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Rockall Studies Group

RSG Project 00/07: Bathymetry Integration of NW Atlantic Data

DRAFT REPORT

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RSG Project 00/7: Bathymetry Integration of NW Atlantic Data

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EXECUTIVE SUMMARY

As part of the continuing RSG Research programme it was decided to integrate bathymetric and seismic surface pick data in the Irish Sector of the Rockall Trough to aid in the interpretation of subsurface geological features from the surface expressions as well as the adding to the overall knowledge of the area.

The overall objectives of the project were to integrate all useable public and private domain digital terrain data, ASCII XYZ data, and seabed picks in the Rockall Trough. The output from the integration is sets of industry standard contoured bathymetric regional and detailed maps at A0 and A3 size, suitable for most aspects of hydrocarbon exploration activities.

The data integration utilised the seabed picks from seismic data made available from the RSG members as well as public domain information from United Kingdom and the United States. The datasets proved to be widely disparate in the vertical domain requiring a substantial analysis of the differences between the derived surface bathymetry. The data integration was accomplished with a vertical accuracy (1 σ) of around 10 metres + 0.05% water depth. Horizontal accuracy (1 σ) is in the order of ± 200 metres. The data showed good correlation with the well data depths in the NE Rockall area. The accompanying text is intentionally brief, reporting the observations made during the data integration together with results and conclusion that stem from the observations.

1. INTRODUCTION

This report presents the methodology and findings of the integration of public and private domain 'bathymetric' data carried out for the Rockall Studies Group (RSG) of the Irish Petroleum Infrastructure Programme Group 2.

The work is designed to provide an integrated bathymetric data set suitable for the needs of hydrocarbon data exploration. The data set is an adjunct for the work carried out for the regional RSG Project 98/23, (Rockall Trough Shallow Stratigraphic Framework and Geohazards Study, Austin 2000), RSG Project 00/5, (Neogene Stratigraphic Framework of NE Rockall Region, Austin 2001) and RSG Project 00/6 (Slope Stability in North East Rockall, Austin 2002).

Source data investigation and preliminary data modelling of the available began during April 2001. The regional extent was increased in May 2001, necessitating the re-acquisition of some public domain data. Additional data from Chevron was received in August 2001. The seabed pick data supplied by the RSG members required a considerable amount of cleaning to remove artefacts. Mike Postle-Hacon carried out the principal integration and reporting with assistance from Chris Ward, Neil Webster and Marnie Whyte.

1.1. Acknowledgements

This publication uses data and survey results acquired during a project undertaken on behalf of the Rockall Studies Group (RSG) of the Irish Petroleum Infrastructure Programme Group 2. The RSG comprises: Agip (UK) Ltd, Anadarko Ireland Company, ARCO Ireland Offshore Inc, BG Exploration & Production Ltd, BP Exploration Operating Company Ltd, British Borneo International Ltd, Elf Petroleum Ireland BV, Enterprise Energy Ireland Ltd, Mobil Oil North Sea Ltd, Murphy Ireland Offshore Inc, Phillips Petroleum Exploration Ireland, Saga Petroleum Ireland Ltd, Shell EP Ireland BV, Total Oil Marine plc, Union Texas Petroleum Ltd, and the Petroleum Affairs Division of the Department of the Marine and Natural Resources.

2. OBJECTIVES AND METHODOLOGY

2.1   The overall objectives of the project were to integrate all useable and available public and private domain digital terrain data, ASCII XYZ data, and seabed picks in the Irish Sector of the Rockall Trough

The original area chosen (**Figure 1**) lies within the rectangle formed by the co-ordinates:

NW Corner   :   57° 00' North   016° 00' West

SE Corner   :   51° 27.0' North 008° 00' West

The final area (**Figure 1**), lies within the rectangle formed by the co-ordinates :

NW Corner   :   57° 00' North   019° 00' West

SE Corner   :   51° 00' North   008° 00' West

The mapping parameters used in the production of bathymetric data set are :

Projection   :   Universal Transverse Mercator

Zone   :   28 North

Spheroid   :   WGS84

Central Meridian   :   15° 00' 00" West

Map Sheet Datum :   WGS84

Datum transformation parameters from ED50 Datum to WGS 84 Datum were :

DX = -89.5m   DY = -93.8m   DZ = -123.1m

RX = 0   RY = 0   RZ = -0.156"   DS = +1.2ppm

Convention : Position Vector Transformation (Bursa Wolf).

2.2   The initial methodology proposed for the integration of the various 'bathymetric' data sets available was as follows:

2.2.1 Load seismic or other data into workstation systems to allow picking of the seabed horizon where this has not already been accomplished.

2.2.2 Check geodetic parameters for each data set and apply datum shift as appropriate to the data sets.

2.2.3 Generate vanilla ASCII XYZ data sets and load in to Petrosys and ERMapper 6.2 for gridding and initial assessment of bathymetry.

2.2.4 Apply velocity and TWT corrections and re-grid data.

2.2.5 Order data sets and re-grid using minimum curvature algorithms.

2.2.6 Production of contour maps from gridded data to facilitate final data editing and QA/QC functions.

2.2.7 Final map construction.

3. BATHYMETRIC DATABASE

The bathymetric database comprised of the following data sets. The boundary domains for these charts are given in **Figure 2**.

3.1. SEISMIC DATA

3.1.1. 2D

Regional

Eireroc_wbot

Eireroc-ci

Donegal

Eireroc_GMD69

Porcupine

3.1.2. 3D

PGS_SRT_9782

ST9810

Shannon Corrib

Slynel Erris

In addition to the RSG PIPCo data sets supplied, another data set from the Dooish Area was added to the seismic data set. This set was made available from a geophysical study carried out by Peter Andresen for Enterprise Oil.

3.2. HARD COPY DATA

Hydrosearch was unable to obtain digital data from the Institut Francais de Recherché pour l'Exploitation de la Mer (IFREMER) as IFREMER was not willing to release the data in that format. However, the following hard copy charts from the CARTOPEP report were available :

Terrasse Hebrides Nord-Est

Terrasse Hebrides

Terrasse Hebrides Sud-Est

Marge Maline Nord

Marge Maline Sud

Marge Nord-Ouest Irlande

RSG provided copies of the Department of Energy, Transport & Communications Petroleum Affairs Division Bathymetry Charts of the Irish Continental Margin in AutoCAD DXF format files. The Charts provided were

Charts 07, 09 and 10.

RSG also provided the bathymetry data from the NERC BGS 1995 Cruise covering most of the Rockall Bank.

3.3. DIGITAL DATA

Hydrosearch sourced and procured the following Public Domain digital bathymetry data.

GEBCO 97 Bathymetry data from the British Oceanographic Data Centre.

ETOPO 5 DEM gridded data from the US National Geophysical Data Centre.

Depth data in ASCII XYZ format at a mixture of 5 arc minute, 1 arc minute and 30 arc second intervals from the US Naval Oceanographic Office Digital Bathymetric Data Base - Variable Resolution (DBDB-V) database.

GEODAS bathymetry trackline data from the US National Geophysical Data Centre.

4. DATA MANIPULATION

4.1. DATA PREPARATION

4.1.1. SEISMIC DATA

All of the seismic data required re-referencing from ED50 Datum, International 1924 Spheroid, UTM Zone 29 CM 9W projection to the mapping data datum which was WGS84 Datum and Spheroid, Universal Transverse Mercator Projection Zone 28 CM 15°W.

The datum and projection shift was performed using Concept System's Geomatrix Software package.

Several of the data sets required TWT corrections to give seabed depths in metres. The seawater velocity value of 1490 metres per second was chosen as being appropriate for the Atlantic Ocean.

The Dooish area 'bathymetry' data was already available in the Petrosys data format and did not require any data preparation.

4.1.2. HARD COPY DATA

IFREMER Data

In order to obtain the digital information, the maps were scanned as TIF images at a resolution of 300 dpi. The digital images were then georeferenced using Blue Marble Geographic's 'Geotranslater' software package to produce GEOTIFF files. The georeferenced files were then loaded into Petrosys and the contours were manually digitised.

PAD Files

The files were stripped back to the basic contour layer and were saved as intermediate drawing files. The intermediate files were then combined into a single file. This file was then edited to remove contour overlaps and any misties. A new set of layer files, one layer per contour level was then generated and the contour polylines were then manually re-assigned to the appropriate layer. The AutoCAD file DWG file was then transformed using SAFE Software's FME package to produce a correctly geo-referenced DXF file for input into the Petrosys package.

4.1.3. DIGITAL DATA

The GEBCO 97 data was extracted as an ASCII stream file using the Utilities Export function from within the GEBCO software. The GEBCO data then reformatted into a conventional space delimited ASCII XYZ file. This was done using a bespoke Visual Basic programme.

The other data sets were available as space delimited ASCI YXZ files and also required reformatting to an ASCII XYZ format using a small Visual Basic programme.

The latitude values required conversion to UTM Zone 28 projected co-ordinates. The data also had to be reformatted into a space delimited text file prior to being read into Petrosys. This co-ordinate conversion work was carried out using Concept System's Geomatrix software that suffered from the limitation of only being able to process 15,000 rows of co-ordinates in one pass. This was a severe limitation as some of the regional data sets contained in excess of 1.3 million rows of data triplets. . The depth values also needed

converting to negative values.   This was carried out using the Surfer 7 package.

4.2.   DATA GRIDDING

A uniform cell size of 1000 metres was chosen for all data sets to allow for experimentation and comparison between the different data types.   At the planned map scales of 1:3,000,000 and 1:500,000 this would represent a data point every 0.33 and 2.0 mm respectively.

The origin for each data set was the bottom left corner of the area of interest which was 219000mE, 5649000mN (50° 55' 26.684"N   018° 59' 55.419"W). The null data depth value was set to –9999.

4.2.1. 2D Seismic Data

Initially, a clipping distance of 25,000 metres was used to fill in the gaps between actual data lines, in order to produce a continuous grid coverage. However, there was concern that these grids would contain large areas of interpolated points that would distort the data set during data merging. For the purpose of merging the files, grids were clipped to a distance of 750m, preserving only true data points. The 2D data grids were then exported in an Earth Resource Mapping ERMapper compatible format for visualisation and checking.

The Dooish data was re-gridded at 1000m intervals in Petrosys.

4.2.2. 3D Seismic Data

The 3D data sets were also clipped to a distance of 750 metres in order to preserve the edge boundaries. The 3D data grids were then exported in an Earth Resource Mapping ERMapper compatible format for visualisation and checking.

4.2.3. Hard Copy Data

The Petrosys contour gridding algorithm was used to grid the IFREMER and PAD contour files at 1000m grid interval with and external clip distance of 750 metres.

4.2.4. Digital Data Sets

The digital data sets were gridded in Petrosys using a minimum curvature algorithm with a minimum level of smoothing and boundary tension. The input grid density varied from 5 arc minutes (approximately 9000 metres) to 30 arc seconds (approximately 900 metres).

The digital data sets, as supplied from the vendors, are in themselves a product extracted from a processed database. Where 'true' values do not exist at the selected grid interval, then a bi-cubic spline interpolated value is supplied. Care was taken to minimise the potential for introduction of artefacts due to using interpolated data.

4.3.   DATA MERGE

The results of the ERMapper visualisation and QC checks showed that the 2D data sets were consistent with each other and there was sufficient overlap to merge the data sets.   The same applied to the 3D seismic data with the exception of the ST9810 set, which was to far to the south.

The GEODAS 97 data set was found to be inconsistent with the other regional data sets, showing positional differences for the Hebrides Terrace and the

Porcupine Seabight in the order of four to five kilometres. The gridded data also showed an elevation change from North to South, with the bathymetry data in the North being shallower by several hundred metres, and those in the south being several hundred metres deeper. The Geodas data has an unspecified Spheroid associated with the data. The raw extracted latitude and longitude values were converted to WGS84 using a variety of assumptions for the spheroid ranging from WGS84 to the Clarke 1886 spheroid and included the Airy spheroid. As none of the transformations could completely remove the positional errors, it was decided to remove the GEODAS data set from the data merge process.

On completion of the checks, the individual data sets were then merged in Petrosys using the 'Regrid' function, which allowed the multiple data sets to be assigned a hierarchy during the re-gridding process. The data sets were merged using a Bartlett three parameter smoothing filter with 3 passes, in order to minimise edge joining effects.

The results of the data merge first pass process gave the following discrete data sets:-

    2D combined

    3D combined

    ST9810

    Regional XYZ

    NERC BGS Cruise

    PAD Contour data

    Dooish Area

    IFREMER combined charts.

The most accurate data sets were considered to be those derived from the IFREMER and the PAD Charts.

As it can be seen for **Figure 5**, the 2D and 3D combined data sets and the Dooish data set overlap the IFREMER data, however, there was significant differences in the depth values for the same grid location (See **Figures 6, 7** and 8). The Surfer 7 Table manipulation facility was used to generate an ASCII file containing the grid point co-ordinates and the depth values from the IFREMER data and the depth values from one of the three other data sets. A Visual Basic programme was written to extract data values were there was concurrent non null data, i.e., there had to be depth values other than –9999 from both depth values. The data was then analysed and charted in an Excel spreadsheet in order to obtain a minimum straight line or low order polynomial function that would scale the 2D combined, 3D combined data and the Dooish data to the IFREMER data, (See **Figures 6, 7** and **8**).

The Porcupine and ST9810 3D data were merged with the regional digital data sets after scaling the depths to the underlying digital data. Neither the Porcupine nor the ST9810 contributed very much to the overall bathymetry detail, (See **Figures 9**, and **10**).

All of the scaled data in the Hebrides Terrace area was merged with the IFREMER data using the same Bartlett smoothing filter as the first pass merge. The ST9810 3D data and the Porcupine 2D data was merge with the Regional XYZ data in the same manner.

The results of the data merge second pass gave the following discrete data sets:-

Data Set Name	Merged Data
IFREMER Region	Regional_2D, Eireroc_wbot_2D, Eireroc_CI_2D, Donegal_2D, Eiroc_GMD69_2D, PGS_SRT_9872_3D, ShannonCorrib_3D, SlynelErris_3D, Dooish, IFREMER Charts,
Regional XYZ	ETOPO5, GEODAS Trackline, DBDB-V, Porcupine_2D, ST9810_3D
NERC BGS Cruise	
PAD Contour data	Charts 7, 9 and 10

The depths in each set were then compared using the same process as was used prior to the second pass data merge. Scaling functions for the four data sets were computed. The areas deemed to be the most accurate were the IFREMER Region and the PAD contour data. The scaling functions derived were for the Regional XYZ to the IFREMER Area, Regional XYZ to PAD Contour, and NERC Cruise to Regional XYZ. The exercise also allowed an assessment to be made of the consistency between the PAD and IFREMER data.

From the analysis, it was concluded that the Regional XYZ data should be re-scaled to the IFREMER data set, (See **Figure 11**). The Regional XYZ to PAD data set analysis showed some anomalies in the 1500m to 2800m depth range. Analysis in ERMapper showed that this was due to positional differences of the seabed slope in the Porcupine Seabight area, (See **Figure 12**). The NERC BGS data was scaled to the re-scaled Regional XYZ data and a final analysis of the new Regional XYZ data to the PAD data was made, (See **Figure 11**).

The end result of these data manipulations were four sets of XYZ data triplets:-

     IFREMER Region

     Re-scaled Regional XYZ

     NERC BGS Cruise

     PAD Contour.

The data was imported into Petrosys and each data set was gridded using a minimum curvature algorithm. A set of contour files for each gridded data set was then produced at 20m intervals. These contour files were then re-imported into Petrosys and the contours were manually edited where there were discrepancies between the data sets. The contour priority was in the order, PAD data, IFREMER data, NERC data, and lastly Regional data.

Once a rational set of contours had been obtained the data sets were merged using the 'Regrid' function as described above using the priorities assigned to the manual contouring exercise.

As a final check, the final grid was imported into ERMapper. The results were used to produce **Figures 3** and **4**.

4.4. DATA INTEGRITY CHECKS

The final data set depth were checked against the known water depths for various well in the Area of Interest. The wells and water depths are shown in **Figure 13**.

The table below list the well numbers and corresponding water depths.

WELL	Water Depth (m)	WELL	Water Depth (m)
005/22-01	-1623	034/05-01	-289
012/13-01	-480	034/15-01	-482
012/13-01A	-480	034/19-01	-432
018/20-01	-354	035/02-01	-391
018/20-02Z	-349	035/06-01	-486
018/20-03	-355	035/08-01	-430
018/20-04	-349	035/08-02	-422
018/25-01	-337	035/13-01	-482
018/25-02	-325	035/15-01	-308
018/25-03	-337	035/17-01	-624
019/05-01	-116	035/18-01	-579
026/21-01	-338	035/19-01	-502
026/22-01	-343	035/21-01	-650
026/22-01A	-370	035/29-01	-804
026/26-01	-360	035/30-01	-703
026/27-01B	-383	036/16-01	-250
026/28-01	-373	043/13A-01	-921
026/28-02	-378	DSDP 610	-2417
026/28-03	-364	DSDP 0610A	-2417
026/28-04	-350	DSDP 0610B	-2417
026/28-04A	-350	DSDP 0610C	-2417
026/28-05	-376	DSDP 0610D	-2445
026/28-A01	-375	DSDP 0610E	-2445
026/28-A01Z	-375	ODP 0980A	-2182
026/28-A02	-375	ODP 0980B	-2179
026/29-01	-321	ODP 0980C	-2179
026/30-01	-249	ODP 0981A	-2184
027/05-01	-201	ODP 0981B	-2184
027/13-01	-191	ODP 0981C	-2464

4.5. CHART PRODUCTION

The bathymetry data of the whole Area of Interest is presented in hard copy format (A0 size) at a scale of 1:1000,000 (See **Map 1**). The data is also presented at A3 size as a scale of 1:2,500,000, (See **Map 2**), which is the same size as the regional maps in RSG Report 98/23.

A detailed map of the NE Rockall area bounded Latitudes 54°N to 57°N and Longitudes 12°W to 9°W at a scale of 1:500,000 was also produced, (See **Map 3**). These maps have been included on the CD-ROM in PDF format.

5. CONCLUSIONS & RECOMMENDATIONS

The bathymetry data should only be used for the needs of hydrocarbon data exploration and should not be used for NAVIGATION purposes.

The data sets do enhance the seabed features where the data is of good quality and high resolution such as the PAD and IFREMER Chart data.

The data vertical accuracy is in the order of (1 σ) of around 10 metres + 0.05% water depth. Horizontal accuracy (1 σ) is in the order of ± 200 metres. The digital public domain data had already been processed and verified by third parties, no apparent anomalies were seen and the data was in close agreement with charted data.

The depth data shallower than the 100 metre contour is not very accurate and should be treated with caution. It is believed that the shallow water data has been distorted by the gridding algorithms.

It is recommended that further integration of shallower water data is carried out using the data that will become available from the Irish Geological Survey multibeam data, in the near future. This will aid the understanding of the geological processes at the break of the continental shelf.

6. CDROM CONTENTS

RSG/007 Report

RSG/007 Figures

Maps 1, 2 and 3 in PDF format

Gridded XYZ Raw Data in ASCII space delimited format:

    2D Data

        Regional Regional

        Eireroc_wbot

        Eireroc-ci

        Donegal

        Eireroc_GMD69

        Porcupine

    3D Data

        PGS_SRT_9782

        ST9810

        Shannon Corrib

        Slynel Erris

        Dooish

    Hardcopy Data

        IFREMER Combined Charts

        PAD ASCII

    Digital Data

        Regional XYZ

        GEODAS trackline data

        ETOPO5 data

        DBDB-V data

Gridded XYZ Processed Data in ASCII space delimited format:

    Final integrated data set