Inversion-Guided Seismic Imaging: A Case Study

Steve Morice
Shell Exploration NZ

New Plymouth 4620, New Zealand
Steve.Morice@stos.co.nz

Jaap van der Toorn
Shell International Exploration & Production
South Rub Al-Khali Company Limited
31952 Saudi Arabia
jaap.vandertoorn@srak.com.sa

Vincent Kong
WesternGeco Australia
Level 5, 256 St Georges Terrace
Perth 6000, Australia
wkong@slb.com

Paul Matheny
Shell International Exploration & Production
Sarawak Shell Bhd
Lutong, Miri, 98100, Malaysia
Paul.matheny@shell.com

Tristan Allen
WesternGeco Australia
Level 5, 256 St Georges Terrace
Perth 6000, Australia
TAllen2@slb.com

SUMMARY

Key objectives of this seismic reprocessing and seismic inversion project are to reduce multiples and noise, and optimize imaging and amplitude fidelity across the three different survey types (marine, transition zone and land) covering the field. A collaborative multi-disciplinary well data analysis, seismic processing, and reservoir characterization approach has been executed. The approach involved iterative, integrated analysis of petrophysical, rock physical, and borehole geophysical data at the onset of the project. These well-related data and products then form reference calibration dataset used to qualify the improvement in seismic data quality though successive stages of seismic data processing and imaging.

In particular, major stages of seismic processing for each of the separate survey types were quality checked by performing fast track simultaneous seismic inversions on minicubes around a chosen representative wells within each survey type. These yielded measurements of the progressive data improvements achieved at each stage; independently for each survey segment, and later, for the merged survey covering the entire field.

The dataset thus processed is termed as an optimized seismic dataset with borehole-calibrated, consistent phase, amplitude, and reflector positioning, towards structural and quantitative interpretation procedures.

Key words: Seismic-reprocessing, inversion-guided, transition-zone, successive-calibration

INTRODUCTION

The field is essentially covered by a combination of two modes of seismic survey, the regular 3D marine and a segment of transition zone seismic as illustrated in fig.1. The reservoirs are of mid to late Eocene, shoreface coastal plain clastic sediments, with porosity ranging from 7 to 11%. Although structurally simple the relief is low, hence sensitive to depth conversion uncertainties, and with challenging thin reservoir intervals.

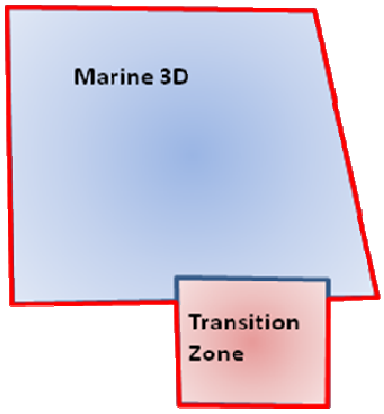

Fig. 1 Schematic of the seismic survey coverages.

The surveys were merged and processed, then reprocessed a number of times, while seismic inversions were also performed repeatedly using a variety of software. Close to 20 wells had been drilled in this field, including injector wells.

Broadly, the aims of this project are to produce a data set for the seismic interpreters to enable them to better define the reservoir and facies distribution, improve velocity control, "see through" gas chimneys, and with the possibilities to look for green fields within the brown field.

The project team identified a number of challenges that need to be overcome, including cleaning up noise contamination, merging of different terrain surveys, seismic multiples attenuation, accurate velocity modelling, without compromise to the seismic resolution.

METHOD AND RESULTS

In principle each of the survey modes were first individually pre-processed to CMP gathers before being taking part in the survey matching routine. The severity of multiples and noise is different for each of the survey types and need to be attacked separately.

Fig 2a show an example of the legacy seismic profile compared with the new processed profile with noise multiples attenuated (fig 2b). In parallel with seismic data processing a number of key wells were selected for petrophysical and rock physics QC and analyses to ascertain the fidelity of the well curves and associated data. These cleaned up well suites would then be used in the seismic data processing velocity QC and comparisons, towards the Well bore seismic comparisons and also for the seismic inversion procedure. Concurrently the borehole geophysicists revisited the checkshots and VSP data of the key wells, regenerating corridor stacks and well bore synthetic seismic data as well as calibrate the time-depth relationships. This tri-functional approach ensured that all the input data are prepared to a common standard and platform.

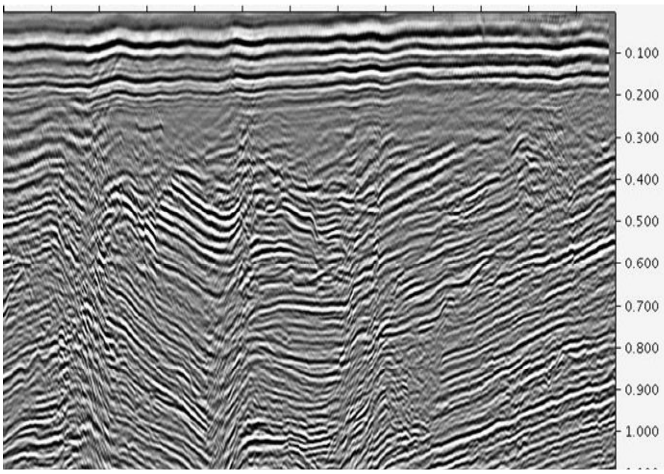

Fig. 2a A legacy seismic profile

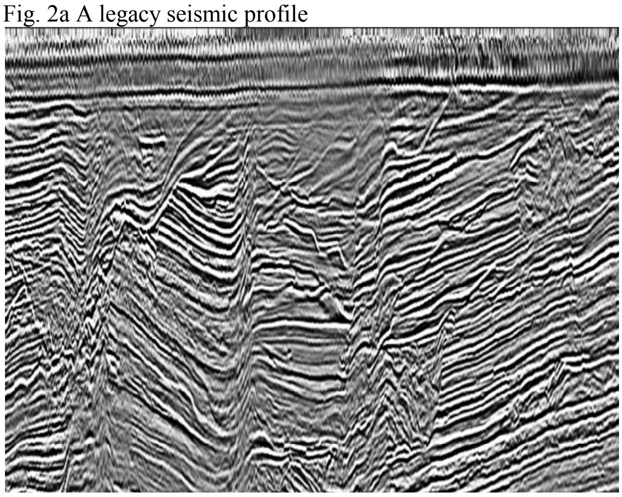

Fig 2b Early output of the noise reduced and demultipled data.

At each major processing milestone mini seismic data cubes were output for the simultaneous seismic inversion, using a representative well in each of the individual survey zones. We kept the well log data constant for each of these mini seismic inversion phases in order to ascertain the goodness of fit of the processed seismic data at each of these phases. Ideally each phase should bring about improvement to the quality of the seismic, and that is represented by the character of the seismic wavelets estimated at each of the calibration wells. Fig 3 show a series of wavelets estimated at one of the wells, with the seismic from each of the successive phases. The "shape" of the wavelet provided an indication of the improvement or degradation of the processed data at that phase.

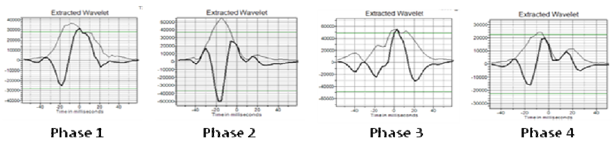

Fig 3 Estimated wavelets at the same well for each phase.

CONCLUSIONS

On completion of the merged 3D seismic data processed and piped through the simultaneous seismic inversion we obtain an integral highly interpretable data set for structural, stratigraphic and log-calibrated lithology for more indepth search for untapped reservoirs and under exploited areas. Cost savings is anticipated for field development and cost effective well planning.

ACKNOWLEDGMENTS

We acknowledge the invaluable technical contributions of Rockphysicist Andrea Paxton, Borehole geophysicist Konstantin Galybin, Reservoir Geophysicist Robert Nesbit all of Schlumberger Australia. Seismic data processing was also ably performed by WesternGeco's Sharon Tan and supervision provided by Staff Geophysicist Richard Paternall.