A Preliminary Report to the U.S. Coast Guard

Reconnaissance of Macondo-1 Well Oil in Sediment and Tarballs from the Northern Gulf of Mexico Shoreline, Texas to Florida

By Robert J. Rosenbauer, Pamela L. Campbell, Angela Lam, Thomas D. Lorenson, Frances D. Hostettler, Burt Thomas, and Florence L. Wong

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Abstract

Hydrocarbons were extracted and analyzed from sediment and tarballs collected from the northern Gulf of Mexico (nGOM) coast that is potentially impacted by Macondo-1 (M-1) well oil. The samples were analyzed for a suite of diagnostic geochemical biomarkers. Aided by multivariate statistical analysis, the M-1 well oil has been identified in sediment and tarballs collected from Louisiana, Alabama, Mississippi, and Florida. None of the sediment hydrocarbon extracts from Texas correlated with the M-1 well oil. Oil-impacted sediments are confined to the shoreline adjacent to the cumulative oil slick of the Deepwater Horizon oil spill, and no impact was observed outside of this area.

Keywords

Deepwater Horizon, Gulf of Mexico, oil spill, oil fingerprinting,

Introduction

From April 20 through July 15, 2010, an estimated 4.4 million barrels (1 barrel = 42 gallons) of crude oil spilled into the northern Gulf of Mexico (nGOM) from the ruptured British Petroleum (BP) Macondo-1 (BP M-1) well located in the Mississippi Canyon lease block 252 (Crone and Tolstoy, 2010). In addition, ~1.84 million gallons of Corexit™ dispersants were applied to the oil both on and below the sea surface (British Petroleum, 2010). An estimate of the total extent of the surface oil slick, derived from wind, ocean currents, aerial photography, and satellite imagery, was 68,000 square miles (Amos, 2010) (fig. 1). Spilled oil from this event poses a potential threat to sensitive habitat along the shores of the nGOM. In response to this threat, the U.S. Geological Survey (USGS) collected near-surface beach and coastal sediment and tarballs from 49 sites along the shores of the nGOM from Texas to Florida before and after oil made landfall. These sites included priority areas of the nGOM, such as coastal wetlands and Department of Interior (DOI) lands at highest risk for oil contamination, including wetlands, shorelines, and barrier islands that could suffer severe environmental damage if a significant amount of oil came ashore. The purpose of this effort was to document pre-impact conditions and post-impact conditions after oil made landfall at a site. The focus of this report is to characterize the post-impact environmental samples for the presence of BP M-1 well oil in a subset of samples where oil may have made landfall.

Results from this report will be compared to similar analyses of the coupled pre-impact samples in a subsequent report. This report complements activities of other USGS scientists and USGS production and research laboratories who are analyzing aliquots of the same samples for volatile organic compounds and other hydrocarbons, oil and grease, trace metals, Corexit surfactants, total and dissolved organic carbon characterization, bacterial populations capable of degrading oils, nutrients such as nitrogen and phosphorus compounds related to oil releases, toxicity of pore water, and benthic macroinvertebrate indicators of shoreline habitat conditions. The USGS was requested to undertake this post-impact sampling and analytical study by the U.S. Coast Guard in New Orleans on September 24, 2010.

Methods

Sampling

Bottom sediment from a subset of 48 of the original 70 pre-impact sites distributed in Texas, Louisiana, Mississippi, Alabama, and Florida affected or potentially affected by the 2010 Deepwater Horizon oil spill in the Gulf of Mexico were collected from October 5 to October 14, 2010. One additional sample was collected from Bay Jimmy near Lafitte, Louisiana (LA- 0 in table 1). Replicate samples were collected from 4 sites. In addition, 20 tarballs were collected from the same subset of 48 sites (table 1). An aliquot of the Macondo-1 well oil was provided by B & B Laboratory, College Station, Texas. Well oil was obtained by BP from the riser insertion tube aboard the drillship Discoverer Enterprise on May 21, 2010, and was absent of any defoamer or dispersant. All samples were collected, processed, and shipped under standard chain of custody protocols according to methods listed in the USGS National Field Manual for the Collection of Water-Quality Data (NFM) (*http://pubs.water.usgs.gov/twri9A/*) as well as other USGS standard operation procedures (Wilde and others, 2010). This standard and documented set of protocols encompassing the entire data-collection process ensured the integrity, consistency, and comparability of the data from site to site and within sites.

Analytical

All samples were extracted and processed in the USGS Pacific Coastal Marine Science Center (PCMSC) organic geochemistry lab located in Menlo Park, California. Samples were kept frozen before extraction, then thawed in their glass jars. Four of the sediment samples and 1 tarball were analyzed in duplicate. The well oil was analyzed with every batch of 10 extractions for a total of 8 separate analyses. Following homogenization of the sediment sample, ~ 100 g of wet sediment was weighed directly into a 300-mL stoppered flask. Two hundred mL of dichloromethane (DCM) and 40 g of $NaSO_4$ were added to the flasks, which were then placed in a sonicating water bath for 90 minutes at 30°C (after Bekins and others, 2005; Hostettler and others, 2007). The extract was filtered through a glass wool-lined champagne funnel containing 30 g $NaSO_4$ into turbo-vap vessels. An additional 100 mL of DCM was added to the previously extracted sediment and the sample again sonicated for 60 minutes at 30°C. The extracts were combined in the turbo-vap vessels, blown down with N_2 to near dryness, and transferred to 5.0-mL KD tubes. Final extract volume in hexane was 5.0 mL. For the tarball samples, ~15 mg were dissolved in DCM, filtered through glass wool to remove particulates, and air-dried to remove the DCM, then taken up in 5.0 mL of hexane. Both sediment and tarball extracts were then loaded onto a liquid chromatography column for compound class separation. Each column was layered at the bottom with about 5 mm of activated copper (to remove elemental sulfur), and with 2.5 g of 5-percent deactivated neutral alumina and 2.5 g and 5.0 g of 62 and 923 silica gels, respectively.

Three separate fractions were collected—saturate (hexane eluent), aromatic (30-percent DCM eluent), and polar. The saturate and aromatic fractions, blown down to 0.5 mL, were analyzed by gas chromatography/mass spectrometry (GC/MS). The gas chromatograph was maintained at 90°C for 2.0 minutes and programmed at a 5°C/min ramp to 310°C. The capillary column (DB-5MS: 30 m, 0.25 mm I.D. containing a 0.25-µm bonded phase) was directly interfaced to the ion source of the mass spectrometer. A separate analysis was carried out with the GC/MS in the single-ion monitoring mode

(SIM). Compound identifications were made either by comparison with known standards or with published reference spectra. Selected biomarker ratios, (appendix 1) were calculated from GC/MS/SIM chromatograms of m/z 191 (terpanes/hopanes) and 217 (steranes) using peak heights; other ratios were calculated from the chromatograms of the aromatic fraction using appropriate extracted ion (EI) values. Either summed areas or peak heights of the compounds were used to determine parameter ratios. Biomarker values were used to correlate the samples and group them according to their probable source locations (Peters and others, 2008; Lorenson and others, 2009).

Results

Macondo-1 Well Oil

The M-1 well oil has been characterized as a light mature oil with an American Petroleum Institute (API) gravity of 38.8° (M. Lewan, USGS, written communication). We used standard oil biomarkers to document the composition of the M-1oil and compared that to unknown hydrocarbon extracts from potentially impacted sediments and oil residues found on the shoreline. Biomarkers are complex organic compounds that occur in petroleum, rocks, and sediments and show little change in structure from their parent organic molecules in living organisms (Peters and others, 2005).

A suite of 19 biomarker parameters were identified from an analysis of the GC/MS spectra of the hexane and 30-percent DCM/hexane extracts of the BP M-1 well oil. These parameters defined a chemical signature (fingerprint) of the BP M-1 well (table 2; appendix 1). Ratios were obtained from an average of 8 separate analyses of the well oil. Similar ratios have been utilized in past studies to genetically relate environmental samples of oil, tar, and sediment to their sources (Hostettler and others, 2004; Kvenvolden and others, 1995; Peters and others, 2008; Lorenson and others, 2009). Of these ratios, 13 were particularly diagnostic of the BP M-1 oil and identifiable in the sediment and tarball samples; these were utilized in this study. Specifically excluded from this set of ratios were pristane and phytane because of confounding environmental input in nature and losses in the oils due to environmental degradation. We defined one ratio for this set based on the dominant sterane composition: the βα C27 diasterane S epimer/ααα C29 sterane S epimer. Patterns from chromatograms of the tricyclic terpanes and hopanes in the 191 *m/z* traces and of the steranes in the 217 *m/z* traces obtained by the GC/MS in single ion monitoring (SIM) mode show several key visual relationships for the M-1 well oil (fig. 2). Particularly notable are the tricyclic terpanes that define the triplet, the C_{24}-tetracyclic terpane, and the C_{26}-tricyclic terpane (S and R epimers) that were uniformly equal. Also of note is the prominence of the 18α(H)-30-norneohopane relative to the 17α,21β(H)-30-norhopane and C_{30} 17α,21β(H)-hopane. The prominence of the diasterane epimer pair (βα C27 diasterane, S & R) is also characteristic of this oil.

Sediment

Total extractable organic matter was low for all sediment samples, ranging from 1.2 to 650 mg/kg and averaging 52.6 mg/kg (table 1). This extractable content often included some biogenic terrigenous material and in some cases a water-soluble precipitate. Replicate analyses of the same sediment yielded an average precision of 3.8 ± 0.6 relative percent for the biomarker parameters. None of the parameters exceeded 10 percent relative error. Average replicate analyses of sediment from the same site yielded a lower average precision of 7.9 ± 1.3 relative percent. Some parameters from this latter set, with low absolute values approached 15 percent relative error. The identification of M-1 well oil in the sediment samples was based on a combination of an interpretation of the compounds identified in the mass spectra of the sediment extracts and a multivariate statistical analysis of the biomarker ratios utilizing hierarchal cluster analyses (HCA) and principal component analyses (PCA).

The extracted hydrocarbon composition of sediment ranged from mostly biogenic terrigenous material to oil or possibly a mixture of oils. There was no clear evidence of any oil present at eight sites, (16 percent). The remaining 41 sites had at least some trace amount of oil and many had distinct oil signatures. Other oil signatures could represent inputs from either natural oil seepage, prevalent in the nGOM (Sassen and others, 2001) or other previous oil spills. Biodegradation ranking of the extracted oil was considered moderate, ranging from 4 to 5, based on a standard ranking of oil biodegradation (Peters and Moldowan, 1993), allowing for robust comparison with M-1 oil. Five of the sites likely contain a mixture of one or more oils, probably derived from natural oil seeps, in addition to M-1 oil.

Some GC/MS spectra obtained from the solvent extracts of the sediment samples were remarkably similar to the reference BP M-1 well oil (figs. 2*C,D*). Others were notably different (figs. 2E,F). For example, note the lower Ts/Tm ratio and the higher αβ C29/αβ C30 ratio (fig 2*E*) and the lower βα27D/αααC29 (fig. 2F) in the sediment sample. A total of 13 individual biomarker parameters were calculated for each sediment sample from the saturate fraction (appendix 2). Biomarker parameters are listed in appendix 2 along with references to their use and other parameters such as age, thermal maturity, depositional environment, degree of biodegradation, and general character.

Tarballs

Nineteen biomarker parameters were determined for 20 tarballs, collected mostly from the Alabama and Mississippi coasts (appendix 2). Sixteen biomarker parameters were calculated from the saturates and three from the aromatics. Except for three samples, there was only minor variation in the geochemical parameters for the tarballs, implying a common source from the M-1 well oil or unknown natural seeps that tap the same oil source.

Statistical Results

Thirteen biomarker parameters common to the oil, sediment, and tarballs were utilized in the statistical analysis (appendix 2). For only one tarball and one sediment sample, a calculation could not be made for a parameter because of the absence of a particular biomarker compound, so an average of that parameter was used, a technique used in other chemometric biomarker analyses (Peters and others, 2008). Each individual chemical analysis was used in the statistical database, including duplicate sediment and tarball samples and multiple analyses of the M-1 well oil. The statistical database was referenced to lab numbers appended with an “s,” “o,” or “t” to designate a sediment, oil, or tarball, respectively. Lab numbers were cross-referenced to site locations (table 1). Results of the two-way HCA show a cluster in red of the M-1 oil samples intermixed with 12 sediment samples (and 1 duplicate) and all but 3 tarballs (fig. 3). Five of the sediment samples were from the Alabama coast, three each from the Mississippi and Louisiana coasts, and one from the Florida coast (fig. 3). These results show that oil in sediment from these 12 sites is genetically linked to the M-1 well oil. A separate cluster offset from the M-1 oil cluster includes six sediment samples (one duplicate) that might be a mixture of M-1 oil with another oil (fig. 3). These six samples occur within a distinct region located in Alabama and western Florida (fig. 4). The tarballs that correlate with the M-1 well oil group within a similar geographic area (fig. 5) The statistical results are consistent with interpretations based on mass spectra alone. Twenty-two percent of the sites surveyed contain oil related to the M-1 well oil. The two-way cluster analysis shows in map form by color intensity the variation in relative range of values for each variable (fig. 3). Dark red are the hghest values, dark blue are the lowest, and intermediate shades of color are intermediate values. A shift in the color pattern is evident between the samples related to M-1 well oil and the other samples.

The results of the PCA depicted in a three-dimensional plot show a tight cluster of the M-1 well oil, and related sediment and tarballs (fig. 6). The first, second, and third principal components are the x, y, and z axes, respectively. Six principal components combine for 80 percent of the total variance. The region encircled and labeled G1 indicates sediments and tarballs that group with M-1 well oil. The region encircled and labeled G2 represents sediments containing a likely mixture of oils, possibly but not verifiably including M-1 well oil.

The extracted hydrocarbon composition of sediment ranged from mostly biogenic terrigenous material to oil or possibly a mixture of oils. A composite map shows the extracted hydrocarbon composition roughly classified by the presence or absence of oil, oil maturity, and correlation of oil with M-1 well oil (fig. 7). A blue pie marker indicates sediment containing oil that correlates with M-1 well oil; a white marker indicates sediment containg mature oil that does not correlate with M-1 well oil; a speckled-pattern marker indicates a possible oil mixture; a red marker indicates sediment containing immature oil or biogenic material that does not correlate with M-1 well oil; and a brown marker indicates terrigenous material only. Pie markers with a combination of colors indicate that the sediment contains a mixture of organic components. Results show that most of the M-1 well correlated oil is from Louisiana, Mississippi, and Alabama, consistent with the spatial extent of the spill.

Conclusions

Hydrocarbons were extracted and analyzed from sediment and tarballs collected from the northern Gulf of Mexico (nGOM) coast that is potentially impacted by M-1 well oil. The identification of M-1 well oil in the sediment samples was based on a combination of an interpretation of the compounds identified in the mass spectra of the sediment extracts and a multivariate statistical analysis of the biomarker ratios utilizing hierarchal cluster analyses (HCA) and principal component analyses (PCA). The M-1 well oil has been identified in sediment and tarballs collected from Louisiana, Alabama, Mississippi, and Florida. None of the sediment hydrocarbon extracts from Texas correlated with the M-1 well oil. The M-1 well oil was genetically linked with 11 of 49 sediment samples and 17 of 20 tarballs. Oil-impacted sediments are confined to the shoreline adjacent to the cumulative oil slick of the Deepwater Horizon oil spill, and no impact was observed outside of this area. Further studies on sediment both onshore and offshore are warranted to place this study into a larger context for the entire nGOM. Additional work is also required to determine the source of other oils found in this study.

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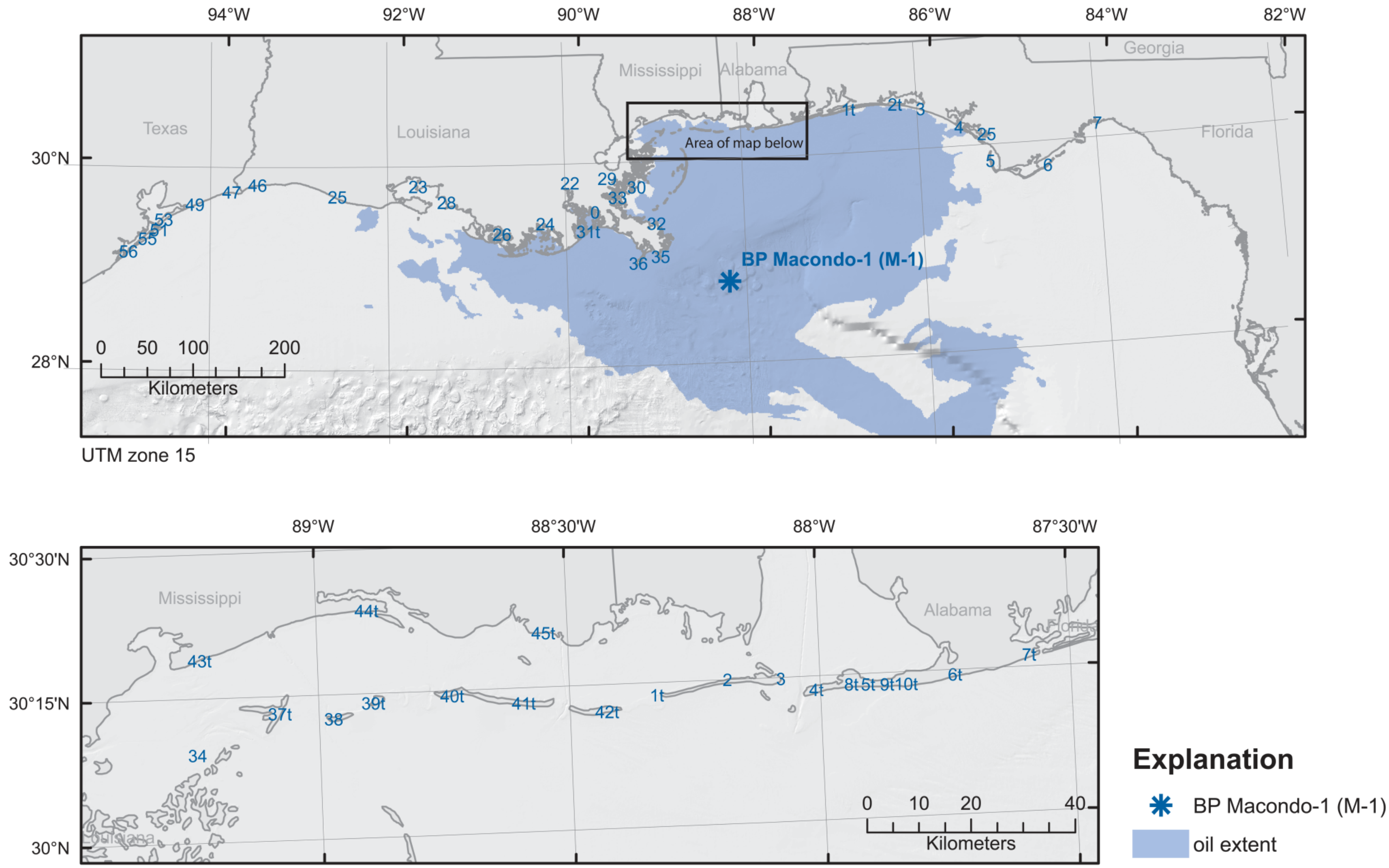

Figure 1. Location map of sediment and tarball samples collected for this study. The blue shading depicts the cumulative areal coverage of the BP M-1 well oil spill derived from wind, ocean currents, aerial photography, and satellite imagery (Amos, 2010). Sample designations are abbreviated for clarity in location; complete sample numbers are listed in the tables and are prefaced by the two-letter state abbreviation. A "t" suffix indicates locations at which both sediment and tarball samples were collected. The location of the Macondo-1 well is also indicated.

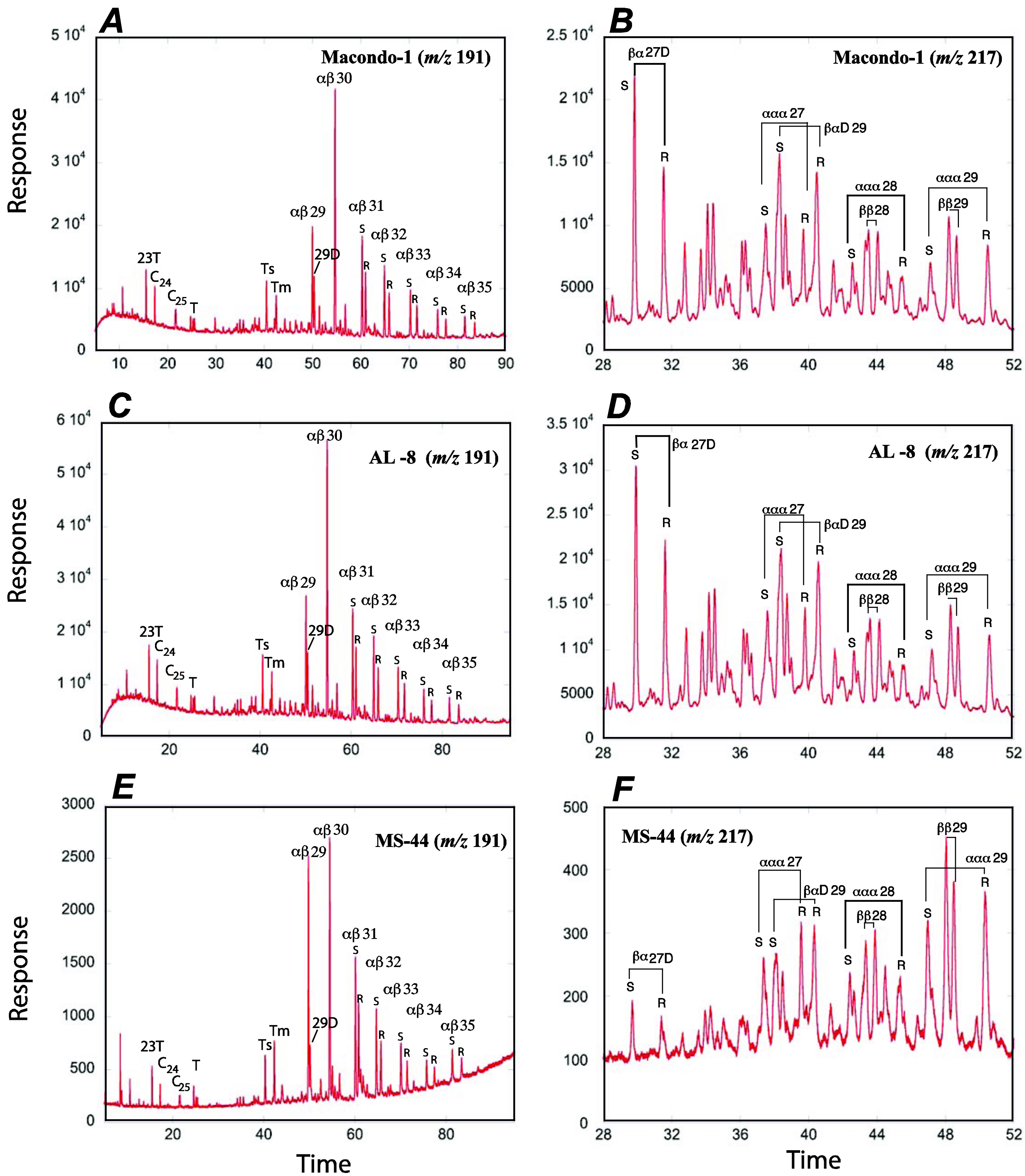

Figure 2. Chromatograms of M-1 well oil and sediment extracts (AL-8; MS-44). Selected ion monitoring (SIM) chromatograms of *m/z* 191, Hopanes (A, C, E), and *m/z* 217, Steranes (B, D, F). Compounds identified in appendix 1. Legend : Steranes, C27 to C29 regular steranes; Hopanes, C29 to C35 regular hopanes; 23T, C23, C24, tricyclic terpanes; T, triplet, Ts and Tm, defined in appendix 1; αβ29, αβ30, αβ31 through αβ35 (S & R epimers), αβ-hopanes with carbon numbers; O, Oleanane; and G, Gammacerane.

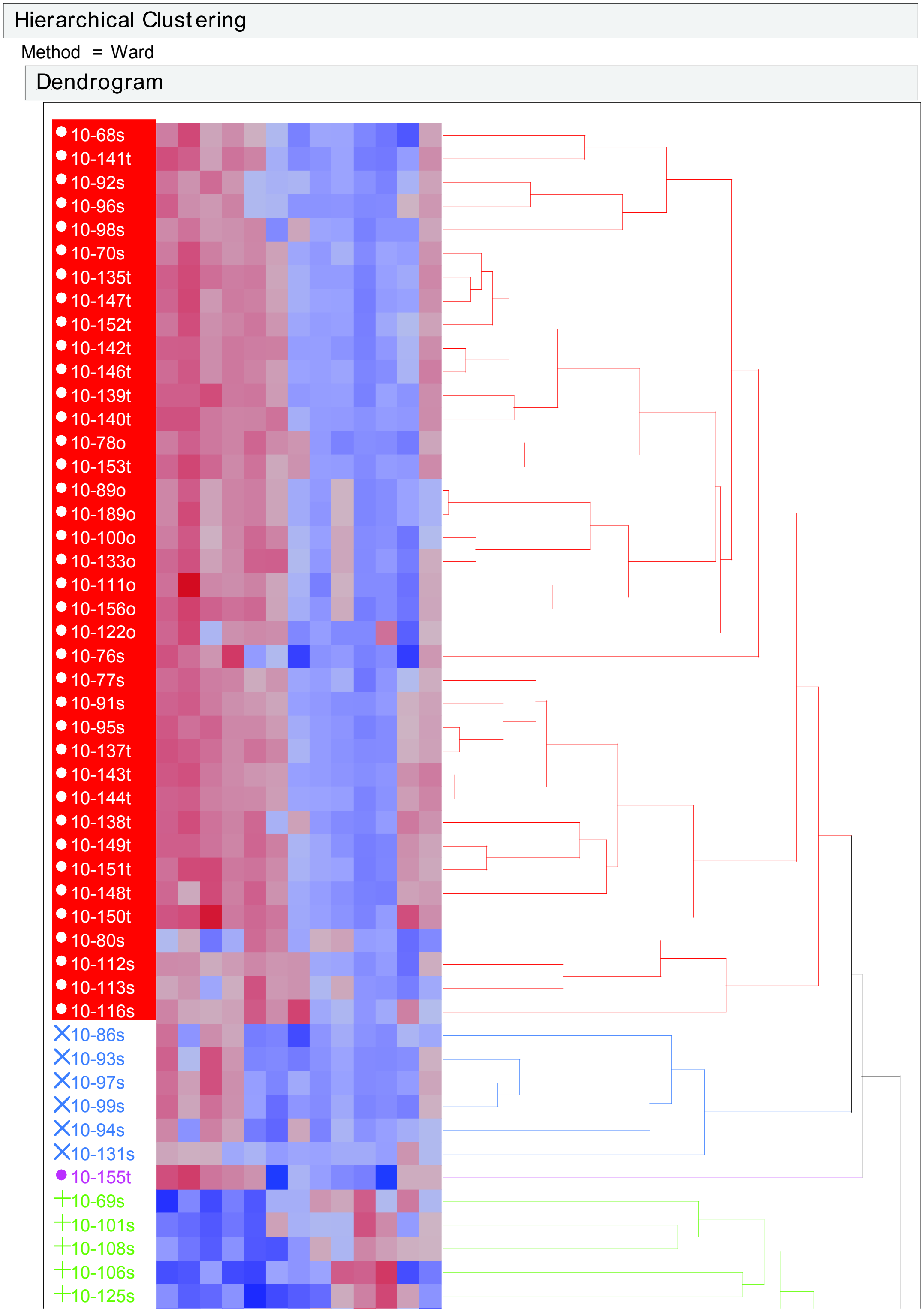

Figure 3. Hierarchical cluster diagram of 59 sediment samples, 7 M-1 well oil splits, and 20 tarballs from the northern Gulf of Mexico coast. The cluster marked in red indicates sediments and tarballs that group with M-1 well oil. The cluster of blue Xs represents a likely mixture of oils, possibly but not verifiably including M-1 well oil. The colored squares are a two-way cluster representing the range in values of each variable, dark red being highest, dark blue lowest, and intermediate shades color being intermediate values.

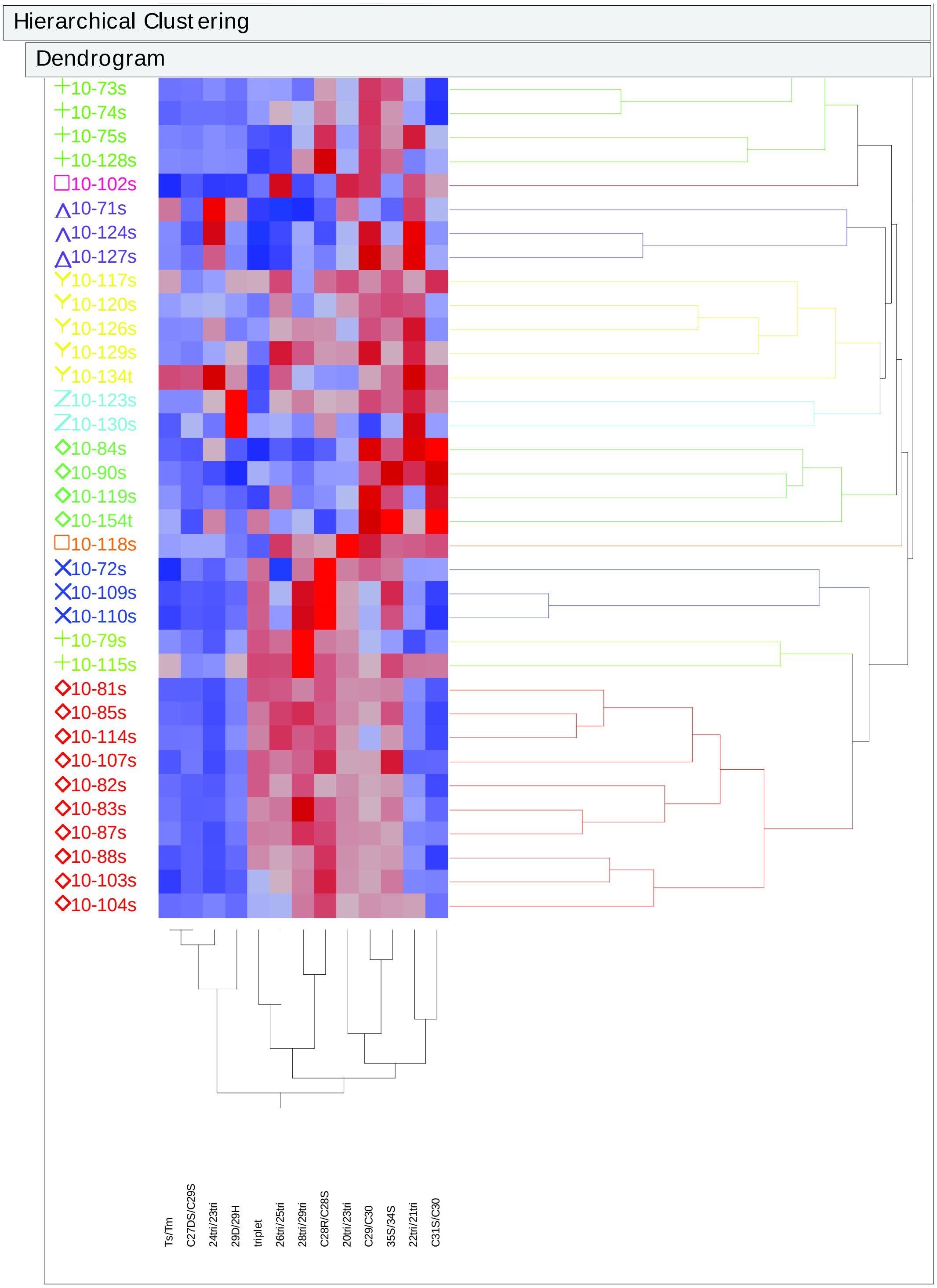

Figure 3 (cont.)

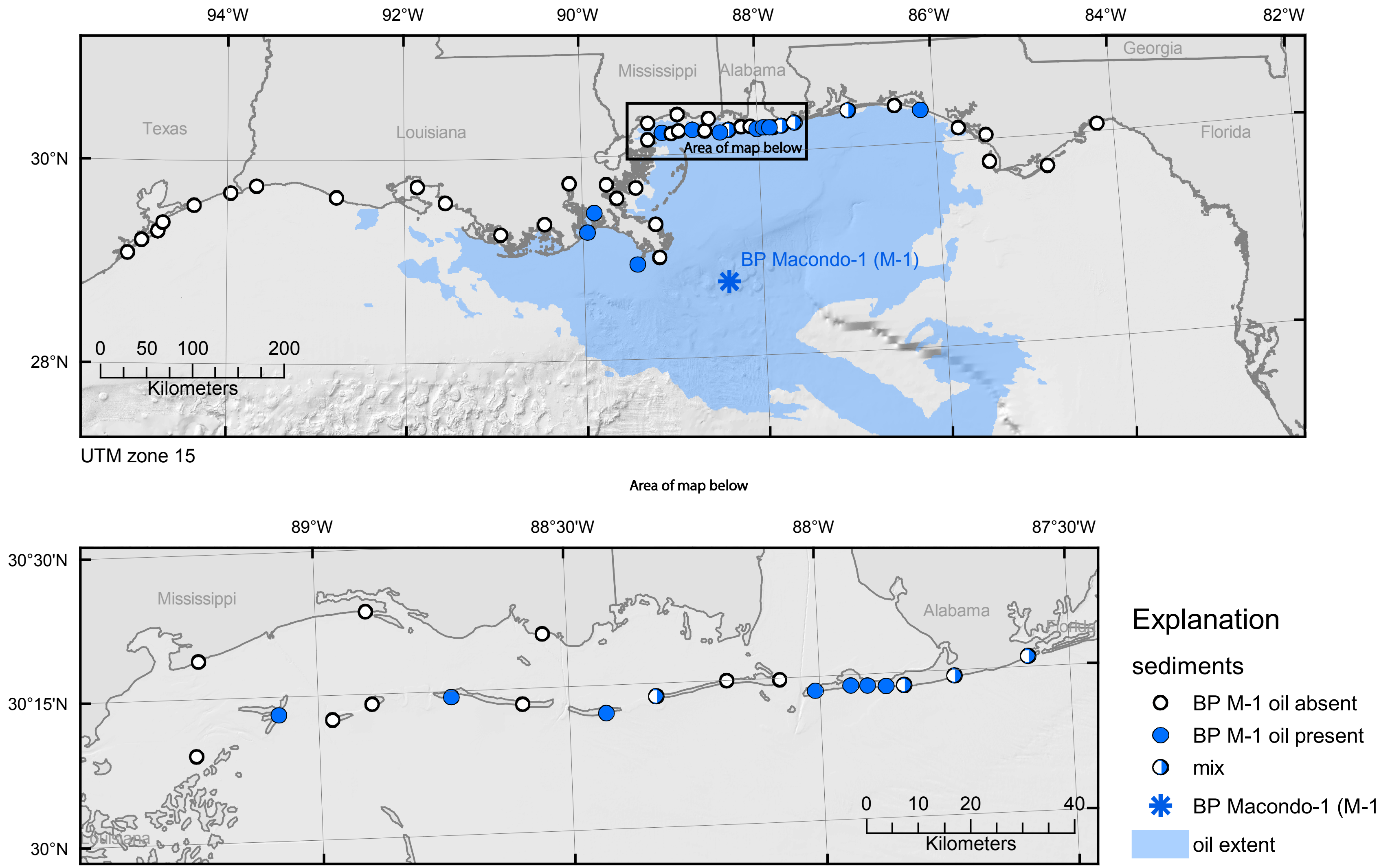

Figure 4. Location map of sediment samples correlated with M-1 well oil. Correlated M-1 oil is indicated with a blue filled circle; uncorrelated oil with an open circle; and a likely mixture of oils, possibly but not verifiably including M-1 well oil, with a half-filled circle.

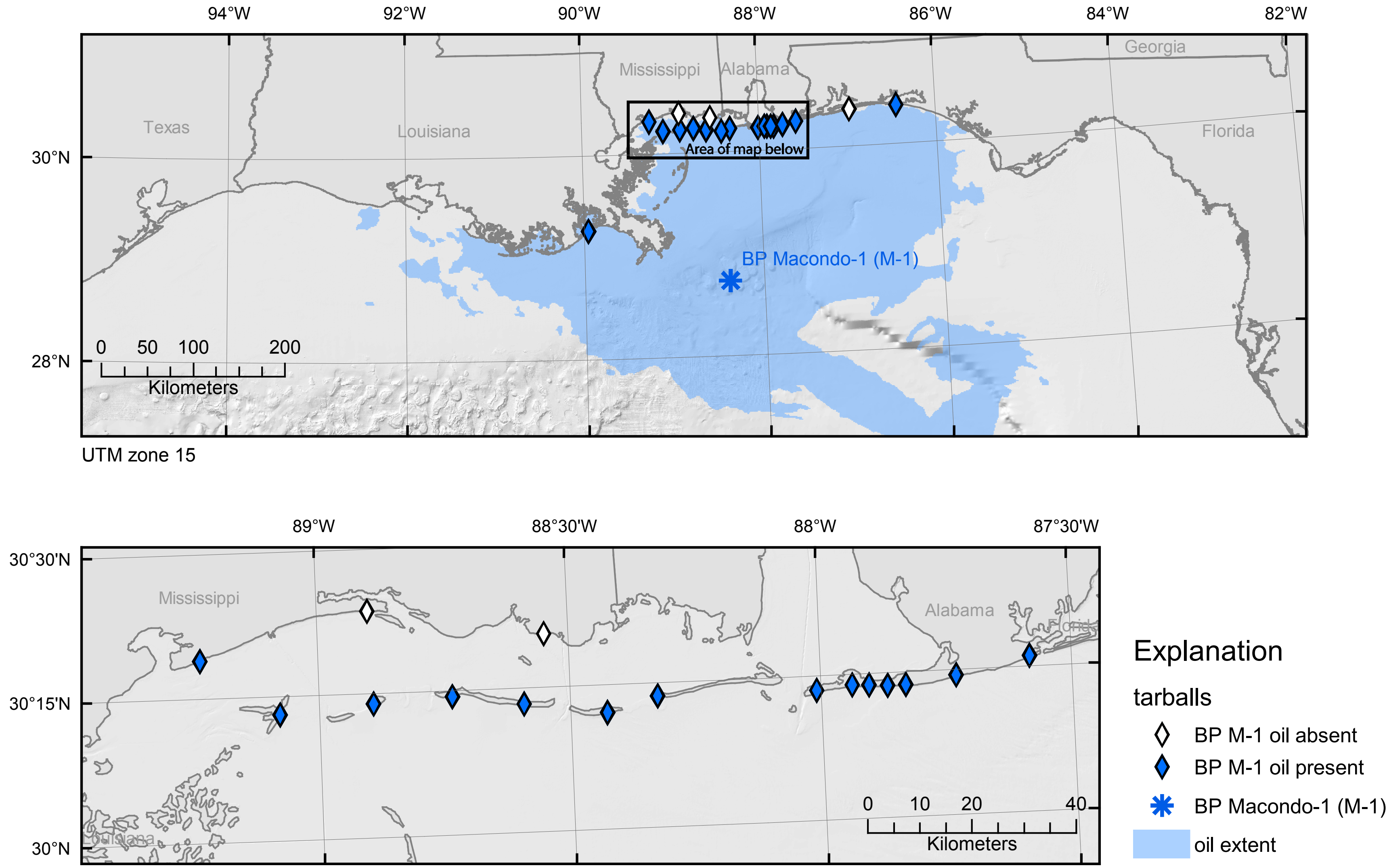

Figure 5. Location map of tarball samples correlated with M-1 well oil. Correlated M-1 tarballs are indicated with a blue filled diamond; uncorrelated tarballs with an open diamond

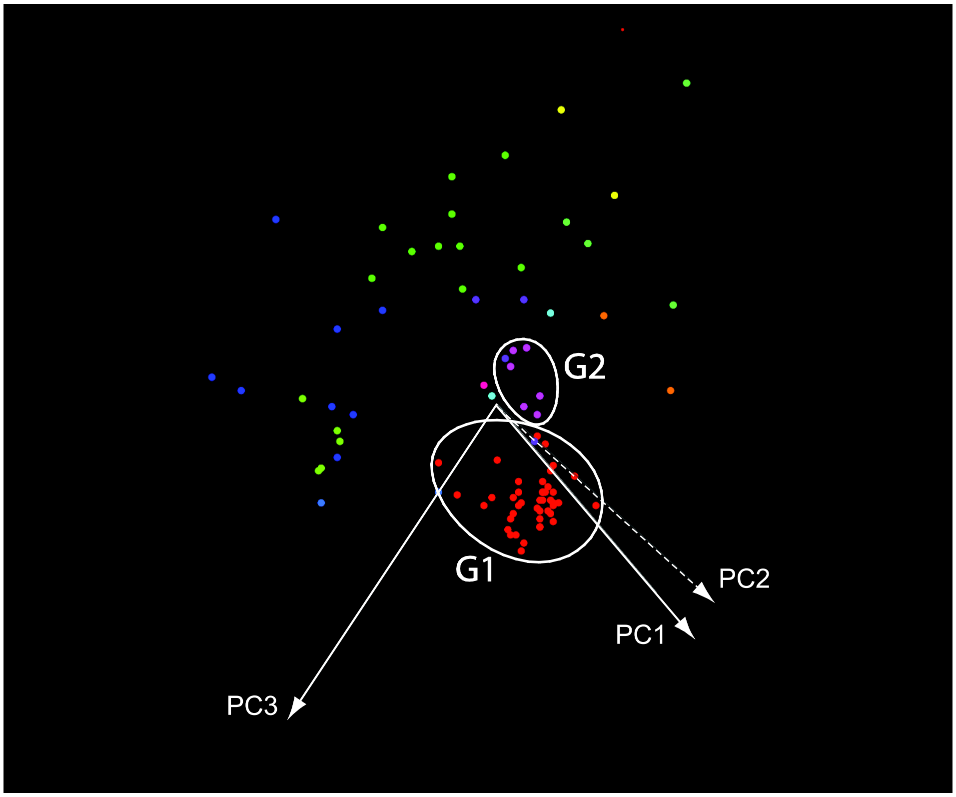

Figure 6. Three-dimensional depiction of a principal components analysis of the M-1 well oil, sediment, and tar samples. The x, y, z axes are the first three principal components PC1, PC2, and PC3 respectively. Variable eigenvectors are not shown for clarity. The region encircled and labeled G1 indicates sediments and tarballs that group with M-1 well oil. The region encircled and labeled G2 represents sediments containing a likely mixture of oils, possibly but not verifiably including M-1 well oil.

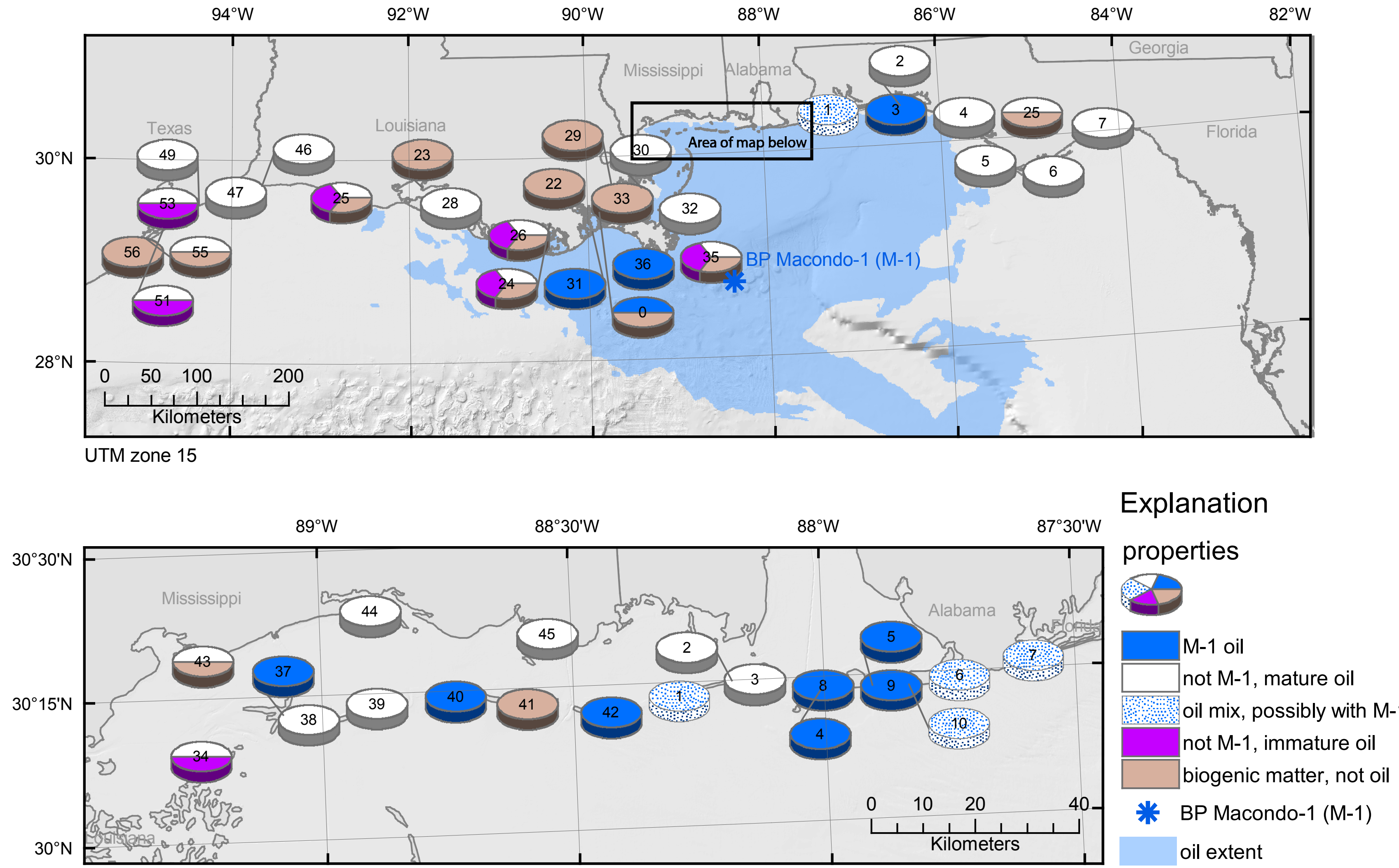

Figure 7. A composite map indicating the approximate geochemical composition of the extracted organic matter. Sample designations are abbreviated; complete sample numbers are listed in the tables and are prefaced by the two-letter state abbreviation. A blue pie marker indicates sediment containing oil that correlates with M-1 well oil; a white marker indicates sediment containing mature oil that does not correlate with M-1 well oil; a red marker indicates sediment containing immature oil and(or) biogenic material that does not correlate with M-1 well oil; and a brown marker indicates terrigenous material. Pie markers with a combination of colors indicate that the sediment contains a mixture of components. The pie diagrams portray sample properties, not proportions. The pie diagrams are offset from the sample locations for clarity.

Table 1. Gulf of Mexico Post-Oil Spill Sampling Sites
[Site: USGS designated number for site locality; Lab ID: Internal PCMSC reference number; * Likely mixture of oil with M-1 well oil, but cannot be conclusively verified by these analyses; ** NC indicates no sample obtained]

Site	Lab ID	Name	Latitude	Longitude	Sample date	mg/Kg dry	Sediment	Tarballs**
FL-1	10-131	DWH GOM Oil Spill-Gulf IS NS nr Navarre, FL	30.36239	-86.97017	10/4/10	5.1	mix*	no
FL-2	10-79	DWH GOM Oil Spill-Henderson Bch SP nr Destin, FL	30.38294	-86.44278	10/5/10	13.7	no	yes
FL-3	10-80	DWH GOM Oil Spill-Grayton Bch SP nr Seaside, FL	30.32406	-86.15506	10/5/10	10.3	yes	NC
FL-4	10-81	DWH GOM Oil Spill-St. Andrews SP nr Panama City,FL	30.12472	-85.73603	10/11/10	8.9	no	NC
FL-5	10-82	DWH GOM Oil Spill-St. Joe P SP nr Port St. Joe, FL	29.77917	-85.40853	10/13/10	4.0	no	NC
FL-6	10-83	DWH GOM Oil Spill-St George IS SP nr E Point, FL	29.69786	-84.76775	10/6/10	4.3	no	NC
FL-7	10-84	DWH GOM Oil Spill-St. Marks NWR nr St. Marks, FL	30.07419	-84.18044	10/7/10	93	no	NC
FL-25	10-85	DWH GOM Oil Spill-BLM Lathrop Bayou nr Panama City, FL	30.04083	-85.43278	10/12/10	8.2	no	NC
AL-1	10-86	DWH GOM Oil Spill West Dauphin Island	30.22743	-88.32639	10/13/10	27.8	mix*	yes
AL-2	10-87	DWH GOM Oil Spill Dauphin Is. AL-2	30.24881	-88.18417	10/7/10	10.0	no	NC
AL-3	10-90	DWH GOM Oil Spill Dauphin Is. AL-3	30.24687	-88.07778	10/6/10	27.7	no	NC
AL-4	10-91	DWH GOM Oil Spill Fort Morgan AL-4	30.22493	-88.00833	10/12/10	73.4	yes	yes
AL-5	10-92	DWH GOM Oil Spill Fort Morgan AL-5	30.23048	-87.90444	10/13/10	50.9	yes	yes
AL-6	10-93	DWH GOM Oil Spill Gulf Shores AL-6	30.24131	-87.73026	10/14/10	40.3	mix*	yes
AL-7	10-94	DWH GOM Oil Spill Orange Beach AL-7	30.26909	-87.58165	10/14/10	14.7	mix*	yes
AL-8	10-95	DHW GOM Oil Spill BLM-1	30.23159	-87.93777	10/13/10	94.2	yes	yes
AL-9	10-96	DWH GOM Oil Spill BLM-2	30.22881	-87.86721	10/14/10	195	yes	yes
AL-10	10-97	DWH GOM Oil Spill Fort Morgan BLM-3	30.22826	-87.83110	10/14/10	44.5	mix*	yes
LA-0	10-98	DWH GOM Oil Spill, Bay Jimmy nr. Lafitte	29.45222	-89.87056	8/23/10	219	yes	NC
LA-22 12:30	10-69	DWH GOM Oil Spill-Jean Lafitte National Park, LA	29.74222	-90.14194	10/13/10	78.0	no	NC
LA-22 12:31	10-101	DWH GOM Oil Spill-Jean Lafitte National Park, LA	29.74222	-90.14194	10/13/10	25.6	no	NC
LA-23	10-102	DWH GOM Oil Spill-Cypremort Point, LA	29.73500	-91.85361	10/5/10	25.6	no	NC
LA-24	10-103	DWH GOM Oil Spill-Lake Felicity, LA	29.34611	-90.42917	10/12/10	13.9	no	NC
LA-25	10-104	DWH GOM Oil Spill-Rockefeller Refuge Beach, LA	29.63556	-92.76722	10/7/10	16.2	no	NC
LA-26	10-105	DWH GOM Oil Spill-Sister Lake, LA	29.25194	-90.92167	10/6/10	10.7	no	NC
LA-28	10-106	DWH GOM Oil Spill-Point Chevreuil, LA	29.57333	-91.53778	10/5/10	35.0	no	NC
LA-29	10-72	DWH GOM Oil Spill-Crooked Bayou, LA	29.72333	-89.72361	10/4/10	279	no	NC
LA-30	10-107	DWH GOM Oil Spill-Mississippi R. Gulf Outlet, LA	29.68556	-89.39583	10/4/10	33.5	no	NC
LA-31 11:00	10-68	DWH GOM Oil Spill-Grand Isle Bch at State Park, LA	29.26028	-89.95028	10/14/10	86.8	yes	yes
LA-31 11:02	10-70	DWH GOM Oil Spill-Grand Isle Bch at State Park, LA	29.26028	-89.95028	10/14/10	95.5	yes	yes
LA-32	10-108	DWH GOM Oil Spill-Mississippi R. at Main Pass, LA	29.32056	-89.18194	10/6/10	27.0	no	NC
LA-33	10-71	DWH GOM Oil Spill-Breton Sound, LA	29.58833	-89.61194	10/4/10	289	no	NC
LA-34	10-110	DWH GOM Oil Spill-Miss. Sound at Grand Pass, LA	30.15194	-89.24583	10/5/10	10.1	no	NC

Table 1 (cont.)

Site	Lab ID	Name	Latitude	Longitude	Sample date	mg/Kg dry	Sediment	Tarballs**
LA-35	10-130	DWH GOM Oil Spill-Mississippi R. at South Pass, LA	28.99750	-89.14889	10/13/10	6.0	no	NC
LA-36	10-112	DWH GOM Oil Spill-Mississippi R. at SW Pass, LA	28.93750	-89.39889	10/11/10	8.2	yes	NC
MS-37	10-113	DWH GOM OIL SPILL-South Cat Island Beach, MS	30.21917	-89.07972	10/14/10	7.0	yes	yes
MS-38	10-114	DWH GOM OIL SPILL-West Ship Island Beach, MS	30.20750	-88.97222	10/15/10	2.4	no	NC
MS-39	10-115	DWH GOM OIL SPILL-East Ship Island Beach, MS	30.23278	-88.89250	10/7/10	17.7	no	yes
MS-40	10-116	DWH GOM OIL SPILL-West Horn Island Beach, MS	30.24028	-88.73500	10/13/10	16.0	yes	yes
MS-41	10-117	DWH GOM OIL SPILL-East Horn Island Beach, MS	30.22250	-88.59250	10/13/10	4.6	no	yes
MS-42	10-76	DWH GOM OIL SPILL-Petit Bois Island Beach, MS	30.20222	-88.42667	10/12/10	651	yes	yes
MS-43	10-118	DWH GOM OIL SPILL-Pass Christian Beach, MS	30.31611	-89.23611	10/8/10	27.9	no	yes
MS-44	10-119	DWH GOM OIL SPILL-BIloxi Beach, MS	30.39333	-88.89944	10/7/10	5.3	no	no
MS-45	10-120	DWH GOM OIL SPILL-Pascagoula Beach, MS	30.34278	-88.54778	10/7/10	11.7	no	no
TX-46	10-123	East Sabine, LA Oil Spill Sample Site	29.74889	-93.66333	10/6/10	5.3	no	NC
TX-47	10-124	Texas Point, TX Oil Spill Sample Site	29.68250	-93.95639	10/6/10	17.3	no	NC
TX-49	10-125	High Island, TX Oil Spill Sample Site	29.55667	-94.36833	10/7//10	17.8	no	NC
TX-51 11:10	10-128	Galveston Island, TX Oil Spill Sample Site	29.30417	-94.76944	10/12/10	10.4	no	NC
TX-51 11:02	10-70	Galveston Island, TX Oil Spill Sample Site	29.30417	-94.76944	10/13/10	11.1	no	NC
TX-51 12:15	10-126	Galveston Island, TX Oil Spill Sample Site	29.30417	-94.76944	NA	4.0	no	NC
TX-53	10-132	Bolivar Peninsula Oil Spill Sample Site	29.38833	-94.71917	10/7/10	7.6	no	NC
TX-55	10-75	West Bay, Galveston Is SPk, Oil Spill Sample Site	29.21417	-94.95389	10/13/10	48.4	no	NC
TX-55 11:10	10-128	West Bay, Galveston Is SPk, Oil Spill Sample Site	29.21417	-94.95389	10/14/10	13.6	no	NC
TX-56	10-129	San Luis Pass, TX Oil Spill Sample Site	29.08667	-95.10861	10/5/10	1.2	no	NC

Table 2. Geochemical Parameters derived for Macondo-1 well oil [parameters defined in appendix 1]

Parameter	M-1 well oil	std deviation
Ts/Tm	1.296	0.047
triplet	1.922	0.068
20Tri/23Tri	0.379	0.022
22Tri/21Tri	0.271	0.018
24Tri/23Tri	0.730	0.034
26Tri/25Tri	0.953	0.056
28Tri/29Tri	1.065	0.088
C29/C30	0.448	0.005
29D/29H	0.523	0.011
C31S/C30	0.388	0.009
35S/34S	0.738	0.015
C28R/C29R	0.483	0.002
C27d S/R	1.548	0.049
C27ds/C29s	2.789	0.110
OI	0.020	0.027
GI	0.045	0.009
PAH-RI	0.576	0.104
C2D/C2P	0.267	0.042
C3D/C3P	0.261	0.016

Appendix 1, Geochemical Parameters used in Tarball, Oil, Sediment Correlation Studies

Parameters used for the chemometric analysis described in text are indicated in red.

Saturate fraction:

Triterpanes (hopanes), m/z 191 SIM chromatograms:

1. Ts/Tm, 18α-22,29,30-trisnorneohopane/17α-22,29,30-trisnorhopane. This ratio is used as both a source and maturity parameter (Seifert and Moldowan, 1978).

2. Triplet, [C_{26}-tricyclic terpane (S?) + C_{26}-tricyclic terpane (R?)/C_{24}-tetracyclic terpane]. This source parameter was used to distinguish coastal tar residues in Prince William Sound (Kvenvolden and others, 1995). Abundant C_{24} tetracyclic is cited (Peters and others, 2005) as indicating carbonate and evaporite source facies, therefore lower values of this ratio (since C_{24} is the denominator) indicate this characteristic.

3. 20Tri/23Tri, C_{20} tricyclic terpane/C_{23} tricyclic terpane. Source parameter.

4. 22Tri/21Tri, C_{22} tricyclic terpane/C_{21} tricyclic terpane. Source parameter, used by Peters and others, 2005, to help distinguish lithofacies.

5. 24Tri/23Tri, C_{24} tricyclic terpane/C_{23} tricyclic terpane. Source parameter, used by Peters and others, 2005, to help distinguish lithofacies.

6. 26Tri/25Tri, C_{26} tricyclic terpanes/C_{25} tricyclic terpanes. peak areas. Source parameter; high values (>1) indicate a lacustrine depositional environment, whereas lower values indicate a marine source.

7. 28Tri/29Tri. C_{28} tricyclic terpanes/C_{29} tricyclic terpanes, peak areas. Source parameter.

8. C_{29}/C_{30}, 17α,21β(H)-30-norhopane/17α,21β(H)-hopane. This ratio is a source parameter adapted from Palacas and others (1984).

9. 29D/29H, 18α(H)-30-norneohopane/17α,21β(H)-30-norhopane. Source parameter.

10. $C_{31}S/C_{30}$, 17α,21β(H)-homohopane (22S)/ 17α,21β(H)-hopane. Source parameter.

11. 35S/34S, 17α,21β(H)-29-pentakishomohopane (22S)/17α,21β(H)-29-tetrakishomohopane (22S). Higher C_{35} than C_{34} 22S homohopanes is an indication of carbonate/evaporite facies or anoxic depositional environment.

12 OI, Oleanane Index, 18α+β(H)-oleanane/17α,21β(H)-hopane. This commonly used source parameter indicates a contribution from Cretaceous and younger plant material (Peters and Moldowan, 1993). In the California coastal tars, oleanane is generally present, but in low amounts.

13 GI, Gammacerane Index, gammacerane/17α,21β(H)-hopane. This ratio is used as a source parameter; abundant gammacerane is a carbonate/evaporite facies indicator and a marker for highly reducing, hypersaline depositional environments (Peters and Moldowan, 1993).

Steranes, m/z 217 SIM chromatograms:

14. C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/ 24-ethyl-5α,14α,17α(H)-cholestane (20R). This source parameter has been modified from discussions in Grantham and Wakefield (1988) and Waples and Machihara (1991).

15. C27d S/R, βα27diasterane S/βα27diasterane R, source parameter

16. C27ds/C29s, βα27diasterane S/24-ethyl-5α,14α,17α(H)-cholestane (20S)

Aromatic fraction

17. PAH-RI, Polycyclic Aromatic Hydrocarbon-Refractory Index. This index is a source parameter, the ratio of the second, usually major, peak containing the C_{26}R and C_{27}S members in the highly refractory C_{26} to C_{28} triaromatic sterane suite (TAS, m/z 231) to that of the first, usually dominant, peak in the monomethyl chrysenes (m/z 242) (Hostettler *and others*, 1999). In this very large data set it can be seen that this previously descriptive-only parameter does reflect a specific facies characteristic. PAH-RI goes from low values in shale, mid values in marl, and high values in carbonate (increasingly anoxic facies) environments. Since PAH-RI compares TAS to a typical petrogenic C_1PAH, high values indicate higher levels of TAS. TAS are known to be a stable product of diagenesis of steranes in a reducing or anoxic environment. Therefore, PAH-RI is another indicator of the anoxic nature of the source environment.

18. ΣC2D/ΣC2P, dimethyl dibenzothiophenes (m/z 212)/dimethyl phenanthrenes (m/z 206). Source parameter indicating relative levels of sulfur-containing PAH to regular PAH (Kaplan and others, 1997; Bence and others, 1996).

19. ΣC3D/ΣC3P, trimethyl dibenzothiophenes (m/z 226)/trimethyl phenanthrenes (m/z 220). Source parameter as #32.

Appendix 2, Geochemical parameters for oil, sediment and tarball samples

[Parameter definitions are in appendix 1; Lab ID: suffixes "s," "t,"and "o" are sediment, tarball, or oil respectively; * same font colors are site replicates; ** color codes are laboratory replicates; values in red font are column averaged (see text); Empty cells: no data]

Lab ID	Site Name*	Ts/Tm	Triplet	20Tri/23Tri	22Tri/21Tri	24Tri/23Tri	26Tri/25Tri	28Tri/29Tri	C29/C30	29D/29H	C31S/C30	35S/34S	OI	GI	C28R/C29R	c27d S/R	C27ds/c29s	PAH-RI	□C2D/□C2P	□C3D/□C3P	color code**
10-131s	FL-1	1.09	1.56	0.270	0.348	0.697	0.756	1.02	0.512	0.38	0.38	0.785	0.042	0.054	0.511	1.62	1.63				
10-79s	FL-2	0.77	2.06	0.497	0.232	0.526	1.041	2.20	0.542	0.35	0.32	0.774	0.065	0.234	0.857	1.60	0.52				
10-80s	FL-3	1.00	1.97	0.423	0.257	0.569	0.992	1.02	0.486	0.39	0.33	0.791	0.045	0.136	0.662	1.62	1.69				
10-81s	FL-4	0.58	2.07	0.481	0.282	0.507	1.093	1.27	0.622	0.28	0.28	0.978	0.093	0.305	1.000	1.44	0.25				
10-82s	FL-5	0.63	2.04	0.494	0.286	0.528	0.918	1.42	0.576	0.28	0.26	0.929	0.109	0.307	0.681	1.00	0.27				
10-83s	FL-6	0.65	1.82	0.517	0.298	0.539	1.019	1.71	0.563	0.28	0.30	1.000	0.120	0.284	1.000	0.79	0.26				
10-84s	FL-7	0.59	0.68	0.259	0.481	0.691	0.596	0.68	0.932	0.20	0.64	1.080	0.031	0.078	0.240	1.59	0.16	0.513	0.294	0.254	
10-85s	FL-25	0.51	1.90	0.504	0.275	0.500	0.834	1.29	0.577	0.24	0.26	1.083	0.085	0.290	0.977	0.95	0.35				1
10-88s	D: FL-25	0.51	1.82	0.485	0.285	0.508	0.899	1.24	0.591	0.23	0.24	0.970	0.083	0.246	1.130	0.95	0.32				1
10-86s	AL-1	1.32	1.27	0.275	0.315	0.744	0.688	0.71	0.462	0.46	0.36	0.732	0.032	0.045	0.445	1.52	0.92				
10-87s	AL-2	0.69	1.88	0.506	0.274	0.506	0.994	1.52	0.619	0.26	0.32	0.903	0.074	0.249	1.060	1.17	0.29				
10-90s	AL-3	0.69	1.53	0.201	0.423	0.507	0.728	0.85	0.723	0.00	0.57	1.326	0.039	0.108	0.469	1.49	0.39				
10-91s	AL-4	1.37	1.77	0.148	0.326	0.770	0.904	1.00	0.453	0.51	0.40	0.772	0.029	0.035	0.465	1.60	2.64	0.317	0.258	0.303	
10-92s	AL-5	1.31	1.60	0.238	0.313	0.792	0.824	1.07	0.460	0.50	0.40	0.713	0.032	0.040	0.458	1.62	1.99	0.417	0.232	0.317	
10-93s	AL-6	1.38	1.31	0.238	0.282	0.828	0.704	0.87	0.448	0.50	0.39	0.730	0.028	0.026	0.431	1.51	1.51				
10-94s	AL-7	1.23	1.26	0.308	0.308	0.762	0.619	1.15	0.463	0.47	0.38	0.788	0.039	0.057	0.372	1.62	0.90				
10-95s	AL-8	1.42	1.83	0.174	0.324	0.802	0.932	1.04	0.428	0.53	0.40	0.735	0.028	0.036	0.478	1.44	2.40	0.316	0.287	0.326	
10-96s	AL-9	1.39	1.60	0.175	0.324	0.730	0.836	0.95	0.443	0.54	0.41	0.731	0.029	0.038	0.442	1.54	2.05	0.333	0.273	0.324	
10-97s	AL-10	1.33	1.45	0.229	0.292	0.829	0.691	1.03	0.447	0.51	0.40	0.737	0.030	0.032	0.414	1.55	1.84	0.562	0.316	0.326	2
10-99s	D: AL-10	1.35	1.45	0.220	0.270	0.787	0.632	0.96	0.437	0.51	0.39	0.735	0.034	0.037	0.411	1.55	1.76	0.570	0.335	0.334	2
10-98s	LA-0	1.21	1.84	0.225	0.285	0.733	0.702	1.15	0.429	0.51	0.40	0.752	0.033	0.039	0.518	1.60	2.37				
10-69s	LA-22 12:30	0.56	1.10	0.405	0.365	0.496	0.815	1.05	0.705	0.27	0.38	0.859	0.066	0.082	0.761	1.80	0.75	0.241	0.110	0.162	
10-101s	LA-22 12:31	0.62	1.11	0.322	0.292	0.526	0.915	1.05	0.721	0.26	0.39	0.963	0.068	0.099	0.611	1.48	0.65				
10-102s	LA-23	0.14	1.23	0.887	0.395	0.454	1.314	0.71	0.780	0.10	0.41	0.748	0.014	0.222	0.357	1.44	0.15				
10-103s	LA-24	0.34	1.58	0.476	0.274	0.502	0.874	1.27	0.581	0.21	0.32	1.000	0.059	0.204	1.222	1.50	0.31				
10-104s	LA-25	0.63	1.54	0.368	0.338	0.585	0.832	1.29	0.615	0.24	0.31	0.927	0.064	0.159	1.078	1.63	0.48				
10-106s	LA-28	0.48	0.96	0.665	0.231	0.630	0.783	0.95	0.698	0.15	0.31	1.143	0.039	0.158	0.514	1.45	0.12				
10-72s	LA-29	0.06	1.95	0.548	0.293	0.540	0.142	1.30	0.703	0.31	0.35	1.000	0.158	0.175	1.730	1.59	0.58				
10-107s	LA-30	0.53	2.04	0.414	0.252	0.498	1.009	1.36	0.587	0.26	0.30	1.229	0.832	0.251	1.189	1.50	0.54				
10-68s	LA-31 11:00	1.26	1.65	0.245	0.242	0.712	0.849	0.89	0.439	0.52	0.40	0.682	0.005	0.040	0.528	1.56	2.87	0.554	0.320	0.330	
10-70s	LA-31 11:02	1.27	1.84	0.291	0.295	0.765	0.915	1.02	0.447	0.50	0.42	0.798	0.036	0.045	0.463	1.56	2.80	0.455	0.299	0.327	3
10-77s	D: LA-31 11:02	1.34	1.67	0.285	0.322	0.767	0.947	1.02	0.411	0.53	0.39	0.762	0.033	0.051	0.489	1.56	2.59	0.550	0.333	0.312	3
10-108s	LA-32	0.83	1.11	0.315	0.327	0.533	0.566	0.95	0.637	0.32	0.39	0.920	0.059	0.087	0.690	1.53	0.54				
10-71s	LA-33	1.29	0.89	0.592	0.409	1.022	0.211	0.42	0.489	0.51	0.38	0.646	0.064	0.030	0.251	1.54	0.40	1.456	0.292	0.266	
10-109s	LA-34	0.40	2.02	0.420	0.285	0.522	0.837	1.65	0.547	0.23	0.25	1.184	0.051	0.278	1.720	1.33	0.22				4
10-110s	D: LA-34	0.37	2.01	0.431	0.290	0.519	0.750	1.67	0.522	0.25	0.23	1.086	0.071	0.229	1.853	1.33	0.21				4
10-130s	LA-35	0.55	1.47	0.188	0.462	0.568	0.812	0.91	0.303	1.36	0.35	0.816	0.087	0.070	0.793	1.57	1.45				
10-112s	LA-36	1.20	1.83	0.243	0.259	0.702	0.945	1.22	0.453	0.49	0.39	0.775	0.016	0.055	0.536	1.44	2.06				
10-113s	MS-37	1.09	2.06	0.399	0.269	0.646	0.936	1.22	0.467	0.45	0.36	0.749	0.050	0.095	0.612	1.56	1.98				
10-114s	MS-38	0.66	1.86	0.443	0.275	0.511	1.197	1.38	0.523	0.31	0.26	0.938	0.091	0.265	1.067	1.32	0.52				
10-115s	MS-39	1.05	2.12	0.541	0.368	0.607	1.124	1.97	0.561	0.44	0.44	1.105	0.143	0.245	1.000	1.50	0.75				
10-116s	MS-40	1.24	2.04	0.323	0.361	0.701	0.965	1.45	0.470	0.47	0.38	0.813	0.047	0.064	0.537	1.44	1.75				
10-117s	MS-41	1.12	1.67	0.714	0.340	0.633	1.135	0.99	0.627	0.46	0.51	1.080	0.271	0.407	0.909	1.11	0.77				
10-76s	MS-42	1.43	1.43	0.197	0.210	0.734	0.853	0.65	0.429	0.69	0.41	0.735	0.028	0.036	0.436	1.60	2.42	0.362	0.312	0.321	
10-118s	MS-43	0.85	1.14	2.859	0.386	0.646	1.175	1.23	0.832	0.27	0.48	1.044	0.081	0.121	0.711	1.68	1.18				
10-119s	MS-44	0.79	0.96	0.346	0.288	0.575	1.021	0.88	0.934	0.22	0.54	1.102	0.034	0.093	0.424	1.67	0.38				
10-120s	MS-45	0.84	1.25	0.447	0.393	0.670	0.987	0.92	0.708	0.34	0.35	1.107	0.111	0.116	0.625	1.52	1.30				
10-123s	TX-46	0.75	1.07	0.403	0.434	0.688	0.880	1.27	0.743	1.00	0.43	1.034	0.150	0.128	0.657	1.47	0.79				
10-124s	TX-47	0.75	0.49	0.317	0.487	0.956	0.524	1.02	0.862	0.32	0.34	0.816	0.189	0.086	0.160	2.45	0.07	0.013	0.102	0.084	
10-125s	TX-49	0.78	0.66	0.390	0.339	0.550	0.529	0.78	0.646	0.32	0.34	1.105	0.115	0.051	0.285	1.76	0.26				
10-73s	TX-51 11:00	0.65	1.45	0.320	0.314	0.598	0.762	1.18	0.771	0.25	0.23	1.078	0.065	0.115	0.735	1.55	0.53				
10-74s	TX-51 11:02	0.59	1.41	0.342	0.300	0.561	0.873	1.10	0.781	0.24	0.21	0.940	0.141	0.081	0.841	1.55	0.45				

Appendix 2 (cont.)

Lab ID	Site Name*	Ts/Tm	Triplet	20Tri/23Tri	22Tri/21Tri	24Tri/23Tri	26Tri/25Tri	28Tri/29Tri	C29/C30	29D/29H	C31S/C30	35S/34S	OI	GI	C28R/C29R	c27d S/R	C27ds/c29s	PAH-RI	□C2D/□C2P	□C3D/□C3P	color code**
10-126s	TX-51 12:15	0.74	1.41	0.314	0.446	0.743	0.891	1.24	0.729	0.27	0.33	1.000	0.153	0.134	0.783	1.25	0.81				
10-127s	TX-53	0.74	0.60	0.348	0.484	0.814	0.491	1.00	0.915	0.29	0.36	0.966	0.233	0.146	0.352	1.37	0.43				
10-75s	TX-55	0.72	1.08	0.269	0.452	0.603	0.535	1.08	0.768	0.28	0.38	0.960	0.076	0.090	1.151	1.59	0.60	0.415	0.019		
10-128s	TX-55 11:10	0.75	0.90	0.280	0.450	0.604	0.542	1.22	0.782	0.30	0.36	1.036	0.085	0.088	1.389	1.49	0.71				
10-129s	TX-56	0.76	1.22	0.479	0.432	0.646	1.272	1.39	0.859	0.44	0.39	0.893	0.281	0.313	0.750	1.13	0.64				
10-78o	M1W	1.27	1.98	0.363	0.267	0.774	0.969	1.21	0.455	0.53	0.40	0.735	0.033	0.060	0.472	1.49	2.60	0.480	0.250	0.247	5
10-89o	M1W	1.23	1.88	0.358	0.299	0.715	0.909	1.04	0.438	0.54	0.37	0.737	0.029	0.046	0.469	1.50	2.66	0.513	0.294	0.254	5
10-100o	M1W	1.26	1.97	0.407	0.263	0.693	0.990	1.08	0.450	0.53	0.38	0.744	0.031	0.047	0.496	1.63	2.68				5
10-111o	M1W	1.32	1.86	0.365	0.261	0.753	0.904	1.06	0.450	0.51	0.40	0.735	0.005	0.048	0.360	1.58	3.77		0.184		5
10-122o	M1W	1.36	1.83	0.390	0.249	0.672	0.964	0.91	0.444	0.51	0.38	0.713	0.009	0.029	0.488	1.53	2.90	0.705	0.298	0.253	5
10-133o	M1W	1.35	2.01	0.405	0.268	0.716	1.072	1.09	0.448	0.52	0.39	0.767	0.011	0.042	0.461	1.59	2.76	0.604	0.311	0.290	5
10-156o	M1W	1.39	1.97	0.389	0.263	0.805	0.907	1.05	0.422	0.57	0.40	0.736	0.005	0.045	0.446	1.63	2.98	0.407	0.267	0.271	5
10-189o	M1W	1.23	1.88	0.358	0.299	0.715	0.909	1.04	0.438	0.54	0.37	0.737	0.029	0.046	0.454	1.59	2.85	0.513	0.294	0.254	5
10-134t	FL1T	1.48	1.02	0.152	0.474	0.973	1.088	1.08	0.582	0.51	0.46	1.036	0.036	0.053	0.447	1.47	2.76	2.560	0.798		
10-135t	FL2T	1.39	1.89	0.202	0.305	0.788	0.903	1.05	0.428	0.55	0.43	0.788	0.031	0.042	0.477	1.60	2.85	0.298	0.280	0.453	
10-137t	AL1T	1.44	1.93	0.162	0.327	0.788	0.985	1.07	0.448	0.52	0.40	0.734	0.009	0.045	0.477	1.55	2.66	0.252	0.282	0.451	
10-138t	AL4T	1.38	1.98	0.132	0.366	0.782	0.822	1.17	0.440	0.54	0.42	0.774	0.011	0.043	0.467	1.48	2.81	0.270	0.277	0.434	
10-139t	AL5T	1.39	1.91	0.217	0.286	0.834	0.928	0.97	0.430	0.55	0.42	0.792	0.008	0.044	0.486	1.65	2.61				
10-140t	AL6T	1.44	1.86	0.194	0.289	0.774	1.028	1.05	0.460	0.54	0.42	0.774	0.010	0.047	0.475	1.57	2.76	0.338	0.286	0.399	
10-141t	AL7T	1.45	1.85	0.237	0.293	0.718	0.815	0.92	0.420	0.57	0.42	0.693	0.007	0.043	0.436	1.53	2.62	0.330	0.291	0.417	
10-142t	AL8T	1.39	1.88	0.167	0.315	0.747	0.998	0.99	0.428	0.56	0.42	0.763	0.007	0.041	0.490	1.51	2.64	0.283	0.282	0.441	
10-143t	AL9T	1.42	1.77	0.175	0.351	0.774	0.929	0.99	0.455	0.52	0.44	0.759	0.007	0.044	0.474	1.58	2.77	0.258	0.285	0.437	
10-144t	AL10T	1.37	1.83	0.216	0.341	0.765	0.924	1.01	0.435	0.53	0.43	0.751	0.008	0.044	0.510	1.46	2.63	0.323	0.293	0.421	
10-146t	LA31T	1.34	1.85	0.243	0.314	0.745	0.927	1.00	0.437	0.56	0.43	0.739	0.007	0.046	0.494	1.50	2.69	0.324	0.297	0.402	
10-147t	LA31T	1.37	1.87	0.227	0.298	0.729	0.913	1.05	0.420	0.55	0.42	0.773	0.007	0.047	0.511	1.57	2.88	0.315	0.290	0.417	
10-148t	MS37T	1.35	2.01	0.154	0.338	0.837	0.953	1.03	0.429	0.54	0.41	0.704	0.008	0.046	0.487	1.61	1.71	0.272	0.259	0.418	
10-149t	MS39	1.39	1.98	0.157	0.351	0.780	0.999	1.07	0.424	0.53	0.40	0.719	0.008	0.045	0.529	1.46	2.62	0.253	0.278	0.430	
10-150t	MS40T	1.43	1.97	0.167	0.395	0.922	1.017	1.03	0.435	0.56	0.42	0.775	0.012	0.046	0.500	1.55	2.83	0.264	0.042	0.463	
10-151t	MS41T	1.32	1.92	0.230	0.349	0.838	0.970	1.06	0.420	0.56	0.40	0.723	0.007	0.049	0.530	1.62	2.85	0.287	0.294	0.400	
10-152t	MS42T	1.30	1.91	0.220	0.321	0.741	0.944	1.02	0.426	0.54	0.40	0.811	0.006	0.041	0.479	1.55	2.81	0.322	0.232	0.382	
10-153t	MS42T	1.36	1.93	0.199	0.289	0.796	0.896	1.22	0.448	0.52	0.42	0.774	0.006	0.046	0.489	1.67	2.91	0.296	0.239	0.398	
10-154t	MS-44T	0.91	1.90	0.194	0.325	0.758	0.750	1.08	0.905	0.26	0.73	1.636	0.007	0.061	0.113	1.41	0.03				
10-155t	MS-45T	1.45	1.79	0.129	0.329	0.778	0.006	1.07	0.426	0.54	0.39	0.074	0.007	0.041	0.490	1.58	3.01	0.274	0.239	0.345	