The 3-D MegaProject in Petroleum Development Oman:  
A 3-D Data Management Concept for Seismic,  
Workstation Support and Interpretation  
Maarten H.P. Ligtendag  
Petroleum Development Oman  

ABSTRACT  

The concession of Petroleum Development Oman (PDO) is covered with some 30,000 square kilometres of 3-D seismic data, consisting of some 90 individual surveys, acquired and processed since 1984. With the 3-D coverage rapidly growing, more and more continuous coverage over large parts of the PDO concession is established. Traditionally surveys were processed on a survey-by-survey basis, incorporating some data from neighbouring surveys whenever possible. This approach resulted in a patchwork of often overlapping stand-alone 3-D projects, all with different datums, amplitude normalisations and processing histories.  

PDO strongly believes in the value of large integrated interpretation projects and the information that can be gained by using them. In order to achieve this the 3-D MegaProject was conducted during part of 1996 and 1997. As part of the 3-D MegaProject all 3-D seismic surveys acquired to date by PDO have been harmonised and merged. The concession area has been split up into four separate 3-D MegaGrids according to the dominant acquisition direction. Within each MegaGrid a consistent in-line and cross-line numbering is used. The data are stored in cubes of 10 by 10 kilometres, referred to as MegaCells, which serve as the 3-D seismic data library. In the future, processing and merging of newly-acquired seismic data will follow the same procedures according to the common framework of MegaCells.  

INTRODUCTION  

The first 3-D seismic survey in Petroleum Development Oman’s (PDO) concession in Oman was acquired in 1984. After a break of three years the 3-D seismic coverage grew rapidly. Figure 1 shows some snapshots of the 3-D coverage at several time instances. From this figure it can be seen that the 3-D surveys at first mostly covered individual prospects/fields and these surveys were consequently processed separately. Over time these individual surveys were extended, until more-or-less continuous coverage was established over large parts of the PDO concession.  

For more information about the development of 3-D seismic acquisition and processing technology in PDO the reader is referred to a paper by Onderwaater et al. (1996). For more information regarding recent data acquisition issues in PDO, the reader is referred to a paper by Wams and Rozemond (1997). Whenever a survey was extended, the new data were processed incorporating some data from the neighbouring surveys. The amount of data incorporated was chosen such that a seamless merge was achieved after migration. Historically the following procedure was adopted, which is also illustrated in Figure 2:  

(1) Process the new survey, including a rim of pre-stack data from the neighbouring existing surveys, if necessary. This depends on the type of acquisition overlap between the surveys, or whether statics problems play a role at the survey boundaries. When, for instance, dunes are present on the survey boundary, a continuous statics solution will be required in order to achieve a seamless merge. In this way the pre-stack data added-on ensures, in most cases, a seamless merge with the existing stacked data of the neighbouring surveys.
Figure 1: Snapshots of 3-D seismic coverage of the PDO concession in 1989, 1992, 1995 and 1998.
In practice a rim of field data is used, mixed with the newly-acquired field data and processed as one. The amount of pre-stack data added-on is kept to a minimum in order to reduce cost. When this approach does not give a satisfactory result more extensive reprocessing of existing data will have to be considered. The rim of pre-stack data used in this step are merely used to enable a seamless merge between stacks of the existing survey and the newly-acquired and processed data.

(2) The next step is to increase the migration aperture of the new survey by including a rim of stacked data from the neighbouring existing surveys. Within PDO, this is commonly referred to as a “post-stack add-on”. The amount of data added-on is a function of the deepest target to be imaged, geological dips and the velocity regime. The data added-on from the neighbouring survey(s) might require amplitude and phase adjustments in order to achieve a proper merge. Occasionally frequency adjustments are necessary. This is normally performed using a spectral shaping or balancing approach, whereby the amplitude spectrum of the old survey is matched to the new data. The stacked data added-on ensure, in this way, a seamless merge with the neighbouring surveys after migration. When possible, Step 1, described above, is omitted to save cost and time and only the existing neighbouring stacked data are used to increase the migration aperture.

(3) After the new survey had been migrated, including the data added on from its neighbours, the new and old surveys were merged on the trace interpretation workstation. This procedure resulted in a large number of overlapping projects, of which version-control became very problematic.

During 1996 the 3-D MegaProject was initiated in PDO with the aim to merge and harmonise all the existing 3-D data volumes. Within this project approximately 30,000 square kilometres (sq km) of migrated seismic data was reworked. Processing issues like amplitude and phase corrections, redatuming, regridding and rotation were addressed where necessary.

In order to control the proliferation of versions it was decided that the merging should be carried out in the processing centre. To support this, a framework of MegaCells was introduced, each with a unique identifier in which the seismic data were stored and loaded. In this manner a library of seismic data was built up from which projects on the Trace Interpretation Systems can easily be composed as...
A complex set of overlapping 3-D surveys was generated during several years of processing. These overlaps make management and version-control problematic both in the processing and in the interpretation Workstation support environment.

To overcome this problem an overlay of cells or tiles was defined as a framework. In each cell the latest processed and merged version of the 3-D seismic data is stored after merging it with its neighbouring surveys.

The subsequent sections will outline in more detail the definitions of MegaCells and MegaGrids and will illustrate their application by various data examples.

**THE MEGACELL AND MEGAGRID DEFINITIONS**

The MegaCell forms the basic block of seismic data within the 3-D MegaGrid. Figure 4 illustrates how the MegaCells have been defined. Each MegaCell consists of 400 in-lines by 400 cross-lines with a spacing of 25 metres (m). In this way each MegaCell covers an area of 10 by 10 kilometres (km). Each MegaCell is assigned a unique identifier, consisting of a one-character grid identification code, followed by a row and column index number. The MegaCell can also be regarded as a very large superbin, in which the contributions from 400 by 400 bins are collected.

In the PDO concession, four dominant acquisition directions exist, which are defined by four regional bin grids: Lekhwair, North, Central and South Oman grids. These grids were already defined before the introduction of the MegaGrid. Figure 5 shows the four MegaGrids overlaying these four regional bin grids. The bottom left point or bin of the very first (bottom left) MegaCell in a particular bin grid coincides with bin (0,0) of that particular regional bin grid.

Figure 3: An example of merged 3-D seismic surveys from North Oman. The left-hand side shows the situation before the introduction of the 3-D MegaGrid. The right-hand side shows the result after merging the surveys. The MegaCells have been displayed as an overlay.
PDO generally acquires 3-D surveys using a bin size of 25 by 25 m. In some cases smaller bin sizes are used, typically 12.5 by 12.5 m, for high-resolution 3-D surveys. In these instances, the final migrated data will be included in the MegaGrid after the migrated dataset has been spatially resampled to a bin grid of 25 by 25 m. The original dataset using the higher resolution bin grid will then also be made available as a stand-alone 3-D survey on the interpretation workstation.

### PROCESSING ISSUES

The 3-D MegaGrid was introduced in PDO in 1996. In order to build up the library of seismic MegaCells all the existing 3-D migrated data were harmonised and merged. In PDO the processing strategy has
always been to increase the migration aperture of new data by considering additional data from neighbouring surveys during the seismic migration process. Data merging and harmonising could therefore be carried out using the migrated data volumes only. Pre-stack reprocessing is necessary when large differences were identified between the pre-stack processing sequences of the merging
surveys and seismic character changes occurred across the merging boundaries. During the 3-D MegaProject the following processing issues had to be addressed:

**Phase Harmonisation**

All the existing data were zero-phased using a deterministic two-step approach. This technique has also been described as Vibroseis zero-phasing (all but one 3-D seismic surveys in PDO are acquired by the Vibroseis method). First, a phase de-absorption is applied, which is equivalent to the application of a phase-only Q-compensation. Secondly, an additional deterministic filter is applied to account for the Vibroseis sweep properties, the geophone and polarity reversal (Onderwaater et. al., 1996; McGinn and Duyndam, 1998).

**Datum and Replacement Velocity**

Two seismic datums and replacement velocities have been defined within the PDO concession, to which the seismic data had to be redatumed. Figure 6 shows an example over South Oman, indicating...
Figure 7: Seismic projects can now easily be built up, by just combining the required cells. This example shows the combination of four separate MegaCells into one single project.

Each MegaCell is stored separately as a 32-bit SEGY file on a mass storage system.

An Oracle database is used to administer the separate cells.

A GIS system is used to maintain an areal overview.

At workstation loading the MegaCells have been combined to form one seismic project.
Figure 8: Display from GIS, outlining the contributing surveys, of which data examples are shown in Figures 9 and 10. The fold is displayed colour-coded. The trajectory of the random line, displayed in Figure 10, is annotated in yellow. The MegaCell outlines are annotated in green.

Figure 9: Time slice at 500 milliseconds, through 38 contributing surveys in South Oman (see Figure 8).
the variety of replacement velocities and seismic datums in use before the introduction of the 3-D MegaGrid. Redatuming was carried out on a survey-by-survey basis and was limited to the application of bulk static time shift to the seismic data.

This approach was chosen in order to minimise structural changes due to the redatuming of the existing seismic surveys. The definition of one datum and replacement velocity for the whole PDO concession was considered. The impact, however, in terms of potential mismatches between individual surveys and in terms of potential structural changes due to the redatuming would have been too severe.

**Grid Definition**

Several surveys were renumbered and rotated in order to fit into their applicable regional bin grid definition.

**Amplitude**

A trace scaling had to be carried out in order to harmonise globally the amplitude of the surveys.

**Storage and Administration**

Proper storage and administration formed an essential part of the 3-D MegaProject. This is illustrated in Figure 7. Each MegaCell is stored as a 32-bit SEGY file on a high-density mass storage system and is available online. To date a volume amounting to a size of approximately 400 Gigabytes is stored on the system. An Oracle database is used to store the locations and some attribute information of the individual MegaCells. In addition a Geographical Information System (GIS) system is used to maintain an overview. This system allows easy and quick retrieval of information about the contributing surveys.

![Figure 10: Random line through the South Oman "Mega 3-D" survey. Refer to Figure 8 for the trajectory.](image-url)
to each MegaCell, including any other information that might be required, e.g. satellite image overlays, prospect information, etc. (Abel, 1998). As Figure 7 illustrates, seismic projects can easily be built up by just combining the required MegaCells during Workstation loading.

**DATA EXAMPLES**

By implementing the MegaGrid approach, large regional 3-D projects can easily be composed. Some examples are shown in Figures 8 to 13. The data examples shown in these Figures were extracted from projects, which completely cover a particular MegaGrid. This was feasible by applying decimation to the MegaCells. During workstation loading every fourth in-line and cross-line was selected. In this manner, a complete set of 3-D volumes can be loaded into one “multi 3-D project”. This facilitates regional geological studies. It also enables inspection of the seismic data quality in any particular location and time.

Figure 8 shows how the contributions from 38 different 3-D surveys have been combined and composed to form the data example shown in Figure 9. Figure 8 also shows a fold of coverage of the different surveys showing the large variety of acquisition geometries of the contributing surveys. Note that this figure has been produced using the PDO GIS system, which makes it possible to display several types of information at the same time. It enables a quick overview of the contributing surveys into each MegaCell to be obtained. Figure 10 shows a random line taken through the same project, the trajectory is indicated in Figure 8.

Figure 11 shows how the contributions from 20 different surveys have been combined in a data example taken from the North Oman MegaGrid. This figure also shows the fold of coverage to indicate the

![Image](http://pubs.geoscienceworld.org/geoarabia/article-pdf/4/1/37/5438977/ligtenda.pdf)

**Figure 11:** Outline of the 20 contributing surveys in the North Oman MegaGrid. The MegaCells are shown in green. The trajectory of the random line shown in Figure 13 is indicated in yellow.
different acquisition geometries. Figure 12 shows a time slice at 1,000 milliseconds through this particular project. Figure 13 shows a random line taken through this project. The trajectory of this random line is indicated in Figure 11.
CONCLUSION

The MegaProject methodology provides an essential, common reference framework for all 3-D seismic datasets in PDO. This reference framework is used for processing and interpretation by employing the workstation support environment. The seismic data are available online as a consistent library of MegaCells, which enable fast, and efficient data retrieval and loading.

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ABOUT THE AUTHOR

Maarten Ligtendag graduated in 1988 in Applied Geophysics from the Faculty of Mining Engineering at Delft University of Technology. He joined Shell International in 1989 and worked as a Seismic Processing Geophysicist at Shell Expro, London until 1993. After a one year posting to Shell Australia working in seismic data processing, Maarten was transferred to Petroleum Development Oman to take up the position as a Seismic Processing Controller.

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