gSOLIDS

Relationship between Geochemical Parameters and Paraffin/Asphaltene Phase Behavior from Petroleum Fluids

Part I: Offshore Gulf of Mexico Oils
Part II: Global Oil Collection

A Proposal from
GeoMark Research

Relationship between Geochemical Parameters and Paraffin/Asphaltene Phase Behavior from Petroleum Fluids

Executive Summary

This proposed study is divided into two parts. Part I deals with a group of 80 oils from the Gulf of Mexico that represent the various petroleum systems in the offshore. These include Tithonian marl/carbonate-sourced oils (Family SE2), oils from Lower Cretaceous shales (Family C1), and the Family SE1 oils along the shelf edge that are the result of mixing between oils generated from both the Tithonian and Cretaceous. The oil families were determined by GeoMark Research using biomarkers and carbon isotopes. Oil quality is largely determined by the nature of the source rock. Carbonates tend to generate high sulfur, low gravity fluids, for example. We characterized these same oil samples as to wax and asphaltene phase behavior using state-of-the-art techniques (e.g., CPM, high temperature GC, quantitative pentane titration). Is it possible to predict potential solids problems based on the petroleum system providence in the deepwater GOM? What effect does biodegradation or mixing of petroleum types have on wax or asphaltene stability?

In Part II we utilized GeoMark's global oil collection and sample over 220 oils that have been well characterized by biomarkers and integrated geological studies as to general source rock type, level of thermal maturity, and degree of biodegradation. Again, we measured wax and asphaltenes and attempt to determine and better quantitate relationships between oil type and solid phase behavior. For example, it is well known that lacustrine source rocks tend to generate waxy oils, but what are the molecular weight ranges and which source rock type is responsible for producing fluids with wax in the C_{70}+ range? Do oils from deepwater marine shales or marls ever generate high wax crude? Are asphaltene stability problems only associated with oils from carbonates or can biodegraded oils from shales also precipitate asphaltenes upon reduction of reservoir pressure?

We also solicited PVT reports and corresponding dead oil samples in the Part II global study. This allowed us to correlate solids phase behavior of live oils (under different reservoir pressure and temperature regimes) with predictions made from dead oil samples based on biomarker classifications and degree of biodegradation, as well as dead oil asphaltene measurements.

Companies may choose to subscribe to either Part I (GOM) or Part II (Global) or both. The cost is US$32,500 for Part I and US$39,500 for Part II. The costs to those companies participating in both studies are reduced 32% to US$49,000. It is planned that Part I will be completed by the end of the third quarter and Part II by the fourth quarter 2001.

Introduction

For years the oil industry has been plagued by problems associated with the deposition of organic solids, mainly paraffin and asphaltenes. These problems are expected to increase in the future as existing reserves are being depleted and offshore exploration continues to grow. The precipitated solids adversely affect the economics of exploiting and developing fields prone to solids deposition. Some of the damaging effects include:

- permeability reduction with formation damage
- reservoir fluid composition changes
- alterations of reservoir wettability
- reduction of the interior diameter and eventual plugging of production strings
- deposit of solids in surface facilities reducing separator and tank volume
- reduced flow and possible plugging of sub-sea pipelines
- increased service costs and lost production during downtime

With today's increased interest in deep-water offshore prospects and the concomitant high cost of development, it is essential for the operator to assess the potential for solids problems. Because paraffin characteristics and asphaltene content varies significantly from reservoir to reservoir, it has been very difficult to develop solutions to solids problems. Remediation and/or preventive methods that are effective in one producing field are not always applicable in other reservoirs or in various wells within the same reservoir (i.e., case specific).

In order to understand and model the phase behavior of paraffinic and asphaltenic fluids, it is crucial to have a comprehensive representation of the solids forming components common to crude oils and gas condensates. However, these components are larger and significantly more complex than those typically represented using standard gas chromatographic (GC) analyses to C_7+ or even C_{30}+. For example, two fluids might have very similar C_{30}+ contents but have widely varying paraffin and asphaltene behavior.

Recognizing these limitations, geochemical data have been collected for both: 1) a global oil set of >220 stock tank oils representative of the world's oil producing basins and 2) a group of 65 oils from the offshore Gulf of Mexico. These data are from GeoMark's OILS™ database and consist of both bulk and molecular data useful in determining the geological origin of crude oils, important in exploration. The bulk parameters include API gravity, sulfur/metals content, and SARA composition, as well as the stable carbon isotopic composition of the saturate and aromatic hydrocarbon fractions. Molecular analyses performed include whole crude capillary gas chromatography (GC) and GC/MS for sterane and terpane biomarkers. Biomarkers are essentially molecular fossils that can be used to predict the nature, depositional environment, and thermal history of the corresponding source rocks that generated the oils.

The nature of the source rock determines, in large part, the composition of the generated petroleum. For example, sediments deposited in lacustrine environments tend to generate high wax crudes upon burial, while marine carbonate-rich source rocks produce oils with abundant asphaltenes. Other geochemical/geological factors including thermal maturity, biodegradation, migration fractionation, and mixing of petroleum types influence the composition of a reservoir fluid.

We correlated inferences drawn from our geochemical data (e.g., source rock type, thermal maturity, degree of biodegradation) with paraffin and asphaltene properties (as determined below) in order to better predict solid behavior during field exploitation.

In this study, paraffin behavior were evaluated using cloud point temperatures, total paraffin contents, and C_{75}+ paraffin distributions using high temperature GC. Cloud point temperatures were measured with a Cross Polar Microscope (CPM) which provides visual confirmation of crystal nucleation and growth. Importantly, cloud point temperatures from the CPM were shown to correlate well with actual field measurements from live oil systems. Therefore, these values have direct applicability towards field operations.

In contrast, asphaltene deposition is considered to be an oftentimes-irreversible process resulting from fluid depressurization; therefore, asphaltene experimental programs are usually conducted on live oil samples that have not been exposed to pressures below reservoir conditions. However, a stock tank oil measurement, termed the Asphaltene Stability Index (ASI), has been shown to provide an estimation of likely asphaltene precipitation behavior when combined with live oil data from standard PVT studies. The ASI is defined as the amount of n-pentane required to initiate asphaltene precipitation from a known quantity of stock tank oil; low ASI values suggest that the asphaltenes were relatively unstable. However, the associated live oil PVT data is also necessary as field observations and laboratory analyses have shown that fluids with likely asphaltene problems have high compressibilities, low asphaltene contents, and are highly undersaturated at reservoir conditions.

Methodology

Geochemical

The crude oils in the global and GOM sets were analyzed in a program where geology and geochemistry were integrated to determine the corresponding source rock type, age, thermal history, and degree of biodegradation. This was accomplished primarily using gas chromatography/mass spectroscopy (GC/MS) analyses for sterane and terpane biomarkers. In addition, the stable carbon isotopic compositions of the saturate and aromatic hydrocarbon fractions were determined. Bulk data pertaining to oil quality issues were also obtained for each oil sample; these include API gravity, SARA analyses (% saturate, aromatic, resin and asphaltene), sulfur content and nickel/vanadium concentrations.

Paraffin

In this study, paraffin content and behavior was evaluated using 1) cloud point temperatures, 2) total paraffin contents, and 3) C_{75}+ paraffin distributions using high temperature GC.

Cloud point temperatures were measured with a Cross Polar Microscope (CPM) which provides visual confirmation of crystal nucleation and growth. The CPM works on the principle of light refraction through a series of concave-convex lenses in order to provide for magnification of an object at a fixed focal point. A CPM apparatus consists of a temperature controlled (programmable) hot stage, a first order wave plate, cross-polars, a light photomultiplier and a video camera and monitor where the entire heating and cooling process may be viewed. The hot stage is mounted on the stage of the microscope to control the sample temperature and, hence, allow for visual determination of the onset of wax crystallization (WPT). Typically, crystal sizes on the order of 1 micron are detectable at the cloud point. The first order wave plate is a crystal of quartz cut so that a beam of polarized white light is divided into its spectral components, and the resultant colors are rotated different amounts with respect to the optic axis of the quartz slice.

The use of CPM for the study of wax crystallization is based on the fact that all crystalline materials rotate the plane of polarization of transmitted polarized light. Hence, by crossing two prisms on opposite sides of the oil sample, all light is initially blocked and the entire field of view appears black. On cooling, the crystallizing material appears as bright spots against this black background.

Experimental trials have shown the CPM method consistently provides the most conservative (or highest) cloud points as compared to other techniques including Differential Scanning Calorimetry, Cold Finger, and viscometry.

Commonly determined petroleum wax content methods (e.g., modified UOP 46-85) will also be performed. This will allow for a comparison with CPM and GC results.

C_{75}+ GC techniques employ a high temperature capillary column (400° C), cold on-column injection to prevent split discrimination, and programmable carrier flow to maintain flow rates as temperatures increase and He becomes more viscous. This allows for measurement of paraffin components up to ~ C_{80}. C_{45} is the normal maximum carbon number observed in traditional whole crude GC.

Asphaltenes

Utilizing the global and GOM oil sets, this study is focused on measuring asphaltene behavior on stock tank oil samples. Unfortunately, asphaltene deposition is considered to be an oftentimes-irreversible process resulting from fluid depressurization; therefore, asphaltene experimental programs are usually conducted on live oil samples that have not been exposed to pressures below reservoir conditions. These fluid samples are gathered in specialized tools that release a pressure maintenance gas (usually Nitrogen) that keeps the sample pressure above reservoir conditions even as the tool cools down exiting the well. In addition, the fluids are transferred into specialized storage cylinders that operate using the same methodology to maintain the samples in a virgin state.

However, in just the past few years, the understanding of asphaltene behavior has improved to the point where some general fluid property information can be combined with compositional measurements to provide an indication of likely asphaltene precipitation. While individually none of the indicators guarantee the presence or lack of asphaltene problems, as a set they do help to understand the likely behavior.

- light oil characteristics (reservoir fluid density < 0.7 g/cc, asphaltene content < 2.0 wt%)
- high degree of undersaturation ($P_{res} – P_{sat}$ > 2000 – 4000 psi)
- resin / asphaltene ratio < 1 or 2 (as obtained from a SARA analysis)
- low asphaltene stability index

The first two indicators are provided in any standard PVT report and for this reason, it is useful that some stock tank oils tested in this program have an associated PVT analysis to obtain the indicators. In contrast, the second two values are obtained from stock tank oils and are measurements ideally suited for the global and GOM oil sets.

Routine asphaltene concentrations have already been determined by excess hexane precipitation from small dead oil samples. Subsequent to determining the $<C_{15}$ fraction (light ends) by evaporation in a stream of nitrogen for 30 min, and asphaltene precipitation using n-hexane (overnight at room temperature), the C_{15+} deasphalted fractions were separated into saturate hydrocarbon, aromatic hydrocarbon, and NSO (nitrogen-sulfur-oxygen compounds or resin) fractions using gravity-flow column chromatography employing a 100-200 mesh silica gel support activated at 400° C prior to use. Hexane was used to elute the saturate hydrocarbons, methylene chloride to elute the aromatic hydrocarbons, and methylene chloride/methanol (50:50) to elute the NSO fraction. Following solvent evaporation, the recovered fractions were quantified gravimetrically.

The Asphaltene Stability Index test is used to determine the “stability” of the asphaltenes in the surrounding oil. This test is a good compliment to the resin/asphaltene ratio evaluation as it is expected that an increased amount of resins will keep the asphaltenes dissolved and/or suspended. The testing system is composed of a visual sample chamber with internal mixing, a near-infrared laser source, fiber optic cables, a receiving power meter and a titrating pump to inject the n-pentane at a controlled rate. Specially developed software controls the injection rate from the pump while also recording the system temperature, time and the transmitted power of the light beam through the sample.

The result from a standard experiment is a slight increase in the transmitted power as the n-pentane is added (i.e., the overall fluid mixture is becoming less dense) until the point when the asphaltenes begin to precipitate. At that point, the solid particles begin to absorb and scatter the laser beam which is indicated as a significant loss of transmitted power on the power meter. From that information, the amount of n-pentane required to initiate precipitation (based on 1 gram of stock tank oil) is defined as the Asphaltene Stability Index.

It is also useful to note that chemical vendors are also using the ASI value, in conjunction with SARA analyses and other compositional indicators, to screen and select chemicals for asphaltene inhibition and remediation.

Samples

Table 1 lists the GOM oil samples that are used in this study. The corresponding well locations and oil family designations are shown on a map in Figure 1. The global oil set is given in Table 2 and mapped in Figure 2.

Objectives

- Develop correlations between geochemical parameters derived from dead oil biomarkers and paraffin/asphaltene behavior in live fluids.
- Establish standardized, comprehensive characterization methods using regular compositional analyses enhanced with geochemical parameters for models.
- Attempt to understand the nature and distribution of oils containing high temperature waxes.
- Determine the source/maturity/biodegradation controls on the propensity of a fluid to develop a solids problem.
- During data collection, construct and organize a database of solids precipitation data.

Deliverables

Results of the study are presented in both analytical and interpretive formats. The analytical data are provided in both hard copy and common digital formats (e.g., Excel™ and Access™). The interpretive report consists of a statistical comparison of all the geochemical, PVT, and solids data ensuring a novel assessment of the character of the waxes and asphaltenes in each oil type.

Costs

Companies may choose to subscribe to either Part I (GOM) or Part II (Global) or both. The cost is US$32,500 for Part I and US$39,500 for Part II. The costs to those companies participating in both studies are reduced 32% to US$49,000.

Timing

The study is completed and available for immediate delivery

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Figure 1. Selected GOM oil samples.

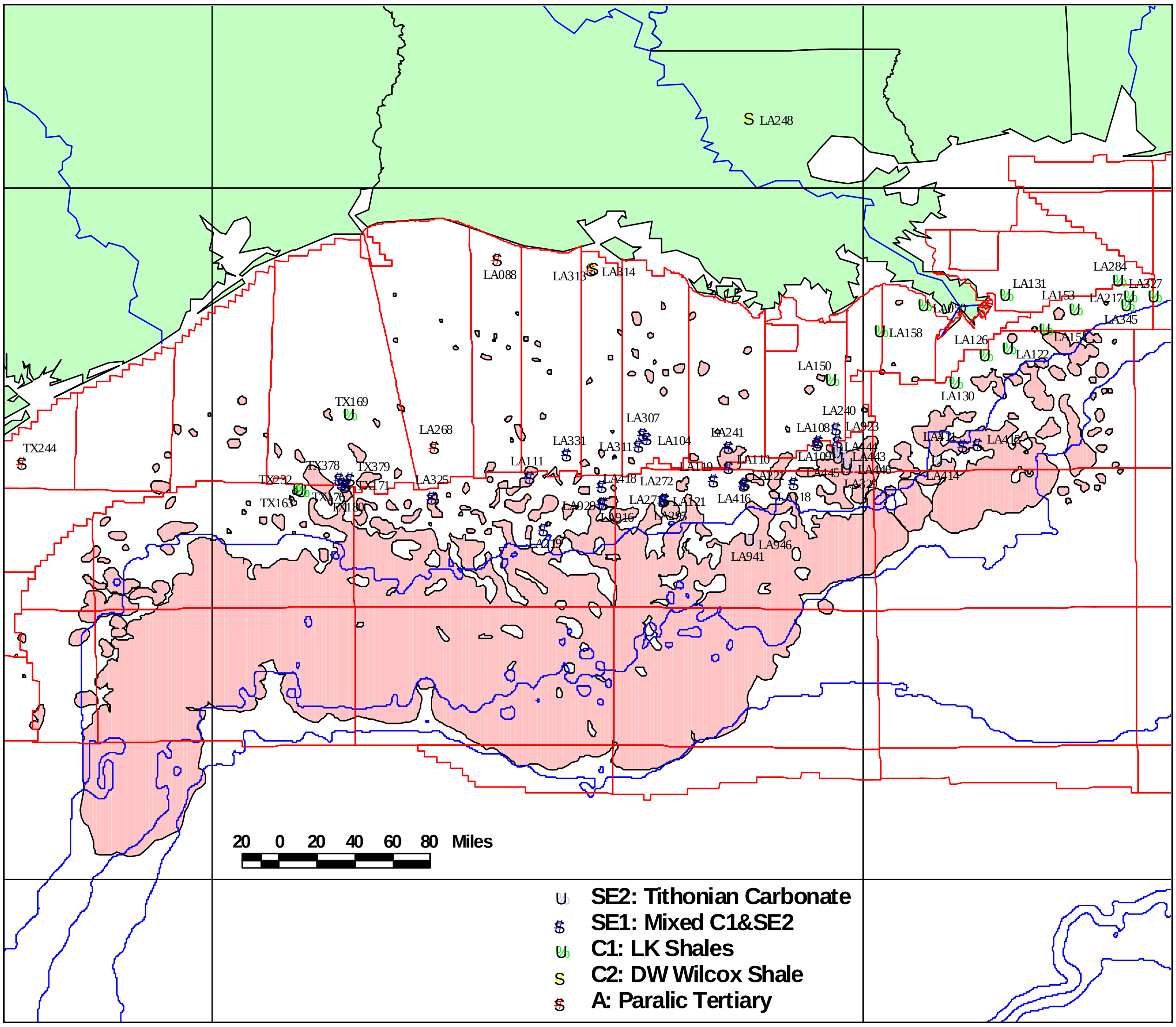

Figure 2. Selected global oil samples.

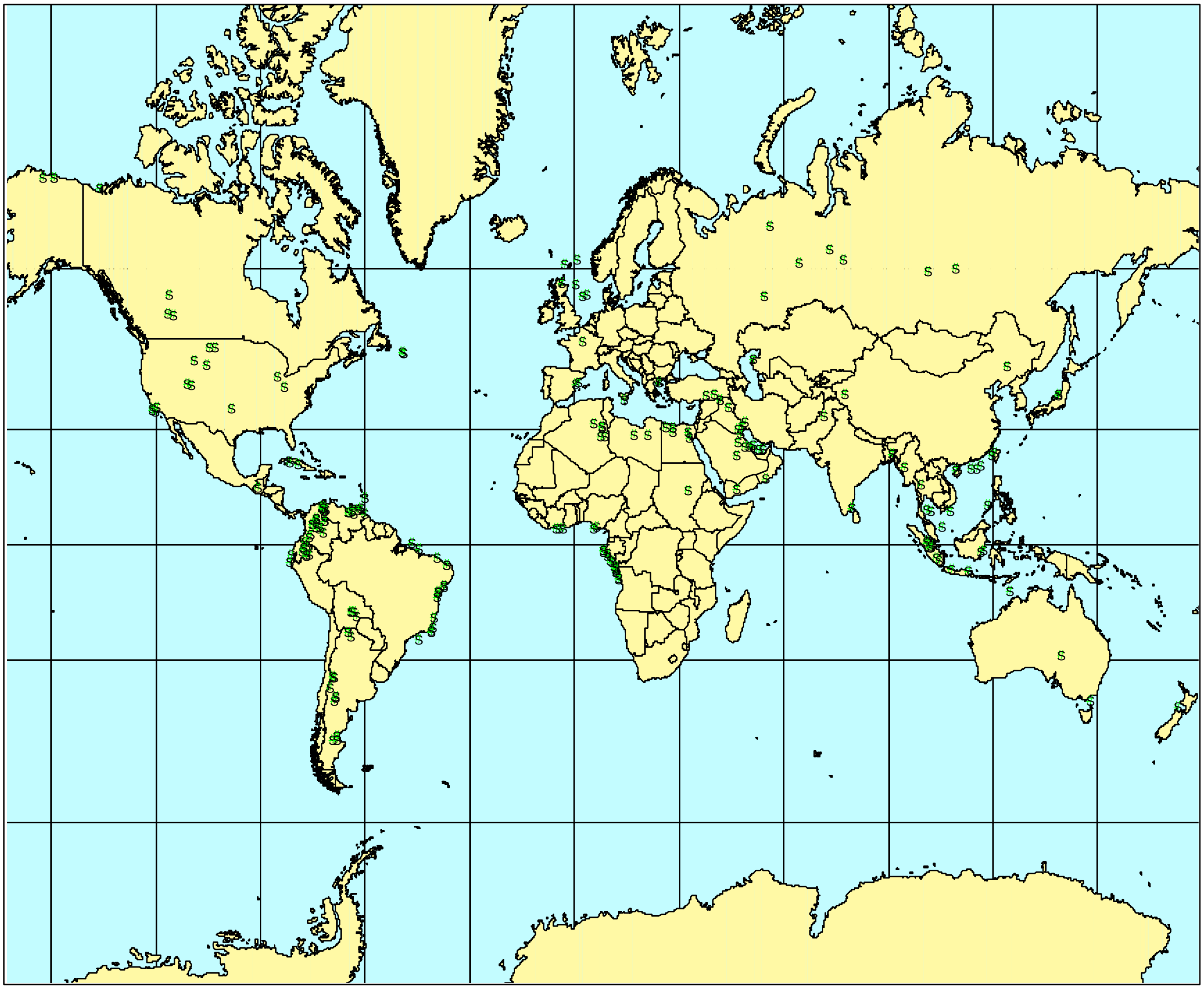

Table 1. GOM oils analyzed for solids.

SampleID	Country/State	Basin/County/Parish	Field	Well
LA0050	Louisiana	Offshore	West Delta 27	
LA0088	Louisiana	Offshore	East Cameron 33	3
LA0104	Louisiana	Offshore	Eugene Island 330	A-2
LA0108	Louisiana	Offshore	Ewing Bank 782	1 ST2
LA0109	Louisiana	Offshore	Ewing Bank 826	#1 ST
LA0110	Louisiana	Offshore	Boxer (Ewing Bank 988)	1
LA0111	Louisiana	Offshore	Garden Banks 72	OCS-G-7435 #1
LA0118	Louisiana	Offshore	Boxer (Green Canyon 18)	2
LA0119	Louisiana	Offshore	Green Canyon 60	1
LA0121	Louisiana	Offshore	Green Canyon 184	6
LA0122	Louisiana	Offshore	Mississippi Canyon 110	OCS-G-5826 #2
LA0130	Louisiana	Offshore	Mississippi Canyon 321	OCS-G-6946 #1
LA0131	Louisiana	Offshore	Main Pass 73	C-8-B
LA0153	Louisiana	Offshore	Phar Lap (Viosca Knoll 862)	2
LA0154	Louisiana	Offshore	Pompano (Viosca Knoll 989)	2
LA0219	Louisiana	Offshore	Auger (Garden Banks 426)	OCS-G-07498 # A004
LA0221	Louisiana	Offshore	Bullwinkle (Green Canyon 65)	OCS-G-05889 # A043
LA0240	Louisiana	Offshore	Teak (S. Timbalier S.A. 260)	S. Timbalier S.A. 260 #1 ST1
LA0241	Louisiana	Offshore	Mahogany (Ship Shoal S.A. 349)	Ship Shoal S.A. 349 #1
LA0248	Louisiana	Livingston	Lockhart Crossing	Callon International Paper #1
LA0268	Louisiana	Offshore	West Cameron 595	#A-7
LA0272	Louisiana	Offshore	Jolliet (Green Canyon 184)	Jolliet #1 DST#2
LA0284	Louisiana	Offshore	Main Pass 259	A-6
LA0307	Louisiana	Offshore	Eugene Island South 339	OCSG-02318 B-14
LA0311	Louisiana	Offshore	Eugene Island South 354	OCSG-10752 D-5
LA0313	Louisiana	Offshore	South Marsh Island 218	OCS 0310 76
LA0314	Louisiana	Offshore	South Marsh Island 217	OCS 0310 72
LA0325	Louisiana	Offshore	Tick (Garden Banks 189)	OCSG-06358 A-18
LA0327	Louisiana	Offshore	Petronius (Viosca Knoll 786)	Petronius #1
LA0331	Louisiana	Offshore	Monazite (Vermilion 375)	#1
LA0345	Louisiana	Offshore	Neptune (Viosca Knoll 826)	3A
LA0411	Louisiana	Offshore	Mars (Mississippi Canyon 807)	
LA0412	Louisiana	Offshore	Ursa (Mississippi Canyon 809)	
LA0414	Louisiana	Offshore	Europa (Mississippi Canyon 934)	
LA0416	Louisiana	Offshore	Rocky (Green Canyon 109)	
LA0418	Louisiana	Offshore	Enchillada (Garden Banks 127)	
LA0443	Louisiana	Offshore	Lobster East (Ewing Bank 873)	#A16
LA0444	Louisiana	Offshore	Lobser West (Ewing Bank 873)	#A19
LA0445	Louisiana	Offshore	Oyster (Ewing Bank 917)	#1
LA0446	Louisiana	Offshore	Arnold (Ewing Bank 963)	#1
TX0163	Texas	Offshore	East Breaks 165-A	A-1
TX0169	Texas	Offshore	High Island A-443	A-05
TX0171	Texas	Offshore	High Island A-382	F-05
TX0176	Texas	Offshore	High Island A-595	OCS-G-2221 #D-10
TX0180	Texas	Offshore	High Island A-596	D-09
TX0244	Texas	Offshore	Agate (Ship Shoal South A 361)	361 #1
LA0916	Louisiana	Offshore	Garden Banks 260	GB 260 #A-3
LA0923	Louisiana	Offshore	South Timbalier 287	ST 287 #2 ST 1

Table 1. GOM oils analyzed for solids.

SampleID	Country/State	Basin/County/Parish	Field	Well
LA0929	Louisiana	Offshore	Garden Banks 259	GB 259 #1 ST 1
LA0344	Louisiana	Offshore	Eugene Island 346-1 (Tanzanite)	EI 346 1
MX0043	Mexico	Offshore	Cantarell	2011D
MX0113	Mexico	Offshore	Cemtec	Chinchorro
MX0095	Mexico	Offshore	Campo Agave	Pozo #52
LA0930	Louisiana	Offshore	Baldpate (GB260)	1 ST 1
LA0936	Louisiana	Offshore	Ladybug (GB409)	1
LA0938	Louisiana	Offshore	Ladybug (GB409)	3
LA0944	Louisiana	Offshore	Fuji 1 (GC506)	1 OCS-G-8880
LA0952	Louisiana	Offshore	Gemini 3 (MC291)	2
LA0955	Louisiana	Offshore	Petronius (VK786)	1
LA0974	Louisiana	Offshore	Matterhorn (MC243)	2 OCS-G-19931
LA0977	Louisiana	Offshore	Matterhorn (MC243)	1 ST1 OCS-G-19931
LA1041	Louisiana	Offshore	Jolliet (GC184)	A1
LA1046	Louisiana	Offshore	Jolliet (GC184)	A11-D

Table 2. Global oils analyzed for solids

Sample ID	Country/State	Basin/County/Parish	Field	Well
UE138	Abu Dhabi		Yaser	1
AL013	Algeria		Hassi Messaoud	
AL019	Algeria		Tin Fouye	TFY-13
AL023	Algeria		Tamadanet	TM-101
AL063	Algeria			BKE-1; DST3
AL067	Algeria		BLK 404	HBN-1
AN007	Angola		Bento	
AN017	Angola		Quinguila	22
AN046	Angola		Sereia	1
AN054	Angola		Caco	1; DST4
AR001	Argentina		P Del Castillo	PC-173
AR021	Argentina		Puesto Cercado	x-2
AR047	Argentina		Lindero Atravesado	LA-41
AR050	Argentina		Caimancito	23
AR056	Argentina	Noroeste	Puesto Guardian	20
AR096	Argentina		Diadema	F-92
AR106	Argentina		Las Heras	LH-1009
AR126	Argentina		Canadon Minerales	CM-3033
AR149	Argentina		Catriel Oeste	177
AR182	Argentina		Chanares Herrados	
AR215	Argentina		Vizcacheras	VI-246
AU001	Australia		Jabiru	PROD. TEST
AU549	Australia		Kingfish	7
BA002	Bahrain		Awali	290
BG013	Bangladesh		Patharia Seep	
BG014	Bangladesh		Sylhet	7
BS001	Barbados		Woodbourne	Hopefield
BO006	Bolivia		Flora River	Seep
BO064	Bolivia		H. Suarez	X1
BO065	Bolivia		La Pena	51
BO099	Bolivia		Churamas	CHU-X1
BR001	Brazil		Wildcat DST	1-PAS-9
BR002	Brazil		Wildcat DST	1-MAS-5
BR004	Brazil		Atum	1-CES-27
BR007	Brazil		Ubarana	7-UB-18D-RJS
BR008	Brazil		Agulha	7-AG-14D-RJS
BR012	Brazil		Caioba	7-CB-21D-SES
BR016	Brazil		Siririzinho	7-SZ-41-SES
BR019	Brazil		Buracica	
BR023	Brazil		Candeias	7-DJ-187-BA
BR026	Brazil		Dom João	7-DJ-674-BA
BR027	Brazil		Wildcat DST	1-BAS-64
BR030	Brazil		Cacao	3-ESS-27D
BR033	Brazil		Wildcat DST	1-RJS-137
BR037	Brazil		Enchova	3-EN-1-RJS
BR040	Brazil		Garoupa	7-GP-8D-RJS
BR042	Brazil		Wildcat DST	1-SPS-6
AF006	Cabinda		Kungulo	71.2

Table 2. Global oils analyzed for solids

Sample ID	Country/State	Basin/County/Parish	Field	Well
CB007	Cabinda		Limba	84.20
CB012	Cabinda		Malongo West	72-40
CB014	Cabinda		Malongo West	72-48
CB023	Cabinda		Kungulo	121-02
CN002	Canada/Alberta		Bear Lake	
CN004	Canada/Alberta		Keystone	
CN050	Canada/Alberta		Slave Field	
CN118	Canada/Newfoundland		Terra Nova	K-07
CN123	Canada/Newfoundland		Terra Nova	E-79
CN143	Canada/Newfoundland		Hibernia	P-15
AS079	Canada/NWT		Adgo	J-27; DST3
CH004	China	Beibu Basin	WAN	9
CH011	China		DAQING	
CH055	China		Shacan	2
CH058	China		Enping	18-1-1A
CH061	China		Liuhua	11/1/01
CH062	China		Lufeng	22-1-2
CO002	Colombia		Cano Limon	3, DST6
CO004	Colombia		Matanegra	1
CO010	Colombia		La Yuca	3, DST7
CO033	Colombia		Toroyacu	3
CO034	Colombia		Toroyacu	3
CO072	Colombia		Cusiana	2A, DST2
CO101	Colombia		La Salina	LS-2
CO102	Colombia		La Salina	B-#2U
CO106	Colombia		La Salina	B-9
CO107	Colombia		La Salina	B-14
CO109	Colombia		Payoa	7U
CO110	Colombia		Payoa	8U
CO131	Colombia		Velasquez	265
CO134	Colombia		Teca	61
CO141	Colombia		Vulcanera	1
CO142	Colombia		Cupiagua	1
CO154	Colombia		Rubiales	2; DST 1
CO171	Colombia		Bonanza	15
CO267	Colombia		Hato Nuevo	1
CO268	Colombia		Los Mangos	18
AF023	Congo		Loango	R305
IC002	Cote d'Ivoire		IVCO	18
IC011	Cote d'Ivoire		Lion	A-1
CU012	Cuba		Echerarri	1
EC007	Ecuador		Sansahuari	1
EC091	Ecuador		Oglan	#A-1
EC110	Ecuador		Payamino	2
EC120	Ecuador		Ecud	4
EG016	Egypt		Umbaraka	3X
EG018	Egypt		Alamein	1X
EG025	Egypt	Western Desert	Abu Gharadig	3

Table 2. Global oils analyzed for solids

Sample ID	Country/State	Basin/County/Parish	Field	Well
EG072	Egypt		Sudr	1
EG073	Egypt		Ramadan	Rio
FR009	France		Chaunoy	19
AF033	Gabon		Lucina Marine	23
AF048	Gabon		Obando Marine	A2
AF061	Gabon		Pelican Marine	A1
AF099	Gabon		Pelican Marine	2
AF015	Ghana		Tano	
GU002	Guatemala		Rubelsanto	2
GA002	Guyana		Karanambo	1 DST7
IA001	India		Karaikal	10
IA010	India		Karaikal	1
ID011	Indonesia		XB	XB-3; DST1
ID030	Indonesia		MADURA	JS-19-1; DST1
ID040	Indonesia		MINAS	70004
ID041	Indonesia		BEKASAP	70013
ID049	Indonesia		SAGO	7
ID051	Indonesia		S. PULAI	2
ID058	Indonesia		N. LIRIK	81
ID078	Indonesia		MERBAU	2
ID087	Indonesia		IBUL	41; DST1
ID104	Indonesia		HANDIL	HQ-2S
ID113	Indonesia		TAMBORA	T-19
ID117	Indonesia			Kelud-1
ID160	Indonesia		ANOA	
IN005	Iran		Karun	KN-1
IN008	Iran		Ab Teymur	AT-1
IN024	Iran		Karanj	
IQ013	Iraq		Rachi	1
IQ020	Iraq		Kirkuk	130
SI007	Italy		Ragusa	51
JA002	Japan		AGA OKI SI	A-13
JA008	Japan		AGA OKI KITA	IA-6
KW007	Kuwait			
LI025	Libya		Facha	1
MY001	Myanmar		MOGUE	
NZ007	New Zealand		NIAGARA	1
AF016	Nigeria		Obagi	
OM012	Oman		Marmul	
PK019	Pakistan		Dhurnal	1
PR024	Peru		Dorissa 1A-1	528
PR059	Peru		Forestal	V
PR076	Peru		Huayuri	50
PH029	Philippines		S. NIDO	1; DST 4
QR012	Qatar		Al Rayyan	1
RU381	Russia/Bashkortostan		Or'obash	109
ES021	Russia/East Siberia		Sobin	5
ES057	Russia/East Siberia		Upper Chona	113

Table 2. Global oils analyzed for solids

Sample ID	Country/State	Basin/County/Parish	Field	Well
RU113	Russia		Ruf'egan	3
RU134	Russia		Savui	107
RU292	Russia		Ergin	26
RU399	Russia		Myltanovskoia	3
SA031	Saudi Arabia		Ghawar (Ain Dar)	
SA088	Saudi Arabia		Ghawar (Haradh)	52
SA105	Saudi Arabia		Hamur	1
SY011	Syria		Souedie	403
SY015	Syria		Ullyan	20
TI006	Thailand		BUNG MUANG	1
TK010	Turkey		Adiyaman	
TK013	Turkey		Sincain	
NWE002	UK		Beatrice (11)	
NWE003	UK		Cormorant (211)	
NWE004	UK		Argyll (30)	
NWE016	UK		Ettrick	20/2-1 DST3A
NWE022	UK		Clair (206)	8-1A DST3
NWE040	UK		Douglas	110/13-1; DST1
AS065	USA/Alaska		Prudhoe Baystate	1; DST1
AS068	USA/Alaska		Prudhoe Baystate	1; DST5
AS077	USA/Alaska		Fish Creek	1
CA001	USA/California		Orcutt	Penn Fee #6
CA008	USA/California		Carpenteria	B-33
CA018	USA/California		Elk Hills	347-33S
MI002	USA/Michigan		Bradford	#3A-10
MT003	USA/Montana		Mondak	#24X-8
ND007	USA/North Dakota		Killdeer	
UT002	USA/Utah		Coyote B	B71073
UT004	USA/Utah		Altamont	B73066
UT005	USA/Utah		Walker Hollow	B76056
WY003	USA/Wyoming		Frannie	W4-375
WY005	USA/Wyoming		Donkey Creek	B-3 Burrpws
VA018	Venezuela		E. Mapiri	ESV-6T
VA031	Venezuela		Mara	DM-116
VA073	Venezuela		Jusepin	NO.455C
VA079	Venezuela		Lagunillas	LL-1095
VA080	Venezuela		Lagunillas	LL-413
VA091	Venezuela		Mene Grande	RD-912
VA093	Venezuela		Mene Grande	75-Z-4L
VA109	Venezuela		La Paz	P-184
VA110	Venezuela		La Paz	P-94
VA113	Venezuela		Punta Benitez	PB-217
VA114	Venezuela		Punta Benitez	PB-41
YN010	Yemen		Shabwa	2
AF004	Zaire		Mibale	2