Faroes Licence 010 Final Report

Faroes Licence 010 Final Report

1 Introduction 1

2 Faroes FL010 Part Relinquishment 2009 3

3 Exploration Activities 6

- 3.1 Seismic Acquisition 6
- 3.2 Seismic Processing and Reprocessing 6
- 3.3 Acquisition of Full Tensor Gradiometer (FTG) data 9
- 3.4 Seabed coring programme 11

4 Seismic Interpretation and Mapping 13

5 Hydrocarbon Potential 15

6 Conclusions 17

List of figures

2.1 Faroes Licence 010 Location Map. Pre-2009 license includes the pink area 4
2.2 Original FL010 and retained FL010 post-2009 5
3.1 ST0513-010 2D seismic programme 6
3.2 Location of reprocessed 2D line ST0513-10034/ST0514 - 1102 7
3.3 GDC (Geokinetics) Final Time Migration 8
3.4 GDC (Geokinetics) Depth Migration in time 8
3.5 TGS Reprocessed OF94/95RE11 dip line across FL010 9
3.6 This survey was designed with emphasis on determining: 10
3.7 >40 km Full tensor gradiometer data indicated a broad basement high in the north of FL010 11
3.8 Seabed coring programme (top) and results (bottom) 12
4.1 TWT Map of the sub-basalt Top Vaila Reservoir 13
4.2 Depth Map of the sub-basalt Top Vaila Reservoir 14
5.1 Faroe-Shetland Basin Stratigraphic Column 16

List of tables

1.1 Licence History 1
1.2 Work Program and licence commitments 1

1 Introduction

On 1st March 2013, Statoil operated Faroese Licence 010 expired with all work commitments fulfilled (Table 1.1 & Table 1.2). Subsequently, Statoil has taken the decision not to extend Faroes Licence 010 into a 4th period.

Table 1.1 Licence History

Date	Event
Jan 2005	• Licence award in 2nd Round to Statoil Faeroyene A/S (100%). • Acquisition of 800 sq. km of Full Tensor Gradiometer data.
Jan 2009	End of 1st Licence period: The licence was partly relinquished. For the retained part of the license an extension of two years was granted against an additional commitment.
Mar 2011	• License extension at end of 2nd licence period, 3rd term entered. • Acquired 54 km 2D seismic data • Re-processed 100 km of vintage seismic data • Argentina reservoir analogue study.
April 2012	Purchased 13350 km of 2D OF94/95RE11 of 2D data, reprocessed by TGS.
January 2013	• Re-interpretation of Slættibøkan Lead using reprocessed OF94/95RE11 data with existing data. • Regional and licence-specific G & G and associated prospectivity study.
1st March 2013	Decision by Statoil not to extend Licence 010 into 4th term.

Table 1.2 Work Program and licence commitments

First period Licence Term (four years, 17 January 2005 to 16 January 2009)
Commitment 1st year: 800 km of full fold 2D long offset seismic data and 800 sq. km of full tensor gradiometer data at a line spacing 750 x 2250 m
Commitment 2nd year: 100 seabed cores. The work program was carried out in full; plus additional 124 km of 2D seismic.
Second Licence Term (two years, 17 January 2009 to 1st March 2011)
Commitment: acquire 54 km and process 136 km of GeoStreamer data over FL010, reprocess 100 km of 2D legacy seismic and carry out a Paleoenvironmental analogue study in Argentina.
Third Licence Term (two years, 1st March 2011 to 1st March 2013).
Commitment: Reprocess 160 km of 2D seismic data, purchase 13550 km of reprocessed data, Re-interpret the Slættibøkan Lead based on existing and new data and participate in regional and licence specific G&G studies.

This decision followed a technical review of the prospectivity within the licence. This study included an interpretation of newly reprocessed OF94/95RE11 2D seismic data, which was used to update Statoil's view of the prospectivity of the Licence. This document summarises the results of that review, in addition to historical technical work carried out by Statoil during its operatorship of FL010 (2005-2013).

2 Faroes FL010 Part Relinquishment 2009

In 2009 Statoil partially relinquished FL010. This Chapter summarises which area was relinquished.

Licence name: FL010
Date Awarded: 17th January 2005
Operator: Statoil Færøyene A.S. (100%)
Partners: N/A

Original Area of Licence

The original licence area consisted of blocks 6204/22, 6204/23, 6204/24, 6204/25, 6204/27, 6204/28, 6204/29a and 6204/30a as shown in the maps (Figure 2.1 & Figure 2.2) with the following corner points. Geodetic datum: ETRF89

62°20'N 04°48'W
62°20'N 04°00'W
62°05'N 04°00'W
62°05'N 04°24'W
62°00'N 04°24'W
62°00'N 04°48'W

Approximate area 1345 sq. km

Area following 2009 Relinquishment

The retained licence area consisted of blocks 6204/23, 6204/24, 6204/25, 6204/30a as (Figure 2.2) with the following corner points. Geodetic datum: ETRF89

62°20'N 04°36'W
62°20'N 04°00'W
62°05'N 04°00'W
62°05'N 04°12'W
62°10'N 04°12'W
62°10'N 04°36'W

Approximate area 675 sq. km
Relinquishment date: 16th January 2009

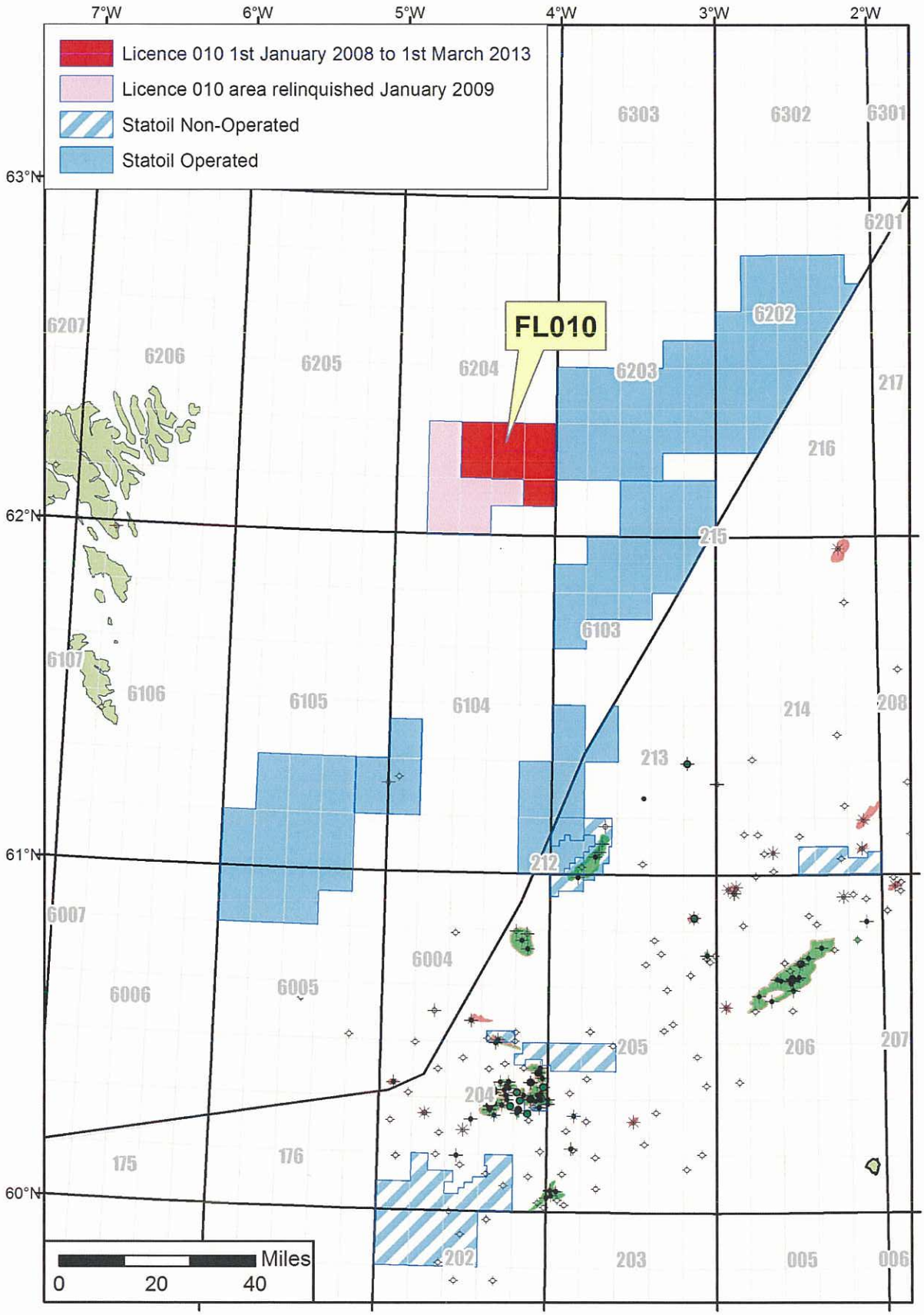

Figure 2.1 Faroes Licence 010 Location Map. Pre-2009 license includes the pink area.

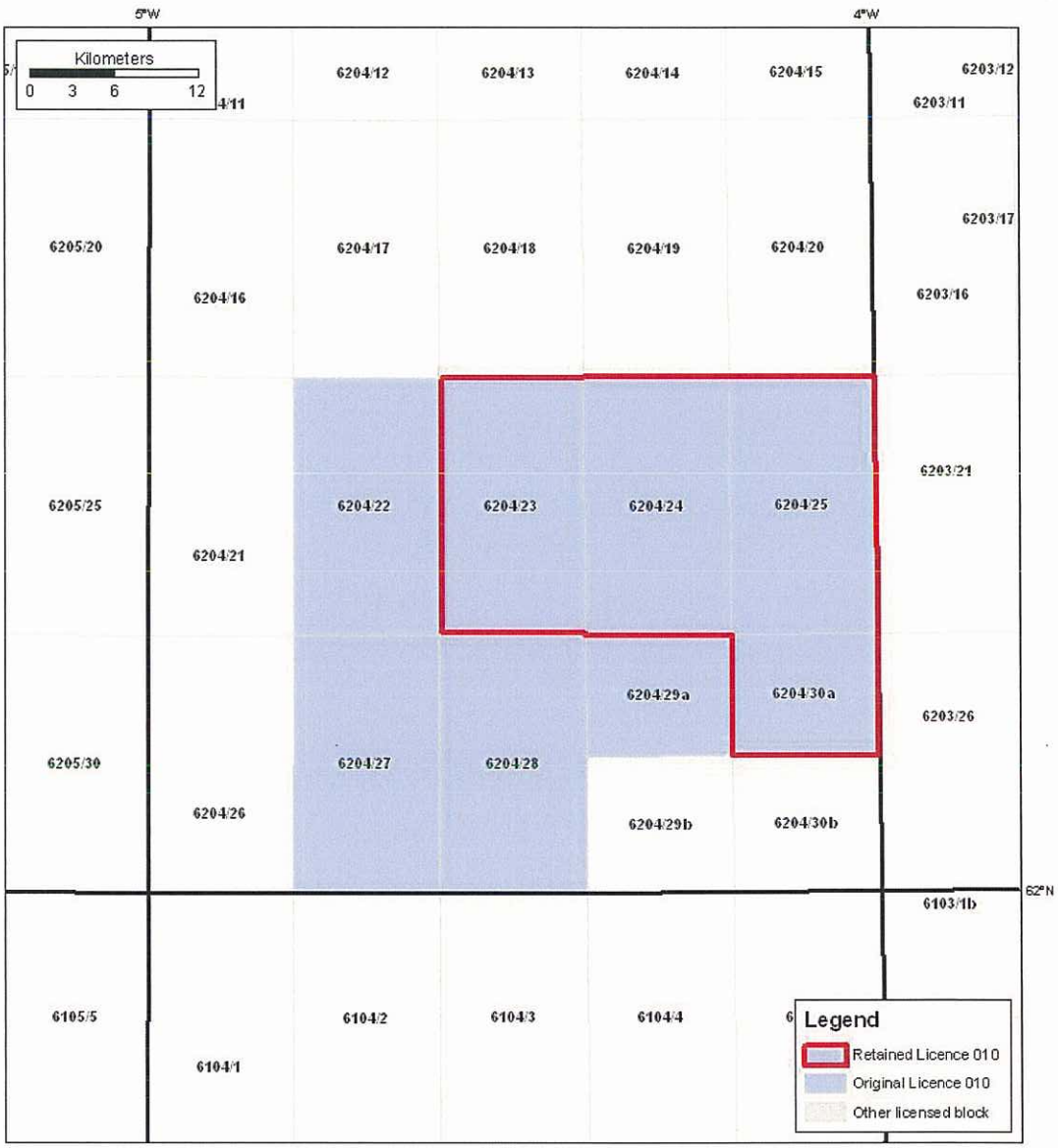

Figure 2.2 Original FL010 and retained FL010 post-2009

3 Exploration Activities

The following chapters give a summary of the main exploration activities performed in the licence, during Statoil's operatorship.

3.1 Seismic Acquisition

A proprietary 2D seismic programme, ST0513-010, was acquired by Statoil in 2005 (Figure 3.1). The survey was 924 km and acquired with deep towed source and cable in order to focus on the low frequencies and reduce the (high frequency) noise in the acquisition. This was a joint survey covering FL009, FL010 and FL011. The close proximity of the planned surveys for FL010 and FL011 meant that for operational reasons lines were acquired across the intervening unlicensed area forming a series of tie lines additional to the one planned tie line which is the property of FL011.

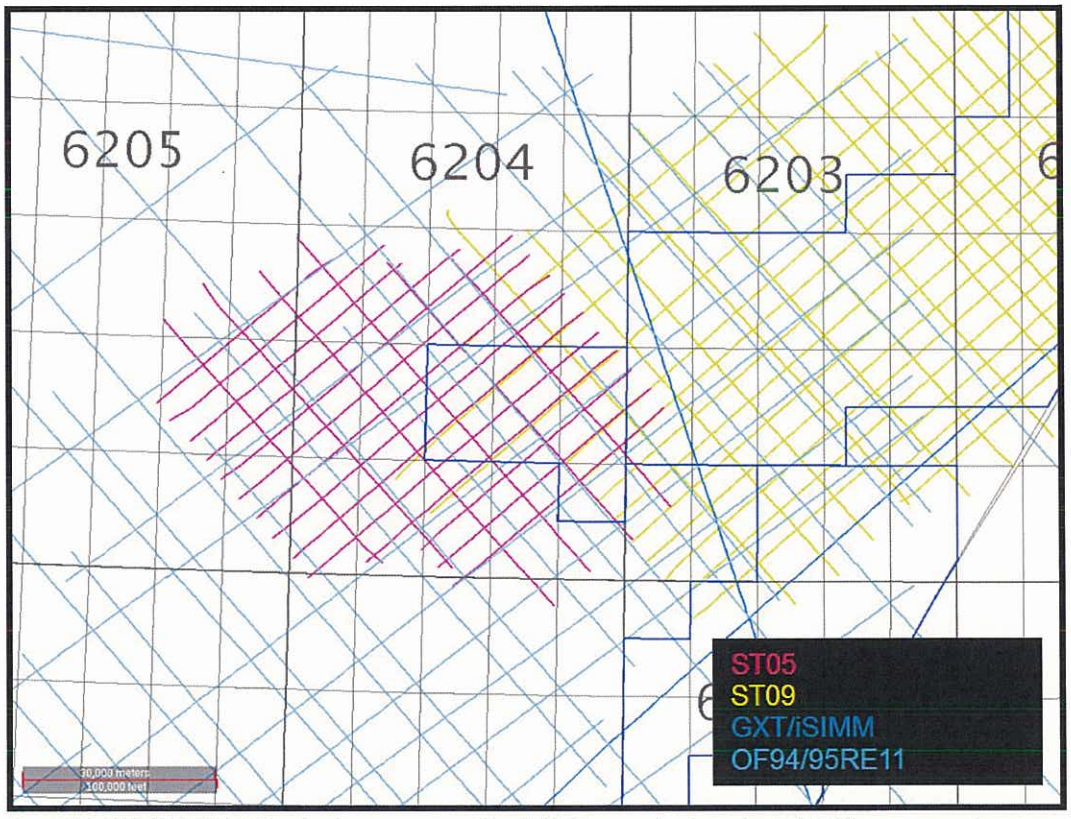

Figure 3.1 ST0513-010 2D seismic programme. The FL010 survey is shown in pink. TGS-reprocessed OF94/95RE11 data is light blue.

3.2 Seismic Processing and Reprocessing

Seismic Processing

The ST0513-010 seismic programme was processed by GeoKinetics (GDC) in 2005/6, with focus on preserving low frequencies. Recent improvements in data quality in both proprietary and speculative data were extended to these data to a limited extent. However, the combination of shallow water and a thin or non-existent overburden to the basalt meant that the processing proved a

much bigger challenge. There is an obvious lack of coherent seismic events below the top basalt. Using this data alone the base basalt is only really interpretable with the help of seismic ties back to nearby FL011 covered by the same survey (see Section 4, Seismic Interpretation and Mapping).

Seismic Re-Processing

As mentioned above, the original processing of the 2D seismic failed to image coherent primary events below the basalt. In fact, the position of the base of the basalt is difficult to interpret any distance from the better quality data within the FL011 area to the east and covered by a number of common tie lines. Previous attempts to improve the data quality by improving coherency and reducing noise have been fairly successful in the basin and it was decided to reprocess a test line in the FL010 area as part of a regional test reprocessing (Figure 3.2).

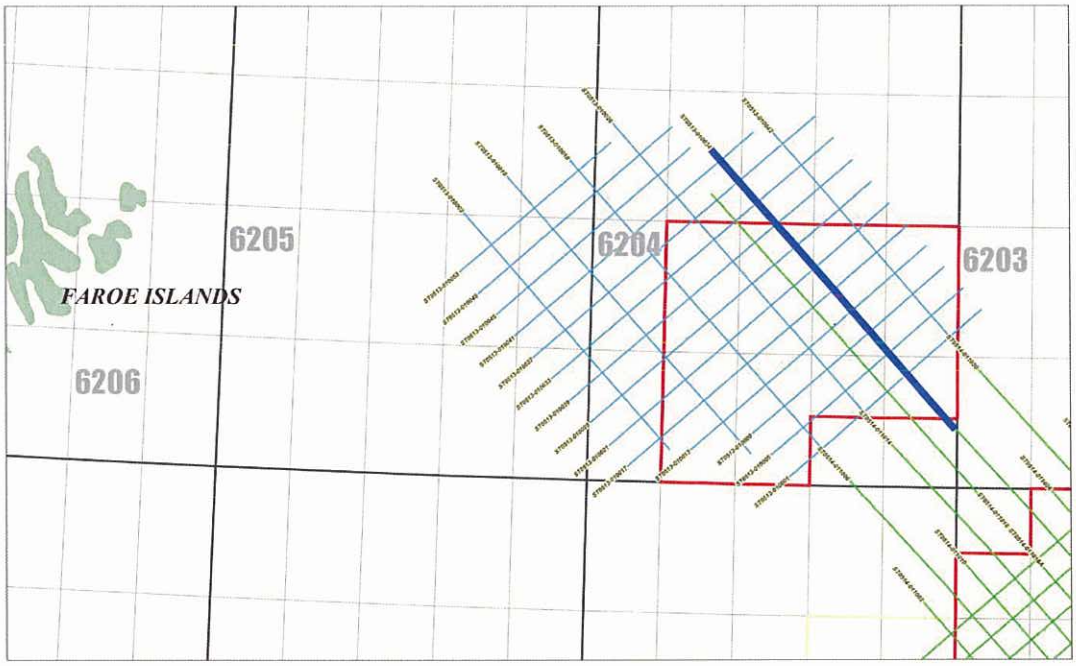

Figure 3.2 Location of reprocessed 2D line ST0513-10034/ST0514 - 1102

Two approaches were chosen. The first method is the beam depth migration offered by Geokinetics (formerly GDC). Beam steering had been very successful when applied to the 3D survey in FL006 and it was decided to attempt it on 2D data here. The second method tested was the Common Reflection Surface (CRS) processing offered by TEEC. The results of those two tests were mixed. The CRS processing didn't produce any uplift in data quality at all while the 2D beam migration shows some improvement below the top Basalt event.

Figure 3.3 and Figure 3.4 show the original time processing performed by Geokinetics and the final beam depth migration stretched to time also by Geokinetics and at least down to 2500ms the beam migration shows more coherent energy.

In 2012 Statoil purchased 13350 km of reprocessed OF94/95RE11 2D lines from TGS in attempt to further understand the geological evolution of FL010 and the basin as a whole. These lines are displayed in Figure 3.1.

Regionally, the OF94/95RE11 data provided a significant uplift in imaging. The main reasons for this were due to a processing workflow that included:

- A much more accurate velocity model due to increased knowledge of the subsurface - e.g. that high velocity basalt was likely to be much closer to the seafloor in FL010.
- Increased multiple suppression due to application of a Radon demultiple process.

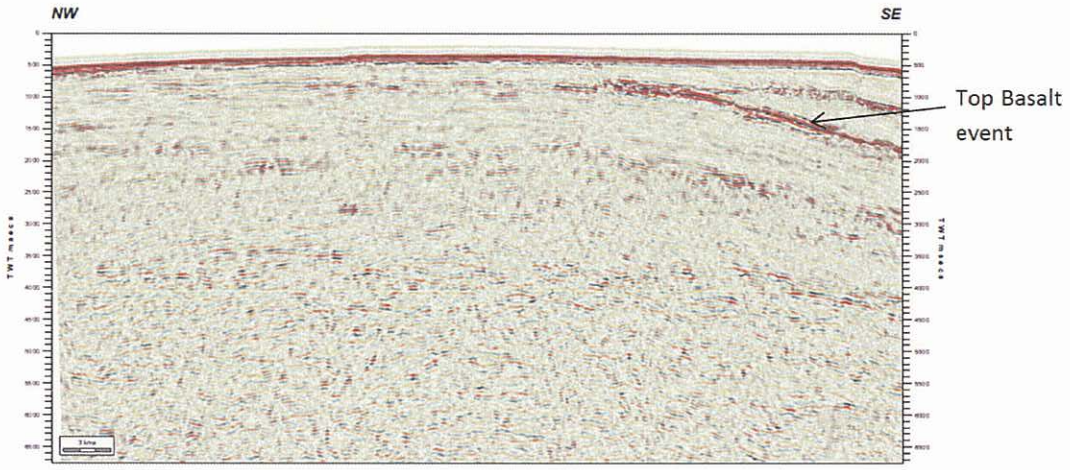

Figure 3.3 GDC (Geokinetics) Final Time Migration

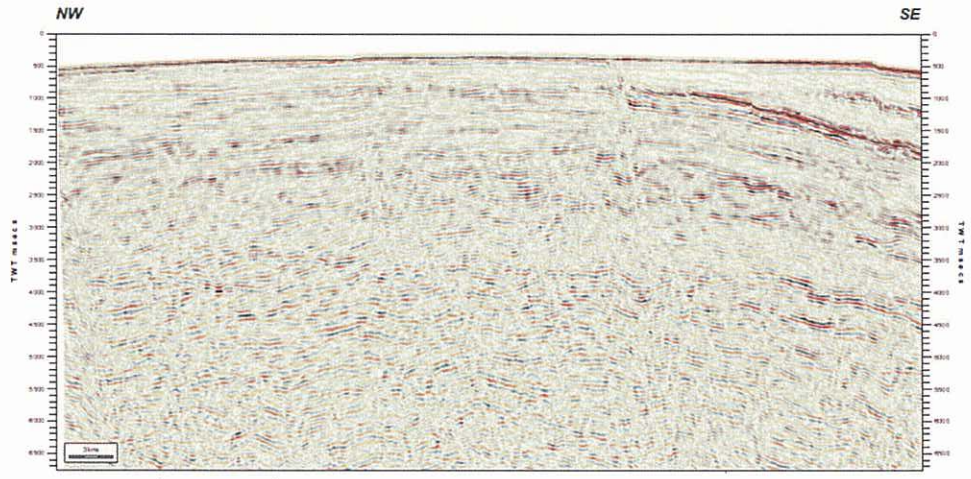

Figure 3.4 GDC (Geokinetics) Depth Migration in time

Unfortunately, of the whole Faroe Platform, the uplift in imaging was least successful over FL010. This is believed to be due to the combination of shallow water depth and basalt close to or outcropping on the seafloor. An OF94/95RE11 dip line across FL010 is shown in Figure 3.5.

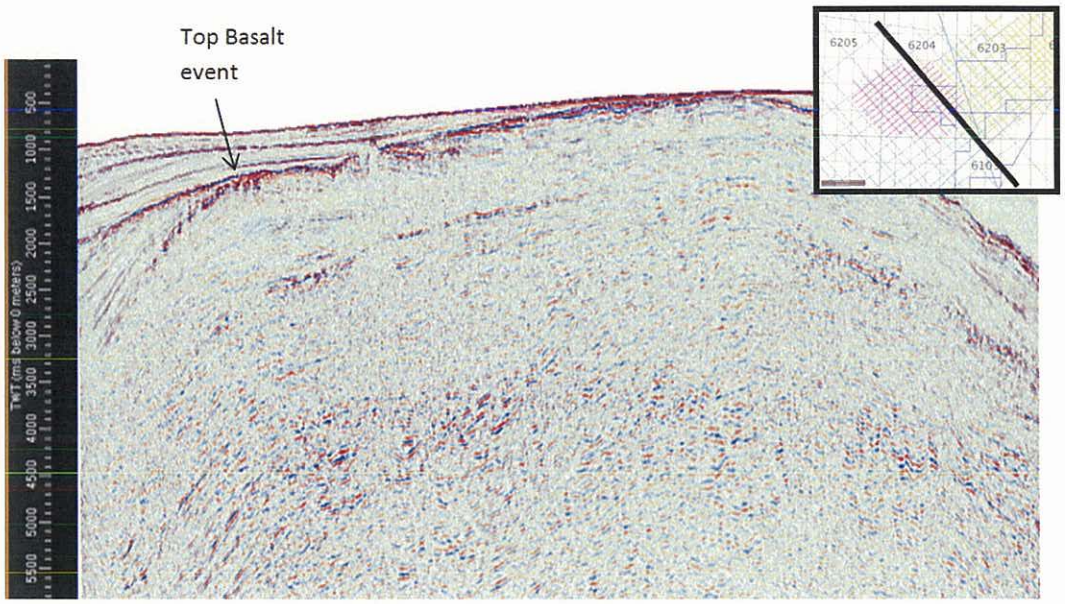

Figure 3.5 TGS Reprocessed OF94/95RE11 dip line across FL010

3.3 Acquisition of Full Tensor Gradiometer (FTG) data

This survey was designed with emphasis on determining:

- Basalt and basement architecture
- Structure
- Sedimentary intervals
- The implications for hydrocarbon prospectivity

The coverage within the combined FL010 and FL011 licence areas is shown in Figure 3.6. The two licences were tied by a wide-spaced swathe.

Merged Tzz for FTG data were acquired over FL010.
FFT techniques were first used to identify dominant wavelength content and separated into constituent components:

Wavelengths > 40km - basement detection;
Wavelengths 20 to 40km - Mesozoic and sub-basalt geology;
Wavelengths 10 to 20km - Palaeocene and Basalt geology
Wavelengths < 10 km - shallow residual effects or enhancement of subtle geology

Of the aforementioned wavelengths the >40 km group seemed to show the most conclusive results. This showed an anomaly interpreted as basement high in the north of the block. This is shown in Figure 3.7. However, this suggests that the high is significantly offset from the crest of the Top Vaila Reservoir structure (see Chapter 4; Seismic Interpretation and Mapping). This is difficult to explain geologically, so these results must be viewed with some scepticism.

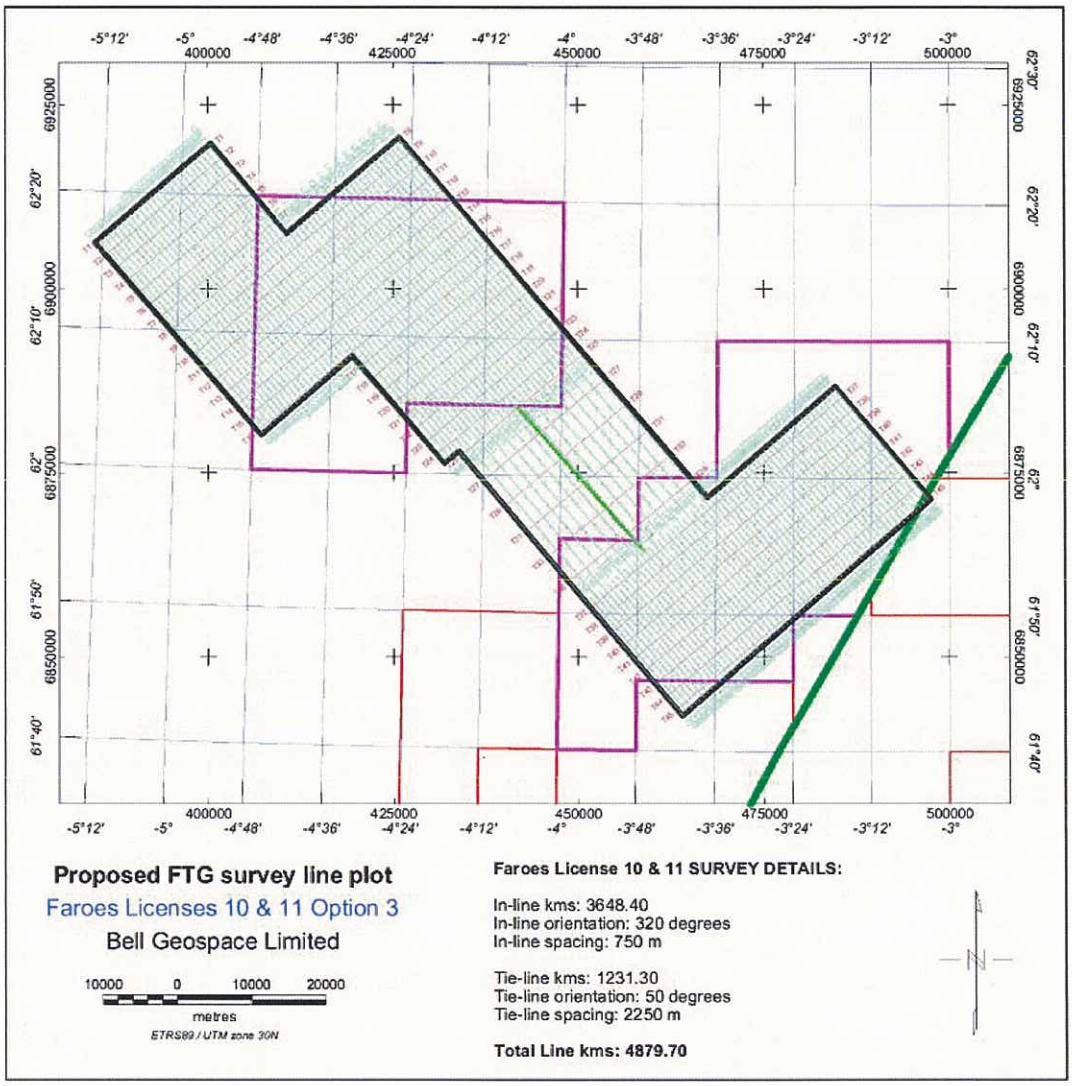

Figure 3.6 This survey was designed with emphasis on determining:

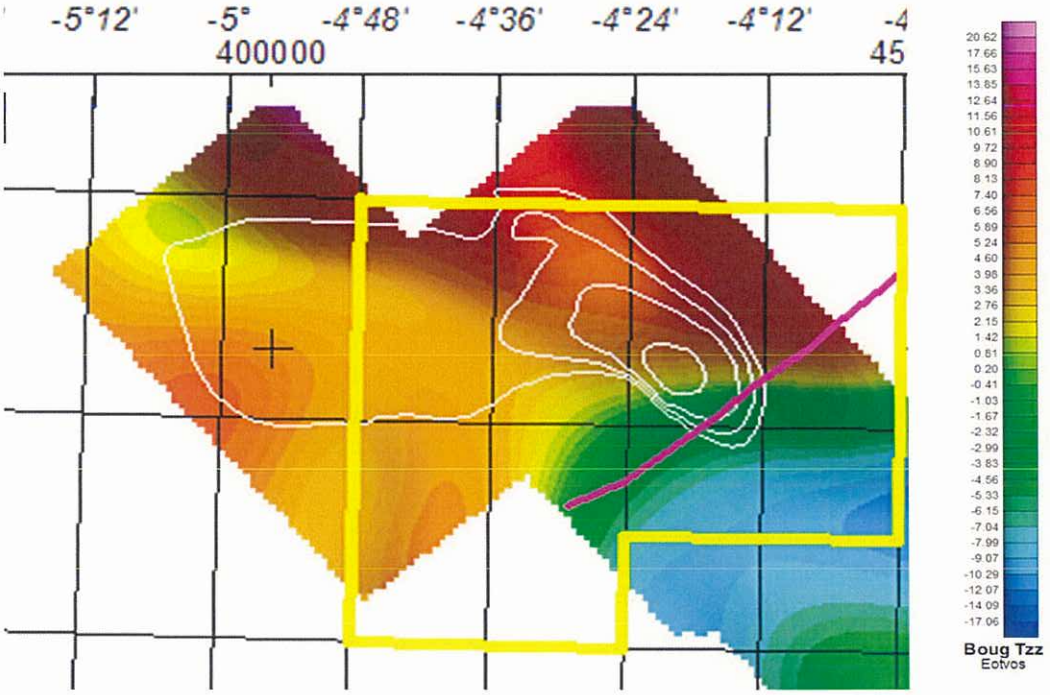

Figure 3.7 >40 km Full tensor gradiometer data indicated a broad basement high in the north of FL010

3.4 Seabed coring programme

Geochemical analysis of seabed cores as a tool in petroleum prospecting is based on the assumption that cap rocks above petroleum reservoirs are unlikely to be totally impervious to hydrocarbons. If this assumption is correct then both light and heavy hydrocarbons migrate upwards from sedimentary sequences source rocks and permeable formations and hydrocarbon reservoirs. Detailed examination of near-surface sediments above a sedimentary basin, applying sensitive chemical analysis techniques should theoretically be capable of detecting the underlying hydrocarbons.

Collection of Samples

All the samples were collected by Geolab Nor using the vessel M/S Polarsyssell. Samples were kept on board in special freezers (-80°C) before they were air-freighted to the laboratory for analyses at the end of the survey.

Location of Sampling Areas and Patterns

Locations for gravity coring locations were selected to sample seabed features, shallow and deeper faults, the crest of the structure and background samples not related to any obvious features.

A total of seventy locations were chosen. Of these, only fourteen were successful due to hard or gravelly seabed. There was no recovery over the crest of the structure. Locations and summary of results are shown in Figure 3.8.

Results & Conclusions

Survey results indicate seepage of mature gas and condensate at virtually all locations within the survey area, probably in the form of micro seeps. No live 'macro seeps' were detected but historic seepage of heavier hydrocarbons is considered to have occurred in many parts of the survey area, particularly the northern and north eastern parts of the survey area. Hydrocarbons are tentatively considered to have been generated from a marine or mixed marine/terrestrial source rock.

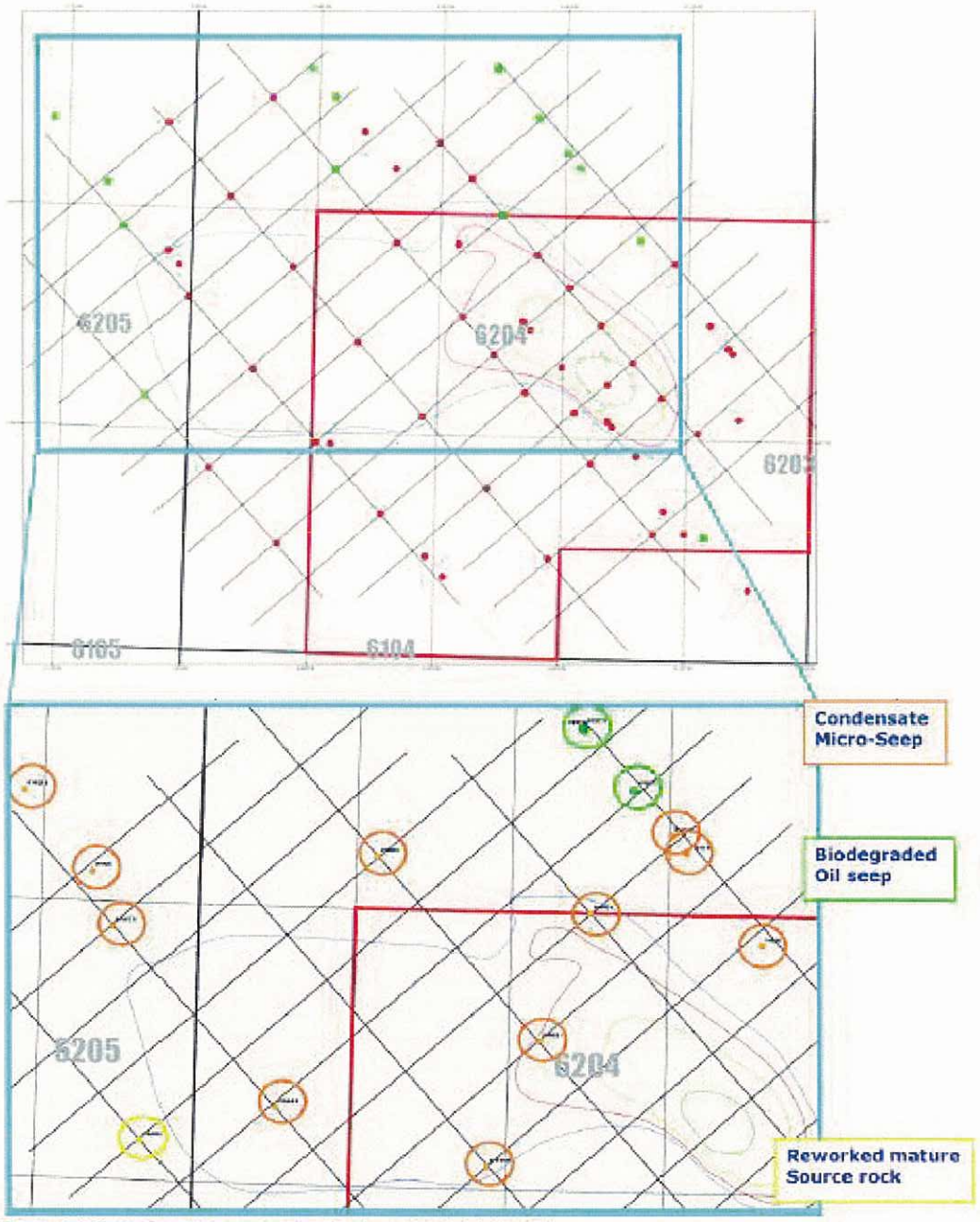

Figure 3.6 Seabed coring programme (top) and results (bottom)

Figure 3.8 Seabed coring programme (top) and results (bottom)

4 Seismic Interpretation and Mapping

Seismic Interpretation is challenging in FL010. Towards the east of the licence there is more confidence due to the tie with FL011 where data quality is significantly better. The top basalt horizon has a clear seismic response and can be mapped with confidence. Statoil's interpretation suggests the basalt is at seabed over part of the licence area. The reprocessed OF94/95RE11 data provides the best sub-basalt imaging of the seismic datasets that cover FL010. Seismic facies changes, such as that at the Base Tertiary Unconformity in particular, are improved in terms of imaging. As the OF94/95RE11 lines are regional, the ability to tie reflectors and sequences over large areas allows for a more confident interpretation than is possible on the ST0513 data, for example. The data has been used to map base basalt and Top Vaila horizons beneath the basalt. The TWT structure maps show that there is possibly structural closure at these deeper levels. However, even on this reprocessed data, the seismic image beneath Top basalt deteriorates in FL010 and so the mapping is considered to be low confidence.

The TWT structure maps were depth converted using a simple layer-cake approach, using constant interval velocities. VSP and sonic velocity data from Brugdan I and Brugdan II (suspended at time of writing) were used to populate the velocity model. This simple approach was used due to a lack of confidence in the seismic velocities below the basalt and the risk, therefore, of introducing artefacts into the resulting depth structure maps. Despite this, when the TWT maps are converted to depth using this method, the geometry of the sub-basalt closure alters and the location of the closure migrates laterally to the south when converted to depth. This is probably due to lateral thickness variations of low velocity clastic rocks in the overburden and also thickness variations in the overlying volcanics, TWT and Depth maps for the Top Vaila Reservoir are shown in Figure 4.1 and Figure 4.2.

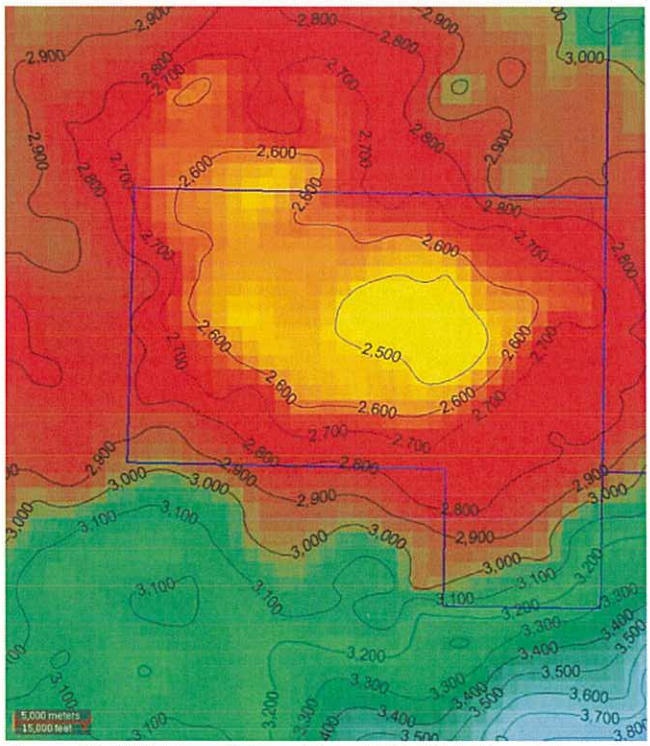

Figure 4.1 TWT Map of the sub-basalt Top Vaila Reservoir

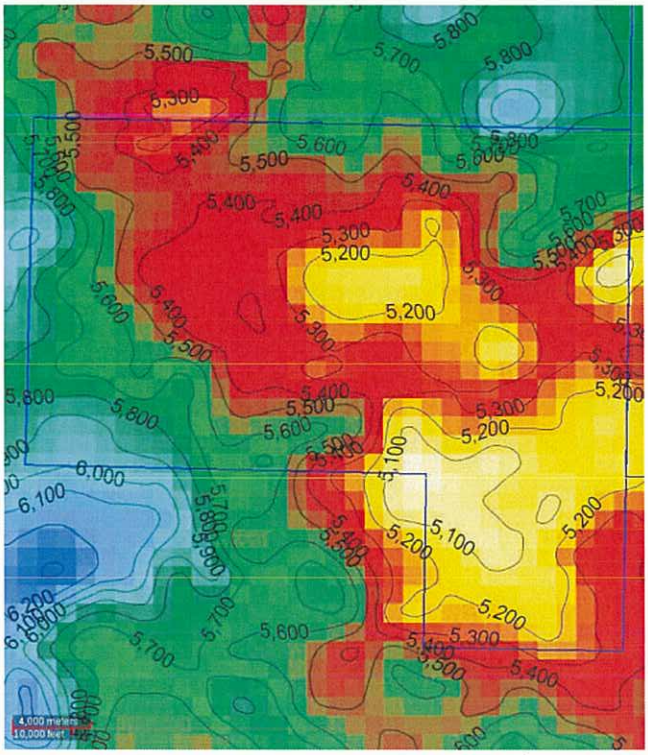

Figure 4.2 Depth Map of the sub-basalt Top Vaila Reservoir

5 Hydrocarbon Potential

Detailed regional-scale evaluation of the entire Faroe-Shetland basin has been completed by Statoil over many years, with recent evaluation focusing on sub-basalt prospectivity towards the western margins of the Basin in the Faroes sector. Prospect evaluation is challenging in this region due to the limitations of sub-basalt imaging and a lack of offset well data, particularly in the sub-basalt section. As discussed in the previous chapter, seismic data quality presents the greatest challenge over FL010 with sub-basalt horizon interpretation being poorly constrained and detailed seismic-stratigraphic analysis futile until an advance in sub-basalt processing can be achieved.

On the Faroes platform, sub-basalt exploration is primarily focused on the Vaila Formation turbidite sandstone play. Detailed regional geological modelling and seismic interpretation (using latest OF94/95RE11 data) suggests that the Vaila Formation reservoir, if present in L010 is likely to be buried too deeply to preserve economic reservoir quality. A significant proportion of the overburden is missing at present day, suggesting the burial depth may have been significantly deeper in the past. In addition, Statoil's regional mapping has shown the risk of volcanic contamination in the reservoir in FL010 to be high compared to other areas of the Faroes Platform. However, confidence in such interpretation still remains low in this area.

Furthermore, the trap geometry and position of the crest of the Slætibøkan Lead is highly uncertain and may not close within the FL010. This is largely due to the insufficient sub-basalt seismic imaging over FL010.

For these reasons, Statoil has downgraded the prospectivity of FL010. However, Statoil may take a different view in future years with the completion of the Brugdan well and integration of the associated data in the regional geological model. Such data may also add to improvements in seismic imaging over FL010. (Figure 5.1).

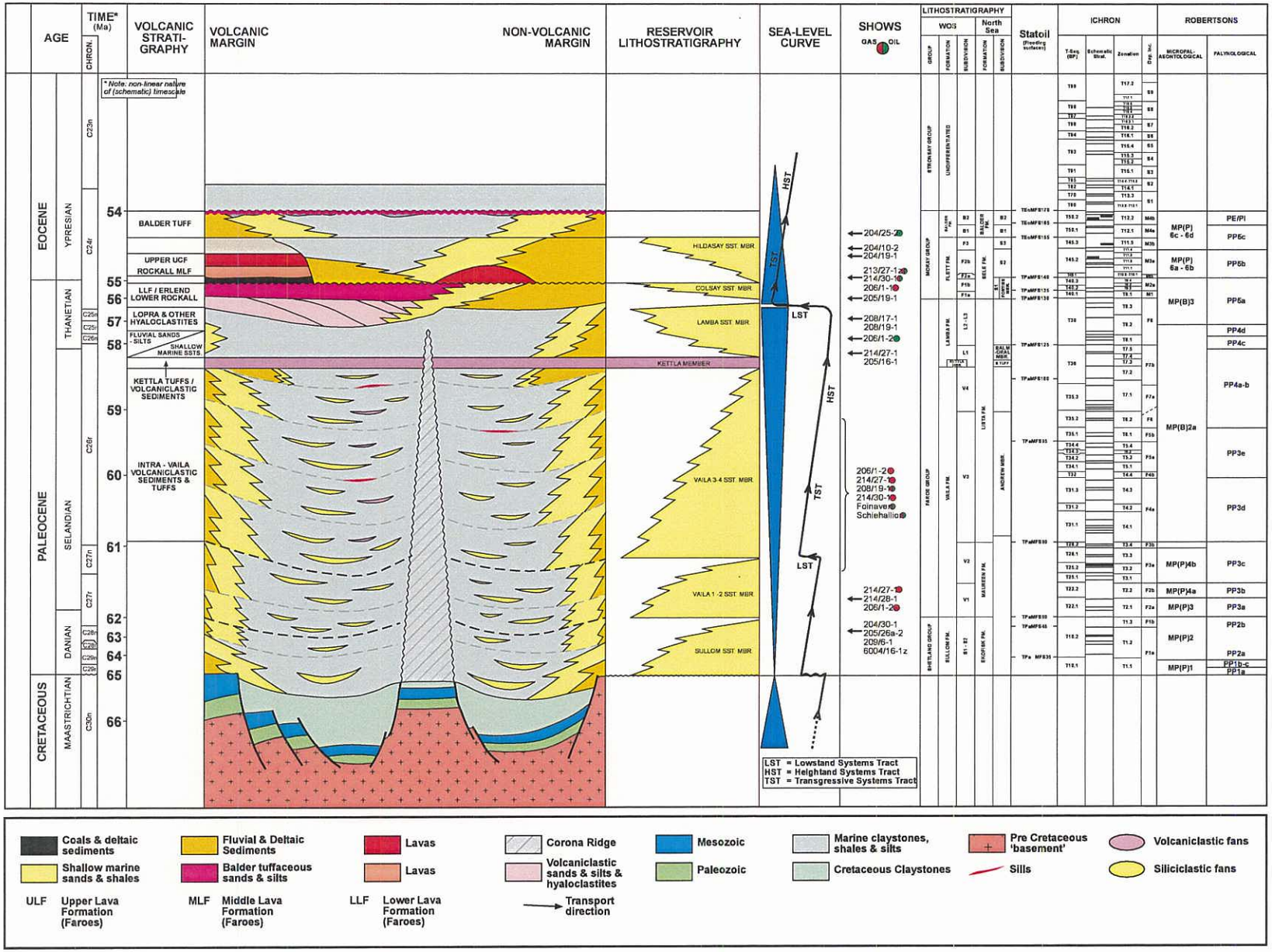

Figure 5.1 Faroe-Shetland Basin Stratigraphic Column.

6 Conclusions

The rationale for Statoil's decision not to extend the exploration period of FL010 to a fourth licence term is presented below.

As described in the 'Prospectivity' Chapter of this report, using recent geological modelling and interpretation of the latest OF94/95RE11 seismic data, Statoil at this time considers the geological risk on the Slætibøkan Lead, to be unacceptably high. The principal risks are:

- Trap geometry/location, largely due to poor sub-basalt seismic imaging
- Reservoir quality/producibility