported herein, an updated table of the short-term and long-term precision of DRs is provided in **Attachment 2**. There are no significant changes to either short- or long-term precision attained to date.

***Results & Discussion***

The complete Alpha Environmental Testing Report (ETR) including all sample preparation data, instrument calibrations, QC data and chromatograms is maintained on file by NewFields (ETR L2407828). The tabulated results for the targeted compounds in each analysis performed are contained in **Attachment 3**. The full-size GC/FID chromatogram obtained in Tier 1 (modified EPA Method 8015D) analysis is provided in **Attachment 4** and selected extraction ion profiles (EIPs) obtained in Tier 2 (modified EPA Method 8270D) are provided in **Attachment 5**. The crude oil assay data provided to me on the 7B cavern oil collected February 7, 2024 is provided in **Attachment 6**.

Specific results most relevant to the study's objectives are presented in **Tables 3 to 4** and **Figures 1 to 5**. Discussion of these results is provided in the following sections.

<u>Character of the February 2024 7B Cavern Oil and Its Comparison to Previous 7B Cavern Oils</u>

**Figure 1** shows the Tier 1 GC/FID (C8+) chromatogram for 7B cavern oil collected on February 7, 2024 (Fig. 1A), along with those of the 7B cavern (reference) oil collected in January 2023 that was analyzed herein (Fig. 1B) and more than 12 months ago (Fig. 1C). Inspection reveals an obvious similarity between these oil's chromatographic features. This same degree of similarity was also evident when the chromatograms for the 7B cavern oils collected in March, May, June and October 2023 were compared to the 7B cavern oil collected in January 2023.[5]

To date, all six of the 7B cavern oil samples collected (January, March, May, June and October 2023), including the February 2024 sample studied herein (Fig. 1A), contain compounds that extend up to ~C40. Resolved compounds (peaks) over this range are dominated by n-alkanes that decline in abundance with increasing carbon number. These prominent n-alkanes occur atop a broad, low unresolved complex mixture (UCM) spanning the oils' chromatograms. Also

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[1] Kienhaus, P.G.M. et al. 2016. CEN methodology for oil spill identification. In: *Standard Handbook of Oil Spill Environmental Forensics: Fingerprinting and Source Identification*, 2nd Ed., S.A. Stout and Z. Wang, Eds., Elsevier Publishing Co., Boston, MA, p. 685-728.

[2] See Table 1, Report 1

[3] See Table 1, Report 4.

[4] See Attachment 3 to Report 4 (per Table 1).

[5] see Table 1, Reports **Error! Bookmark not defined.**, 5 and 10.

resolved are numerous acyclic isoprenoids, including pristane (Pr) and phytane (Ph) that occur in similar but not identical proportions to each other in all six cavern oils (Pr/Pr ~1.0) and to nearby n-alkanes (C17/Pr and C18/Ph; see Fig. 1 insets and Table 3).

The more detailed characteristics of the 7B cavern oil collected in February 2024 are revealed in its Tier 2 GC/MS extracted ion profiles (EIPs) contained in Attachment 5. Those EIPs depicting petroleum biomarkers, i.e., triterpanes, steranes, and triaromatic steroids, used in oil spill fingerprinting are shown in **Figures 2 to 4**, respectively. Each figure again contains the EIPs for the 7B cavern oil collected on February 7, 2024 (Fig. 2A, 3A and 4A), along with those of the 7B cavern (reference) oil collected in January 2023 that was analyzed herein (Fig. 2B, 3B and 4B) and ~13.6 months ago (Fig. 2C, 3C, and 4C). Inspection of these EIPs further reveals the comparability of the 7B cavern oil collected in February 2024 to those collected and analyzed previously. The EIPs for these previously analyzed 7B cavern oil samples from March, May, June and October 2023 (not shown) were contained in attachments to earlier reports, which further demonstrated the similarity in petroleum biomarkers among all of the cavern 7B oils samples collected since January 2023.

This last point can be demonstrated quantitatively using the 30 diagnostic ratios (DRs) measured throughout the Sulphur Dome studies. **Table 3** provides an inventory of the 30 DRs calculated from the concentrations of selected PAHs and biomarkers in the 7B cavern oils collected to date, including the October 2023 sample analyzed herein. (Because each of the 7B cavern oil samples were analyzed in duplicate the average DRs of each duplicate pair are given.) Those DRs that are presently determined to be less precisely measured over both the short term and long term of the Sulphur Dome studies (per Attachment 2) are "greyed out" as they tend to exhibit higher standard errors under repeatability and/or reproducibility conditions ($RSD_r$ and $RSD_R$) using the CEN protocol's 95% confidence level criteria.[6,7]

The green and red color-coding in Table 3 reveals those diagnostic ratios that statistically match (green) and statistically differ (red) from the January 2023 7B cavern oil (avg.). All 17 of the most precisely measured DRs in the February 2024 7B cavern oil (avg.) are statistically matched to the January 2023 cavern oil analyzed 13.6 months ago. With one exception there are statistical matches for all 17 precisely measured DRs between the 7B cavern oils (avg.) collected in March, May, June and October 2023 and the January 2023 cavern oil (Table 3).[8] Thus, the five 7B cavern oils collected in March, May, June and October 2023 and in February 2024 are "positive matches" to the January 2023 7B cavern oil. Collectively, these results indicate that:

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[6] Kienhaus, P.G.M. et al. 2016. CEN methodology for oil spill identification. In: *Standard Handbook of Oil Spill Environmental Forensics: Fingerprinting and Source Identification*, 2nd Ed., S.A. Stout and Z. Wang, Eds., Elsevier Publishing Co., Boston, MA, p. 685-728.

[7] The quantitative (statistical) comparisons relied upon the 95% confidence level under conditions of repeatability ($r_{95\%}$) for each diagnostic ratio wherein:

$$r_{95\%} = 2.8 * RSD_r \text{ where } RSD_r = 5\% \text{ standard error, thus}$$

$$r_{95\%} = 14\%$$

If the $r_{95\%}$ between the measured diagnostic between two samples <14% the ratios were considered to statistically **match**, and *vice versa*. The comparable criterion ($R_{95\%}$) is used to compared precisely measured DRs under conditions of reproducibility. See Attachment 3 within Footnote 4 for further discussion.

[8] The one exception, DBT3/PA3 in the March 2023 7B cavern oil, had a $R_{95\%}$ of 16.1%, i.e., only slight exceeding the 14% match criteria. This DR has mildly fluctuated and was previously considered to be among the less reliable DRs (e.g., see Report 5 per Table 1).

- The specific character of the 7B cavern oil has not changed since chemical fingerprinting of the cavern oil began in January 2023.
- All six cavern oils collected and analyzed over the past ~13 months are comprised of the same unweathered[9] crude oil.
- Notable distinguishing features of the 7B cavern oil are reflected in several DRs (Table 3) including:
  - Relatively high amounts of tetracyclic terpane (high T6a/T6bc ratio), Ts (T11/T12 and T11/T19), bisnorhopane (T14a/T19), and homohopanes (T21/T19 and T34 to T35/T19);
  - Near equal amounts of pristane and phytane (Pr/Ph) and of norhopane and hopane (T15/T19); and
  - Relatively low amounts of oleanane (T18/T19) and moretanes (T20/T19).

In addition, and as was previously observed, the 7B cavern oils exhibit conventional (equilibrated) proportions of C32 homohopane 22S and 22R epimers (T27/T26), a feature that is distinct from the Yellow Rock locally produced crude oils studied to date.[10]

Crude Oil Assay Results

The crude oil samples studied to date via chemical fingerprinting (Table 2) also have been analyzed via standard crude oil assay, including the 7B cavern oil collected in February 2024 studied herein (Attachment 6). In addition to the assay data collected for the oil samples in Table 2, the assay data for oils from the Sulphur Mines Strategic Petroleum Reserve (SPR) in 1989 were also provided by USDOE in response to a FOIA request.[11] A compilation of the available assay data most useful in assessing the similarity/differences between crude oils are provided in **Table 4**.[12]

The assay data collected on the February 2024 7B cavern oil are in close agreement with the results collected for Cavern 7 oil dating back to November 2022, i.e., the first-time assay data were collected in the on-going Sulphur Dome study (Table 4). The 7B cavern oils are clearly distinct from the locally-produced crude oils represented by the Yellow Rock well oils studied to date but are relatively comparable to the historic SPR oils (Table 4). These relationships are visually evident in **Figure 5**, inspection of which shows:

- The 7B cavern oil has remained consistent (between November 2022, when it was first analyzed, and February 2024) and is clearly distinguishable from the locally produced Yellow Rock oils.
- The 7B cavern oils exhibit "bulk" features generally consistent with SPR oil(s) historically stored in Sulphur Dome's caverns.

The latter of these conclusions tends to support the apparent predominance of residual SPR oil that presently remains within Cavern 7. In fact, documents provided in response to your FOIA request indicate that more than 100,000 bbl of non-recoverable/trapped SPR oil, reportedly "*sour*

[9] *Unweathered* is used here since this oil exhibits no obvious evidence of *weathering*, a term that refers to changes an oil can experience due to various processes (e.g., evaporation, water-washing, photo-oxidation, biodegradation). The changes due to weathering are well recognized and accounted for in oil spill identification protocol, which instead focuses upon those chemical fingerprinting features resistant to weathering.

[10] See Reports 4, 5 and 6 (per Table 1).

[11] See Attachment 8 in Report 5 (per Table 1).

[12] See Footnote 5 for further discussion.

*crude primarily purchased from Mexico*", may have remained in the Sulphur Mines caverns upon completion of drawdown in the early 1990s.[13] Notably, the 7B cavern oils' average sulfur content (1.371 wt%; Table 4) is clearly "*sour*" (*def*. S > 0.5 wt%).

***Summary of New Findings***

Chemical fingerprinting of 7B cavern oil collected on February 2, 2024 was conducted and the results were compared to 7B cavern oils collected on January 25, March 30, May 25, June 16 and October 25, 2023. Results showed that all six 7B cavern oils are comprised of the same specific type of unweathered crude oil and are "positive matches" to one another. Additionally, the "bulk" crude oil assay data collected on the 7B cavern oil collected on February 2024 are also consistent with 7B cavern oil results dating back to November 2, 2022, when the recent cavern monitoring began. Collectively, these result show:

- There has been no change in the chemical fingerprints or "bulk" properties of the crude oil recovered from the 7B cavern well since these data were first collected in late January 2023 and early November 2022, respectively. Thus,
- There is no evidence that locally produced crude oil is currently entering Cavern 7.

All earlier conclusions regarding (1) the distinct chemical fingerprinting and "bulk" property differences that exist between the 7B cavern oil and the locally produced Yellow Rock oils and (2) the multiple surface oils/sheens (that actually contained oil) being are derived from spilled, leaked, or seeped locally produced oils remain unchanged. These results further show:

- There is no evidence that locally produced crude oil ever (historically) entered Cavern 7.
- There is no evidence that oil is presently leaking from Cavern 7 to impact the area's near surface environment.

Please let me know if you have any questions.

Sincerely,


Scott A. Stout, Ph.D., P.G.
Sr. Geochemist

*Attachments:*
1: Chain-of-custody
2: Updated RSD table
3: Tabulated concentrations of TPH/SHC, PAH, and biomarkers
4: Full size GC/FID chromatograms
5: Selected GC/MS extraction ion profiles
6: Bulk assay data for the sample studied

[13] DOE document: SM COARB 07-13-93; e.g., p. 29 and 31 of 73.

**Table 1: NewFields reports on the Westlake Sulfur Dome Study prepared to date.**

All reports authored by S.A. Stout

| Report No. | Title | Report Date |
|---|---|---|
| 1 | Chemical fingerprinting of oils, Westlake Sulphur Dome Study. | Mar. 10, 2023 |
| 2 | Chemical fingerprint of oily net – No. 20, Westlake Sulfur Dome Study. | Apr. 27, 2023 |
| 3 | Chemical fingerprint of 7B cavern oil – March 30, 2023, Westlake Sulfur Dome Study. | May 3, 2023 |
| 4 | 7B Cavern Oil, Cavern 4 Oil, Select Yellow Rock Well Oils, and a Bubble Site 24 Sheen – May 2023, Westlake Sulphur Dome Study. | July 11, 2023 – Amended July 14, 2023 |
| 5 | Chemical fingerprint of 7B cavern oil, selected Yellow Rock well oils and a Central Lake sheen – June 2023, Westlake Sulfur Dome Study. | July 25, 2023 |
| 6 | Chemical fingerprinting of additional Yellow Rock well oils – mid- to late-August 2023, Westlake Sulphur Dome Study. | Oct. 4, 2023 |
| 7 | Chemical fingerprint of floating materials, Central Lake and Bubble Site 14 – September 11, 2023, Westlake Sulphur Dome Study. | Oct. 5, 2023 |
| 8 | Chemical fingerprint of Bubble Site 14 sheen – September 20, 2023, Westlake Sulphur Dome Study. | Oct. 17, 2023 |
| 9 | Chemical fingerprint of Bubble Site 19 sheen – October 15, 2023, Westlake Sulphur Dome Study. | Nov. 7, 2023 |
| 10 | Chemical fingerprint of 7B cavern oil – October 2023, Westlake Sulfur Dome Study. | Nov. 21, 2023 |
| 11 | Chemical Fingerprint of Surface Oil near Bubble Site 24 – February 26, 2024, Westlake Sulphur Dome Study | Mar. 25, 2024 |

## Table 2: Inventory of samples from the current study and studied previously.

### *Current Study Samples*

| Client/ Field ID | Lab ID | Matrix | Date Collected | Description of Sample |
|---|---|---|---|---|
| 7B Oil* | L2407828-01 | Oil | 2/7/2024 | Cavern oil from brine well 7B |
| 7B** | L2361423-02 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |

### *Previously-Studies Samples*

| Client/ Field ID | Lab ID | Matrix | Date Collected | Description of Sample |
|---|---|---|---|---|
| Bubble Site Oil | L2410930-01 | Oil | 2/26/2024 | Surface oil collected near bubble site No. 24 |
| 7B** | L2361423-02 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| 7B Oil* | L2363877-01 | Oil | 10/25/2023 | Cavern oil from brine well 7B |
| 7B** | L2361423-02 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| Westlake #19 | L2361423-01 | Net | 10/15/2023 | Surface sheen from bubble site No. 19 |
| 7B** | L2361423-02 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| No. 14 Sheen Sample | L2355855-01 | Net | 9/20/2023 | Surface sheen from bubble site No. 14 |
| 7B** | L2355855-02 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| Algae Sample Central Lake | L2353106-02 | Net | 9/11/2023 | Sheen with pond "scum/algae"; suspected biologic |
| No. 14 Sheen Sample | L2353106-03 | Net | 9/11/2023 | Surface sheen from bubble site No. 14 |
| 7B** | L2353106-04 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| 253998* | L2348036-01 | Oil | 6/16/2023 | Yellow Rock 253998 |
| 41842 | L2348036-02 | Oil | 6/16/2023 | Yellow Rock 41842 |
| 189416 (1250') | L2348036-04 | Oil | 6/16/2023 | Yellow Rock 189416 from 1250' (bottom of oil column) |
| 189416 (170') | L2348036-05 | Oil | 6/16/2023 | Yellow Rock 189416 from 170' (top of oil column) |
| 7B** | L2348036-03 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| Pad Oil | L2335058-01 | Oil | 6/16/2023 | Stock tank oil used as cavern blanket/pad |
| 7B* | L2335058-02 | Oil | 6/16/2023 | Cavern oil from brine well 7B |
| 252112 | L2335058-03 | Oil | 6/16/2023 | Yellow Rock 252112 |
| 109963 | L2335058-04 | Oil | 6/16/2023 | Yellow Rock 109963 |
| 185997 | L2335058-05 | Oil | 6/16/2023 | Yellow Rock 185997 |
| 209459 | L2335058-06 | Oil | 6/16/2023 | Yellow Rock 209459 |
| Sheen | L2335058-07 | Net | 6/12/2023 | Surface sheen from central lake |
| 7B** | L2335058-08 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| 209459 | L2325505-01 | Oil | 5/2/2023 | Yellow Rock 209459 |
| 185997 | L2325505-02 | Oil | 5/2/2023 | Yellow Rock 185997 |
| Cavern 4 | L2325505-03 | Oil | 5/25/2023 | Cavern oil from brine well PPG No. 4 |
| Cavern 7B* | L2325505-04 | Oil | 5/25/2023 | Cavern oil from brine well 7B |
| 210185 | L2325505-05 | Oil | 5/25/2023 | Yellow Rock 210185 |
| Tank Battery | L2325505-06 | Oil | 5/25/2023 | Yellow Rock Tank Battery |
| 7B** | L2325505-07 | Oil | 1/25/2023 | Site-specific reference oil; 7B Cavern Oil (Jan 2023) |
| BS-24 | L2325505-08 | Net | 5/22/2023 | Surface sheen from bubble site No. 24 |
| Cavern 7B* | L2317387-01 | Oil | 3/30/2023 | Cavern oil from brine well 7B |
| No. 20 | L2313362-01 | Net | 3/9/2023 | Surface oil sheen on water body west of the salt dome |
| 7B* | L2305221-04 | Oil | 1/25/2023 | Cavern oil from brine well 7B |
| 110159 | L2305221-02 | Oil | 1/25/2023 | Yellow Rock 110159 |
| Stock Tank | L2305221-03 | Oil | 1/25/2023 | Stock tank oil used as cavern blanket/pad |
| Brine Well 22 BS* | L2305221-01 | Net | 1/25/2023 | Surface oil brine well 22 excavation |
| Central Pond | L2305221-05 | Net | 1/25/2023 | Surface sheen from central pond |

* sample prepared and analyzed in duplicate

**re-analysis of Jan. 25, 2023 oil (L2305221-04) for quality control only

**Table 3: Diagnostic ratios for the 7B cavern oil collected in January 2023 *versus* the 7B cavern oils collected in March, May, June and October 2023, and in February 2024 analyzed over a span of approximately 13.6 months.**

Top three ratios are derived from Tier 1 GC/FID data; all others from Ti er 2 GC/MS data.

| CEN - Diagnostic Ratios | CEN Diagnostic Ratios per Alpha Abbreviations | Cavern Oil 7B (Jan. 21, 2023; Avg. n=2) | 7B Cavern Oil (Mar. 2023; Avg; n=2) | 7B Cavern Oil (May 2023; Avg; n=2) | 7B Cavern Oil (June 2023; Avg; n=2) | 7B Cavern Oil (Oct. 2023; Avg; n=2) | 7B Cavern Oil (Feb 2024; Avg; n=2) |
|---|---|---|---|---|---|---|---|
| | Analysis Date | 2/4/2023 | 4/26/2023 | 6/18/2023 | 7/15/2023 | 11/9/2023 | 3/19/2024 |
| NR-C17/pris | C17/Pr | 2.38 | 2.41 | 2.66 | 2.36 | 2.71 | 2.73 |
| NR-C18/phy | C18/Ph | 2.17 | 2.14 | 2.13 | 2.09 | 2.08 | 2.17 |
| NR- pris/phy | Pr/Ph | 1.01 | 1.00 | 0.90 | 1.00 | 0.94 | 0.96 |
| NR-4-MD/1-MD | 4-MDBT/1-MDBT | 2.14 | 2.71 | 2.15 | 2.40 | 2.06 | 2.42 |
| NR-2-MP/1-MP | 2-MP/1-MP | 1.01 | 0.97 | 1.06 | 1.05 | 1.07 | 1.03 |
| NR-27Ts/30ab | T11/T19 | 0.23 | 0.23 | 0.24 | 0.23 | 0.24 | 0.24 |
| NR-27Tm/30ab | T12/T19 | 0.29 | 0.26 | 0.26 | 0.25 | 0.27 | 0.27 |
| NR-28ab/30ab | T14a/T19 | 0.20 | 0.18 | 0.19 | 0.18 | 0.18 | 0.19 |
| NR-29ab/30ab | T15/T19 | 0.84 | 0.83 | 0.83 | 0.85 | 0.83 | 0.86 |
| NR-30O/30ab | T18/T19 | 0.04 | 0.03 | 0.00 | 0.04 | 0.00 | 0.05 |
| NR-31abS/30ab | T21/T19 | 0.59 | 0.59 | 0.58 | 0.62 | 0.60 | 0.61 |
| NR-27dbR/27dbS | S4/S5 | 0.50 | 0.53 | 0.46 | 0.45 | 0.44 | 0.54 |
| NR-27bb/29bb | (S14+S15)/(S26+S27) | 0.85 | 0.88 | 0.86 | 0.81 | 0.84 | 0.84 |
| NR-SC26/ RC26+SC27 | TAS09/TAS01 | 0.13 | 0.14 | 0.14 | 0.13 | 0.13 | 0.13 |
| NR-SC28/RC26 + SC27 | TAS02/TAS01 | 0.69 | 0.71 | 0.69 | 0.67 | 0.72 | 0.71 |
| NR-RC27/RC26+ SC27 | TAS03/TAS01 | 0.75 | 0.78 | 0.78 | 0.75 | 0.75 | 0.78 |
| NR-RC28/RC26+SC27 | TAS04/TAS01 | 0.58 | 0.59 | 0.58 | 0.58 | 0.59 | 0.60 |
| DR-Ts/Tm | T11/T12 | 0.82 | 0.87 | 0.92 | 0.89 | 0.89 | 0.90 |
| DR-29Ts30ab | T16/T19 | 0.21 | 0.20 | 0.20 | 0.21 | 0.19 | 0.20 |
| DR-29bb/29aa | (S26+S27)/(S25+S28) | 1.15 | 1.82 | 1.33 | 1.49 | 1.55 | 1.57 |
| DR-C2-dbt/C2-phe | DBT2/PA2 | 2.28 | 2.07 | 2.06 | 2.16 | 2.21 | 2.30 |
| DR-C3-dbt/C3-phe | DBT3/PA3 | 2.62 | 2.23 | 2.32 | 2.51 | 2.59 | 2.46 |
| DR-C28C29/30ab | T7 to T10/T19 | 0.19 | 0.23 | 0.24 | 0.22 | 0.26 | 0.23 |
| DR-29aaS/29aaR | S25/S28 | 1.36 | 1.22 | 1.28 | 1.34 | 1.27 | 1.18 |
| DR-C20TA/C21TA | TAS05/TAS06 | 0.95 | 1.30 | 1.19 | 1.32 | 1.29 | 1.35 |
| DR-TA21/ RC26+SC27 | TS06/TAS01 | 0.49 | 0.40 | 0.40 | 0.39 | 0.36 | 0.41 |
| DR-C24Tet/C26Tri | T6a/T6bc | 1.60 | 1.67 | 1.55 | 1.55 | 1.78 | 1.60 |
| DR-30ba/30ab | T20/T19 | 0.07 | 0.08 | 0.07 | 0.09 | 0.08 | 0.09 |
| DR-35ab/30ab | (T34 to T35)/T19 | 0.33 | 0.33 | 0.31 | 0.38 | 0.34 | 0.37 |
| DR-32abR/32abS | T27/T26 | 0.74 | 0.72 | 0.74 | 0.75 | 0.70 | 0.76 |
| | **Conclusion:** | | **Positive Match** | **Positive Match** | **Positive Match** | **Positive Match** | **Positive Match** |

red: statistical non-match to 7B Cavern Oil (Jan. 21, 2023; Avg.)

green: statistical match to 7B Cavern Oil (Jan. 21, 2023; Avg.)

grey: indicates less precision ratio (per Attachment 3)

Dup: sample prepared and analyzed in duplicate

Avg: average of duplicate ratios

**Table 4: Selected crude oil assay results for the 7B cavern oils, Yellow Rock (locally produced) crude oils, and Other oils from Sulphur Dome along with historic data for Strategic Petroleum Reserve oils from Sulphur Dome from 1989.** New data for 7B cavern oil studied herein indicated within red box; na – not analyzed

| | Client ID | Date Collected | API gravity | Sulfur (wt%) | V (ppm) | Ni (ppm) | V/ (V+Ni) |
|---|---|---|---|---|---|---|---|
| **7B Cavern Oils** | | | | | | | |
| Cavern Oils | 7B Cavern Oil | 11/2/2022 | 32.8 | 1.380 | 23 | 6.1 | 0.79 |
| | 7B Cavern Oil | 1/18/2023 | 34.0 | 1.400 | 23 | 5.9 | 0.79 |
| | 7B Cavern Oil | 1/25/2023 | na | na | 12 | 3.8 | 0.76 |
| | 7B Cavern Oil | 3/30/2023 | 33.6 | 1.370 | 100 | 26 | 0.79 |
| | 7B Cavern Oil | 5/25/2023 | 33.5 | 1.401 | 23 | 6 | 0.79 |
| | 7B Cavern Oil | 6/16/2023 | 34.0 | 1.350 | 25 | 6 | 0.81 |
| | 7B Cavern Oil | 10/25/2023 | 33.9 | 1.362 | 21 | 5 | 0.81 |
| | 7B Cavern Oil | 2/7/2024 | 34.1 | 1.336 | 25 | 6 | 0.81 |
| | | Average | 33.7 | 1.371 | 31 | 8.1 | 0.79 |
| | | St. Dev. | 1.4 | 0.033 | 28 | 7.3 | 0.01 |
| **Yellow Rock (Locally Produced) Oils** | | | | | | | |
| Yelllow Rock Oils | 189416 | 11/2/2022 | 26.0 | 0.302 | 1.2 | 7.0 | 0.15 |
| | 110159 | 1/25/2023 | na | na | 0.4 | 3.7 | 0.10 |
| | 209459 | 5/2/2023 | 22.8 | 0.435 | 2.0 | 8.0 | 0.20 |
| | 185997 | 5/2/2023 | 21.5 | 0.407 | 2.0 | 9.0 | 0.18 |
| | 210185 | 5/25/2023 | 22.8 | 0.476 | 2.0 | 10.0 | 0.17 |
| | Tank Battery | 5/25/2023 | 27.0 | 0.327 | 1.0 | 6.0 | 0.14 |
| | 252112 | 6/16/2023 | 27.7 | 0.295 | 1.0 | 5.0 | 0.17 |
| | 109963 | 6/16/2023 | 24.1 | 0.431 | 2.0 | 8.0 | 0.20 |
| | 185997 | 6/16/2023 | 23.0 | 0.411 | 2.0 | 10.0 | 0.17 |
| | 209459 | 6/16/2023 | 21.6 | 0.433 | 2.0 | 9.0 | 0.18 |
| | 253998 | 8/17/2023 | 16.9 | 0.747 | 2.3 | 9.6 | 0.19 |
| | 41842 | 8/17/2023 | 26.6 | 0.403 | 2.0 | 22.2 | 0.08 |
| | 189416 (1250') | 8/29/2023 | 20.7 | 0.450 | <0.1 | 10.9 | <0.01 |
| | 189416 (170') | 8/29/2023 | 20.8 | 0.447 | <0.1 | 8.3 | <0.01 |
| | | Average | 23.2 | 0.428 | 1.7 | 9.1 | 0.16 |
| | | St. Dev. | 3.1 | 0.112 | 0.6 | 4.3 | 0.04 |
| **Other Oils** | | | | | | | |
| Other | Pad Oil | 1/18/2023 | 29.1 | 1.17 | 19 | 4.94 | 0.79 |
| | Stock Tank | 1/25/2023 | na | na | 19.3 | 4.7 | 0.80 |
| | Cavern 4 | 5/25/2023 | 31.2 | 1.55 | 42 | 9 | 0.82 |
| | Pad Oil | 6/16/2023 | 29.3 | 1.27 | 18 | 5 | 0.78 |
| **Sulphur Mines Strategic Petroleum Reserve Oils** | | | | | | | |
| SPR Oils | SM007 | 6/14/1989 | 31.9 | 1.69 | 23.1 | 10.1 | 0.70 |
| | SM007* | 6/14/1989 | 32.4 | 1.75 | 32.7 | 9.0 | 0.78 |
| | SM006 | 5/31/1989 | 31.0 | 1.42 | 34.0 | 20.6 | 0.62 |
| | SM006* | 5/31/1989 | 32.9 | 1.56 | 41.6 | 11.6 | 0.78 |
| | SM002 | 8/14/1989 | 32.7 | 1.63 | 52.8 | 10.6 | 0.83 |
| | Cavern 7 | 1989 rpt. | 32.5 | 1.80 | na | na | na |
| | Cavern 6 | 1989 rpt. | 32.7 | 1.60 | na | na | na |
| | Cavern 2-4-5 | 1989 rpt. | 32.9 | 1.60 | na | na | na |

* sample values from Word files provided by DOE; other SM### sample values from Excel file provided

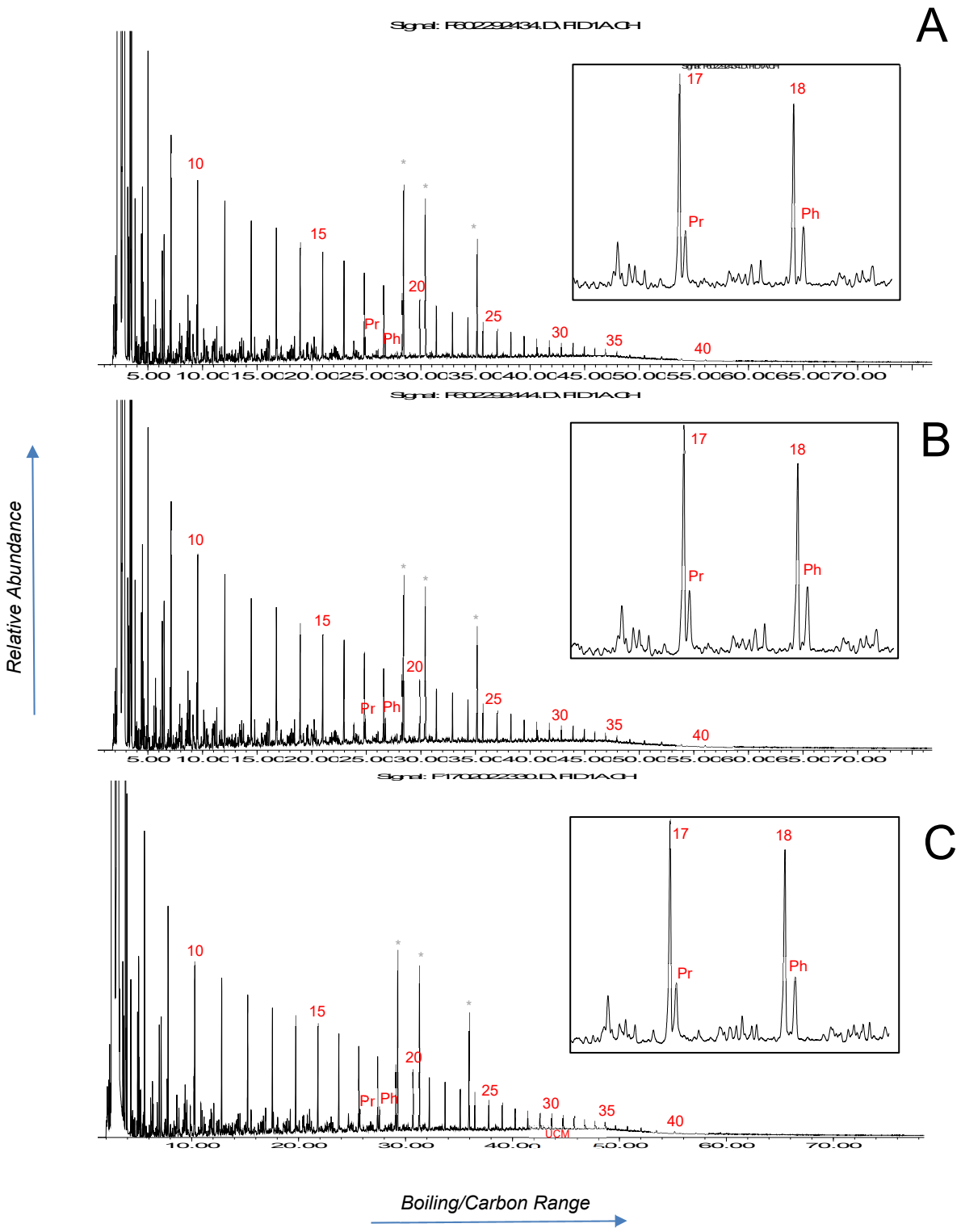



**Figure 1:** GC/FID (C8+) chromatograms for (A) 7B Cavern oil collected February 2, 2024 analyzed herein, (B) 7B Cavern oil collected Jan. 21, 2023 analyzed herein, and (C) 7B Cavern oil collected Jan. 21, 2023 analyzed Feb. 2, 2023. Insets show further expanded view of C17-C18 range. #: n-alkane carbon number; Pr: pristane; Ph: phytane; UCM: unresolved complex mixture; *: internal standard.

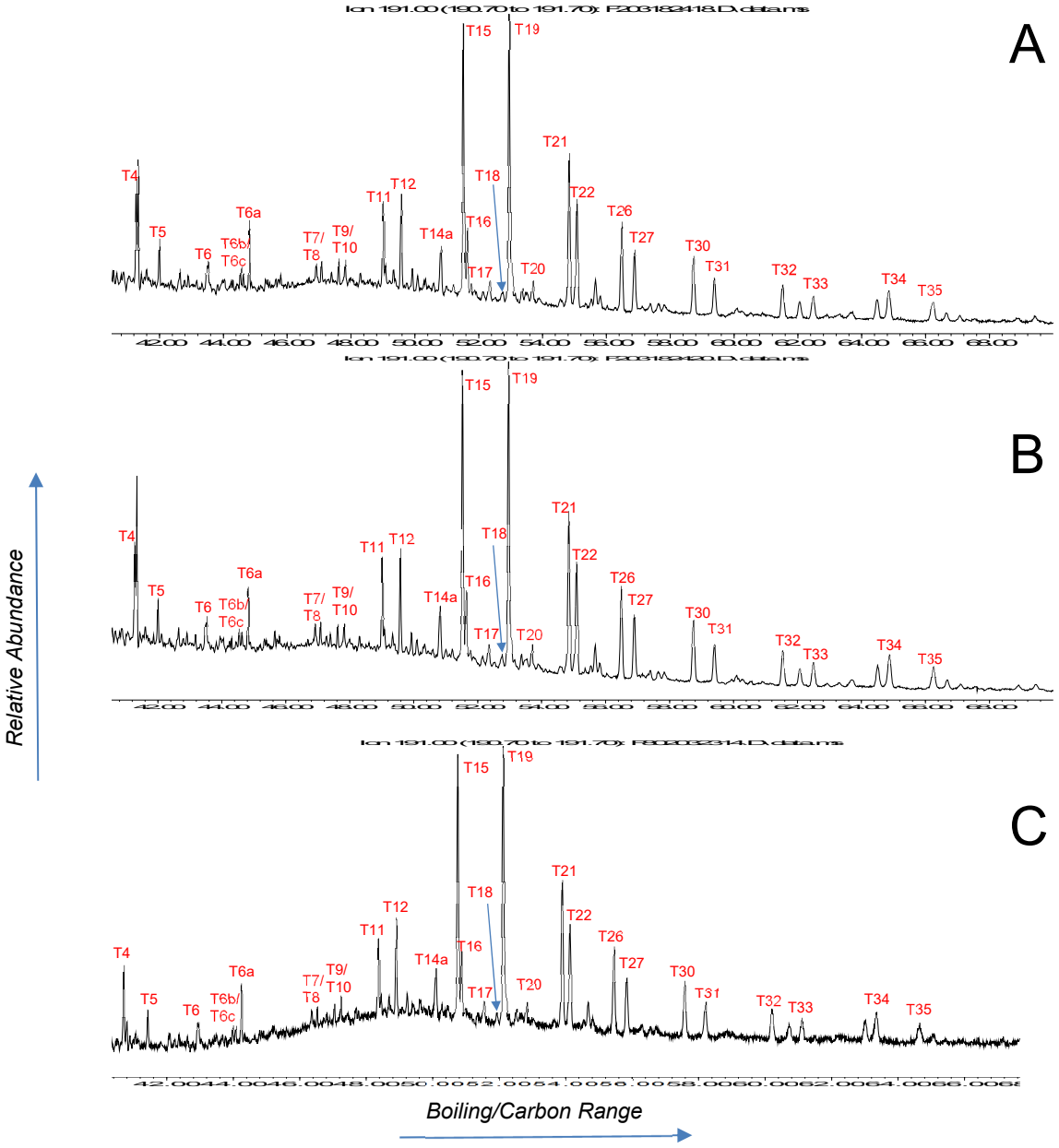



**Figure 2:** Partial extracted ion chromatograms (*m/z* 191 for (A) 7B Cavern oil collected February 2, 2024 analyzed herein, (B) 7B Cavern oil collected Jan. 21, 2023 analyzed herein, and (C) 7B Cavern oil collected Jan. 21, 2023 analyzed Feb. 2, 2023. red labels: various triterpane biomarkers, see Attachment 3, Table A3-2 for compound names.

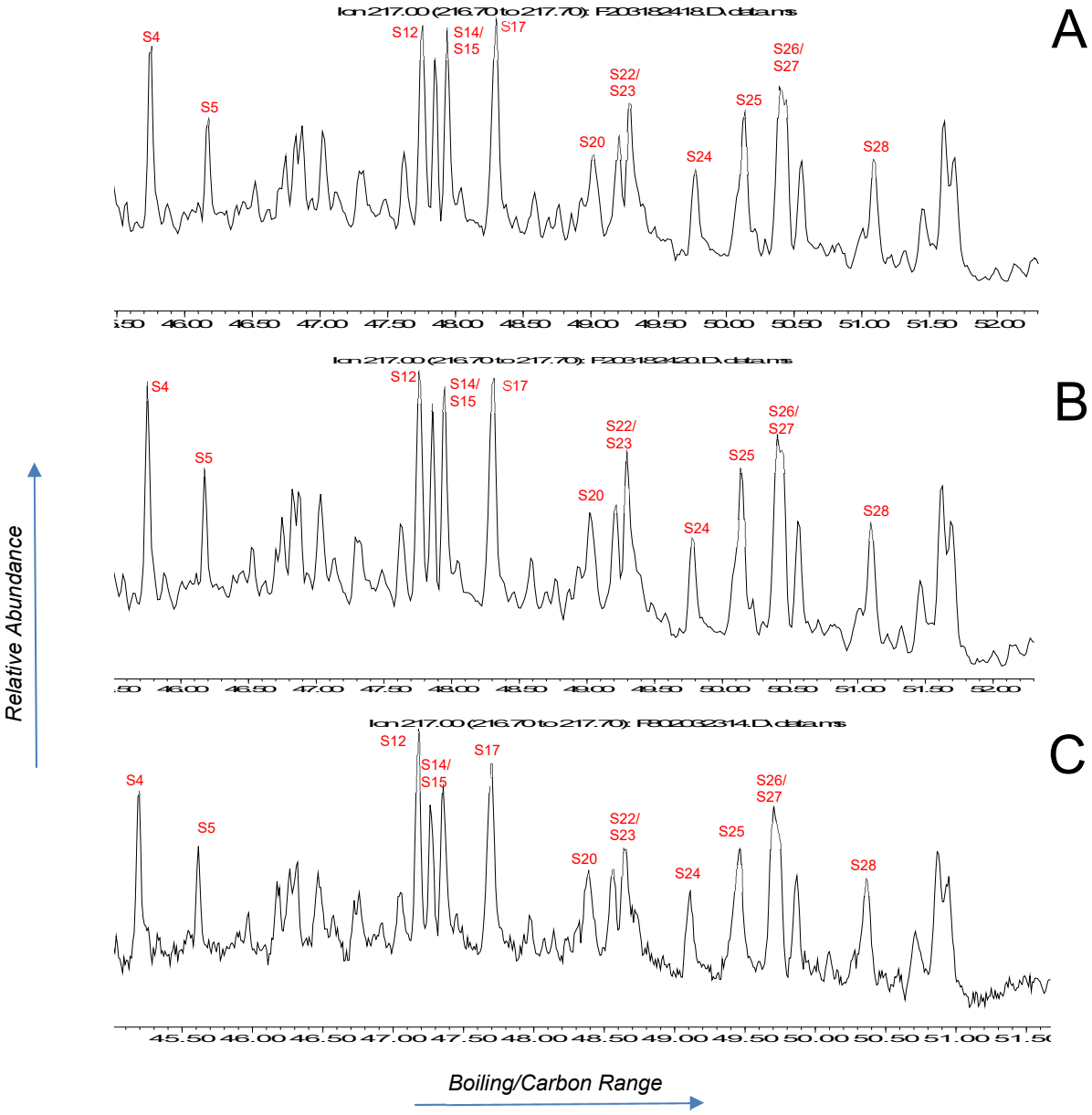



**Figure 3:** Partial extracted ion chromatograms (*m/z* 217 for (A) 7B Cavern oil collected February 2, 2024 analyzed herein, (B) 7B Cavern oil collected Jan. 21, 2023 analyzed herein, and (C) 7B Cavern oil collected Jan. 21, 2023 analyzed Feb. 2, 2023. red labels: various triterpane biomarkers, see Attachment 3, Table A3-2 for compound names.

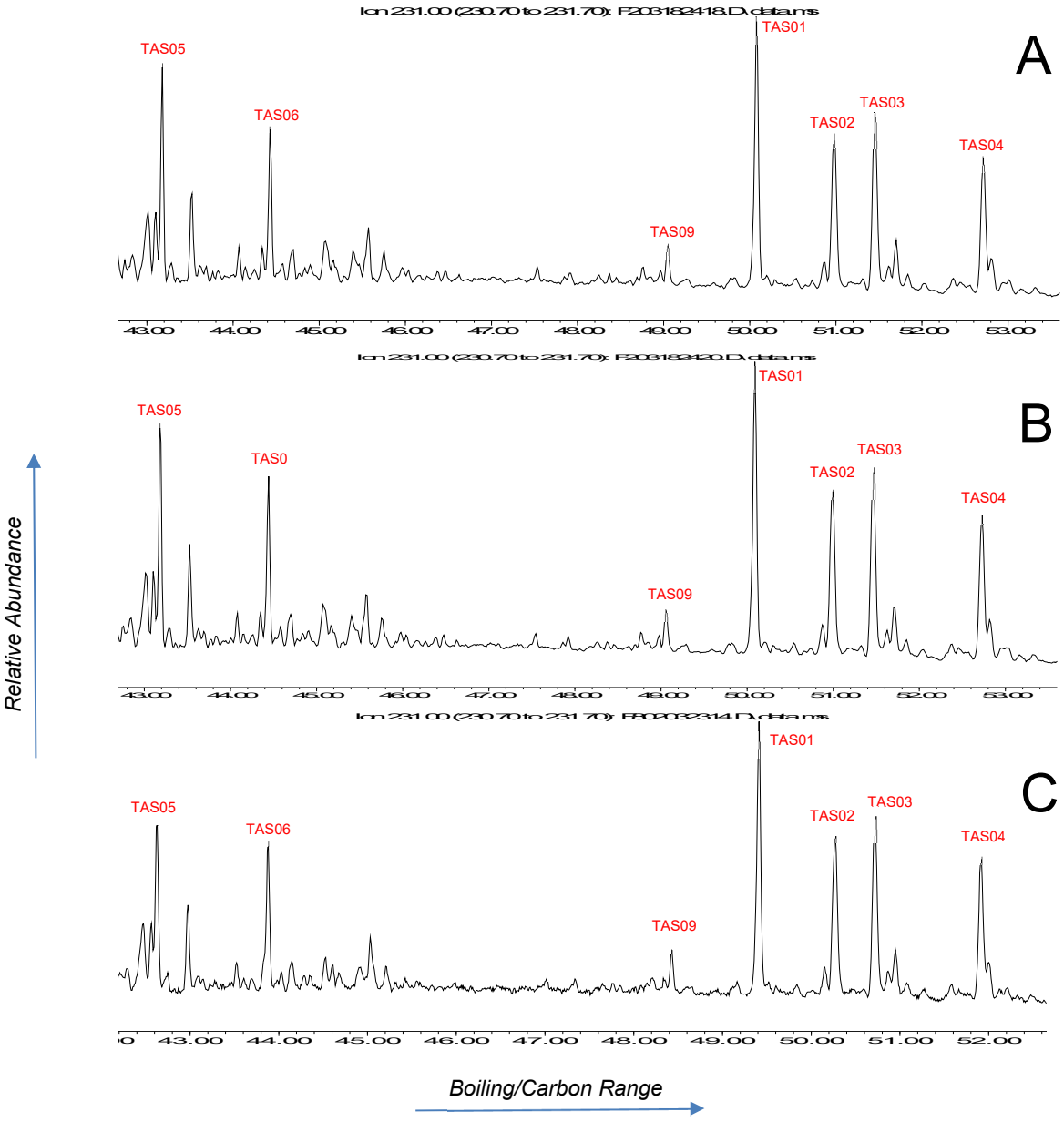



**Figure 4:** Partial extracted ion chromatograms (*m/z* 231 for (A) 7B Cavern oil collected February 2, 2024 analyzed herein, (B) 7B Cavern oil collected Jan. 21, 2023 analyzed herein, and (C) 7B Cavern oil collected Jan. 21, 2023 analyzed Feb. 2, 2023. red labels: various triterpane biomarkers, see Attachment 3, Table A3-2 for compound names.

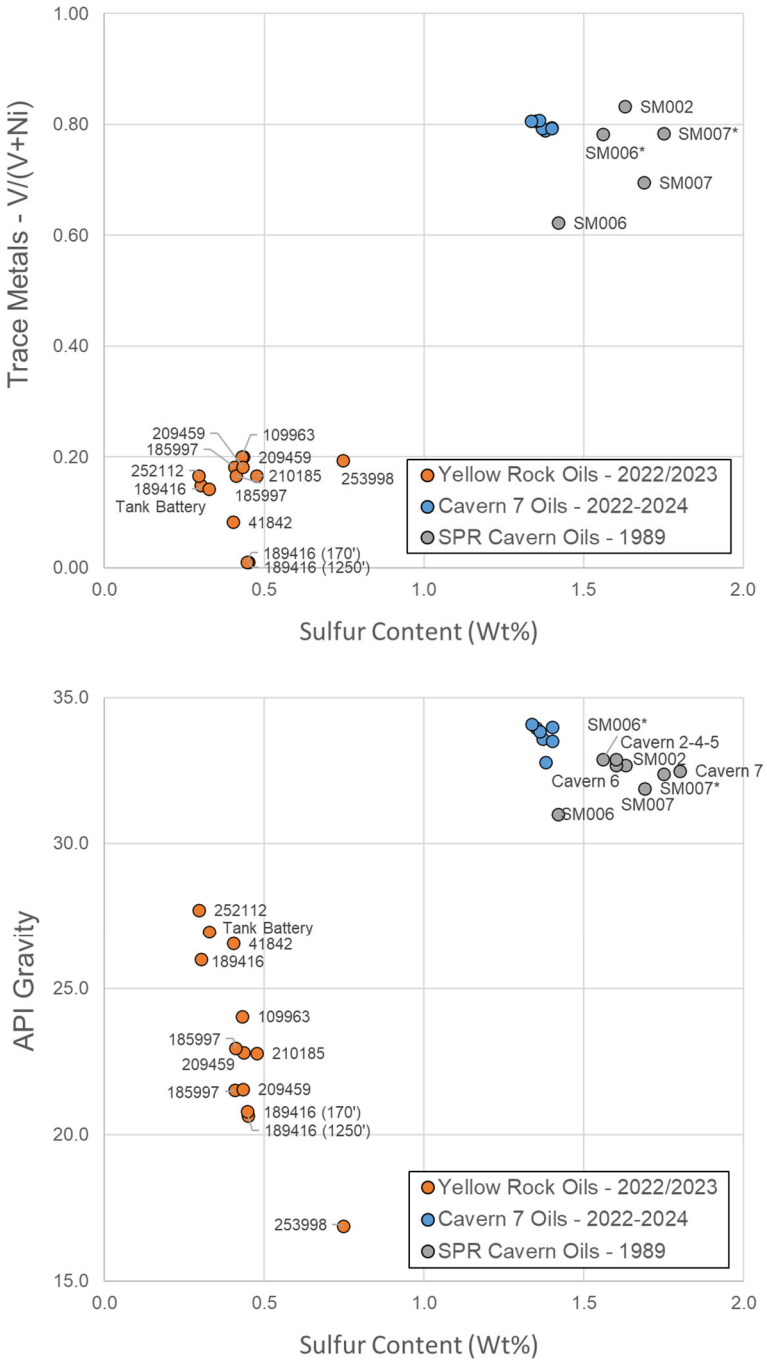



**Figure 5:** Crude oil assay results for the Cavern 7 oils and Yellow Rock (locally produced) oils recently studied and historic SPR cavern oils from 1989. All data from Table 4.

# ATTACHMENTS

Attachment 1

Chain-of-Custody

NewFields
Perspective. Vision. Solutions.

2/12/24

# Chain of Custody

LZ407828

***Environmental Forensics Practice LLC***

| Proj. No | Proj. Name |
|---|---|
| 0722101 | Sulphur Dome |

SAMPLERS: Signature

| DATE | TIME | LAB ID | CLIENT ID | SAMPLE DESCRIPTION | MATRIX (* see below) | GC-FID-TPH ($C_6^+$) | GCMS-Alkyl PAH | GCMS-Biomarkers | PIANO - VOA | Organic Lead | METALS | PCB | Pesticides | PRESERVED | Total Number of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ANALYSIS REQUESTED→ "NUMBER OF CONTAINERS" | | | | | | | | | | | | | | | |
| 2/7/2024 | 0800 | -01 | Cavern 7 Oil | Oil | O | X | X | X | X | | | | | | 2 |

| Relinquished by: | Date/Time | Received by: | Date/Time |
|---|---|---|---|
| | 2/7/24 2/8/24 | Fedex | |
| Relinquished by: Fedex | Date/Time 2/12/24 16:18 | Received by: | Date/Time 2/12/24 16:18 |
| Relinquished by: | Date/Time | Received by: | Date/Time |

* O=Oil
SO=Soil
SE=Sediment
T=Tissue
W=Water

Samples to be shipped to: Alpha Laboratory
320 Forbes Blvd.
Mansfield, MA 02048
Tel: (508) 844-4117
Attn: Sue O'Neil

Comments:

Contact Scott Stout for further details.

# Attachment 2

**Average short-term and long-term relative standard deviations ($RSD_r$ and $RSD_R$) calculated for the 30 diagnostic ratios used in the Sulphur Dome monitoring studies to date.**

| CEN - Diagnostic Ratios | CEN Diagnostic Ratios per Alpha Abbreviations | Sulphur Dome Site Precision: Repeatability $RSD_r$ | Sulphur Dome Site Precision: Reproducibility $RSD_R$ | Most Precise Ratios* |
|---|---|---|---|---|
| NR-C17/pris | C17/Pr | 1.8 | 5.1 | |
| NR-C18/phy | C18/Ph | 0.8 | 2.5 | x |
| NR- pris/phy | Pr/Ph | 1.5 | 4.0 | x |
| NR-4-MD/1-MD | 4-MDBT/1-MDBT | 2.4 | 8.7 | |
| NR-2-MP/1-MP | 2-MP/1-MP | 2.0 | 3.7 | x |
| NR-27Ts/30ab | T11/T19 | 3.1 | 3.9 | x |
| NR-27Tm/30ab | T12/T19 | 1.9 | 2.8 | x |
| NR-28ab/30ab | T14a/T19 | 3.3 | 6.1 | |
| NR-29ab/30ab | T15/T19 | 1.9 | 2.8 | x |
| NR-30O/30ab | T18/T19 | 6.9 | 59 | |
| NR-31abS/30ab | T21/T19 | 1.3 | 2.9 | x |
| NR-27dbR/27dbS | S4/S5 | 6.0 | 15 | |
| NR-27bb/29bb | (S14+S15)/(S26+S27) | 3.2 | 2.3 | x |
| NR-SC26/ RC26+SC27 | TAS09/TAS01 | 2.3 | 4.5 | x |
| NR-SC28/RC26 + SC27 | TAS02/TAS01 | 2.7 | 2.0 | x |
| NR-RC27/RC26+ SC27 | TAS03/TAS01 | 1.7 | 1.9 | x |
| NR-RC28/RC26+SC27 | TAS04/TAS01 | 2.9 | 1.8 | x |
| DR-Ts/Tm | T11/T12 | 2.4 | 4.5 | x |
| DR-29Ts30ab | T16/T19 | 3.8 | 3.7 | x |
| DR-29bb/29aa | (S26+S27)/(S25+S28) | 3.9 | 12 | |
| DR-C2-dbt/C2-phe | DBT2/PA2 | 0.7 | 3.2 | x |
| DR-C3-dbt/C3-phe | DBT3/PA3 | 0.7 | 3.9 | x |
| DR-C28C29/30ab | T7 to T10/T19 | 5.1 | 9.3 | |
| DR-29aaS/29aaR= | S25/S28 | 7.1 | 21 | |
| DR-C20TA/C21TA | TAS05/TAS06 | 3.8 | 9.5 | |
| DR-TA21/ RC26+SC27 | TS06/TAS01 | 3.7 | 8.4 | |
| DR-C24Tet/C26Tri | T6a/T6bc | 5.4 | 6.0 | |
| DR-30ba/30ab | T20/T19 | 4.3 | 11 | |
| DR-35ab/30ab | (T34 to T35)/T19 | 4.4 | 6.8 | |
| DR-32abR/32abS | T27/T26 | 1.9 | 3.1 | x |

*both $RSD_r$ and $RSD_R$ < 5% based on current QC datasets

$RSD_r$ = average RSD for sample duplicate pairs studied to date

$RSR_R$ = average RSD for 7B cavern (reference) oil studied to date

# Attachment 3

# Tabulated Concentrations

**Table A3-1: Concentrations (mg/kg) of n-alkanes and isoprenoids in the samples studied.**

| Client ID | CAVERN 7 OIL | CAVERN 7 OIL (dup) | 7B |
|---|---|---|---|
| Lab ID | L2407828-01 | WG1889779-4 | L2407828-02 |
| Date Collected | 2/7/2024 | 2/7/2024 | 1/25/2023 |
| Date Analyzed | 3/1/2024 | 3/1/2024 | 3/1/2024 |
| Analytes | Result | Result | Result |
| n-Nonane (C9) | 10,300 | 10,200 | 11,100 |
| n-Decane (C10) | 9,320 | 9,270 | 10,200 |
| n-Undecane (C11) | 9,180 | 9,100 | 10,000 |
| n-Dodecane (C12) | 8,280 | 8,290 | 9,160 |
| n-Tridecane (C13) | 7,760 | 7,720 | 8,480 |
| 2,6,10 Trimethyldodecane (1380) | 1,340 | 1,340 | 1,450 |
| n-Tetradecane (C14) | 7,080 | 7,110 | 7,630 |
| 2,6,10 Trimethyltridecane (1470) | 1,940 | 1,940 | 2,180 |
| n-Pentadecane (C15) | 6,380 | 6,440 | 6,990 |
| n-Hexadecane (C16) | 5,940 | 5,880 | 6,380 |
| Norpristane (1650) | 1,240 | 1,220 | 1,350 |
| n-Heptadecane (C17) | 5,020 | 5,030 | 5,480 |
| Pristane | 1,850 | 1,830 | 2,030 |
| n-Octadecane (C18) | 4,170 | 4,160 | 4,480 |
| Phytane | 1,920 | 1,910 | 2,090 |
| n-Nonadecane (C19) | 3,680 | 3,620 | 3,930 |
| n-Eicosane (C20) | 3,520 | 3,490 | 3,830 |
| n-Heneicosane (C21) | 2,720 | 2,670 | 2,970 |
| n-Docosane (C22) | 2,540 | 2,590 | 2,820 |
| n-Tricosane (C23) | 2,130 | 2,110 | 2,310 |
| n-Tetracosane (C24) | 2,100 | 2,090 | 2,250 |
| n-Pentacosane (C25) | 1,800 | 1,780 | 1,950 |
| n-Hexacosane (C26) | 1,480 | 1,470 | 1,610 |
| n-Heptacosane (C27) | 1,240 | 1,230 | 1,360 |
| n-Octacosane (C28) | 1,030 | 1,020 | 1,140 |
| n-Nonacosane (C29) | 1,150 | 1,120 | 1,240 |
| n-Triacontane (C30) | 822 | 832 | 934 |
| n-Hentriacontane (C31) | 884 | 903 | 1,080 |
| n-Dotriacontane (C32) | 635 | 621 | 756 |
| n-Tritriacontane (C33) | 618 | 616 | 730 |
| n-Tetratriacontane (C34) | 519 | 512 | 612 |
| n-Pentatriacontane (C35) | 560 | 562 | 688 |
| n-Hexatriacontane (C36) | 322 | 343 | 398 |
| n-Heptatriacontane (C37) | 314 | 296 | 371 |
| n-Octatriacontane (C38) | 334 | 318 | 378 |
| n-Nonatriacontane (C39) | 222 | 248 | 298 |
| n-Tetracontane (C40) | 208 | 198 | 256 |
| Total Saturated Hydrocarbons | 111,000 | 110,000 | 121,000 |
| Total Petroleum Hydrocarbons (C9-C44) | 674,000 | 632,000 | 719,000 |

## Table A3-2: Concentrations (mg/kg) of PAHs, related compounds and petroleum biomarkers in the samples studied.

| | | CAVERN 7 OIL | CAVERN 7 OIL (dup) | 7B |
|---|---|---|---|---|
| | Client ID | | | |
| | Lab ID | L2407828-01 | WG1889779-4 | L2407828-02 |
| | Date Collected | 2/7/2024 | 2/7/2024 | 1/25/2023 |
| | Date Analyzed | 3/19/2024 | 3/19/2024 | 3/19/2024 |
| | Analytes | Result | Result | Result |
| D0 | cis/trans-Decalin | 263 | 256 | 225 |
| D1 | C1-Decalins | 468 | 456 | 392 |
| D2 | C2-Decalins | 412 | 402 | 356 |
| D3 | C3-Decalins | 255 | 255 | 222 |
| D4 | C4-Decalins | 268 | 270 | 242 |
| BT0 | Benzothiophene | 11 | 11 | 10 |
| BT1 | C1-Benzo(b)thiophenes | 66 | 66 | 60 |
| BT2 | C2-Benzo(b)thiophenes | 223 | 222 | 192 |
| BT3 | C3-Benzo(b)thiophenes | 408 | 403 | 352 |
| BT4 | C4-Benzo(b)thiophenes | 333 | 328 | 287 |
| N0 | Naphthalene | 303 | 302 | 267 |
| N1 | C1-Naphthalenes | 942 | 931 | 808 |
| N2 | C2-Naphthalenes | 1,480 | 1,460 | 1,260 |
| N3 | C3-Naphthalenes | 1,310 | 1,300 | 1,130 |
| N4 | C4-Naphthalenes | 750 | 747 | 659 |
| B | Biphenyl | 44 | 44 | 37 |
| DF | Dibenzofuran | 33 | 33 | 29 |
| AY | Acenaphthylene | 5.5 | 5.8 | 4.9 |
| AE | Acenaphthene | 10 | 10 | 9 |
| F0 | Fluorene | 66 | 66 | 58 |
| F1 | C1-Fluorenes | 163 | 163 | 144 |
| F2 | C2-Fluorenes | 277 | 273 | 243 |
| F3 | C3-Fluorenes | 295 | 292 | 261 |
| A0 | Anthracene | nd | nd | nd |
| P0 | Phenanthrene | 116 | 115 | 103 |
| PA1 | C1-Phenanthrenes/Anthracenes | 320 | 320 | 284 |
| PA2 | C2-Phenanthrenes/Anthracenes | 412 | 416 | 379 |
| PA3 | C3-Phenanthrenes/Anthracenes | 312 | 304 | 273 |
| PA4 | C4-Phenanthrenes/Anthracenes | 149 | 150 | 134 |
| RET | Retene | nd | nd | nd |
| DBT0 | Dibenzothiophene | 255 | 254 | 224 |
| DBT1 | C1-Dibenzothiophenes | 648 | 649 | 586 |
| DBT2 | C2-Dibenzothiophenes | 950 | 957 | 865 |
| DBT3 | C3-Dibenzothiophenes | 756 | 758 | 673 |
| DBT4 | C4-Dibenzothiophenes | 393 | 390 | 352 |
| BF | Benzo(b)fluorene | 3.5 | 4.4 | 3.8 |
| FL0 | Fluoranthene | 2.4 | 2.1 | 1.8 |
| PY0 | Pyrene | 12 | 12 | 11 |
| FP1 | C1-Fluoranthenes/Pyrenes | 50 | 51 | 45 |
| FP2 | C2-Fluoranthenes/Pyrenes | 99 | 98 | 89 |
| FP3 | C3-Fluoranthenes/Pyrenes | 128 | 130 | 116 |
| FP4 | C4-Fluoranthenes/Pyrenes | 117 | 116 | 105 |
| NBT0 | Naphthobenzothiophenes | 54 | 54 | 49 |
| NBT1 | C1-Naphthobenzothiophenes | 169 | 170 | 154 |
| NBT2 | C2-Naphthobenzothiophenes | 261 | 262 | 238 |
| NBT3 | C3-Naphthobenzothiophenes | 228 | 228 | 207 |
| NBT4 | C4-Naphthobenzothiophenes | 164 | 166 | 150 |
| BA0 | Benz[a]anthracene | 1.7 | 1.7 | 1.4 |
| C0 | Chrysene/Triphenylene | 21 | 23 | 21 |
| BC1 | C1-Chrysenes | 45 | 43 | 40 |
| BC2 | C2-Chrysenes | 72 | 72 | 67 |
| BC3 | C3-Chrysenes | 101 | 100 | 91 |
| BC4 | C4-Chrysenes | 73 | 72 | 65 |

Table A3-2 (cont.)

| | | CAVERN 7 OIL | CAVERN 7 OIL (dup) | 7B |
|---|---|---|---|---|
| | Client ID | | | |
| | Lab ID | L2407828-01 | WG1889779-4 | L2407828-02 |
| | Date Collected | 2/7/2024 | 2/7/2024 | 1/25/2023 |
| | Date Analyzed | 3/19/2024 | 3/19/2024 | 3/19/2024 |
| | Analytes | Result | Result | Result |
| BBF | Benzo[b]fluoranthene | 3.2 | 2.9 | 2.9 |
| BJKF | Benzo[j]fluoranthene/Benzo[k]fluoranthene | nd | nd | nd |
| BAF | Benzo[a]fluoranthene | nd | nd | nd |
| BEP | Benzo[e]pyrene | 9 | 9 | 8 |
| BAP | Benzo[a]pyrene | 1.5 | 1.5 | 1.6 |
| PER | Perylene | 1.6 | 1.6 | 1.5 |
| IND | Indeno[1,2,3-cd]pyrene | 0.5 | 0.6 | 0.5 |
| DA | Dibenz[ah]anthracene/Dibenz[ac]anthrace | 0.6 | 0.6 | 0.7 |
| GHI | Benzo[g,h,i]perylene | 2.9 | 2.8 | 2.7 |
| CAR | Carbazole | 11.4 | 10.2 | 9.3 |
| 4MDT | 4-Methyldibenzothiophene | 280 | 282 | 259 |
| 2MDT | 2/3-Methyldibenzothiophene | 244 | 243 | 217 |
| 1MDT | 1-Methyldibenzothiophene | 116 | 116 | 103 |
| 3MP | 3-Methylphenanthrene | 57 | 58 | 52 |
| 2MP | 2-Methylphenanthrene | 72 | 72 | 63 |
| 2MA | 2-Methylanthracene | 2.8 | 2.7 | 2.3 |
| 9MP | 9/4-Methylphenanthrene | 110 | 110 | 100 |
| 1MP | 1-Methylphenanthrene | 70 | 70 | 59 |
| 2MN | 2-Methylnaphthalene | 737 | 730 | 633 |
| 1MN | 1-Methylnaphthalene | 688 | 679 | 588 |
| 26DMN | 2,6-Dimethylnaphthalene | 606 | 600 | 524 |
| 235TMN | 2,3,5-Trimethylnaphthalene | 166 | 163 | 109 |
| PY2 | 2-METHYLPYRENE | #REF! | #REF! | #REF! |
| PY4 | 4-METHYLPYRENE | 3.1 | 3.2 | 2.9 |
| PY1 | 1-METHYLPYRENE | 12.8 | 12.8 | 11.8 |
| T4 | C23 Tricyclic Terpane | 28 | 28 | 27 |
| T5 | C24 Tricyclic Terpane | 14 | 13 | 11 |
| T6 | C25 Tricyclic Terpane | 15 | 14 | 13 |
| T6a | C24 Tetracyclic Terpane | 18 | 18 | 14 |
| T6b | C26 Tricyclic Terpane-22S | 5.8 | 6.7 | 4.8 |
| T6c | C26 Tricyclic Terpane-22R | 4.1 | 5.5 | 4.2 |
| T7 | C28 Tricyclic Terpane-22S | 5.0 | 5.8 | 6.3 |
| T8 | C28 Tricyclic Terpane-22R | 6.3 | 6.3 | 5.3 |
| T9 | C29 Tricyclic Terpane-22S | 6.6 | 7.1 | 5.5 |
| T10 | C29 Tricyclic Terpane-22R | 7 | 8 | 6 |
| T11 | 18a-22,29,30-Trisnorneohopane-TS | 28 | 27 | 22 |
| T11a | C30 Tricyclic Terpane-22S | 5.9 | 6.2 | 4.6 |
| T11b | C30 Tricyclic Terpane-22R | 6.1 | 5.6 | 5.8 |
| T12 | 17a(H)-22,29,30-Trisnorhopane-TM | 31 | 30 | 27 |
| T14a | 17a/b,21b/a 28,30-Bisnorhopane | 23 | 21 | 20 |
| T14b | 17a(H),21b(H)-25-Norhopane | nd | 3.8 | 4.1 |
| T15 | 30-Norhopane | 100 | 97 | 85 |
| T16 | 18a(H)-30-Norneohopane-C29Ts | 24 | 23 | 22 |
| X | 17a(H)-Diahopane | 4.4 | 4.0 | 4.2 |
| T17 | 30-Normoretane | 11 | 11 | 10 |
| T18 | 18a(H)&18b(H)-Oleananes | 6.0 | 5.2 | 6.6 |
| T19 | Hopane | 116 | 113 | 101 |
| T20 | Moretane | 10 | 11 | 9 |
| T21 | 30-Homohopane-22S | 70 | 69 | 61 |
| T22 | 30-Homohopane-22R | 53 | 53 | 46 |

Table A3-2 (cont.)

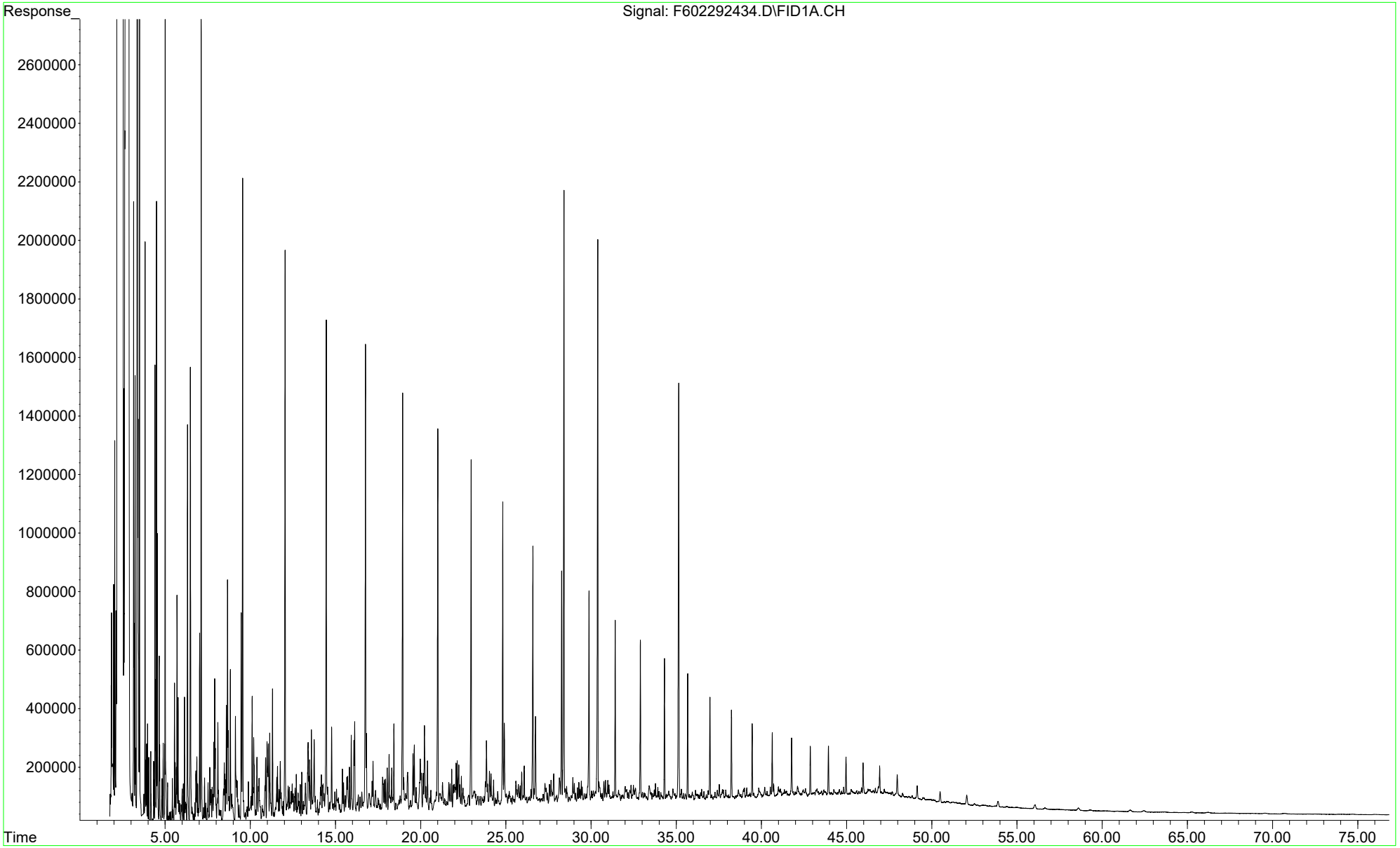
| | | CAVERN 7 OIL | CAVERN 7 OIL (dup) | 7B |
|---|---|---|---|---|
| | Client ID | | | |
| | Lab ID | L2407828-01 | WG1889779-4 | L2407828-02 |
| | Date Collected | 2/7/2024 | 2/7/2024 | 1/25/2023 |
| | Date Analyzed | 3/19/2024 | 3/19/2024 | 3/19/2024 |
| | Analytes | Result | Result | Result |
| T22A | T22a-Gammacerane/C32-diahopane | 14 | 14 | 12 |
| T26 | 30,31-Bishomohopane-22S | 43 | 43 | 38 |
| T27 | 30,31-Bishomohopane-22R | 34 | 32 | 28 |
| T30 | 30,31-Trishomohopane-22S | 33 | 33 | 29 |
| T31 | 30,31-Trishomohopane-22R | 23 | 24 | 20 |
| T32 | Tetrakishomohopane-22S | 23 | 22 | 20 |
| T33 | Tetrakishomohopane-22R | 17 | 18 | 15 |
| T34 | Pentakishomohopane-22S | 24 | 23 | 22 |
| T35 | Pentakishomohopane-22R | 18 | 19 | 16 |
| S4 | 13b(H),17a(H)-20S-Diacholestane | 34 | 32 | 29 |
| S5 | 13b(H),17a(H)-20R-Diacholestane | 17 | 19 | 14 |
| S23 | 14b,17b-20S-Methylcholestane | 39 | 38 | 35 |
| S26 | 14b(H),17b(H)-20R-Ethylcholestane | 58 | 55 | 42 |
| S27 | 14b(H),17b(H)-20S-Ethylcholestane | 30 | 33 | 33 |
| TAS05 | C20 PREGNANE | 112.0 | 113.0 | 105.0 |
| TAS06 | C21 20-METHYLPREGNANE | 83.9 | 82.7 | 74.4 |
| TAS07 | C22 20-ETHYLPREGNANE (A) | 43.7 | 42.1 | 37.2 |
| TAS08 | C22 20-ETHYLPREGNANE (B) | 27.5 | 25.7 | 23.4 |
| TAS09 | C26,20S TAS | 26.6 | 26.2 | 24.5 |
| TAS01 | C26,20R+C27,20S TAS | 206 | 204 | 183 |
| TAS02 | C28,20S TAS | 148 | 145 | 131 |
| TAS03 | C27,20R TAS | 160 | 158 | 142 |
| TAS04 | C28,20R TAS | 123 | 125 | 111 |
| TAS10 | C29,20S TAS | 60.5 | 49.0 | 52.0 |
| TAS11 | C29,20R TAS | 19.8 | 23.7 | 17.7 |

# Attachment 4

# GC/FID Chromatograms

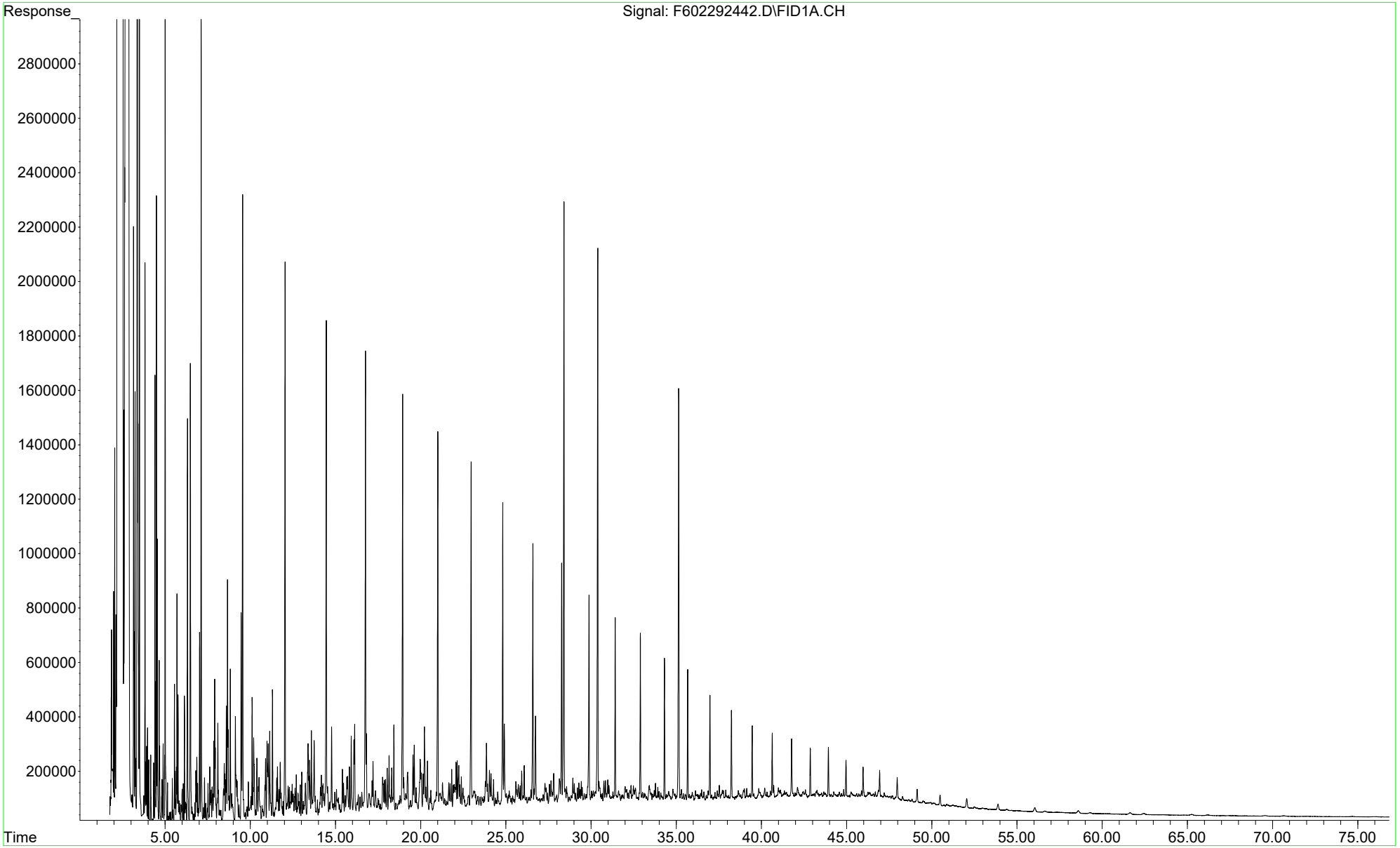
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\SH
... C\F602292434.D
Operator : FID6:AMV
Instrument : FID6
Acquired : 01 Mar 2024 9:29 am using AcqMethod FID6A.M
Sample Name: L2407828-01,42,,
Misc Info : WG1890844,WG1889779,ICAL20420

CAVERN 7 OIL
L2407828-01



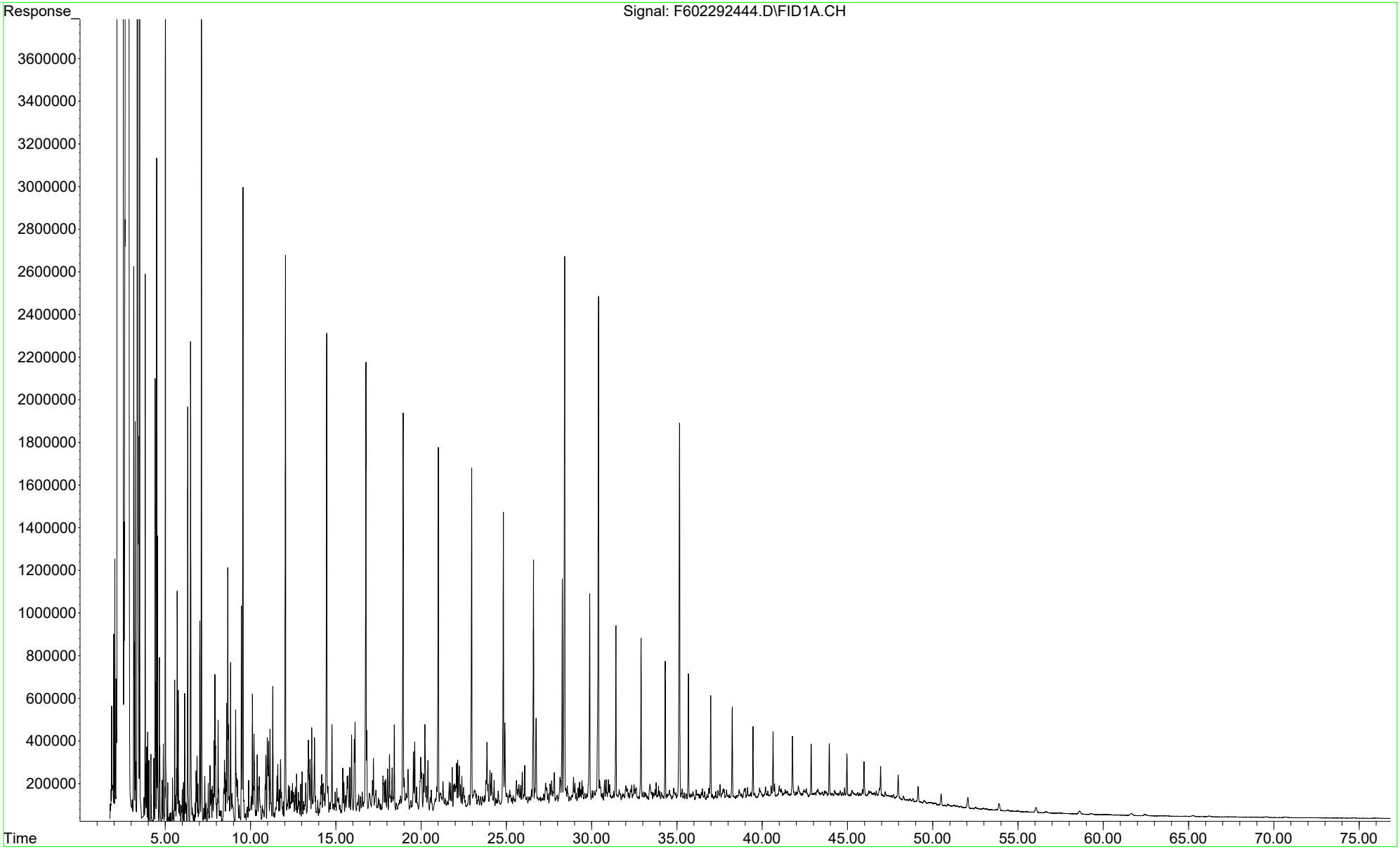
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\SH
... C\F602292442.D
Operator : FID6:AMV
Instrument : FID6
Acquired : 01 Mar 2024 3:17 pm using AcqMethod FID6A.M
Sample Name: WG1889779-4,42,,
Misc Info : WG1890844,WG1889779,ICAL20420

CAVERN 7 OIL Duplicate
WG1889779-4



File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\SH
... C\F602292444.D
Operator : FID6:AMV
Instrument : FID6
Acquired : 01 Mar 2024 4:44 pm using AcqMethod FID6A.M
Sample Name: L2407828-02,42,,
Misc Info : WG1890844,WG1889779,ICAL20420

7B
L2407828-02
Reference Oil

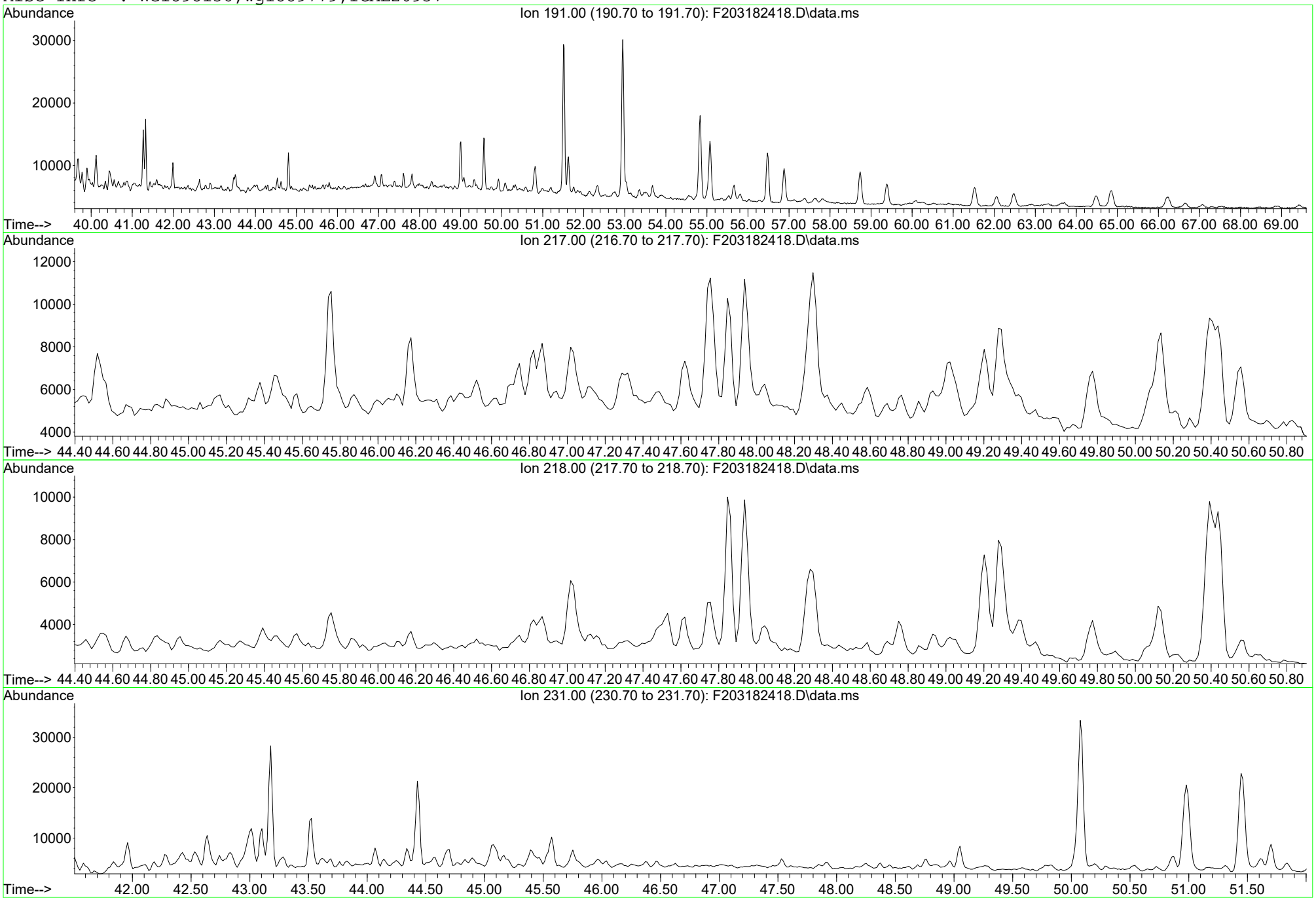


# Attachment 5

# GC/MS Extracted Ion Profiles

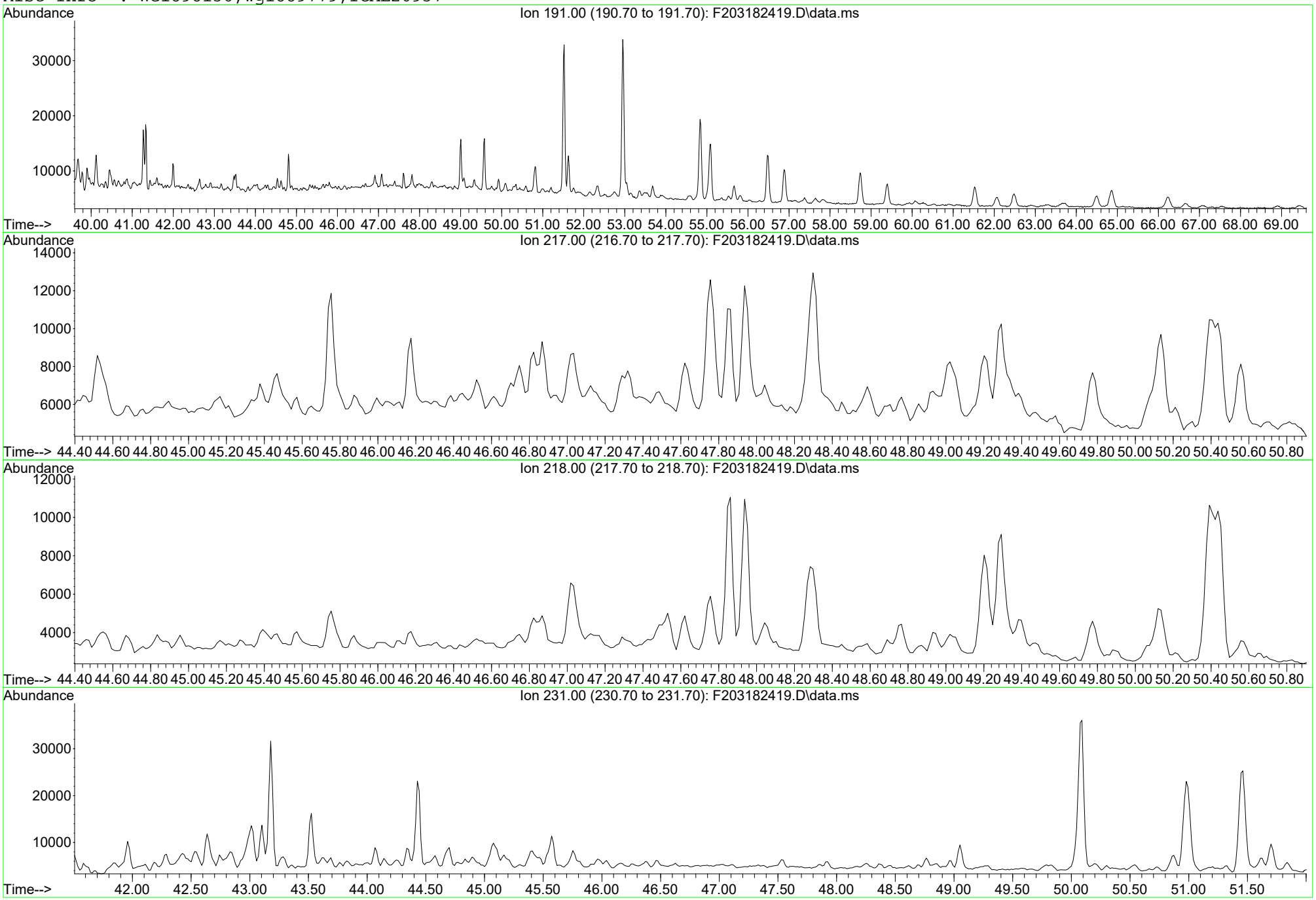
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
... KPAHBIO\F203182418.D
Operator : PAH2:cnc
Instrument : PAH2
Acquired : 19 Mar 2024 7:30 pm using AcqMethod FRNC2A.M
Sample Name: L2407828-01
Misc Info : WG1898136,wg1889779,ICAL20937

CAVERN 7 OIL
L2407828-01



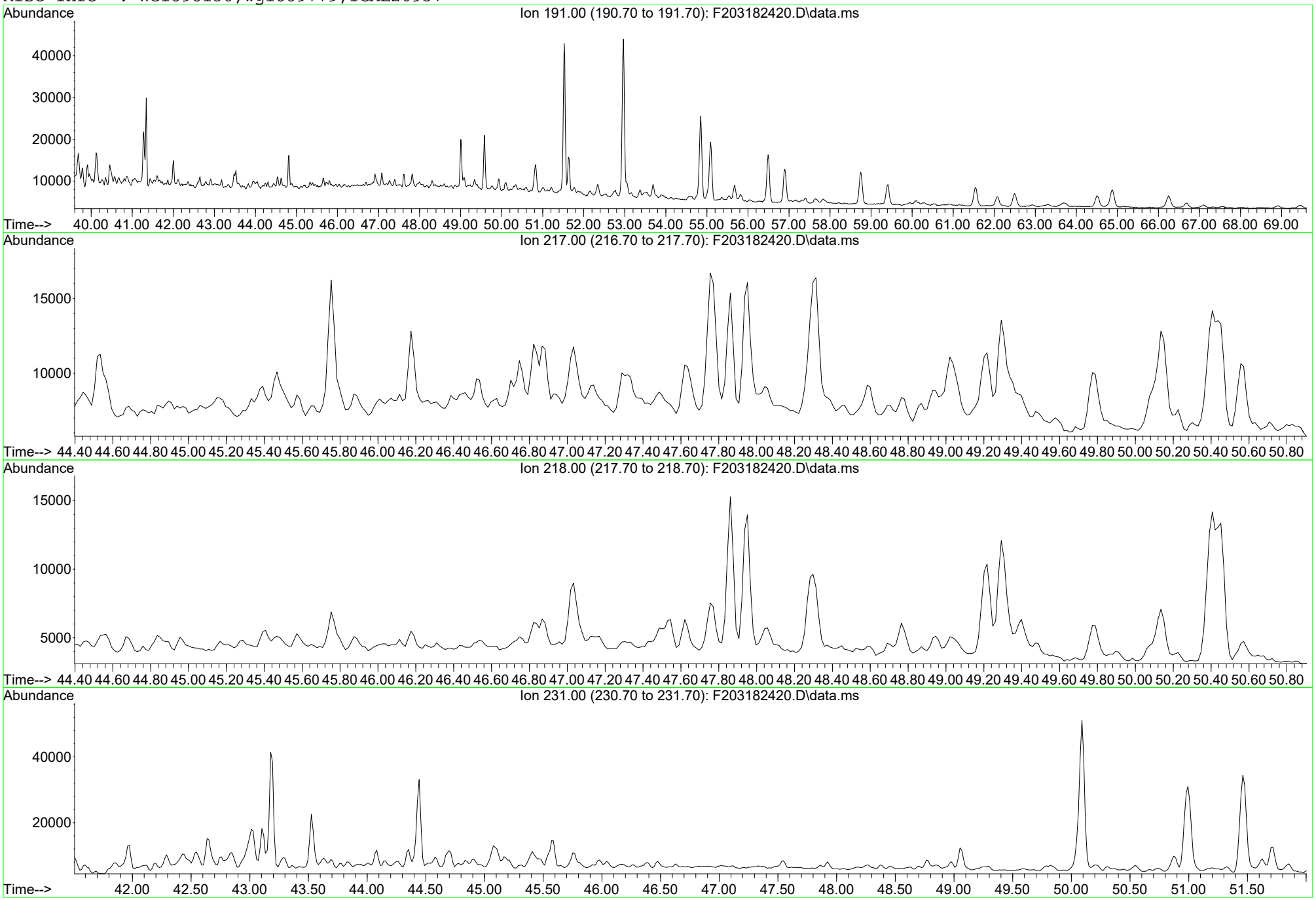
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
... KPAHBIO\F203182419.D
Operator : PAH2:cnc
Instrument : PAH2
Acquired : 19 Mar 2024 8:59 pm using AcqMethod FRNC2A.M
Sample Name: wg1889779-4,32,,
Misc Info : WG1898136,wg1889779,ICAL20937

CAVERN 7 OIL Duplicate
WG1889779-4



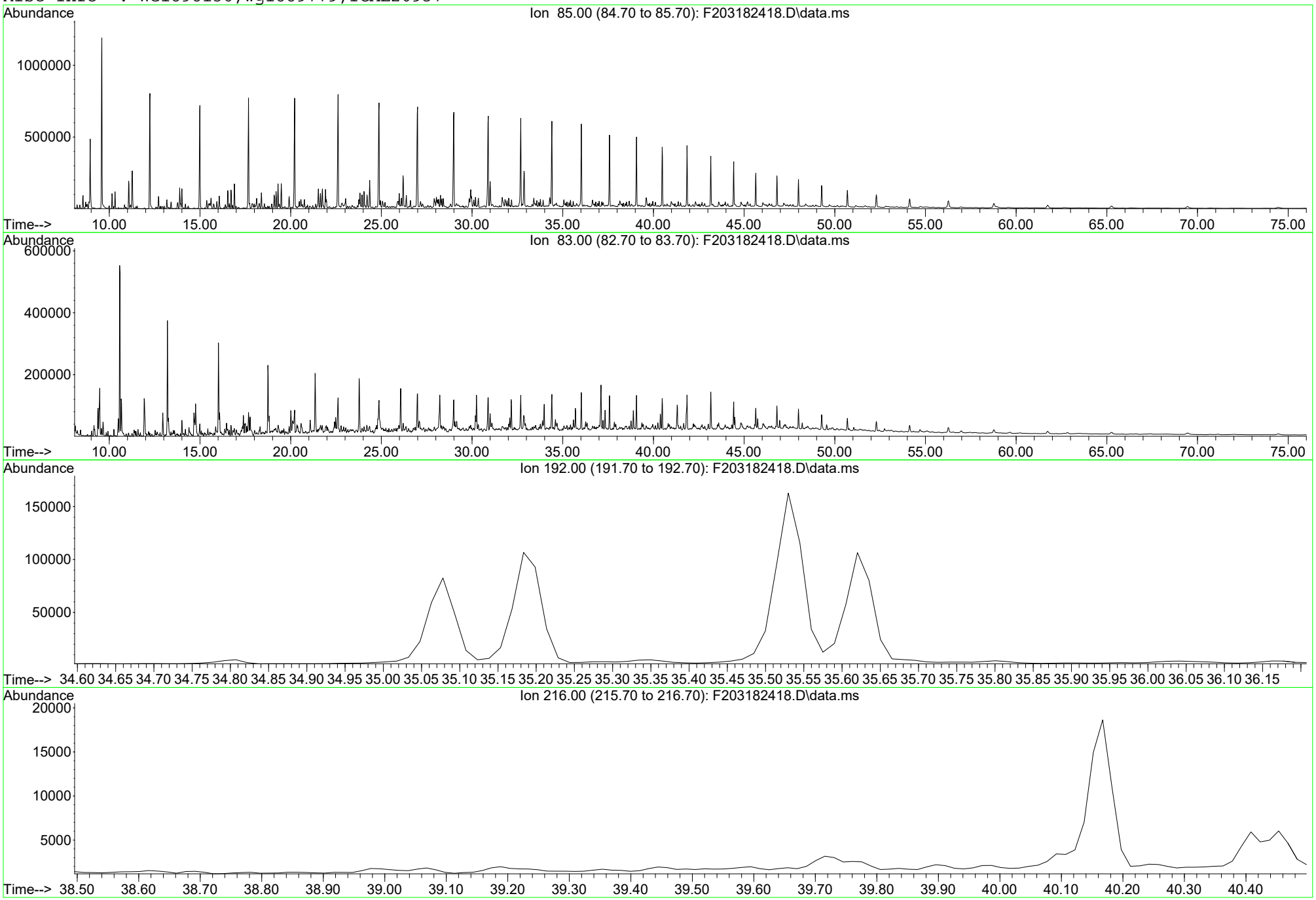
```
File       :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
...         KPAHBIO\F203182420.D
Operator   : PAH2:cnc
Instrument :    PAH2
Acquired   : 19 Mar 2024  10:28 pm using AcqMethod FRNC2A.M
Sample Name: l2407828-02,32,,
Misc Info  : WG1898136,wg1889779,ICAL20937
```

7B
L2407828-02
Reference Oil



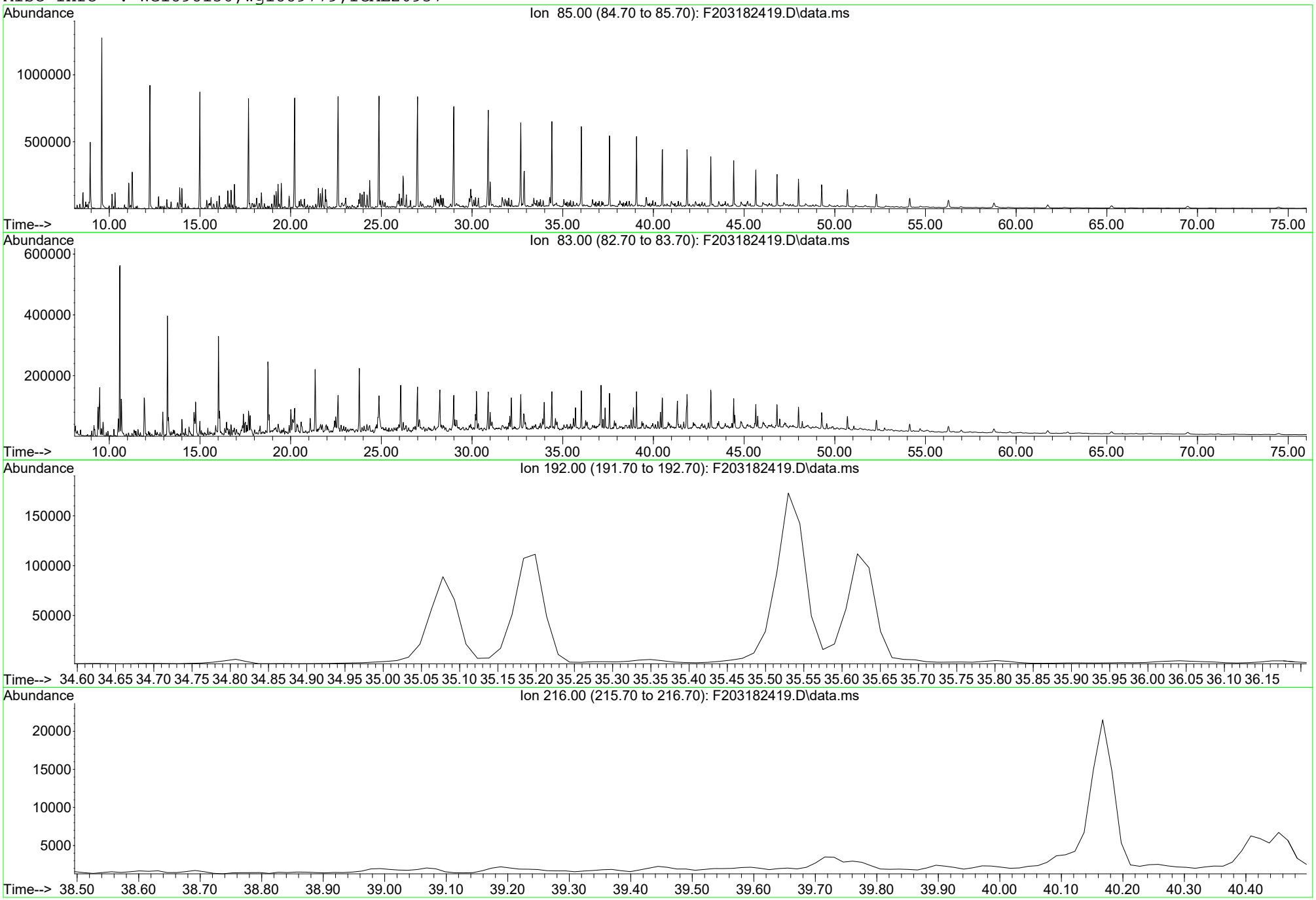
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
... KPAHBIO\F203182418.D
Operator : PAH2:cnc
Instrument : PAH2
Acquired : 19 Mar 2024 7:30 pm using AcqMethod FRNC2A.M
Sample Name: L2407828-01
Misc Info : WG1898136,wg1889779,ICAL20937

CAVERN 7 OIL
L2407828-01



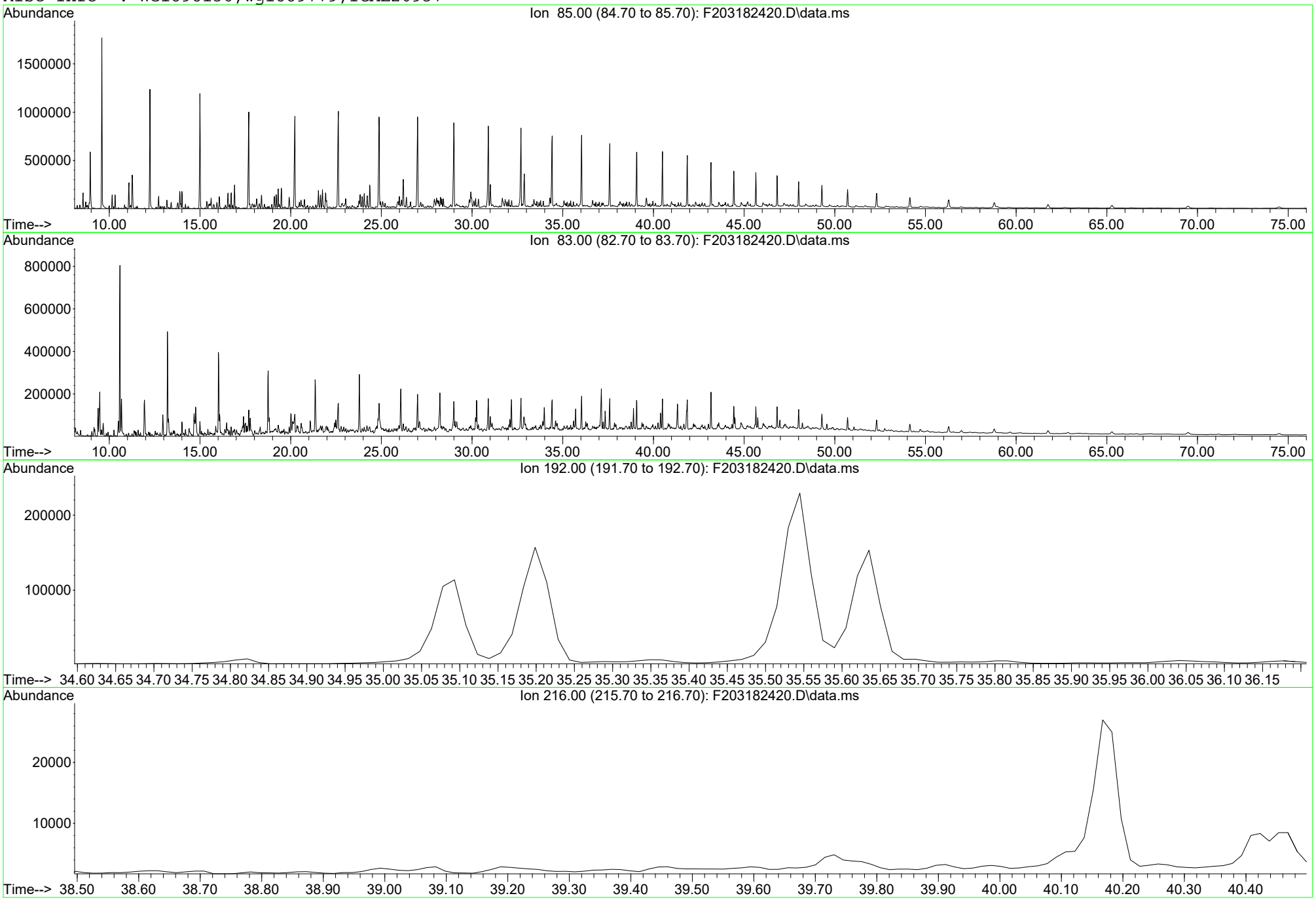
File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
... KPAHBIO\F203182419.D
Operator : PAH2:cnc
Instrument : PAH2
Acquired : 19 Mar 2024 8:59 pm using AcqMethod FRNC2A.M
Sample Name: wg1889779-4,32,,
Misc Info : WG1898136,wg1889779,ICAL20937

CAVERN 7 OIL Duplicate
WG1889779-4



File :D:\West Lake Salt Dome_850.000079.023\Alpha Data\L2407828\AL
... KPAHBIO\F203182420.D
Operator : PAH2:cnc
Instrument : PAH2
Acquired : 19 Mar 2024 10:28 pm using AcqMethod FRNC2A.M
Sample Name: l2407828-02,32,,
Misc Info : WG1898136,wg1889779,ICAL20937

7B
L2407828-02
Reference Oil



# Attachment 6

# Crude Oil Assay for October 2023 7B cavern oil

**Houston Laboratories**
8820 Interchange Drive
Houston, TX 77054
Phone 713-660-0901

# Certificate of Analysis

Number: 1030-24020292-001A

Scott Himes
ERM
840 W. Sam Houston Parkway North
Houston, TX 77024-4613

Feb. 16, 2024

Station Name: Cavern 7 Oil
Method: ASTM D-86
Analyzed: 02/13/2024 00:00:00 by KAR

Sampled By:
Sample Of: Liquid Spot
Sample Date: 02/07/2024 08:00
Sample Conditions:

## ASTM D-86 Distillation

| % Recovery | °F @ 772 mm Hg |
|---|---|
| Initial Boiling Point | 132 |
| 5 | 194 |
| 10 | 248 |
| 20 | 324 |
| 30 | NR |
| 40 | NR |
| 50 | NR |
| 60 | NR |
| 70 | NR |
| 80 | NR |
| 85 | NR |
| 90 | NR |
| 95 | NR |
| Final Boiling Point | 400 |
| Volume % Recovery | 27.0 |
| Volume % Residue | 73.0 |
| Volume % Loss | 0 |

**Comments:** Temperatures are uncorrected for barometric pressure.
Visual color is Crude.
IBP to 400°F Naphtha Cut Mass Fraction = 0.2385

Michael Staley

Data reviewed by: Michael Staley, ASTM Manager

Quality Assurance: The above analyses are performed in accordance with ASTM, UOP, GPA guidelines for quality assurance, unless otherwise stated.

# Certificate of Analysis

Number: 1030-24020292-001A

**Houston Laboratories**
8820 Interchange Drive
Houston, TX 77054
Phone 713-660-0901

Scott Himes
ERM
840 W. Sam Houston Parkway North
Houston, TX 77024-4613

Feb. 16, 2024

Station Name: Cavern 7 Oil
Sample Conditions:

Sampled By:
Sample Of: Liquid Spot
Sample Date: 02/07/2024 08:00

## Analytical Data

| Test | Method | Result | Units | Detection Limit | Lab Tech. | Analysis Date |
|---|---|---|---|---|---|---|
| Salt in Crude Oil | ASTM D-3230 | 20.0 | lbs/1000 bbls | | CMN | 02/09/2024 |
| Sulfur Content by X-ray | ASTM D-4294 | 1.336 | wt% | | EC | 02/15/2024 |
| Organic Chloride | ASTM D-4929 | <1.0 | ppmw | | MG | 02/13/2024 |
| API Gravity @ 60.001 °F | ASTM D-5002 | 34.09 | ° | | EC | 02/15/2024 |
| Specific Gravity @ 60.001/60.001 °F | ASTM D-5002 | 0.8545 | _ | | EC | 02/15/2024 |
| Density @ 60.001 °F | ASTM D-5002 | 0.8537 | g/ml | | EC | 02/15/2024 |
| Nickel | ASTM D-5708A | 6 | ppmw | | CMN | 02/10/2024 |
| Vanadium | ASTM D-5708A | 25 | ppmw | | CMN | 02/10/2024 |
| Iron | ASTM D-5708A | <1 | ppmw | | CMN | 02/10/2024 |

**Comments:**
AS-D-4929: Sample analyzed by ASTM D-4929 procedure B.

Data reviewed by: Michael Staley, ASTM Manager

Quality Assurance: The above analyses are performed in accordance with ASTM, UOP, GPA guidelines for quality assurance, unless otherwise stated.

# SPL, Inc.

## Analysis Request Chain of Custody Record

SPL

| SPL Work Order No.: | Acct. Mate Code: | Dept. Code | Page | Pages |
|---|---|---|---|---|
| | | | 1 | 1 |

| Report To: (Company Name): | ERM | | | Project/Station Name: | Project/Station Number: | Project/Station Location: | Requested TAT* |
|---|---|---|---|---|---|---|---|
| Address: | 840 W. Sam Houston Parkway North<br>Suite 600 | | | Special Instructions: | | | 10 business days |
| City/State/Zip: | Houston | TX | 77024-4613 | | | | |
| Contact: | Scott Himes | Scott.Himes@erm.com | | Indicate Billing Type: (Place "X", where appropriate) | Net 30 day Acct. | Check # | |
| Phone: | 832-209-8811 | Fax: | | | Credit Card | <<<Contact SPL, Inc for CC payment arrangements. | *Surcharges May Apply (See quote for details) |

| Invoice To: (Company Name): | ERM | | |
|---|---|---|---|
| Address: | 840 W. Sam Houston Parkway North<br>Suite 600 | | |
| City/State/Zip: | Houston | TX | 77024-4613 |
| Contact: | Scott Himes | Scott.Himes@erm.com | |
| Phone: | 832-209-8811 | Fax: | |
| Client PO# or Ref. No.: | | | |
| Contract/Proposal #: (i.e. SPLQ####) | SPLQ10978 | | |

† Terms: Cylinders will be rented for $10/cyl. All cylinders checked out are to be returned within 21 days, whether they contain sample or not. Cylinders not returned after 30 days will be considered lost and will be billed at current replacement cost.

| Sample ID (used to log/track sample) | Sample Date | Sample Time | Sample Type (Gas/Liq. /Solid) | Duplicate | Composite | Spot | Cylinder Tracking Info† Cylinder # | Date Out | Date In | AS-D-5002 | AS-D-4294 | ASTM D-5708 | AS-D-3230 | ASTM D-86-IBP-400°F | AS-D-4929 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cavern 7 Oil | 02/07/24 | 8:00 AM | Liq | | | X | | | | X | X | X | X | X | X | |
| | | | | | | | | | | | | | | | | |
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Requested Analysis (Place an "X" next to Sample ID below)

| | | | | | | |
|---|---|---|---|---|---|---|
| Sampled By-Print Name: | DAVID SANGUINETTI | | | Received By-Company: | | |
| Signature: | | | | | | |
| Relinquished By-Print Name: | DAVID SANGUINETTI | Date: 2/8/24 | Time: 10:10 AM | Received By-Print Name: | Aaron Mattiner | Date: 2/8/24 Time: 10:10 AM |
| Signature: | | | | Signature: | | |
| Relinquished By-Print Name: | Aaron Mattiner | Date: 2/8/24 | Time: 12:39PM | Received By-Print Name: | | Date: 2/8/24 Time: 14:41 |
| Signature: | | | | Signature: | | |
| Relinquished By-Print Name: | | Date: | Time: | Received By-Print Name: | | Date: Time: |
| Signature: | | | | Signature: | | |

| Choose SPL Facility>>> | Corporate HQ - Houston, TX | Ship to Address: | 8820 Interchange Dr., Houston,TX 77054 | Phone: | 713.660.0901 |
|---|---|---|---|---|---|

Note - As a convenience to our clients, this form is available in an electronic format. Please contact one of our offices above for the form to be e-mailed to you.