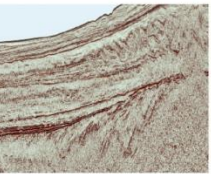
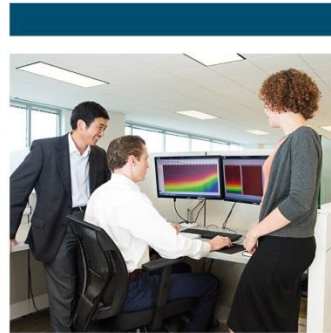




# Invitation to Participate

Multi-Client Seismic Program

## 2D Survey Program Offshore Somalia



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## Executive Summary

This is an invitation from Spectrum to participate in their 2D multiclient seismic acquisition program in the unexplored offshore area of Somalia. It has been designed in collaboration with the Federal Government of Somalia, to cover the shelf, slope and basin floor settings in order to address potential hydrocarbon prospectivity in Permo-Triassic, Jurassic and Cretaceous basins where multibillion barrel hydrocarbon accumulation potential is expected.

The main objective is to offer the most up to date 2D imaging and acquisition technology while at the same time aiming to accelerate exploration drilling by making the data available in time for the licencing round announcement. Subject to operational conditions, acquisition will have a 7 month turnaround.

Our strategy is to produce the best possible image of the deep section imaging down to the Moho or acoustic basement, without compromising the shallow section. To address this exploration challenge, the acquisition methodology to be used includes a long streamer length up to 10km, source and streamer with a 7 m depth separation and a record length of 15 seconds. Gravity and Magnetic data will also be acquired in conjunction with the seismic data which will allow for independent verification of structure and the preparation of high density depth to basement maps. This survey has been designed to infill and complement the recently acquired seismic data in 2014.

**Graham Mayhew**

**Executive Vice President Multi-Client, Africa Region**

## Contact

To request additional information or schedule a meeting, please contact:

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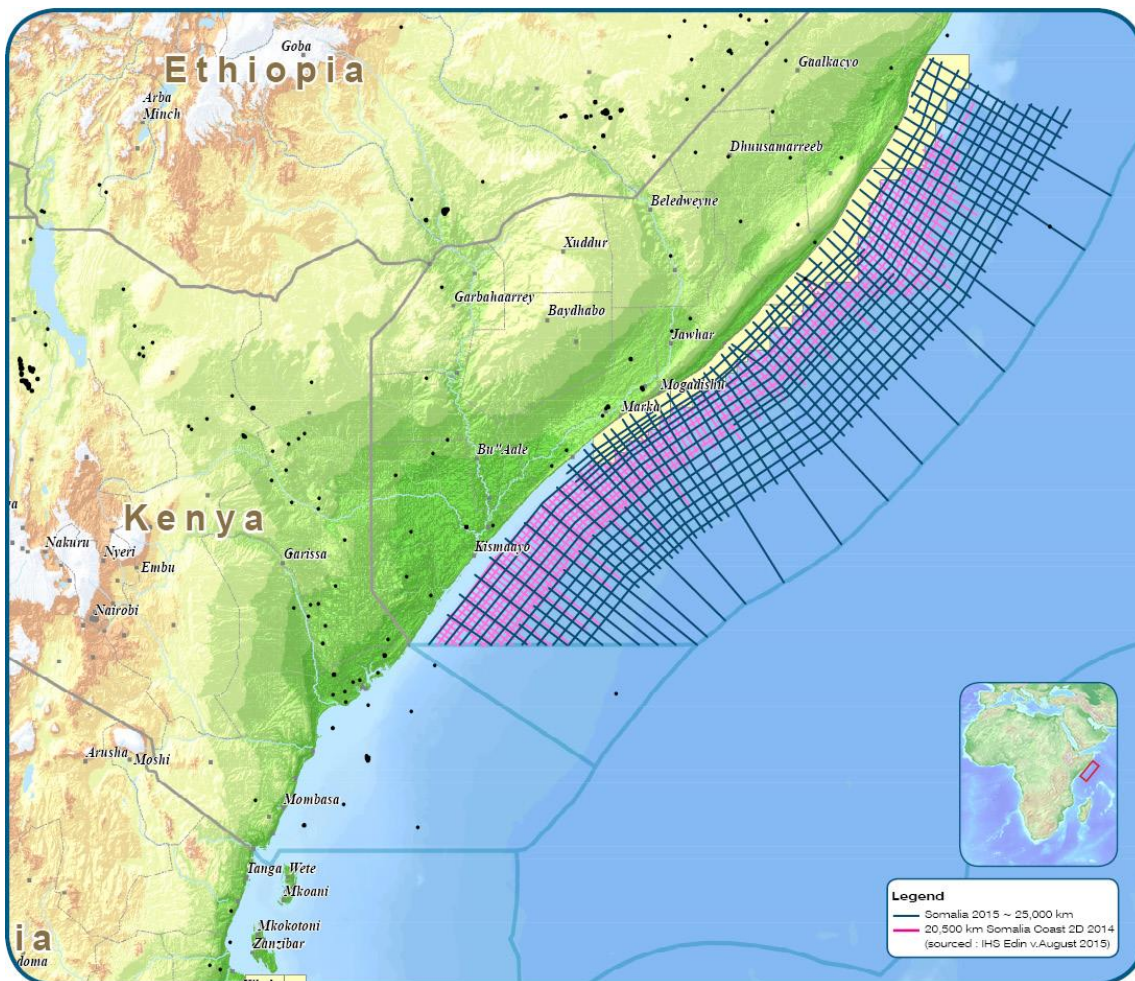
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## Spectrum Somalia 2D Survey Program

Spectrum has entered into a co-operation agreement with the Federal Government of Somalia to acquire approximately 28,000 km of modern 2D seismic data during Q4 2015. The data will be acquired between water depths of 30 m – 4000 m, resulting in coverage over the shelf, slope and basin floor with dip, strike and recording time intervals suitable for defining a range of leads and prospects.

Streamer lengths of 10,050 m will be used in order to adequately record information at all offsets, further assisting imaging of the underlying syn-rift geometries. Modern processing algorithms will be applied to allow optimal imaging of the steeply dipping extensional and compressional features and illumination of subtle amplitude anomalies.

The survey will be acquired over a 7 month period and each seismic survey vessel will be permanently attended by four security/chase (escort) boats.



*Proposed survey coverage*

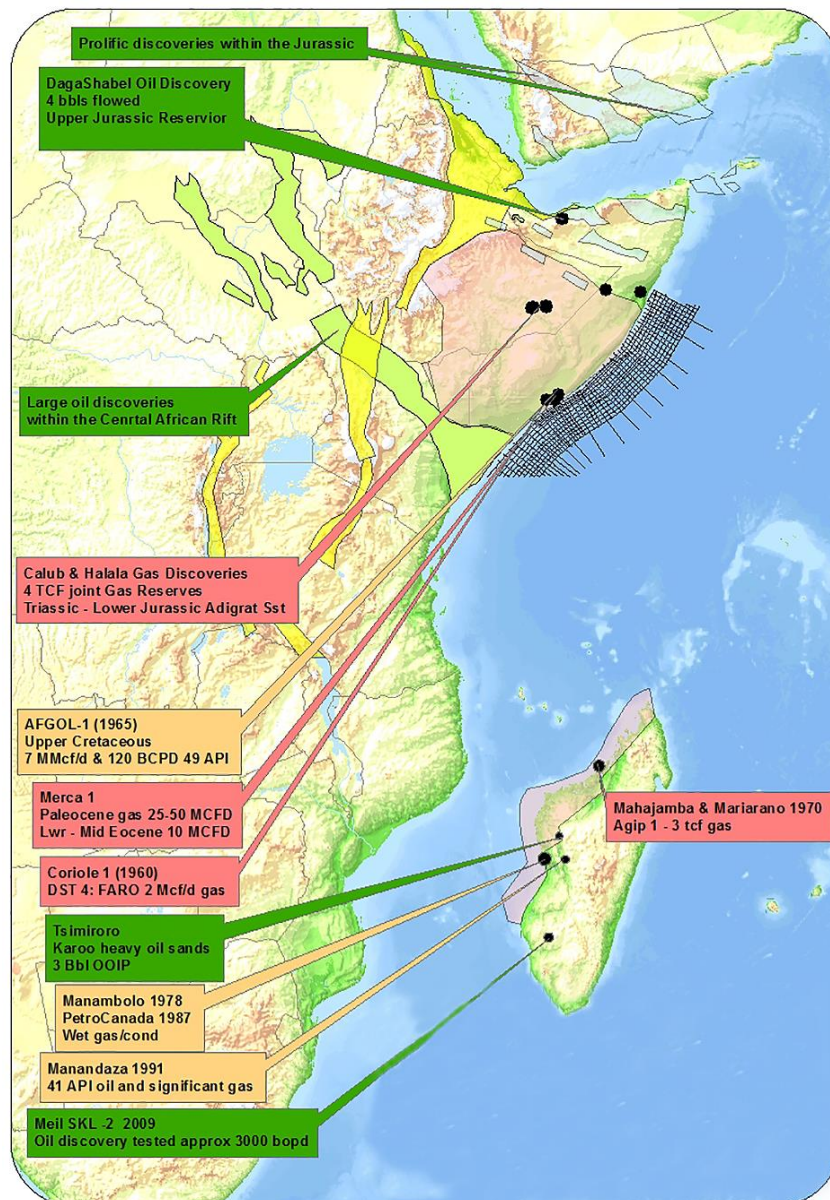


## Exploration History & Geological Overview

### Exploration History

Following the installation of the Federal Government in Somalia, the country has begun to enjoy a more optimistic outlook and explorers are starting to return to the region. Somalia has three main oil producing basins – the Permo-Triassic, Jurassic and Cretaceous basins.

Notable successes in the East Africa region to date have been the discoveries of multi-billion barrel exhumed oil fields within the Permo-Triassic basins of Madagascar and the huge undeveloped Permo-Triassic gas fields of the Ethiopian Ogaden basin.



East Africa Discoveries

Significant discoveries within Jurassic sediments have been made onshore Yemen and proof of this Jurassic petroleum system has been established in northern Somalia with the drilling of the Standard Vacuum 1959 Daga-Shabel discovery well. The Cretaceous petroleum system has also proven to be a strong producer in South Sudan and is only lightly explored in southern Somalia.

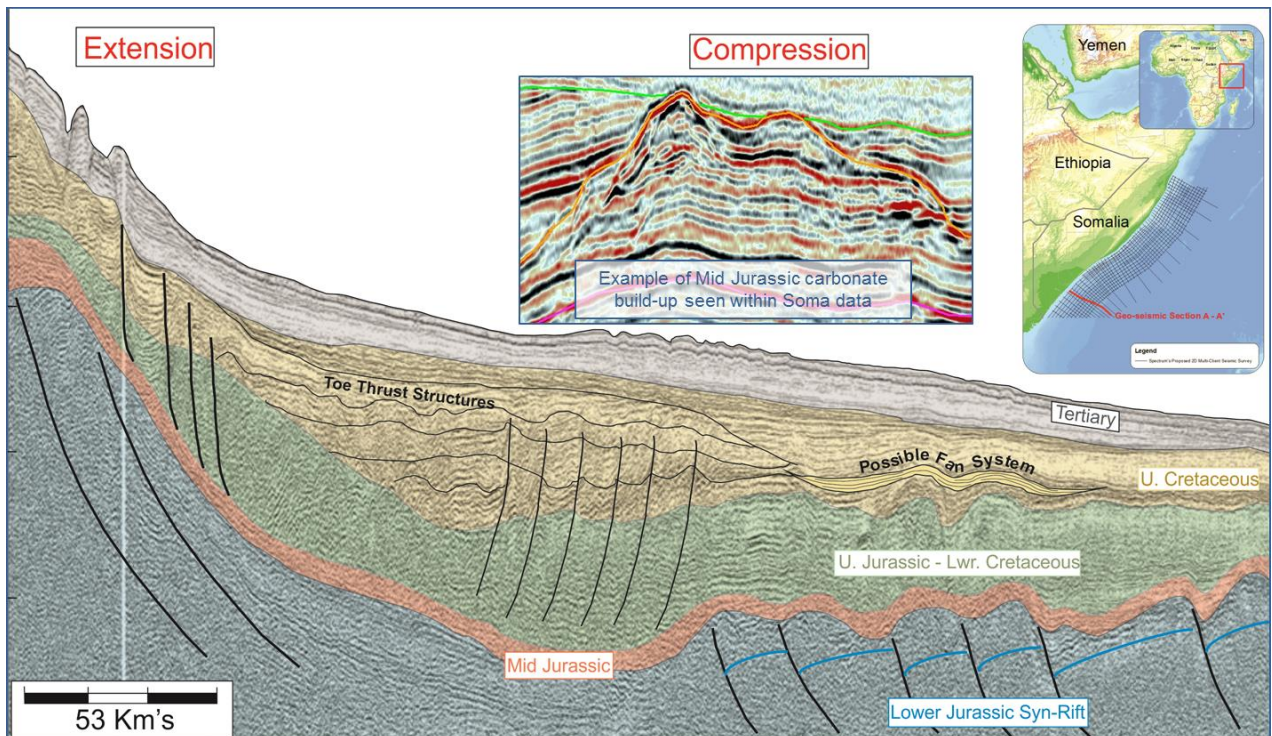
All of these basins have significant exploration potential, but remain underexplored due to previous above ground risks; it is only now with the recent developments in stability within Somalia that the potential of these basins can begin to be unlocked.

## Geological Overview

Academic seismic data covering the East African coast show a number of interesting structural and stratigraphic play types. Starting from the coast of Somalia and working south west to Tanzania, the sections clearly display large rotated fault blocks with Permo-Triassic, Jurassic and Cretaceous potential. Large scale structural inversion features also exist and create sizeable traps within the overlying strata.

Higher up the section, a detachment layer is visible and a number of rotated extensional fault blocks can be seen on the slope with toe thrusts at the base. These detachment-related features may be sourced by the under laying décollement surface, or by deeper Triassic / Jurassic sources, and could be excellent traps.

Laterally extensive fans are also visible as amplitude anomalies draping over uplifted Triassic and Jurassic structures. Where sealed, these fans could be excellent exploration targets.

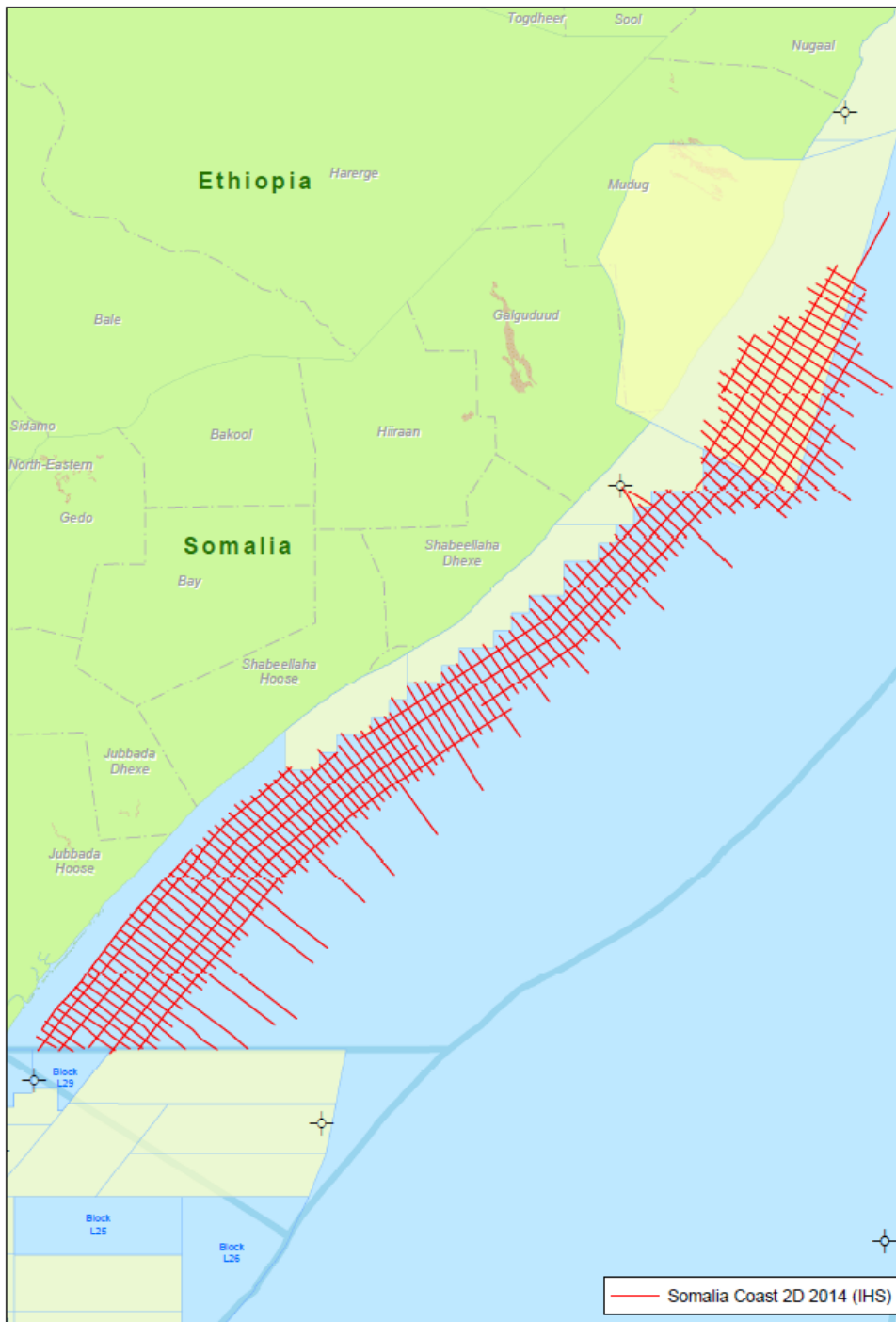


Cross Section Offshore Somalia

## Previous Surveys

Soma Oil & Gas Exploration Limited commenced an offshore seismic acquisition programme in February 2014. The acquisition was carried out by SeaBird Exploration and concluded in June 2014 with over 20,500 km lines of 2D seismic data having acquired across a 122,000 km<sup>2</sup> area. These data are now being marketed and licensed by Spectrum on behalf of the FGS.

The seismic acquisition programme was completed with no security or HSE incidents.



Existing Soma 2014 survey grid



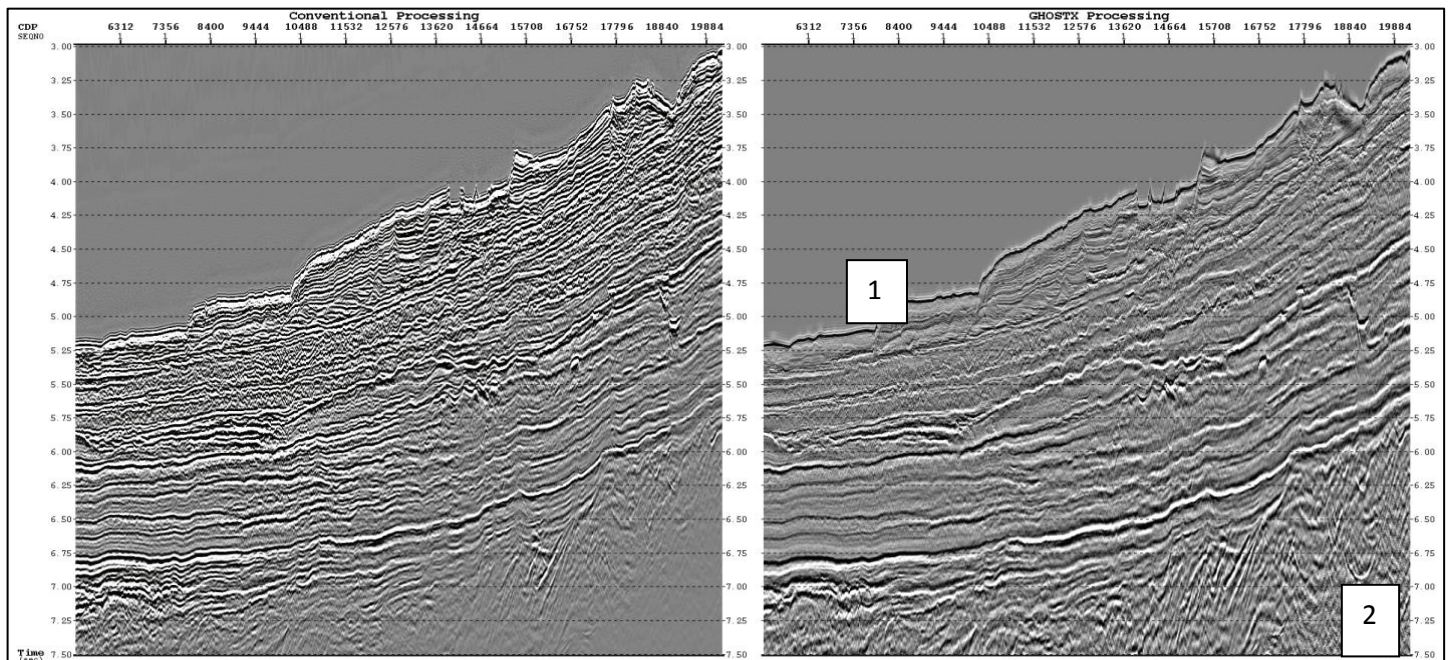
## Offshore and Onshore Processing

### Offshore Processing

Brute stacks of the data acquired will be available in real time throughout the survey period. Data drops will be carried out at regular intervals throughout the survey period and shipped back to the UK for immediate processing.

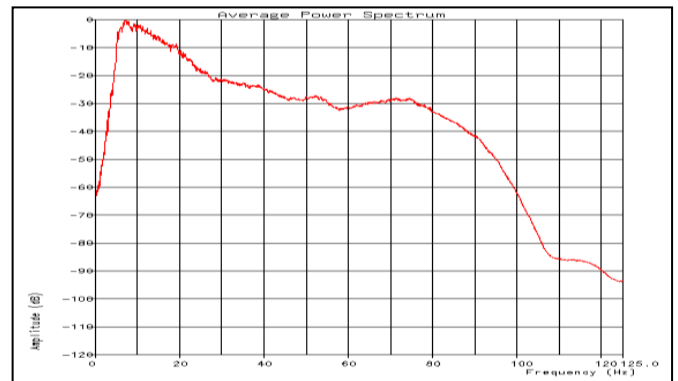
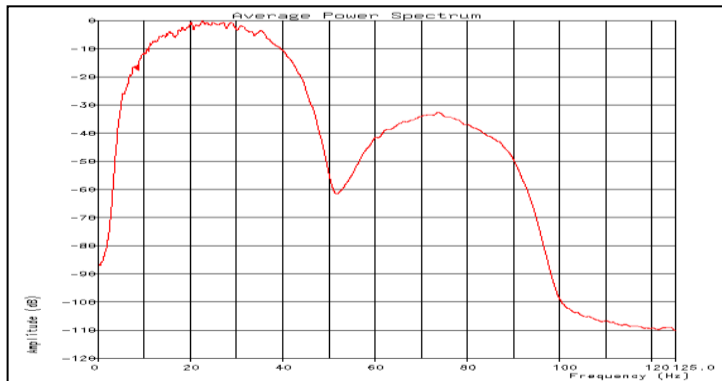
### Onshore Processing

There is an option to utilise Broad Band processing technology during the processing phase of the project. This technique has been used on datasets globally and provided significant uplift over the conventional workflows. This will be evaluated during the data processing stage.



Conventional processing

Broad Band processing



In the above examples, Broad Band processing has significantly reduced the noise within the shallow section [1] whilst also remarkably improving the imaging of the deeper syn-rift section [2].



## PSTM Sequence

The proposed processing flow is listed below. Actual processes and order will be determined by appropriate testing procedures and confirmation by Spectrum.

- Reformat, output to internal processing format
- Low-cut Filter
- Zero phase conversion – using a modelled source signature or extracted wavelet.
- Resample to 4 ms sample rate with application of zero phase anti-alias filter
- Amplitude recovery -  $T^2$  gain correction or similar
- Swell noise attenuation (multi-domain as required)
- Multiple attenuation – SRME
- Coherent noise attenuation (Tau-p) by modelling and subtraction (optional)
- Deconvolution in Tau-P domain if required
- Adjacent trace summation including spatial anti alias filter prior to trace drop (optional)
- Initial velocity analysis (2km)
- Multiple attenuation using high resolution Radon demultiple
- Inverse Q Compensation – Phase Only
- CMP domain Tau-p or Diffracted multiple noise attenuation by modelling and subtraction
- Pre-migration noise attenuation (Optional)
- Remove gain correction
- First pass ray traced or curved ray Kirchhoff pre-stack time migration
- Migration velocity analysis (1km)
- Second pass ray traced or curved ray Kirchhoff pre-stack time migration
- Multiple attenuation using high resolution Radon demultiple. (Optional)
- High density residual velocity analysis
- NMO, Inner and outer trace muting
- Stack – full offset plus upto 4 angle stacks – 1/N fold compensation
- SEG Y output (Angle Stacks)
- Post migration noise attention (Optional)
- Inverse Q compensation – Amplitude only
- Time and space varied band-pass filtering
- Gun and cable static
- SEG Y output (RAP)
- Scaling
- SEG Y output (equalised)

Optionally, the data may be processed through a Broadband sequence. In this case, the suggested flow is below:

- Reformat, output to internal processing format.
- Low-cut Filter
- Swell noise attenuation (multi domain as required)
- De-ghosting\*
- Zero phase de-signature and de-bubble\*
- Resample to 4ms sample rate with application of zero phase anti-alias filter.
- Amplitude recovery -  $T^2$  gain correction or similar.
- Coherent noise attenuation (Tau-P) by modelling and subtraction.
- Initial velocity analysis (2km).
- Multiple attenuation – SRME.
- Deconvolution in Tau-P domain and time variant muting if required.
- Inverse Q Compensation – Phase Only
- Multiple attenuation using high resolution radon demultiple.
- Pre-migration noise attenuation Diffracted Multiple Attenuation First pass Kirchhoff pre-stack time migration
- Migration velocity analysis (1km)
- Second pass anisotropic (curved ray) Kirchhoff pre-stack time migration
- Multiple attenuation using high resolution radon demultiple
- High density residual velocity analysis
- Inner and outer trace muting
- Stack – full offset plus angle stacks
- Residual gain correction
- Gun and cable static
- Residual Noise Attenuation Q Compensation – Amplitude Only
- Time and space varied bandpass filtering Data dependent scaling.
- SEG Y output.

Note: \*Exact position in flow will be determined during parameter test phase

### Standard PSTM Deliverables

- Final Filtered & Scaled PSTM Stack (all offsets)
- Final Filtered Unscaled PSTM Stack (all offsets)
- Final PSTM Angle Stacks (3-4 ranges TBC)
- PSTM Velocity Field
- Final Processing Report
- Other products such as PSTM gathers are available on request

## 2D Pre-Stack Depth Processing Sequence

- Input from PSTM sequence
- PSTM Time VRMS smoothed and converted to depth interval
- Water velocity analysis, water flood KPSDM, and water bottom surface picking
- Kirchhoff PSDM (or equivalent) with initial velocity model – input to tomography
- Full KPSDM sequence with 2-3 iterations of isotropic tomography (preferably grid-based)
- If there are geological constraints that require interpretation, then those need to be taken into consideration once the basin tomography has completed (see image below)
- TOS interpretation
- Salt velocity analysis and salt-flood KPSDM
- BOS interpretation
- Build salt model
- Depending on geology, overhang salt interpretation may need to occur
- Subsalt velocity analysis via tomography (Kirchhoff), velocity scanning based on stack response, and/or Structural / well based trends (if available)
- Final isotropic KPSDM
- Post migration processing
- Data dependent scaling
- SEG Y output

## Standard PSDM Deliverables

- Final Filtered & Scaled PSDM Stack
  - Final Filtered Unscaled PSDM Stack
  - Final Filtered & Scaled PSDM Stack (depth to time)
  - Final Filtered Unscaled PSDM Stack (depth to time)
  - 3D Regional Velocity Model
  - Final Processing Report
- 
- Other products such as PSDM gathers are available on request
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## Survey Parameters and Survey Outline

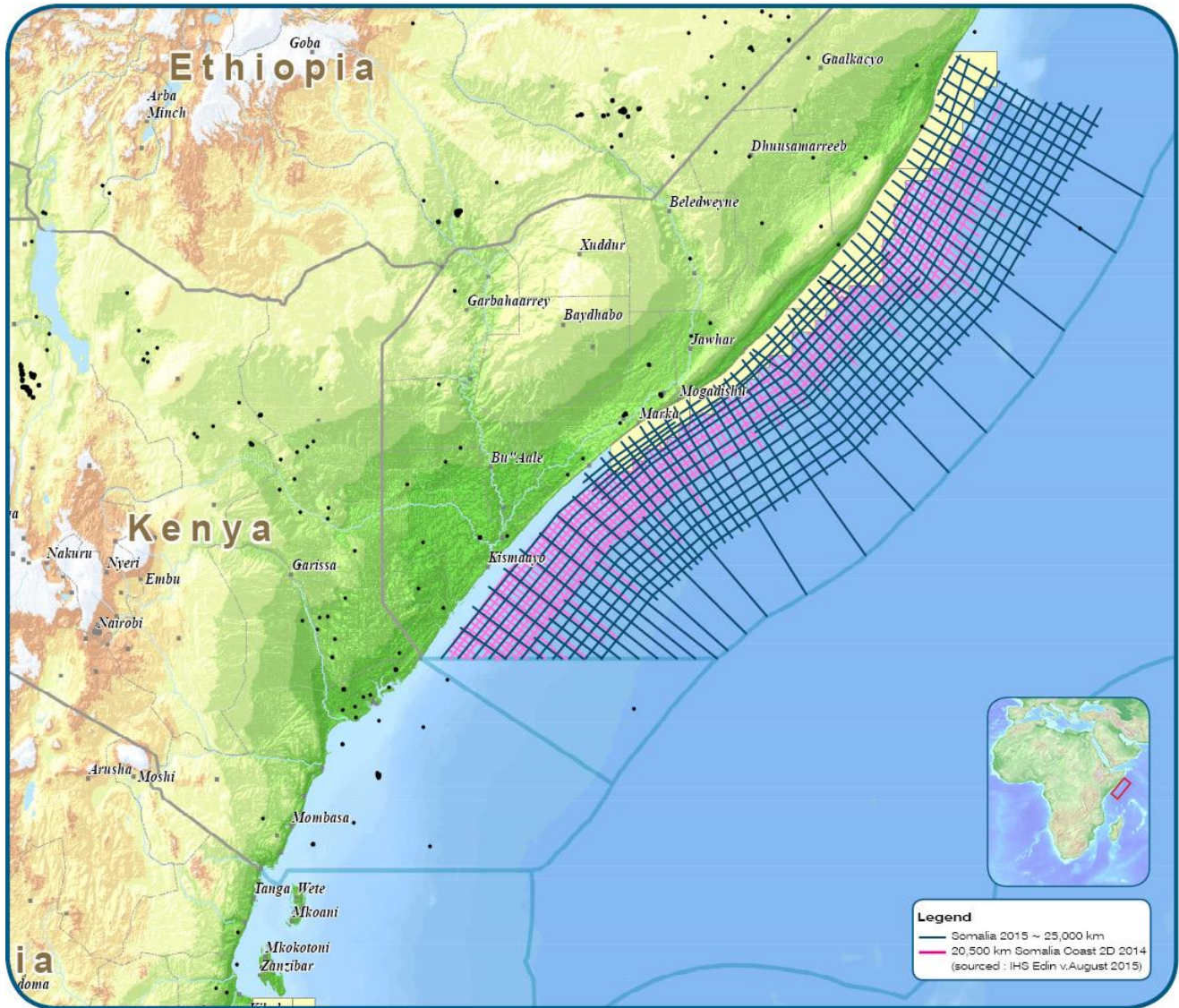
### Survey Parameters

Optimal Acquisition Parameters will be confirmed upon review of the survey seismic survey design

	Parameters
Shot Point Interval	37.5m
Source	~ 4600 cu. In
Source Depth	8m*
Number of Streamers	One
Streamer Length	10,050m
Group Interval	12.5m
Streamer Depth	15m*
Sample Rate	2ms
Record Length	15,000ms

Note: \* Subject to vessel operational restrictions and water depths

## Survey Outline



## License Fee Schedule

All rates are for a **Single Company License Fee, exclusive of applicable taxes.**

### Pre-commitment (Sponsor) Rate

Whole Survey (Circa 25,000km)	\$700/km
>10,000km.(Minimum Commitment)	\$800/km

Available for Companies prior to acquisition commencing. All Pre-commitment sponsors will also get access to the full PSDM.

### Early Sales Rate

Whole Survey (Circa 25,000km)	\$800/km
5,000-10,000km	\$850/km
5,000km (Minimum Commitment)	\$900/km

Available for Companies prior to processing completion

### Late Sales Rate

Whole Survey (Circa 25,000km)	\$900/km
5,000-10,000km	\$950/km
5,000km (Minimum Commitment)	\$1,000/km

Available for Companies after processing completion

### Block Award Uplifts:

No Block award uplifts are applicable to the Pre-commitment sponsors. However, Block award uplifts of \$500 per km will be applied to all kilometres within the awarded block(s) for Early or Late Sales

### Partner Rates:

Partner rates will only be offered to bon-fide partner groups that license a common database as follows;

- First Partner: 100% of the licence fee
- Second Partner: 80% of the licence fee
- Third and Subsequent Partners: 60% of the licence fee

### Other:

There is a minimum line segment length of 100km if licensing part lines.



## Optional Products

PSDM	Included above. (Otherwise \$100/km)
Fast Model' PSDM	\$50 per km
Angle Stack Volumes (Near, Mid, Far & Ultra-Far)	\$10 / km / angle
Gravity & magnetic data – licensed lines	\$15 per km
Gravity & magnetic data – unlicensed lines	\$30 per km
Field Tape Access	\$100 per km
Gather Data Access	\$100 per km

## Compensation – Payment Terms

Standard Pre-commitment:

30% on mobilisation (signature if acquisition has commenced)

60% on acquisition, invoiced on the monthly production

10% on processing, invoiced on the monthly production