Data collection about complex geophysical research of an object in the North Atlantic for the network optimization of future 3D seismics

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Key words: marine geophysical data, gravimetric, magnetometric and bathymetric measurements

Abstract
A selection of marine geophysical data was made from the Rockall Trough area, west of Scotland, in the North Atlantic. Data from gravimetric, magnetometric and bathymetric measurements aimed at searching and exploring objects for petroleum geophysics were used. The maps of these measurements are analyzed and more profound attention is paid to an anomalous area on the bathymetric relief of this area, known as Anton Dohrn. On the basis of the analysis of the physical parameters a section with a high oil and gas potential has been identified.

Подбор на данни за комплексно геофизично изследване на обект в Северния Атлантик, за оптимизиране на мрежа за бъдещи 3D сеизмични изследвания

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Ключови думи: морски геофизични данни, гравиметрични, магнитометрични и батиметрични измервания

Резюме
Извършена е селекция на морски геофизични данни от района на падината Рокал, западно от Шотландия в Северния Атлантик. Използвани са данни от гравиметричните, магнитометрични и батиметрични измервания, насочени към търсене и проучване на обекти за целите на петролната геофизика. Анализирани са картите от тези измервания и е обърнато по-задълбочено внимание на аномален участък в дънния релеф на района, известен като Anton Dohrn. Въз основа на анализ на физичните параметри е набелязан участък с висок нефтогазов потенциал.

Introduction

The area of the Rockall Trough area, west of Scotland, in the North Atlantic, is famous with several round plutons. (UKOilandGasData, 2017) Due to the intensive sedimentation the plutons are surrounded by sedimentary rocks, some of them containing hydrocarbon deposits. The analogy in the structure and similarity of the geophysical fields with other similar objects in the region is the main prospective suggestion requiring complex geophysical exploration to discover other hydrocarbon deposits in the investigated area. This was the main reason for marine geophysical measurements done by different companies for oil and gas exploitation.

The main purpose of this study and the collection of data and maps

The purpose of this study is to analyze the maps of magnetic, gravitational and bathymetric studies, to examine the potential of the southern pluton Anton Dohrn and, on the basis of the physical parameters examined, to identify areas potentially promising in oil and gas terms.
The research has been performed by several local marine expeditions during the last years. The location of the site is presented on fig.1. (Powis and Penwarden, 2016)
Due to the secure requirements of the firm which is performed geophysical exploration and is interested of this region, the publicity of many data is restricted. (UKOilandGasData, 2017)
The survey consisted of 8100 km of 2D data which was acquired from August 2015 to September 2015.
The WG Vespucci and WG Tasman acquired the Rockall Trough 2D survey for the Oil and Gas Authority on the UK Continental Shelf west of the Hebrides, Orkney and Shetland Isles. The program covering a total of 8,947.305km, of which WG Vespucci acquired 5,032.0125 km and WG Tasman acquired 3,864.9. The survey was acquired in water depths ranging from 75m to 2000m.

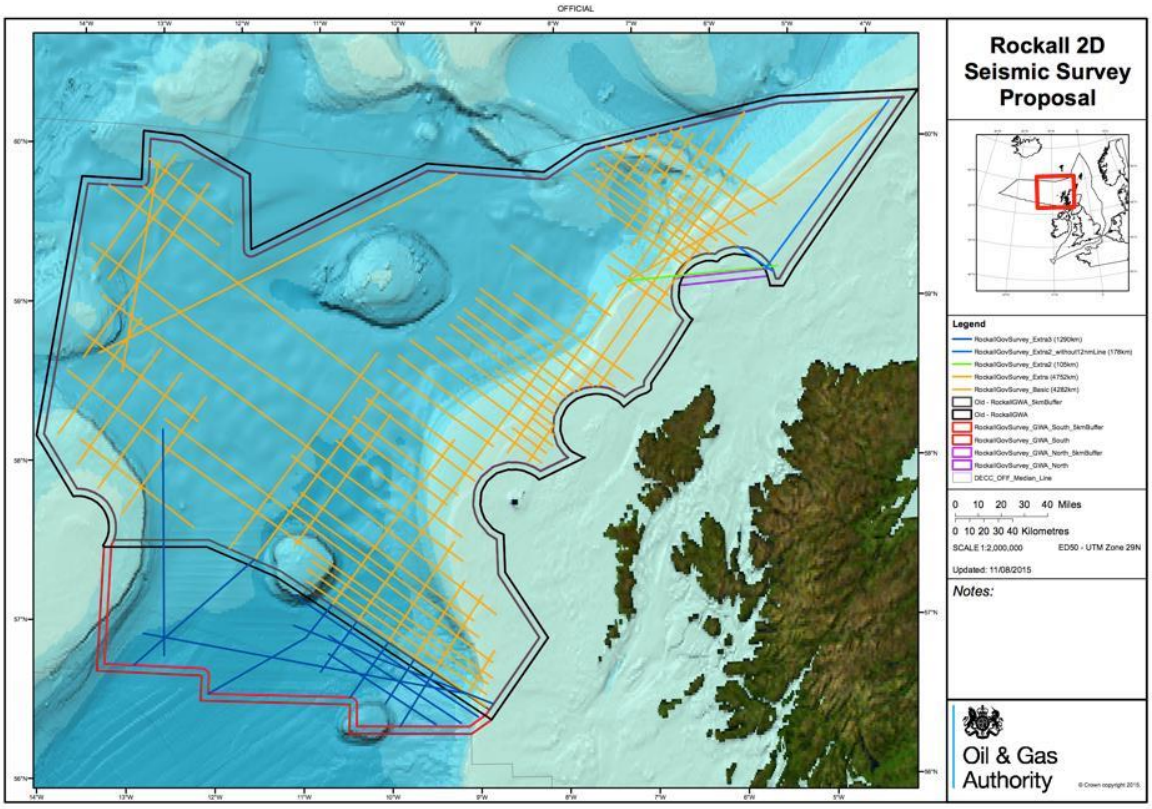


Fig.1. Area of study with seismic survey proposal

Working hypothesis

Two major forms of igneous bodies are encountered in the basin; large (km) scale igneous domes (plutons) which can be encountered from sea level through to the basement; and smaller scale igneous sheets which are commonly found concordant to the strata packages. The major reservoir interval in the basin is located within the Paleocene turbiditic sands, which are commonly the strata packages intruded by the igneous sheets. (Добрев, 1984) A more recent target of interest within the basin is the basement plain.
We will focus on areas with reduced density and reduced magnetic properties that are inherent in turbiditic sands and sandstone in general.

Results

1. Bathymetry

The Echo sounder used is a Kongsberg SIMRAD, EA600, using 3 frequencies (18 KHz/ 38 KHz / 200 KHz), water velocity 1500 m/s and draft = 0m.
Kongsberg Simrad EA600 echo sounders provided the water depth data recorded on both ships.
The Bathymetry map (fig.2) clearly shows the pluton of great amplitude and the continental slope.
The depth to the top of the pluton is about 600m, and the depth to the bottom about 2100-2200m. Its diameter is about 50 km.

2. Bouguer Gravity

The marine gravity measuring unit was Dynamic Gravity Systems (DGS), AT1M-IU
The Dynamic Gravity Systems gravity meter is a full feedback, magnetically damped system using a zero length spring sensor mounted on a gyro-stabilized platform with associated electronics.
The platform is gyroscopically stabilized with two single axis gyros with a short time constant, thus minimizing the turn transients. The meter **AT1M** has a static accuracy of better than 0.01 milligal. Recordings are made to the nearest 0.01 milligal.
LaCoste and Romberg Gravity meter S-52 was installed onboard the WG Vespucci.

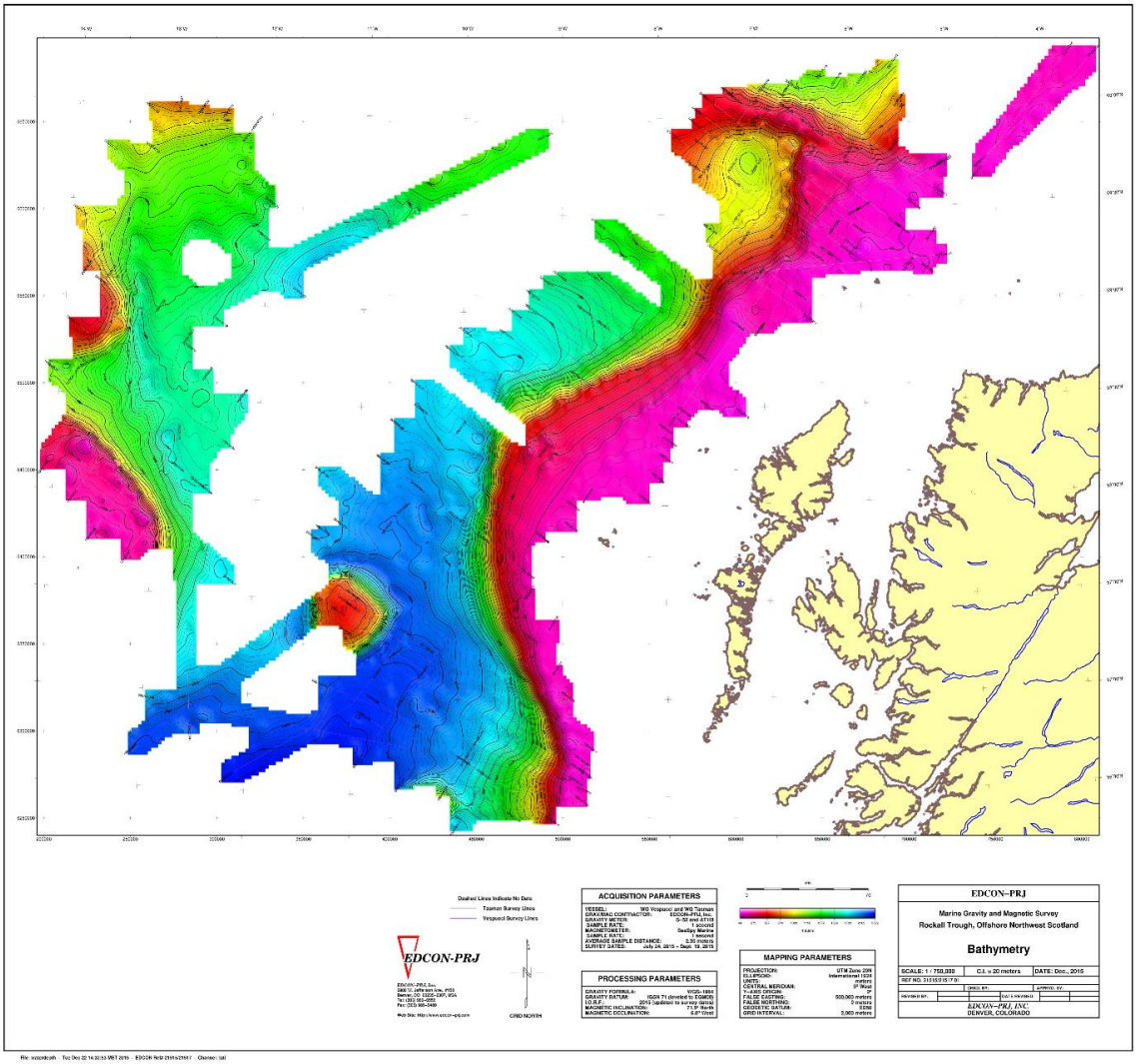


Fig.2. Bathymetry map ,Scale: 1/750,000, C.I. = 20m

The marine gravity system was LaCoste & Romberg Model S gravity sensor serial number **S-52** with the Air Sea II control system.

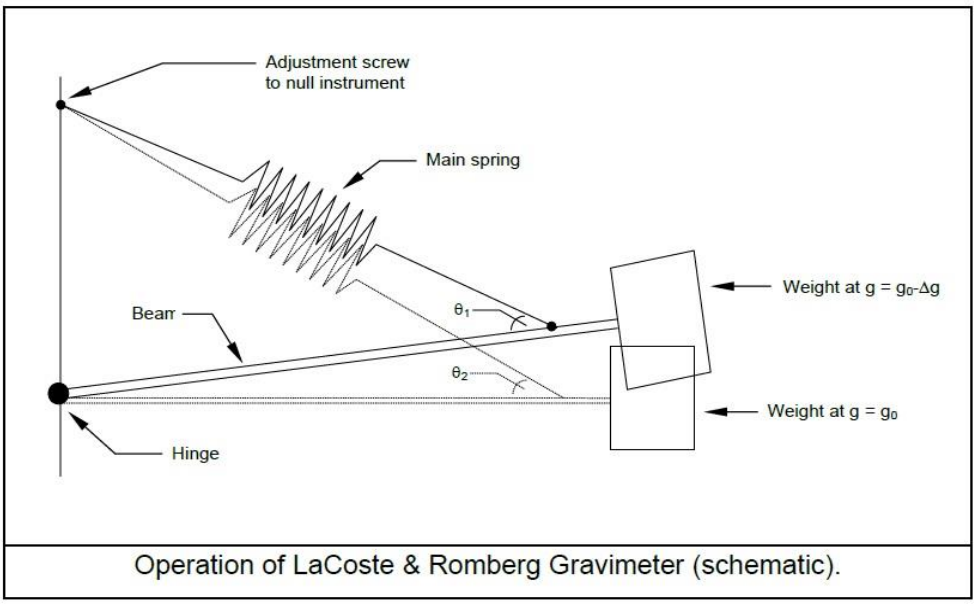


Fig.3. Schematic of LaCoste & Romberg gravimeter operation

The LaCoste & Romberg marine gravity meter (fig.3) is a highly damped zero length spring sensor mounted on a gyro stabilized platform with associated electronics.

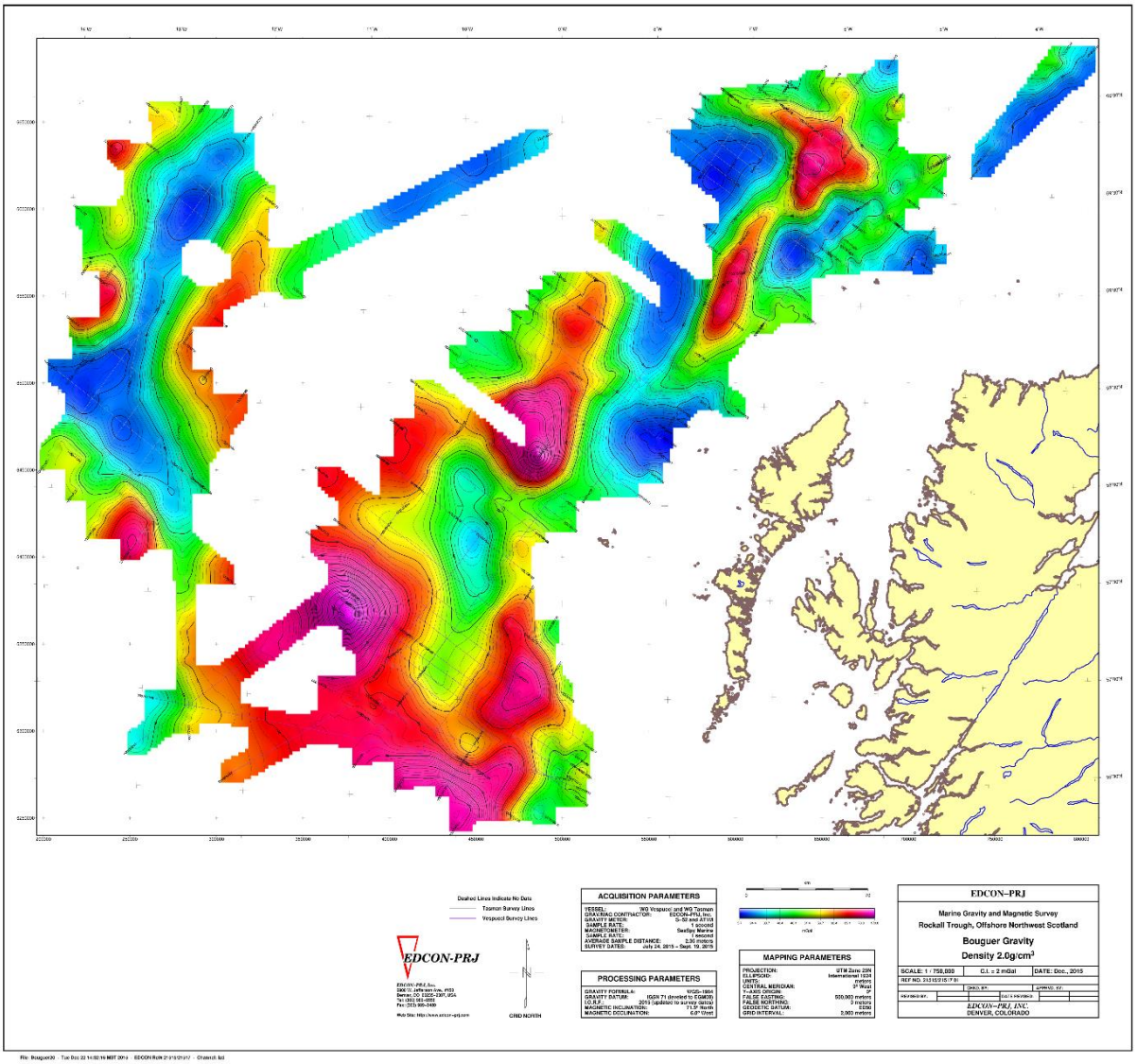


Fig.4. Bouguer Gravity map , Density 2.0 g/cm3, Scale: 1/750,000, C.I. = 2 mGal, Sample rate: 1 second

On this map (fig.4), one of the plutons and some other places with high density of the rocks are well visible. In the central part between three bodies with increased density, there is a reduced area that may be of interest after we reviewing the other maps.

3. Free-Air Gravity

After the correction, we continue to observe (fig.5) a zone with reduced density that confirms the observed on the previous map and clearly distinguishes the greater density of the continental slope.

4. Magnetic Anomaly

The Magnetometer system utilized onboard M/V WG Tasman was the Marine Magnetics SeaSPY2 tow fish #61013 with Electronic Module S/N 13847, and tow fish #61014 with Electronic Module S/N 13848 was kept in reserve as a spare.
The Magnetometer system utilized aboard the MV WESTERN VESPUCCI is the Marine Magnetics SeaSpy I.
The SeaSpy is a high sensitivity total field magnetometer that is designed to be towed behind a marine vessel (fig.6) and contains an Overhauser total field sensor which operate on the proton spin resonance principal. This affect allows The SeaSpy to measure with one to two orders of magnitude more sensitivity but with a fraction of the power required for a standard proton sensor.

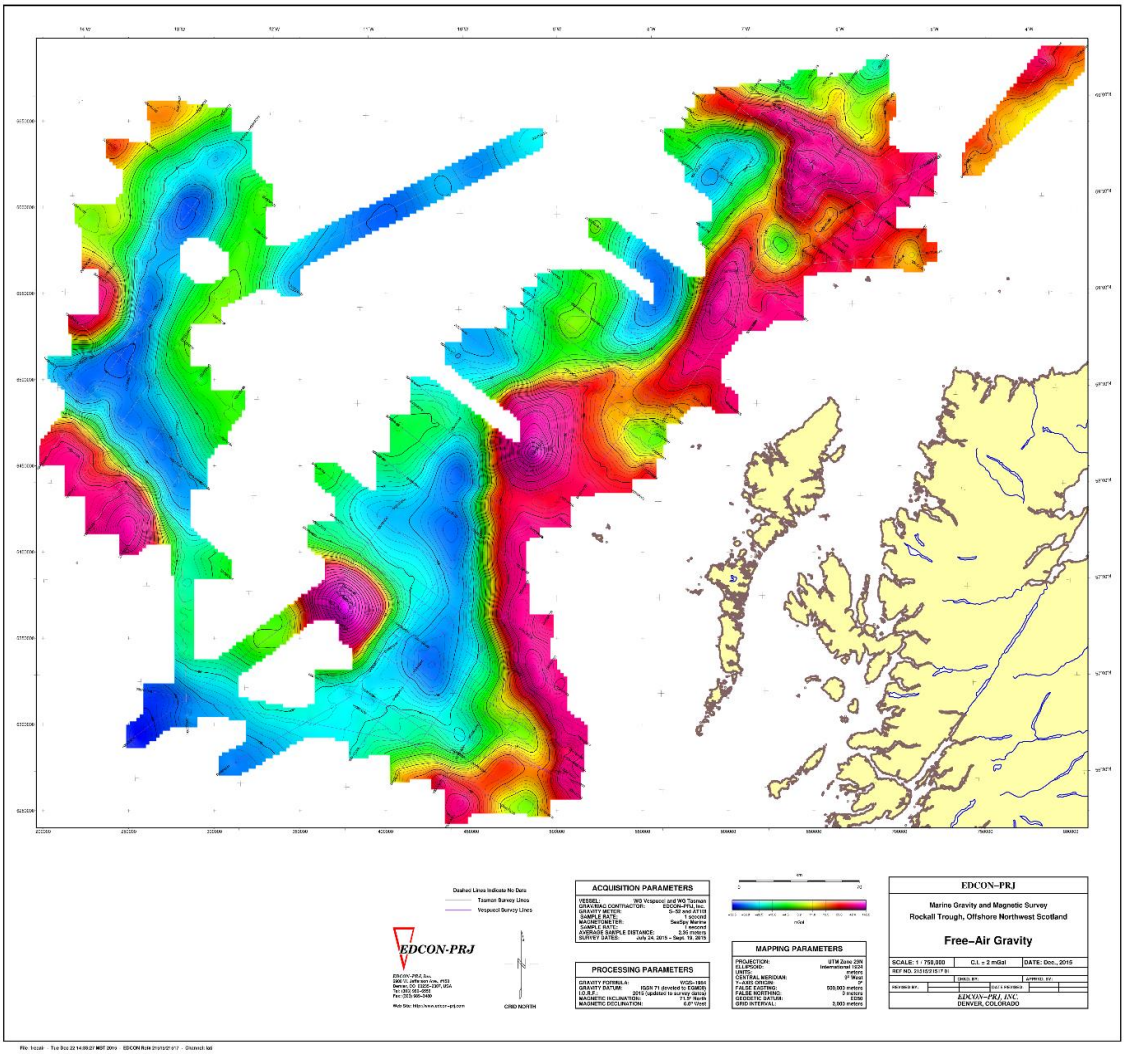


Fig.5. Free-Air Gravity map, Scale: 1/750,000, C.I. = 2 mGal, Sample rate: 1 second

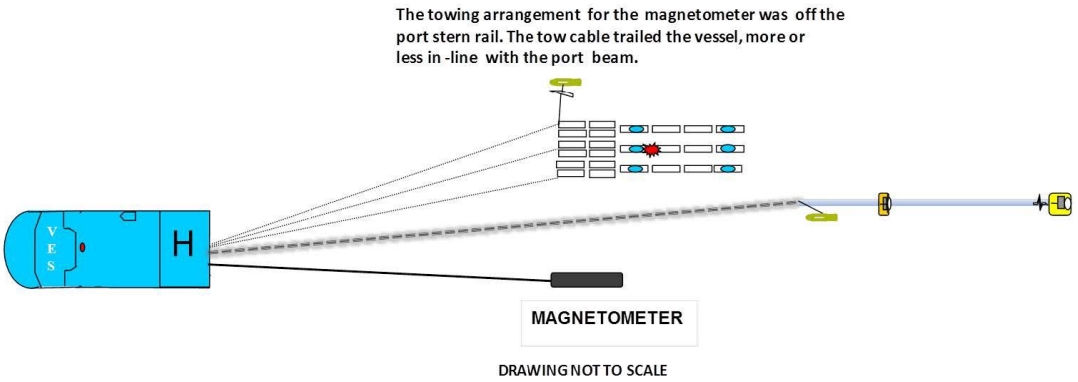


Fig.6. Schematic of magnetometer towing system

On this map (fig.7), we observe degraded magnetic field values over the reduced density zone of the previous gravity map. Above the southern pluton there is an elevated magnetic field value that derives from the volcanic origin of the body. (Telford and Sheriff, 1990) The field above the continental slope is also increased, but there are also many small stretches of low magnetic field.

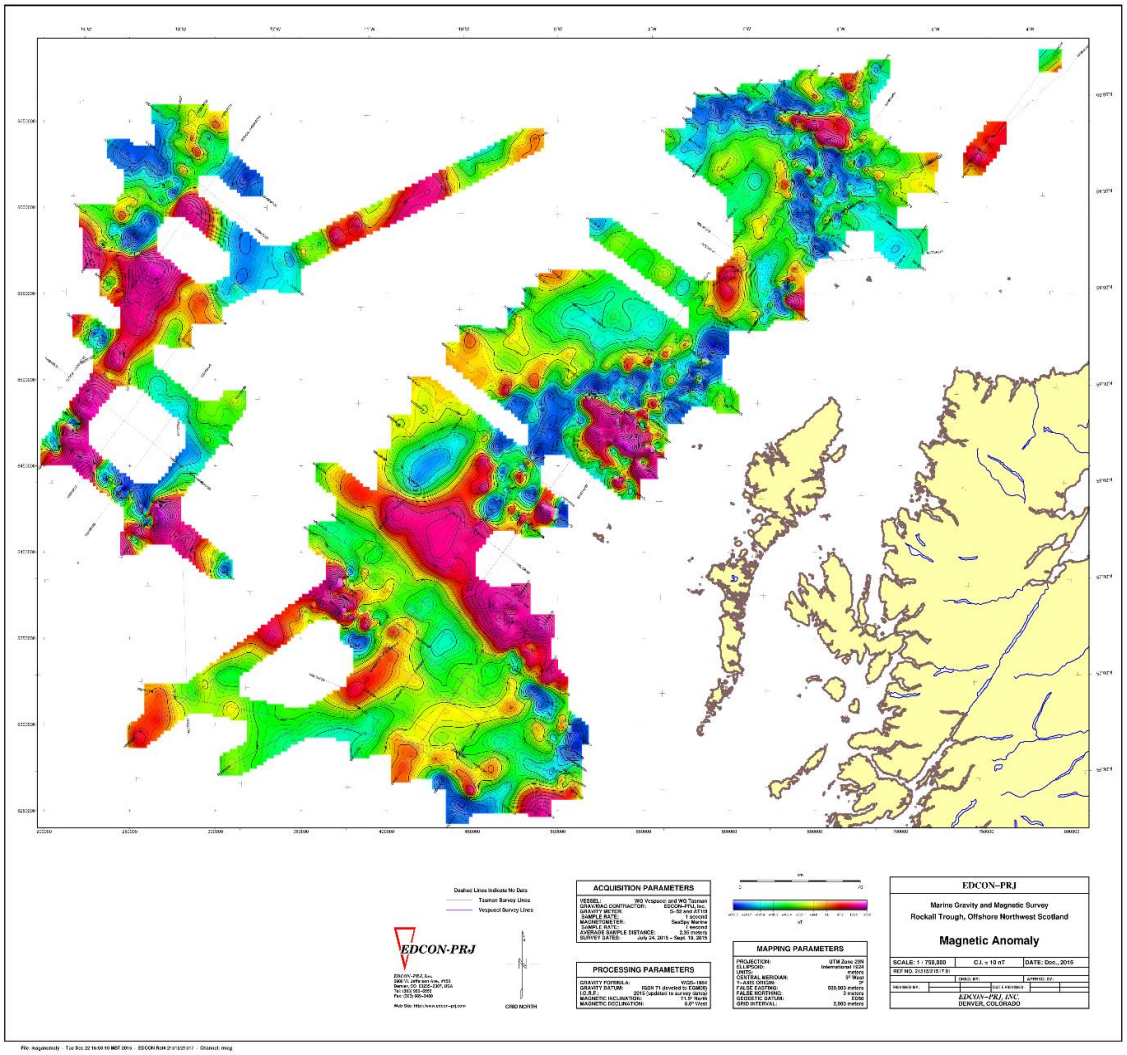


Fig.7. Magnetic Anomaly map, Scale: 1/750,000, C.I. = 10nT, Sample rate: 1 second

5. Reduction to Pole of Magnetic Anomaly

After the correction of the magnetic field, we continue to observe (fig.8) the area with a reduced magnetic field and an increased one above the southern pluton. The area with low magnetic field force and the reduced gravitational field force is a potential interest to the more detailed oil and gas study which should be confirmed after seismic data interpretation.

Conclusions

From the attached maps (fig.9) and studies, the southern dome, which is of interest to us in the present work, clearly shows the high density and heterogeneous magnetism due to the volcanic nature of the body and its clear sea-bed pronounced on the bathymetric map. (Sheriff, 1995) The obtained primary data gives us enough insight into the area and, together with the geological situation, points us to potentially promising areas on which 3D seismic networks can be designed and located. Analyzing of the gravimetric and magnetic data points us to an area located southeast of the southern dome and close to it.
The depths of these deposits usually are located at 2100-2200m. The area stands out with reduced gravitational force and reduced magnetic field values. According to preliminary geological data, there are Paleocene turbiditic sands, which are promising and interesting for the petroleum geophysics.
A deeper analysis of this area will be the result of a further work where we will look at its oil potential in more details.

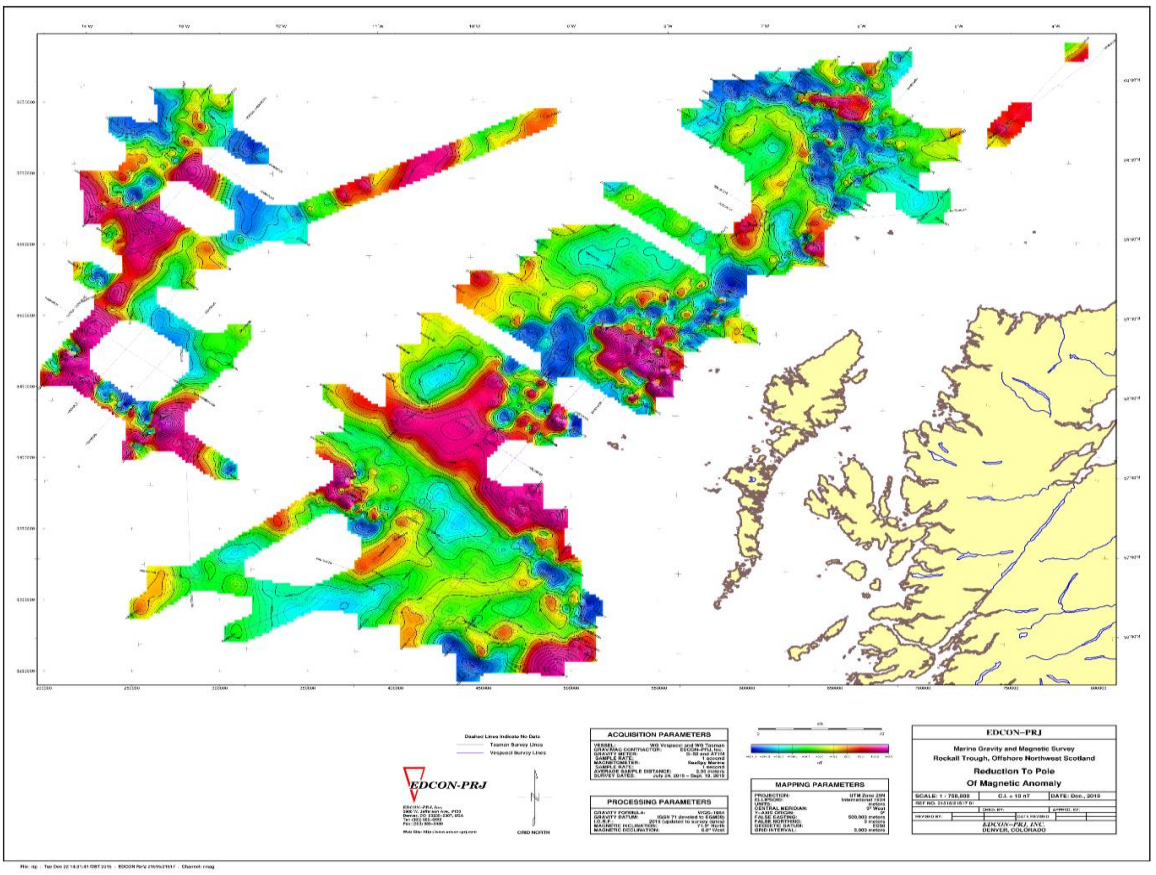


Fig.8. Reduction to Pole of Magnetic Anomaly map, Scale: 1/750,000, C.I. = 2 mGal, Sample rate: 1 second

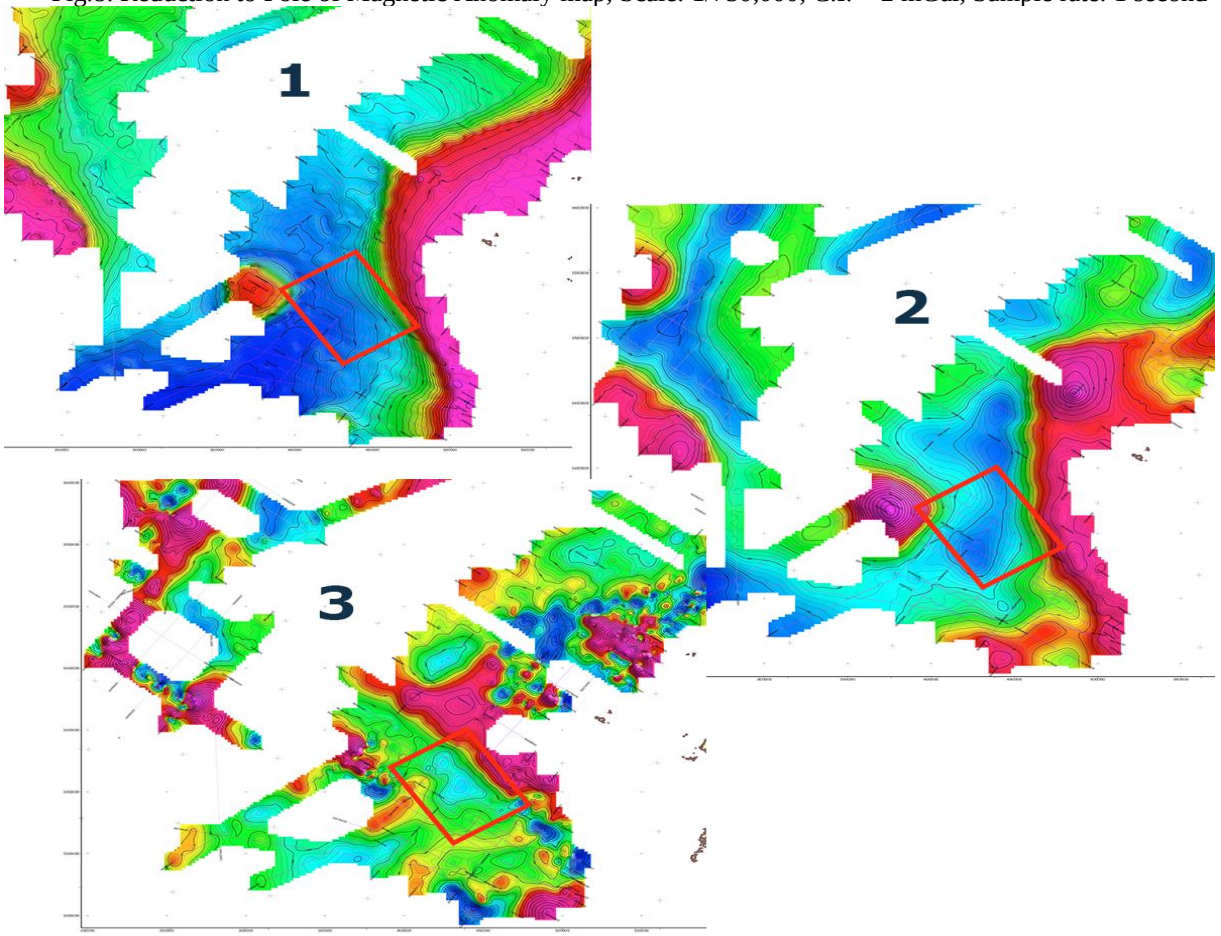


Fig.9. An area selected for more detailed exploration of its oil potential and designing a 3D seismic network.
1 - Bathymetry map, 2 - Free-Air Gravity map, 3 - Reduction to Pole of Magnetic Anomaly map

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