

# **SOUTH ATLANTIC OIL STUDY**

**DETAILED PETROLEUM GEOCHEMISTRY  
OF CRUDE OILS FROM THE SOUTH ATLANTIC**

**GEOMARK**

**A PROPOSAL**

## EXECUTIVE SUMMARY

The South Atlantic possesses multiple world-class petroleum systems along both continental margins (Brazil and West Africa). Past studies have documented active pre- and post-salt systems on both sides of the Atlantic. Recent discoveries in Brazil and Angola indicate that additional deep-water potential exists along both margins. However, not all recent wells have been successful and source rock questions exist where facies character and thermal maturity levels can only be predicted from models, or measured from analyses of oils and seeps.

Past GC/MS biomarker studies revealed much about the petroleum systems of Brazil and West Africa, but many questions remain incompletely addressed or unanswered. Recent studies (Dahl et al., 1994, and McCaffrey et al., 1994) have demonstrated the effectiveness of GC/MS/MS analyses in providing valuable refinement to source character, source age, and thermal maturity interpretations. For these reasons, GeoMark Research has performed GC/MS/MS analyses on its set of 311 South Atlantic oil samples, and has initiated a study presenting these results within a regional interpretation. The purpose of this study is to refine the characterization of a) source quality, b) thermal maturity, c) age prediction, and d) biodegradation previously provided by GC/MS Studies. Specifically, we intend to:

- Present and map source environments and relative oil maturities.
- Define Post-Salt oil families and suggest the most likely source horizons in terms of depositional environment, maturity, and age. These oil families are more complex than previously recognized because of the abundance of source units.
- Define the Pre-Salt oil families and suggest the most likely source horizons in terms of depositional environment, maturity, and age.
- Detail mixed oil families involving both Pre- and Post-Salt mixes, and entirely Post-Salt mixes.

The cost of the study is US \$42,500. Participants are not required to contribute samples.

## INTRODUCTION

The South Atlantic has been a global focus for the petroleum industry since the late 1950's and early 1960's following initial discoveries in Nigeria and Gabon. Significant successes have continued on a regular basis involving Brazil, the Congo, and Angola. Recently, the size of the discoveries has increased as exploration has advanced into the deepwater. The first Campos Basin (Brazil) giants were discovered in the mid-1980s and the giant finds in Angola only in the last four years. The first giant deepwater field was found in the Santos Basin (Brazil) last year, an important deepwater discovery (500 MMBOR) was made in Rio Muni, and confirmation of the deepwater potential of Nigeria was obtained.

However, not all wells have been successful and there have been deepwater disappointments. Our analysis of the results to date suggests that the South Atlantic fairway is characterized by an exceptional abundance and range of source rocks, an adequate frequency of reservoirs, quality seals, and a wide range of structural targets. However, large regions with unfavorable maturation levels are apparent. Much of the Post-Salt/drift succession is immature, only reaching maturity in major Tertiary depocenters such as the Congo, Niger, and Amazon. The Pre-Salt/rift succession is generally mature. Where the Pre-Salt is mature, migration pathways are not always present through the salt or topmost clastic units. We consider that ultimate reserves will be dictated primarily by the maturity of the Post-Salt succession; and where the Salt is not present, by the combined maturity levels of the rift and drift section.

Source rocks are present throughout the deepwater Post-Salt/drift succession. In the Aptian salt basin these initially accumulated in hypersaline environments. Younger Albian to Cenomanian carbonate and marl sources are present as well as a wide range of marine clastic source units whose deposition began in the Cenomanian and continues to the present. Tertiary sources are present in major fluvial-deltaic depocenters. Depositionally complex source facies may exist in the Aptian transition zone between the rift and drift succession. These are expected to include marine horizons at the top of the Pre-Salt succession, which is normally lacustrine. Comprehensive understanding of these environments is required, as away from the depocenters the maturity of the conventional Post-Salt cover will be low and older sources will be needed to charge available reservoir section. This is currently an issue in the Angola deepwater. Fortunately, all of the oil types are recognizable by biomarker analysis.

In the Congo Fan and locally in the onshore Kwanza Basin of Angola, both the Pre- and Post-Salt have contributed to the charge and complex mixtures of oil types are present. The early charge tends to be biodegraded, the younger charge fresh. Complex mixtures of Post-Salt Cretaceous and Tertiary aged oils, some of which are biodegraded, also characterize the deepwater discoveries in Angola. Complex charges may also be present in the deepwater Niger Delta.



**Figure 1.** Location of Crude Oil Samples Selected for Analysis.

## METHODOLOGY AND EXPLORATION APPLICATIONS

Between 1992 and 1996 GeoMark Research performed numerous petroleum system studies in South Atlantic Basins utilizing Multiple Ion Detection GC/MS analyses. These studies revealed much about the character, distribution, quality, and thermal maturity of the major Pre- and Post-Salt oil families on both sides of the Atlantic. However, questions remain concerning the source rocks in both Brazil and West Africa.

We have assembled a more comprehensive data set (285 samples), and have analyzed each of these samples for Metastable Reaction Monitoring GC/MS/MS analyses. GC/MS/MS analysis is a powerful technique that enables a more precise analysis of an oil sample. Because it reduces interference and permits more exact measurement of specific ions, the GC/MS/MS technique takes biomarker evaluations one step further. Specifically, we accomplished the following:

- Construct a more exact biomarker defined age control for the South Atlantic Cretaceous oils.
- Provide a more precise model of the various lacustrine, marine, and “transitional” organic facies that may be sourcing oil in both the West African and Brazilian Basins. Map the distribution of these oil families.
- Refine the thermal maturity levels for the various oil families.
- Provide a more exact characterization of the unmixed oil families, and estimate the components and percentages of mixed samples.

## ANALYTICAL PROGRAM

The following techniques have been performed on each sample and will form the analytical database of this report/project:

- API Gravity
- % Sulfur
- Nickel/Vanadium concentration
- C15+ vs. <C15
- Deasphalting
- Liquid Chromatography (%Sat %Aro %NSO)
- Capillary GC of Whole Crudes
- Stable Carbon Isotopes for both Sat and Aro Hydrocarbon Fractions
- GC/MS of branched/cyclic fraction for Terpane/Sterane Distributions (quantitative)
- GC/MS of Aromatic Hydrocarbon Fraction (qualitative)
- GC/MS/MS Metastable Reaction Monitoring of Terpane/Sterane Fraction

## **PRESENTATION OF RESULTS**

Results of the study are presented in both analytical and interpretive formats to insure all findings are accessible to explorationists and research personnel. All of the analytical data will be provided in hard copy and on magnetic media.

Analytical data is presented in **Data Volumes**, and includes the following:

- physical property data
- liquid chromatographic data
- gas chromatographic results
- stable carbon isotope data
- GC/MS mass chromatograms.
- GC/MS/MS mass chromatograms

## **PARTICIPATION**

The cost of the study is US \$42,500.

## **TIMING**

The project is completed and available for immediate delivery.

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## REFERENCES

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## APPENDIX A

## Samples Analyzed for this Study

ID	Lat	Long	Country	Basin	Field	Well	Reservoir Age
AN052	-7.3676	12.4871	Angola	Lower Congo	4-24	1; DST2	Albian
AN012	-7.34	12.5882	Angola	Lower Congo	4-26 (Kiabo)	1; DST1	Turonian
AN013	-7.525	12.4704	Angola	Lower Congo	4-44	1; DST2	Cenomanian
AN051	-7.5318	12.6591	Angola	Lower Congo	4-46	1; DST3	Cenomanian
AN133	-10.9179	13.51683	Angola	Benguela	Abacaxi	1	
AN001	-10.9173	13.5141	Angola	Benguela	Abacaxi	1; DST1	Upper Cretaceous
AN132	-10.1309	12.9937	Angola		Ametista	1; DST 1	
AN028	-6.603611	12.282778	Angola	Lower Congo	Atum	1; DST1	Albian
AN029	-6.603611	12.282778	Angola	Lower Congo	Atum	1; DST2	Albian
AN030	-6.603611	12.282778	Angola	Lower Congo	Atum	1; DST4	Albian
AN031	-6.594722	12.299722	Angola	Lower Congo	Atum East	1; DST2	Albian
AN084	-9.140166	13.122027	Angola	Block 20	Baleia	1	
AN067	-10.0562	13.5125	Angola	Kwanza	Bamvo	1; DST11	Upper Aptian
AN006	-9.15	13.125	Angola	Kwanza	Benfica		Aptian
AN065	-9.151	13.126	Angola	Kwanza	Benfica		Upper Aptian
AN039	-8.9378	13.1812	Angola	Kwanza	Bento	3	Albian
AN007	-8.9378	13.1812	Angola	Kwanza	Bento		Albian
AN063	-8.9377	13.1815	Angola	Kwanza	Bento		Albian
AN044	-6.4779	12.4871	Angola	Lower Congo	Cabeça da Cobra	12	Cenomanian
AN054	-7.1613	12.4182	Angola	Lower Congo	Caco	1; DST4	Turonian
AN073	-8.8129	13.4179	Angola	Lower Congo	Cacuaco	4	Aptian
AN056	-8.8125	13.4175	Angola	Kwanza	Cacuaco	4	Aptian
AN053	-6.1011	12.1691	Angola	Lower Congo	Camarao East	1; DST4	Albian
AN024	-6.815556	12.392778	Angola	Lower Congo	Cavala	1; DST1	Albian
AN025	-6.815556	12.392778	Angola	Lower Congo	Cavala	1; DST2	Albian
AN026	-6.815556	12.392778	Angola	Lower Congo	Cavala	1; DST3	Albian
AN027	-6.815556	12.392778	Angola	Lower Congo	Cavala	1; DST4	Albian
AN059	-8.581	13.562	Angola	Kwanza	Caxito	Seep	Upper Aptian
AN060	-8.585	13.565	Angola	Kwanza	Caxito	Seep	Upper Aptian
AN068	-8.65	13.2375	Angola	Lower Congo	Cegonha	1; DST3	Albian
AN005	-11.006	13.5403	Angola	Benguela	DenDen	1; DST1	Pre Salt
AN032	-6.368056	12.245556	Angola	Lower Congo	Enguila South	1; DST4	Albian
AN069	-8.8125	13	Angola	Lower Congo	Falcao	1	
AN075	-8.8125	13	Angola	Lower Congo	Falcao	1	
AN062	-9.625	13.575	Angola	Kwanza	Galinda		Upper Aptian
AN040	-6.1838	12.386	Angola	Lower Congo	Ganda	3; DST3	Upper Aptian
AN047	-6.18382	12.386	Angola	Lower Congo	Ganda	5	Cenomanian
AN042	-6.2114	12.2987	Angola	Lower Congo	Kitona	19	Cenomanian
AN064	-9.0125	13.25	Angola	Kwanza	Legua	1	Miocene
AN057	-8.4937	13.4875	Angola	Kwanza	Libongo	Seep	Upper Aptian
AN058	-8.495	13.49	Angola	Kwanza	Lifune	Seep	Upper Aptian
AN072	-8.3125	12.9125	Angola	Lower Congo	Lonzo	1	
AN014	-8.825	13.2937	Angola	Kwanza	Luanda	13	Cenomanian
AN050	-6.34926	12.5147	Angola	Lower Congo	Luango	2	Cenomanian
AN048	-6.25735	12.44669	Angola	Lower Congo	Lumueno	17	Cenomanian
AN002	-10.9355	13.6129	Angola	Benguela	Maboque	1; DST1	Pre Salt
AN019	-6.3819	12.178889	Angola	Lower Congo	Mavanga	3; DST1	Albian
AN070	-8.5625	13.175	Angola	Lower Congo	Muambo	1; DST2	

AN074	-8.4	13.0875	Angola	Lower Congo	Mubafo	1; DST1	Albian
AN004	-11.2097	13.5605	Angola	Benguela	Mucua	1; DST1	Pre Salt
AN135	-11.21068	13.568	Angola	Benguela	Mucua	1	
AN003	-8.9812	13.3625	Angola	Kwanza	Mulenvos		Albian
AN038	-8.8312	13.2938	Angola	Kwanza	Mulenvos North	3	Albian
AN016	-6.2665	12.3952	Angola	Lower Congo	N'Zombo	27	Albian
AN041	-6.2435	12.3309	Angola	Lower Congo	N'Zombo Northeast	38	Albian
AN134	-7.0998	12.3386	Angola	L. Congo	Pacassa	2	
AN080	-7.0999	12.3387	Angola	Lower Congo	Pacassa	101	
AN071	-8.385	13.1625	Angola	Lower Congo	Pakubalu	1; DST1	Albian
AN081	-6.9454	12.3766	Angola	Lower Congo	Palanca	201	
AN045	-6.1884	12.4458	Angola	Lower Congo	Pambo	3	Cenomanian
AN082	-6.2153	12.3555	Angola	Lower Congo	Pinda	1	Cenomanian
AN083	-6.2153	12.3555	Angola	Lower Congo	Pinda	1	Cenomanian
AN055	-6.0873	11.8318	Angola	Lower Congo	Pitangueria	1; DST6	Olig-Eoc
AN035	-6.636944	12.290278	Angola	Lower Congo	Polvo	1; DST5	Albian
AN008	-9.1625	13.2812	Angola	Kwanza	Quenguela		Miocene
AN011	-9.0875	13.2437	Angola	Kwanza	Quenguela North	10	Miocene
AN049	-6.3511	12.4393	Angola	Lower Congo	Quifuma	1; DST3	Cenomanian
AN043	-6.216	12.3566	Angola	Lower Congo	Quinfuquena	4	Cenomanian
AN017	-6.3235	12.455	Angola	Lower Congo	Quinguila	22	Cenomanian
AN018	-6.338694	12.293333	Angola	Lower Congo	Raia	1; DST1	Albian
AN034	-6.6452	12.3411	Angola	Lower Congo	Sarda	1; DST1	Albian
AN046	-6.1838	12.3143	Angola	Lower Congo	Sereia	1	Cenomanian
AN033	-6.825	12.427	Angola	Lower Congo	Sulele South	3; DST3	Albian
AN020	-6.904	12.438667	Angola	Lower Congo	Tamboril	1; DST1	Albian
AN021	-6.904	12.438667	Angola	Lower Congo	Tamboril	1; DST2	Albian
AN022	-6.904	12.438667	Angola	Lower Congo	Tamboril	1; DST3	Albian
AN023	-6.904	12.438667	Angola	Lower Congo	Tamboril	1; DST4	Albian
AN010	-9.6625	13.3212	Angola	Kwanza	Tobias	6	Aptian
AN066	-9.25	13.1375	Angola	Kwanza	Uacongo		Upper Aptian
AN061	-11	14	Angola	Benguela		Outcrop	
AF018	6.18	2.62	Benin	Benin	Dahomey Emb.	DO-A3	Maastrichtian
BR020	-12.40418	-38.3679	Brazil	Reconcavo	Agua Grande		Lower Cretaceous
BR008	-4.8751	-36.2699	Brazil	Potiguar	Agulha	7-AG-14D-RJS	Upper Cret./Tert.
BR009	-4.9059	-36.2607	Brazil	Potiguar	Agulha	7-AG-16D-RJS	Upper Cret./Tert.
BR018	-12.1135	-38.4881	Brazil	Reconcavo	Aracas		Lower Cretaceous
BR004	-2.9738	-38.958	Brazil	Cearã	Atum	1-CES-27	Aptian
BR019	-12.1956	-38.494	Brazil	Reconcavo	Buracica		Lower Cretaceous
BR029	-19.0767	-39.6555	Brazil	Espirito	Cacao	1-ESS-26	Albian/Cenomanian
BR031	-19.1028	-39.6534	Brazil	Espirito	Cacao	3-ESS 29D	Albian/Cenomanian
BR030	-19.099	-39.6482	Brazil	Espirito	Cacao	3-ESS-27D	Albian/Cenomanian
BR012	-11.03	-36.939	Brazil	Sergipe	Caioba	7-CB-21D-SES	Lower Cretaceous
BR011	-11	-36.985	Brazil	Sergipe	Camorim	7-CM-6-SES	Lower Cretaceous
BR023	-12.6559	-38.66043	Brazil	Reconcavo	Candeias	7-DJ-187-BA	Lower Cretaceous
BR022	-12.66331	-38.56677	Brazil	Reconcavo	Candeias		Lower Cretaceous
BR017	-10.622	-36.97	Brazil	Sergipe	Carmopolis		Aptian
BR041	-22.4703	-40.4475	Brazil	Campos	Cherne	3-CH-1-RJS	Upper Cretaceous
BR006	-3.0825	-38.8012	Brazil	Cearã	Curimã	1-CES-19	Aptian
BR026	-12.64892	-38.66524	Brazil	Reconcavo	Dom João	7-DJ-674-BA	Upper Jurassic
BR025	-12.60418	-38.64289	Brazil	Reconcavo	Dom João		Upper Jurassic
BR013	-11.09791	-36.95939	Brazil	Sergipe	Dourado	7-DO-8-SES	Camp/Eocene
BR037	-22.7106	-40.695	Brazil	Campos	Enchova	3-EN-1-RJS	Tertiary
BR038	-22.7083	-40.655	Brazil	Campos	Enchova	4-RJS-38	Tertiary

BR040	-22.37849	-40.41148	Brazil	Campos	Garoupa	7-GP-8D-RJS	Albian
BR014	-11.185	-37.068	Brazil	Sergipe	Guaricema	7-G23D-SES	Camp/Eocene
BR028	-15.2921	-38.8696	Brazil	Bahia Sul (Almada)	Ilheus	1-BAS-37	Aptian
BR021	-12.35806	-38.20025	Brazil	Reconcavo	Miranga		Lower Cretaceous
BR015	-10.696	-37.204	Brazil	Sergipe	Riachuelo	7-RO-13-SES	Apto-Albian
BR010	-10.6737	-36.6425	Brazil	Sergipe	Robalo	7-RB-5D-SES	Camp/Eocene
BR016	-10.62	-37.106	Brazil	Sergipe	Siririzinho	7-SZ-41-SES	Aptian
BR024	-12.45343	-38.49177	Brazil	Reconcavo	Taduipe		Lower Cretaceous
BR007	-4.9059	-36.2607	Brazil	Potiguar	Ubarana	7-UB-18D-RJS	Aptian
BR027	-13.725	-38.9083	Brazil	Bahia Sul	Wildcat DST	1-BAS-64	
BR005	-3.1888	-38.5627	Brazil	Cear�	Wildcat DST	1-CES-33A	Lower Cretaceous
BR003	-0.9492	-43.8054	Brazil	Barreirinhas	Wildcat DST	1-MAS-20	Upper Cretaceous
BR002	-0.4891	-44.1012	Brazil	Barreirinhas	Wildcat DST	1-MAS-5	Upper Cretaceous
BR001	0.8136	-46.125	Brazil	Foz do Amazonas	Wildcat DST	1-PAS-9	Oligocene
BR032	-23.6422	-41.4734	Brazil	Campos	Wildcat DST	1-RJS-104	Tertiary
BR034	-22.3674	-40.5777	Brazil	Campos	Wildcat DST	1-RJS-110	Tertiary
BR035	-22.7281	-40.6212	Brazil	Campos	Wildcat DST	1-RJS-116	Tertiary
BR036	-23.4841	-41.2256	Brazil	Campos	Wildcat DST	1-RJS-125A	Tertiary
BR039	-22.1961	-40.8351	Brazil	Campos	Wildcat DST	1-RJS-127	Aptian
BR033	-21.7582	-40.1849	Brazil	Campos	Wildcat DST	1-RJS-137	Upper Cretaceous
BR043	-24.5845	-44.5897	Brazil	Santos	Wildcat DST	1-SPS-18	Upper Cretaceous
BR042	-24.42	-44.25	Brazil	Santos	Wildcat DST	1-SPS-6	Upper Cretaceous
CB003	-5.5652	11.988	Cabinda	Congo	Kali	95-03	Pre Salt
CB021	-5.5625	11.985	Cabinda	Congo	Kali	95-03	Neocomian
CB023	-5.3968	11.9863	Cabinda	Congo	Kungulo	121-02	Aptian
AF006	-5.5377	12	Cabinda	Congo	Kungulo	71.2	Upper Cretaceous
CB022	-5.4119	11.9889	Cabinda	Congo	Kungulo	71-02	Albian
CB007	-5.5055	12.0597	Cabinda	Congo	Limba	84.20	Upper Cretaceous
CB019	-5.4667	12.0556	Cabinda	Congo	Limba	84-21	Aptian/Neocomian
CB020	-5.4667	12.0556	Cabinda	Congo	Limba	84-21	Aptian/Neocomian
CB024	-5.7769	12.0558	Cabinda	Congo	Livuite	132-04	Cenomanina
CB006	-5.3584	12.0827	Cabinda	Congo	Malongo North	59.06	Upper Cretaceous
CB017	-5.3217	12.0923	Cabinda	Congo	Malongo North	60-09	Neocomian
CB015	-5.395	12.0731	Cabinda	Congo	Malongo North	73-16	
CB016	-5.375	12.0833	Cabinda	Congo	Malongo North	73-67	Neocomian
CB018	-5.4125	12.1617	Cabinda	Congo	Malongo South	73-09	
CB002	-5.409	12.1562	Cabinda	Congo	Malongo South	73-53	Upper Cretaceous
AF005	-5.4136	12.046	Cabinda	Congo	Malongo W.	72.23D	Upper Cretaceous
CB010	-5.4147	12.0497	Cabinda	Congo	Malongo West	72-09	
CB011	-5.4133	12.0397	Cabinda	Congo	Malongo West	72-18	
CB008	-5.4111	12.0361	Cabinda	Congo	Malongo West	72-22D	
CB009	-5.4167	12.05	Cabinda	Congo	Malongo West	72-31	
CB012	-5.4056	12.05	Cabinda	Congo	Malongo West	72-40	Aptian
CB013	-5.3833	12.0333	Cabinda	Congo	Malongo West	72-46	Neocomian
CB014	-5.3847	12.0375	Cabinda	Congo	Malongo West	72-48	
CB005	-5.414	12.0465	Cabinda	Congo	Malongo West	84-14	Pre Salt
CB001	-5.2574	11.9191	Cabinda	Congo	Numbi	D5	Albo-Cenomanian
CB004	-5.6572	11.8134	Cabinda	Congo	Sanha	117-3X	Albian
CB025	-5.2083	11.8323	Cabinda	Congo	Wamba	A4	Albian
CB026	-5.6903	11.7672	Cabinda	Congo	Wilcat	117-4X	
AF014	4.0919	8.841	Cameroon	Rio Del Ray	Isongo	#C-1	Miocene
AF013	2.875	9.8125	Cameroon	Douala	Kribi	#A-1	Albian
AF024	-4.8345	12.1149	Congo	Congo	Kundji	1	Pre Salt
AF026	-4.4853	11.1057	Congo	Congo	Litella	1X; DST2B	Albian

AF025	-4.4853	11.1057	Congo	Congo	Litella	1X; RFT3	Albian
AF104	-4.4853	11.1057	Congo	Congo	Litella Marine	1X; RFT27	
AF106	-4.3931	11.2589	Congo	Congo	Loango	306	
AF105	-4.3945	11.2562	Congo	Congo	Loango	610	
AF022	-4.3952	11.2573	Congo	Congo	Loango	A2	Albian
AF023	-4.3952	11.2573	Congo	Congo	Loango	R305	Albian
AF027	-3.9	11.225	Congo	Congo	Tietie	1X	Pre Salt
AF007	-4.4228	11.4136	Congo	Congo	Zatchi	2	Albian
IC043	4.811	-3.152	Cote d'Ivoire	Ivory Coast	Agip E1	E1-1X	
IC001	5.01489	-3.57884	Cote d'Ivoire	Ivory Coast	Belier	IVCO-18	Senonian?
IC010	5.05	-3.85	Cote d'Ivoire	Ivory Coast	Belier	Outpost	Senonian
IC036	5.061	-3.87	Cote d'Ivoire	Ivory Coast	Belier	Outpost	
IC015	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Foxtrot	B1-1X	Albian
IC019	5.087	-3.725	Cote d'Ivoire	Ivory Coast	Gazell	2	Senonian
IC037	5.088	-3.716	Cote d'Ivoire	Ivory Coast	Gazelle	1	
IC038	5.087	-3.725	Cote d'Ivoire	Ivory Coast	Gazelle	2	
IC009	5.1	-3.725	Cote d'Ivoire	Ivory Coast	Gazelle	?	Senonian
IC002	5.05	-3.85	Cote d'Ivoire	Ivory Coast	IVCO	18	Senonian
IC003	5.05	-3.85	Cote d'Ivoire	Ivory Coast	IVCO	18	Senonian
IC041	5	-3.58	Cote d'Ivoire	Ivory Coast	IVCO	18; DST5	
IC004	5.05	-3.85	Cote d'Ivoire	Ivory Coast	IVCO	25; RFT	Maastrichtian
IC005	5.05	-3.85	Cote d'Ivoire	Ivory Coast	IVCO	25; RFT	Maastrichtian
IC042	5.038	-3.771	Cote d'Ivoire	Ivory Coast	IVCO	25; RFT1	
IC039	5.018	-3.872	Cote d'Ivoire	Ivory Coast	IVCO	8; DST3B	
IC040	5.018	-3.872	Cote d'Ivoire	Ivory Coast	IVCO	8; DST4	
IC006	5.05	-3.85	Cote d'Ivoire	Ivory Coast	Kudu	AGIP E1-1X	Albian
IC011	5.02794	-4.80276	Cote d'Ivoire	Ivory Coast	Lion	A-1	Albian
IC035	5.0369	-4.9349	Cote d'Ivoire	Ivory Coast	Lion	A-1X	
IC012	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	A-2	Albian
IC018	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	A3	Senonian
IC013	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	B-1	Albian
IC017	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	B-1;RFT	
IC029	5.028	-4.8003	Cote d'Ivoire	Ivory Coast	Lion	B1-8X	Senonian
IC014	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	B-2	Albian
IC016	5.05	-4.775	Cote d'Ivoire	Ivory Coast	Lion	B-3	Albian
IC030	5.0224	-4.6004	Cote d'Ivoire	Ivory Coast	Lion	B4 St	Albian
IC031	5.0276	-4.7834	Cote d'Ivoire	Ivory Coast	Lion	B5	Senonian
IC033	5.0586	-3.9509	Cote d'Ivoire	Ivory Coast	Lion	D2	Senonian
IC049	4.992	-4.836	Cote d'Ivoire	Ivory Coast	Lion		
IC032	5.1178	-4.0339	Cote d'Ivoire	Ivory Coast	Panthere	D1	Cenomanian
IC034	5.1178	-4.0339	Cote d'Ivoire	Ivory Coast	Panthere	D1	Cenomanian
AF019	3.9724	8.5377	Equatorial Guinea	Rio Del Ray	Alba		Miocene
AF082	-0.908	8.671	Gabon	Gabon	Anguille	37	Senonian
AF012	-0.9081	8.6709	Gabon	Gabon	Anguille	AGM-42	Santonian
AF072	-0.88572	8.67564	Gabon	Gabon	Anguille Marine	44	Senonian
AF083	-0.77035	8.75623	Gabon	Gabon	Anguille North East	3	Senonian
AF073	-0.7703	8.7562	Gabon	Gabon	Anguille South East	2	Senonian
AF043	-1.34082	8.73777	Gabon	Gabon	Ayol Marine	1	Senonian
AF081	-1.27683	8.7963	Gabon	Gabon	Baliste Marine	3	Miocene
AF049	-1.27777	8.802	Gabon	Gabon	Baliste Marine	5	Senonian
AF051	-1.6147	8.7993	Gabon	Gabon	Barbier Marine	5	Senonian
AF074	-1.61478	8.79933	Gabon	Gabon	Barbier Marine	12	Miocene
AF044	-1.47515	9.11787	Gabon	Gabon	Batanga	2	Senonian
AF063	-1.27865	8.73087	Gabon	Gabon	Baudroie Marine	5	Senonian

AF084	-1.2786	8.7309	Gabon	Gabon	Baudroie Marine	6	Senonian
AF075	-1.27869	8.73095	Gabon	Gabon	Baudroie Marine	2A	Senonian
AF076	-1.2358	8.73912	Gabon	Gabon	Baudroie North Marine	3	Senonian
AF052	-1.49609	9.09041	Gabon	Gabon	Breme Marine	9	Senonian
AF050	-0.71656	8.76827	Gabon	Gabon	Clairette	44	Senonian
AF064	-1.02624	8.76811	Gabon	Gabon	Doree Marine	1	Senonian
AF030	-2.07415	9.80745	Gabon	Congo	Echira	3	Aptian
AF031	-2.79049	10.04275	Gabon	Congo	Gamba	9	Aptian
AF054	-1.14033	8.4633	Gabon	Gabon	Girelle Marine	9	Senonian
AF078	-1.49153	8.72418	Gabon	Gabon	Gonelle Extension Nord Marine	1	Senonian
AF055	-1.54159	8.73344	Gabon	Gabon	Gonelle Marine	N6	Senonian
AF053	-0.83358	8.63892	Gabon	Gabon	Grande Anguille A Marine	7	Senonian
AF077	-0.83703	8.63895	Gabon	Gabon	Grande Anguille A Marine	6C	Senonian
AF056	-1.45726	8.66561	Gabon	Gabon	Grondin Marine	16	Senonian
AF032	-2.84522	10.0755	Gabon	Congo	Ivinga	8	Aptian
AF085	-0.26753	9.20703	Gabon	Gabon	Konzi Marine	A6	Turonian
AF086	-0.02675	9.207	Gabon	Gabon	Konzi Marine	B1	Turonian
AF087	-0.2676	9.20705	Gabon	Gabon	Konzi Marine	B8	Turonian
AF065	-0.26757	9.2071	Gabon	Gabon	Konzie Marine	A1	Turonian
AF008	-3.7125	10.75	Gabon	Congo	Lucina		Neocomian
AF033	-3.7134	10.7493	Gabon	Congo	Lucina Marine	23	Neocomian
AF034	-3.7134	10.7493	Gabon	Congo	Lucina Marine	23	Neocomian
AF057	-1.53537	8.82516	Gabon	Gabon	Mandaros Marine	4	Senonian
AF035	-0.37353	9.202	Gabon	Gabon	M'Boumba	2	Cenomanian
AF021	-3.775	10.95	Gabon	Congo	M'Bya	GMB7	Barr/Neoc
AF039	-3.83518	10.9387	Gabon	Congo	M'Bya North Marine	C1	
AF040	-3.8349	10.93852	Gabon	Congo	M'Bya North Marine	C4	Barremian
AF036	-3.93738	10.93912	Gabon	Congo	M'Bya South Marine	5	Barremian
AF037	-3.9372	10.939	Gabon	Congo	M'Bya South Marine	A6	Barremian
AF038	-3.93748	10.93938	Gabon	Congo	M'Bya South Marine	B4	Barremian
AF046	-1.07326	8.71259	Gabon	Gabon	Merou-Sardine South Marine	1	Senonian
AF042	-1.24717	10.0002	Gabon	Gabon	Niungo	1	Aptian
AF047	-2.527	9.1598	Gabon	Gabon	Nombo Marine	2	Eocene/Paleocene
AF059	-0.81758	8.8173	Gabon	Gabon	N'Tchengue	8	Miocene
AF067	-0.8	8.79154	Gabon	Gabon	N'Tchengue North	1	Miocene
AF068	-0.88664	8.80229	Gabon	Gabon	N'Tchengue Ocean	5	Senonian
AF071	-1.27445	8.65345	Gabon	Gabon	Obando Marine	A1	Senonian
AF048	-1.2744	8.6534	Gabon	Gabon	Obando Marine	A2	Senonian
AF011	-1.0276	8.5974	Gabon	Gabon	Octopus	OCT-A	Campanian
AF102	-1.026	8.59	Gabon	Gabon	Octopus Marine	A2	Senonian
AF070	-1.46	8.955	Gabon	Gabon	Oguendjo Marine West	B10	Senonian
AF090	-1.492	8.9233	Gabon	Gabon	Oguendjo Marine West	B4	Senonian
AF095	-1.492	8.9233	Gabon	Gabon	Oguendjo Marine West	B4	Senonian
AF089	-1.4919	8.9545	Gabon	Gabon	Oguendjo Marine West	B7	Senonian
AF096	-1.458	8.953	Gabon	Gabon	Oguendjo Marine West	B8	Senonian
AF094	-1.461	8.959	Gabon	Gabon	Oguendjo Marine West	B9	Senonian
AF069	-1.481	8.916	Gabon	Gabon	Oguendjo Marine West	C1	Senonian
AF097	-1.485	8.926	Gabon	Gabon	Oguendjo Marine West	C3	Senonian
AF093	-1.49	8.918	Gabon	Gabon	Oguendjo Marine West	C6	Senonian
AF091	-1.487	8.915	Gabon	Gabon	Oguendjo Marine West	C7	Senonian
AF088	-1.492	8.923	Gabon	Gabon	Oguendjo Marine West	C8	Senonian
AF098	-1.493	8.919	Gabon	Gabon	Oguendjo Marine West	C9	Senonian
AF092	-1.4335	8.9405	Gabon	Gabon	Oguendjo Marine West	Z1	Senonian
AF009	-1.4687	8.9007	Gabon	Gabon	Oguendjo West	OGW-Z2	Maatrichtian

AF010	-1.3309	9.0459	Gabon	Gabon	Olende	OL-6	Santonian
AF062	-0.12533	9.38	Gabon	Gabon	Oyan Marine	1	
AF066	-1.13397	8.5873	Gabon	Gabon	Pageau Marine	4	Senonian
AF099	-1.1987	8.7012	Gabon	Gabon	Pelican Marine	2	Senonian
AF061	-1.1973	8.7036	Gabon	Gabon	Pelican Marine	A1	Senonian
AF100	-1.1987	8.7012	Gabon	Gabon	Pelican Marine	A2	Senonian
AF101	-1.198	8.7022	Gabon	Gabon	Pelican Marine	A3	Senonian
AF079	-0.80766	8.77427	Gabon	Gabon	Port Gentil Ocean	6	Senonian
AF058	-0.84653	8.76382	Gabon	Gabon	Port Gentil South Marine	3	Senonian
AF041	-1.9273	9.8599	Gabon	Congo	Rabi Kounga	53	Aptian
AF060	-1.16425	8.69844	Gabon	Gabon	Torpille Marine	18	Senonian
AF103	-1.436	8.7002	Gabon	Gabon	Torpille North East Marine	1	Senonian
AF080	-1.457	8.7015	Gabon	Gabon	Torpille North East Marine	3	Senonian
AF045	-1.4925	8.923	Gabon	Gabon		IMB-4A	Senonian
AF015	4.95	-3.0125	Ghana	Tano/Ivory Coast	Tano		Albian
AF029	4.4485	6.3217	Nigeria	Niger Delta	Kanuskiri		Miocene
AF017	5.761	4.9081	Nigeria	Niger Delta	Meren	Offshore	Miocene
AF016	5.2647	6.6709	Nigeria	Niger Delta	Obagi		Miocene
NI001	5.012	5.9014	Nigeria	Niger Delta	Opuekeba	1X	
AF028	5.0092	7.0276	Nigeria	Niger Delta	Umuechem		Miocene
ZA003	-5.61	12.237	Zaire	Congo	East Mibale	2	Albian
AF020	-5.9605	12.17	Zaire	Congo	GCO	1D	Albian
ZA001	-5.808	12.317	Zaire	Congo	Liawenda	29	
ZA002	-5.9033	12.3845	Zaire	Congo	Makelekese	1	
AF004	-5.8364	12.4182	Zaire	Congo	Mibale	2	Albian