Brasil MegaSurvey – A Regional Study of the Campos Basin

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Abstract

In the frontier, deepwater province of the Campos Basin, finding hydrocarbon resources proves challenging due to a poor understanding of the stratigraphy, subsurface structure and depositional systems. All of which must be understood in a regional as well as a local context.

To date, exploration companies' regional models have been based on a mixture of 2D and 3D seismic data of varying size, vintage, orientations and quality. Consequently the interpretation results have been incomplete and lacking detail. To address these issues, PGS has initiated the Brasil MegaSurvey Projects (working with partners Gaia and NUPETRO) utilising a two-phase approach in the Campos Basin.

Phase 1 (Regional Well Correlation Project) aims to extend the sequence stratigraphy in the proximal area into the frontier, deep-water regions of the Campos Basin, where well data is sparse. This will provide a better understanding of the main depositional systems (reservoirs) and its extent into the depocentre of the Basin.

Phase 2 (Regional 3D Interpretation) utilises a large, consistent 3D seismic data set, produced by merging a number of volumes of 3D seismic. A consistent horizon interpretation that is tied to released well control will enable asset-focussed oil companies to concentrate on the more detailed 'search for the subtle trap' to find, understand, and develop potential prospects. The MegaSurvey provides both the regional picture and prospect-size detail from a single dataset and visualisation of the subsurface both on a scale and resolution that has hitherto been unavailable.

The results of the projects are leading to a step changed in the understanding of the Campos Basin, especially the Upper Cretaceous deepwater turbidites and fan systems.

Introduction

The Campos Basin presently shows approximately 44 oil fields, seven giants, holding up to 85% of total Brasilian oil reserves and 40% of total natural gas reserves (Guardado et al., 2000). The basin produces mostly from turbiditic sandstones of the Carapebus Formation (Cretaceous-Tertiary), comprising 80% of the total production. Other important reservoirs are calcarenites of the Macaé Formation (Albian), bioclastic lacustrine carbonates of the Lagoa Feia Formation (Barremian), and fractured basalts of the Cabiúnas Formation (Neocomian). However the majority of these fields are located within the shallow water, shelf area of the Campos Basin. Finding prospects in the deepwater region, especially those with subtle geophysical expression is a challenge, and a thorough understanding of the geology is essential. To achieve this, the subsurface structure and depositional systems must be understood in a regional as well as a local context.

In the Campos Basin there is a considerable amount of 3D seismic data including surveys that have been acquired for field development and production and non-propriety data. However surveys are of different vintages, orientations, and quality. This makes it difficult to extract, use, and compare information from adjacent surveys. The lack of stratigraphic knowledge within the deepwater area also makes it a challenge for exploration companies to venture into this area.

To address this problem, PGS initiated the MegaSurvey Project of the Campos Basin. Phase 1 extends the sequence stratigraphy from the proximal area to the deeper parts of the basin, using a serious of regional 'pseudo' 2D lines and regional grids derived from 3D data.

Phase 2 merged a number of 3D surveys into a large, consistent 3D data set (Fig. 1). The 3D MegaSurveys will enable companies to view their assets in a regional 3D seismic perspective, with regionally consistent interpretation, released well data, and interpreted structural profiles. Interpretation of the Campos Basin MegaSurvey (18,000 km^2) is expected to be completed in December 2005.

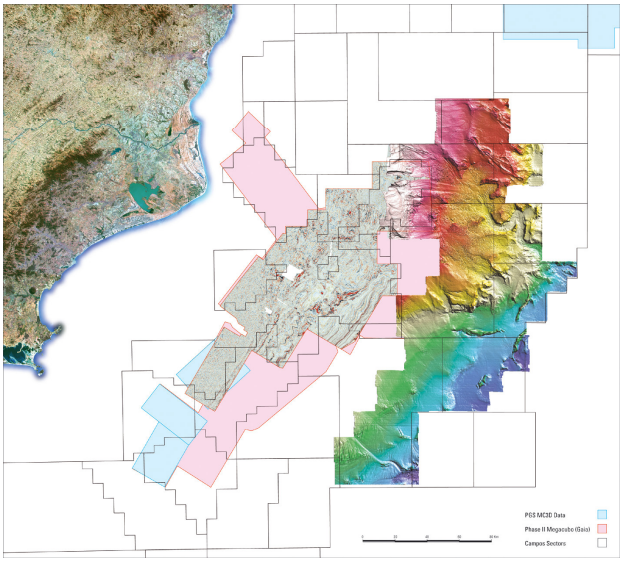

Figure 1 Campos Basin showing the merged 3D seismic data extent (Fugro Mega Cubo & PGS MegaSurvey) in the deepwater region, overlain by the Sea Bed interpretation.

Methodology

Pseudo-2D Lines Extraction

For Phase 1, two sets of seismic data were used for interpretation (Fig. 2): a) extracted 'pseudo' 2D regional lines and b) a regional 3D 10 km grid for interpretation constraints.

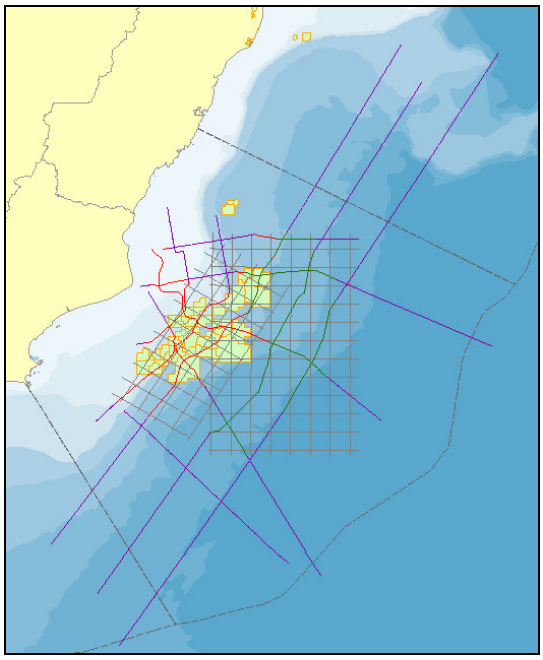

Figure 2 Map of 'pseudo' 2D lines and extracted grid from 3D data in the Campos Basin.

The 'pseudo' 2D lines are composites of 2D and extracted '2D' from a 3D seismic volume. Each line was processed with static, amplitude, gain and polarity corrections. Along with the seismic data, a total of 161 wells were used to correlate and tie the lithological and stratigraphical information to the seismic data on a basin-wide scale. Synthetic generation was also carried out for key wells that tied to the 'pseudo' 2D lines.

3D Data Merging

Phase 2 requires the merging of the various 3D seismic volumes in the area as the underlying data for interpretation.

The 3D seismic surveys are usually available as final time-migrated datasets. These first undergo a quality control process (QC), and are then loaded onto the PGS processing system to merge the surveys together.

The different vintages, data acquisition, and processing of the input surveys result in considerable variation in data quality. Thus, some adjustments of the data are necessary to achieve the optimal merge of all the different surveys. The MegaSurvey sequence consists of:

- input final migration (SEG-Y);
- interpolation, rebinning to standard grid;
- polarity checking;
- phase analysis;
- amplitude matching;
- time matching (bulk shifts);
- output final merged volume

QC of the merges is vital and is performed by inline/crossline analysis of both amplitude and time data in an interactive workstation review process. The main objective is to preserve the character of the original seismic data while maintaining the overall quality of the final product.

Interpretation, Visualisation and Analysis

The vast size of the MegaSurvey projects pushes both the interpretation hardware and software to their limits. An initial feasibility study was carried out to determine a range of project parameters for data loading, autotracking, gridding, and mapping. This work developed both a data management and interpretation methodology for these projects.

Interpretation of the 'pseudo' 2D lines and the 3D 10 km grid provided a framework of a series of gridded TWT structure maps for eleven of the key regional horizons across the Campos Basin. These horizons will provide the framework for more detailed regional mapping using the merged 3D data set. The horizon interpretations are tied to the 161 wells.

The merged 3D seismic data is loaded to a number of visualisation systems including HoloSeis, DeskSeis, VuPak. Visualisation is a very effective tool for QC of the MegaSurvey interpretation. Interpreted horizons are loaded into ERMapper and by using the rotation and illumination capabilities of the software, any merge problems or interpretation misties are quickly identified as lineaments that are clearly non-geological. An iterative process of interpretation and QC enables consistent and accurate interpretation across the entire MegaSurvey. ERMapper also allow rotation, shaded relief, and illumination displays that provide new insights into the subsurface structure and depositional systems (Fig. 3).

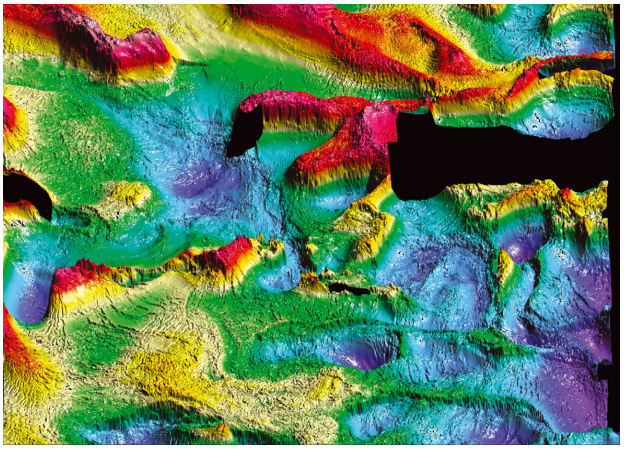

Figure 3 Detail of the Blue Marker horizon in the Campos Basin.

Interpretation Results

The Campos Basin Phase 1 interpretation focuses on eleven principal regional horizons (Figs. 4 and 6):

- Sea Bed;
- Mid-Miocene;
- Mid-Oligocene (Blue Marker; see Fig. 3);
- Mid-Eocene;
- Top Cretaceous;
- Top Cenomanian;
- Nr Top Albian;
- Top Salt;
- Base Salt;
- Coquinas; and
- Acoustic Basement.

Phase 2 will select eight of the above horizons for full interpretation on the merged 3D seismic volume.

The released well data for the project were obtained from ANP/BDEP, and were used as the basis for deriving the stratigraphic tops, associated two way times and lithostratigraphical correlation based on log data.

Structure and Stratigraphy

The Campos Basin is a one of a series of passive margin depressions that formed along the Brasilian coast during the break-up of the Gondwana Supercontinent in Early Cretaceous time (Emery *et al.*, 1975). The main structural trends observed in the adjacent onshore region of the Campos Basin shows a northeast trend. These structures are formed by faults that were generated during the Brasilian Orogeny (Late Precambrian) and played a major role in determining the distribution of the tectonic extension in the area of the Campos Basin. The Paraiba do Sul River, which had a fundamental role in the development of the petroleum systems in the Campos basin, follows a zone of weakness associated with this old Precambrian fault system (Hasui & Ponçano, 1978; Macedo, 1990).

Salt movement has played a significant role in the Campos Basin and figure 3 shows the structural detail associated with salt migration, revealing areas of salt withdrawal and salt walls.

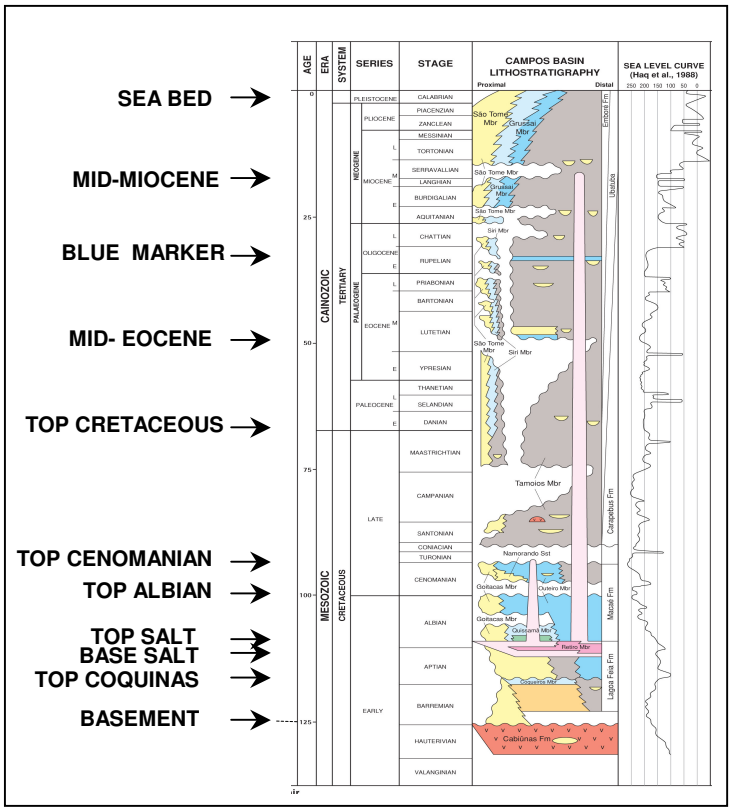

Figure 4 Lithostratigraphic column and the regional horizons interpreted in Phase 1.

Interpretation of the Campos Basin reveals the following characteristics of these main horizons and sequences; based on SEG-Y normal polarity dataset:

Acoustic Basement

The acoustic basement is characterised as an increase in acoustic impedance and picked as a peak. The basement

shows the regional structural trends within the Campos basin, that is, prominent northeast trending fault patterns, and northwest transtensional pull apart transfer zones.

Coquinas

The Coquinas reflects the onset of the transition phase in the Campos Basin and shows an increase in acoustic impedance and therefore picked as a peak. The Coquinas and overlying transition phase sediments are highly productive source rock of the Lagoa Feia Formation.

Salt

The evaporitic deposits is regional in extent and the top of the salt picked as an increase in acoustic impedance and picked as a peak

Albian

The Albian is characterised as the change from a shallow carbonate sea environment to the clastic input of the Upper Cretaceous and Tertiary. The change form clastics to carbonates generates an increase in acoustic impedance and is picked as a peak

Cenomanian

The Cenomanian is a transgressive event picked as an increase in acoustic impedance throughout the region. The Cenomanian marks an important change where large scale turbidites are deposited

Cretaceous

The Cretaceous-Tertiary boundary is marked by an increase in acoustic impedance throughout the region and is picked as a peak.

Eocene

Due to regional variation in the Eocene marker, from diaimitic marker to sand turbities, the seismic signature varies from a trough to a peak. Therefore, the Top of the Eocence has been picked on the zero crossing across the region.

Blue Marker

The regional expression of the Blue Marker (Mid Oligocene) is a transgressive carbonate event (maximum flooding surface). The strong regional increase in acoustic impedance is characterised as a strong peak throughout the region.

Miocene

The Top Miocene is marked by an increase in acoustic impedance and picked regionally as a peak. The Top Miocene defines a sequence boundary covered locally by productive turbidite sands and in the more proximal areas, it define the Miocene prograding delta.

Conclusions

Regional mapping and correlation within the Compos Basin have shown that the reservoirs that are present in the proximal area extents into the deeper basinal regions. Seismic attribute analysis beneath the Blue Marker shows detail of the channel systems in the deep water area of the Campos Basin (Fig. 5).

This initial work on the Campos Basin MegaSurvey has allowed visualisation of the subsurface both on a scale and resolution that has hitherto been unavailable. For the first time, the regional picture and prospect-size detail are both available from a single dataset.

The Campos Basin MegaSurvey allows:

- evaluation of entire basin in single data set;
- regional seismic attribute analysis / interpretation
- conistent seismic to well correlation
- evaluating regional play fairways;
- re-evaluating held acreage;
- evaluating open acreage;
- re-evaluating producing fields;
- re-evaluating abandoned fields; and
- defining well locations.

The MegaSurvey Projects are also likely to form the basis of a number of further studies including basin modelling, potential field modelling, and further seismic attribute analysis.

The MegaSurvey Projects provide an essential new tool to help fully unlock the potential of the Campos Basin.

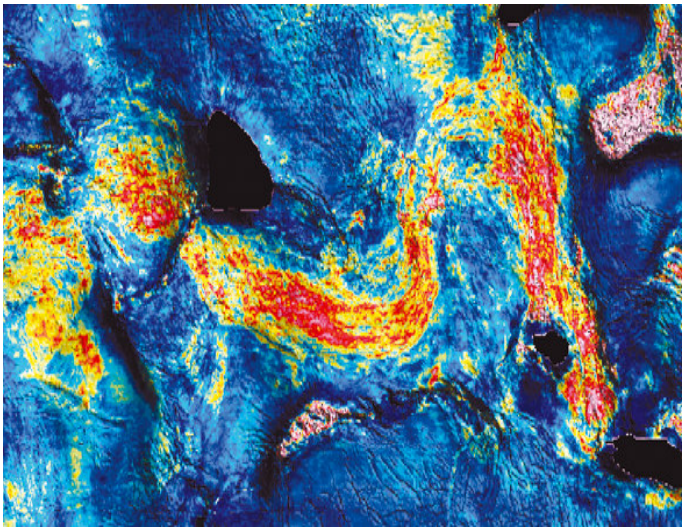

Figure 5 Seismic attribute analysis illustrating the channel systems and salt walls within the deepwater Campos Basin area.

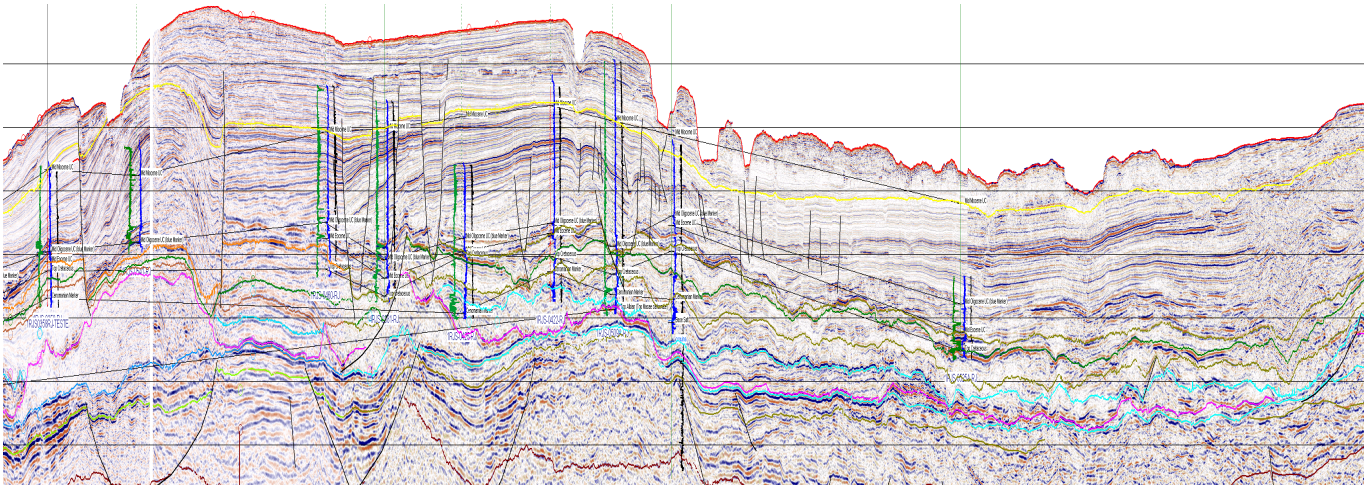

Figure 6 Interpretative cross-section of the 'pseudo' 2D line tied to well data.

Acknowledgments

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