ओएनजीसी
ONGC

Broadband Processing of Conventional 3D Seismic Survey Improves the Reservoir Characterization of Gas Hydrate Deposits in an Offshore India Basin

aspentech | Case Study

> “The final broadband processed data are much superior to the conventional processed data showing vertical fault systems and a thin hydrate reservoir.”
>
> - Dr. Anand Prakash, Chief General Manager, ONGC

CHALLENGE

Find a way to help interpreters at ONGC successfully identify and map hydrate deposits in the Krishna Godavari (KG) basin off the coast of India, through more accurate reservoir characterization.

SOLUTION

Advanced broadband processing technology included in Aspen Echos™ was used to obtain new details from legacy seismic data. Velocity model refinement using grid tomography and depth imaging in Aspen GeoDepth™ provided additional information about the presence of gas hydrates in the reservoir. AVO analysis using Aspen SeisEarth™ enhanced mapping of the gas hydrate deposits.

VALUE CREATED

- Broadband processing enabled the extraction of additional information from legacy data without the need for further costly acquisition.
- Sharper subsurface images provided a more detailed description of the reservoir and enhanced data interpretability.
- Better mapping of gas hydrate deposits led to identification of the site for pilot production drilling.

Overview

Gas hydrate exploration in India has gained momentum since the discovery of the richest gas hydrate deposits in the world in the deep water of the Krishna Godavari (KG), Andaman and Mahanadi basins, offshore India. The presence of highly concentrated gas hydrate accumulations in a sand-rich reservoir significantly alters the physical properties of sediments, allowing these to be directly detected by conventional seismic data analysis and interpretation. 3D seismic data is the most powerful tool available for identifying gas hydrate reservoirs. Due to its limited bandwidth (10-60Hz), however, conventional seismic data is inadequate for analyzing thin reservoirs and mapping minor fault systems, especially in hydrate reservoirs which are less than 800 m below seafloor (MBSF).

Higher-Resolution Seismic Images and a Better Description of the Reservoir

The study area is located off the East Coast of India in the Krishna Godavari (KG) Basin (Figure 1). Several wells had been drilled and cores tested in the area. Gas hydrates in sand-rich reservoirs with varying grain sizes, from coarse silt to gravel taken from core samples, were encountered in the wells. Conventional seismic data showed poor temporal resolution in the target zone, and it was severely masked by ghost energy, so that it was impossible to obtain any reservoir level information. Minor fault systems at the reservoir level were not discernible.

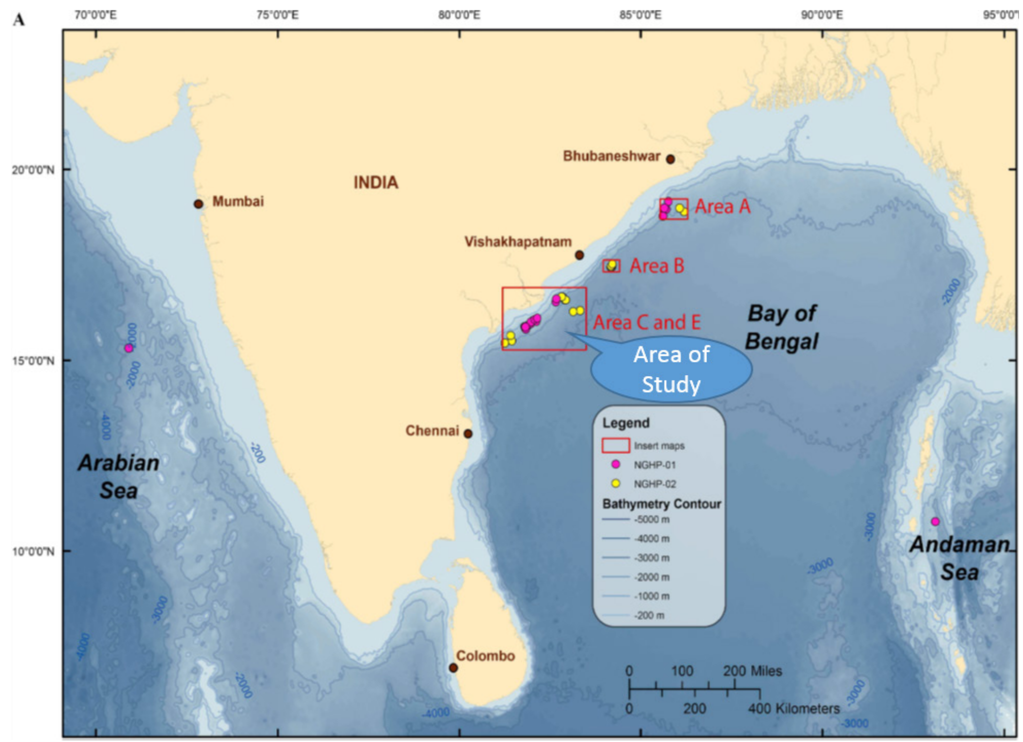


Figure 1. The study falls within areas C and E (marked).

In order to obtain higher-resolution seismic images and a better description of the reservoir, the legacy 3D seismic data was reprocessed using Aspen Echos processing software to de-signature and de-ghost the data. This was followed by Kirchhoff Prestack Migration using RMS velocity and Eta fields. Finally, the 3D dataset was depth migrated in Aspen GeoDepth using an interval velocity model derived following five grid tomography iterations.

Superior Results from Broadband Processing

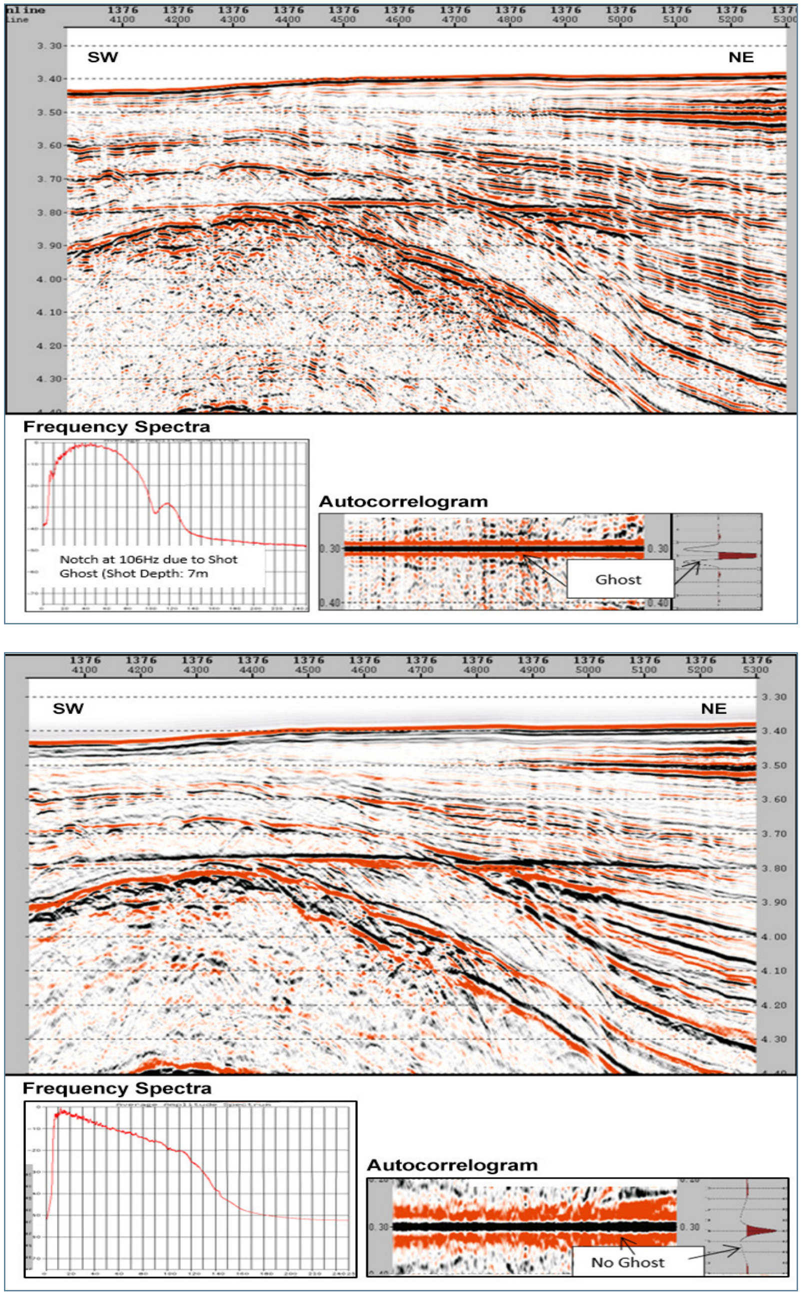


Figure 2. Seismic section, frequency spectra and autocorrelogram before (top) and after de-ghost process (bottom).

Figure 2 shows the effectiveness of de-ghost processing using Aspen Echos. Final broadband processed data are superior to conventionally processed data, showing vertical fault systems and a thin hydrate reservoir. Due to the tuning effect of thin beds and the ghost effect in the conventionally processed data, the BSR (Bottom Simulating Reflector) was continuous and high amplitude, and masked the fault system (circled). The broadband data clearly eliminated those effects and produced a superior image.

In an RMS amplitude map (Figure 3), it was possible to see two separate hydrate accumulations in the study area. Minor faults at the reservoir level could be clearly observed.

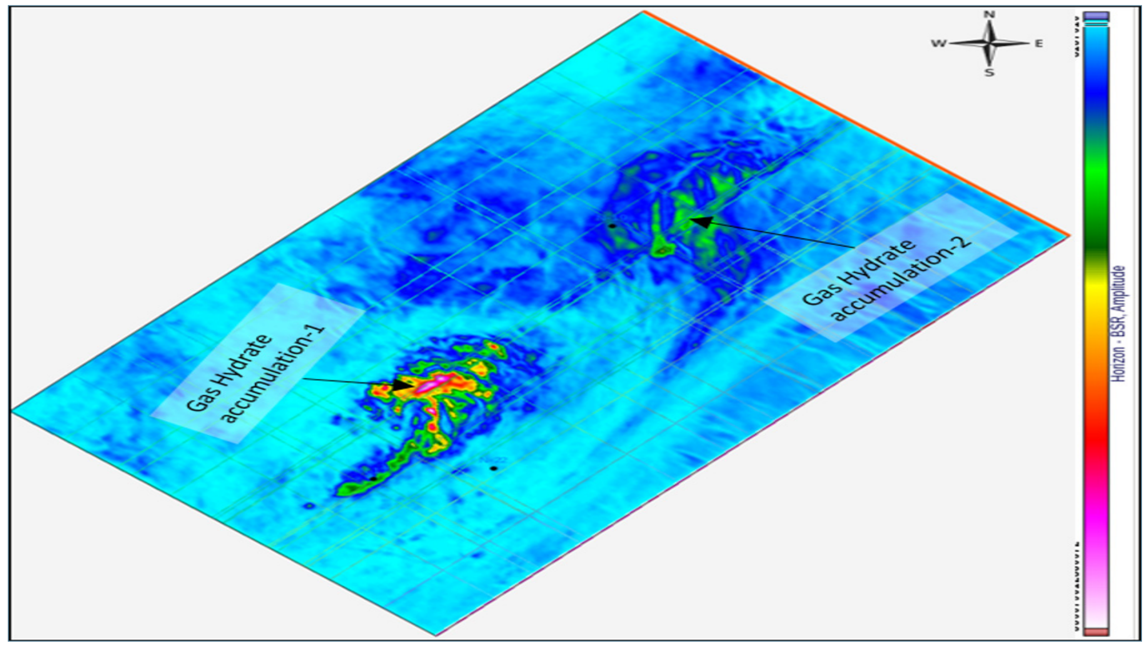


Figure 3. The RMS amplitude map along BSR indicates two separate gas hydrate pools in the area; the amplitude variation indicates the varying concentrations of gas hydrates.

AVO analysis of the prestack time-migrated (PSTM) data using Aspen SeisEarth QSI demonstrated that the BSR was showing a class III AVO anomaly. Horizon slices (Figure 4) seen along BSR from AVO attribute volumes – Intercept, Gradient, Product (I*G) and Scaled Poisson's Ratio – revealed striking images showing gas hydrate distribution in the reservoir concentrating at the structural highs.

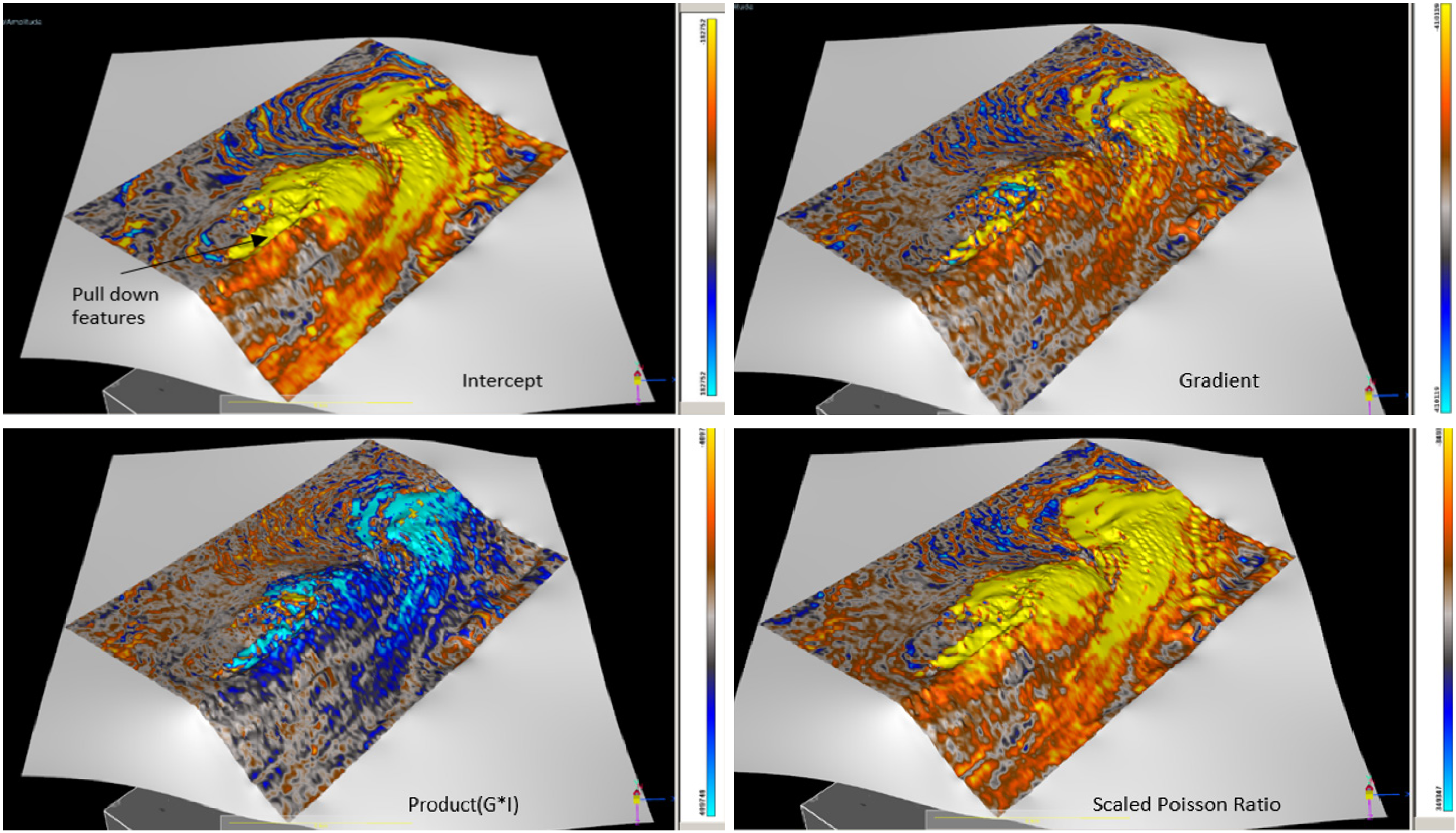


Figure 4. Horizon slices taken from AVO attributes (I, G, I*G and Poisson Ratio). Gas hydrate distribution at structural highs. Pull down features due to gas above the hydrate layer and faulted BSR.

A Kirchhoff anisotropic prestack depth migration (PSDM) and final interval velocity field obtained by several iterations of grid tomography, produced a significantly improved seismic image. Figure 5 shows a representative PSDM section across the hydrate accumulation displaying minor and major faults cutting the BSRs and running up to the seafloor.

The deeper BSR is observed for the first time in the PSDM section which was not seen in the PSTM processed data.

Several wells were drilled with logging measurements to probe the two hydrate accumulations in the study area. Resistivity logs clearly indicated a hydrate layer of ~30m thickness.

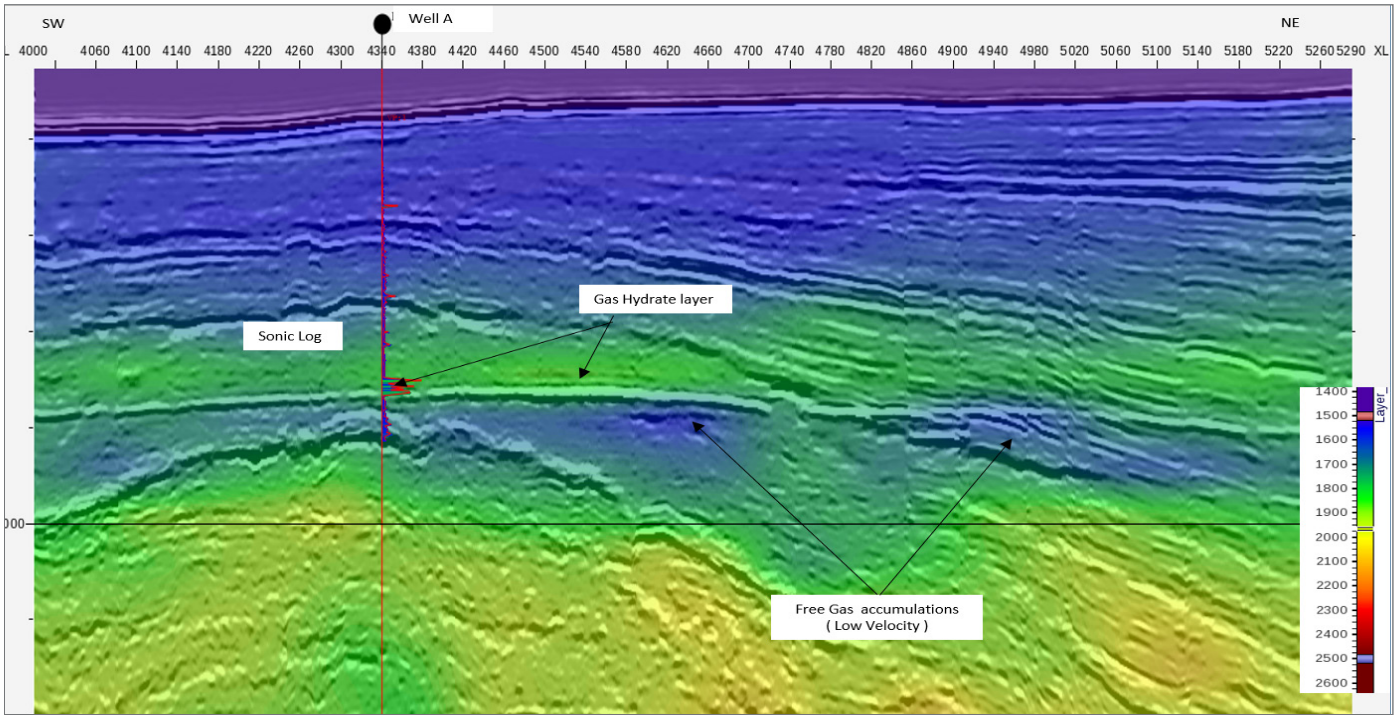


Figure 5. PSDM section overlaid by interval velocity and sonic log matches with the high velocity hydrate layer with BSR at depth ~2865 m. The low interval velocity below BSR indicates some free gas accumulations.

Conclusions

Broadband processed seismic data, whose bandwidth is more than four octaves (4-120 Hz) higher than traditional processing, helped depict minor reservoir level faults, leading to more accurate delineation of the hydrate reservoir.

The RMS amplitude of the mapped BSR horizon clearly indicated two separate deposits of gas hydrates in the area. The depth-migrated seismic data showed additional hydrate layers below the primary layer. This was confirmed during drilling.

Small scale faults in the reservoir and faults running up to the seafloor clearly established the ongoing melting of hydrates and escape through the seafloor.

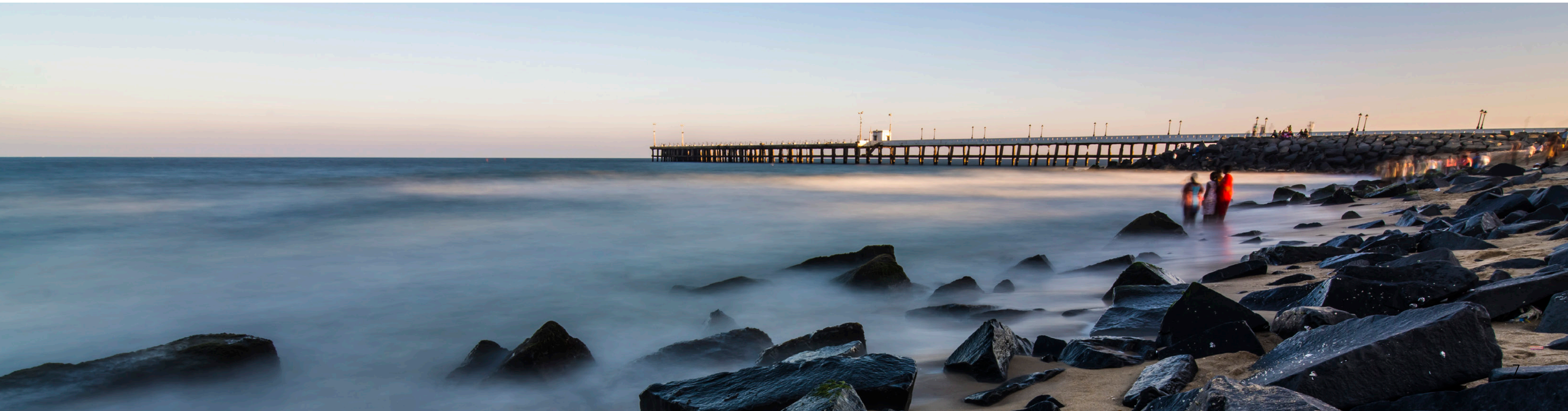
The velocity field obtained by several iterations of fine grid tomography showed a high-velocity hydrate layer above BSR and some free gas accumulations below BSR showing very low velocity. This correlated well with the sonic log. The gas reserves were comparable (by volume) with the reserves of major conventional gas fields.

Benefits

The use of broadband processing enabled the extraction of additional information from legacy data without the need for further costly acquisition. The broadband processed data, characterized by sharp and clean wavelets that deliver an increased frequency bandwidth, provided significantly improved subsurface images, enabling more detailed interpretation.

Depth migration of the 3D data enhanced interpretability and improved the reservoir description. A deeper hydrate layer was observed for the first time on the PSDM section which had not been visible in the PSTM data.

Better mapping of gas hydrate deposits led to identification of the site for pilot production drilling.



About AspenTech

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

aspentech.com