

Presalt Imaging in the Santos Basin

Imaging method improves resolution, decreases uncertainty in presalt plays.

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PGS' data domain Least-Squares Migration (LSM) delivers high-resolution images with more reliable amplitudes to provide accurate rock and fluid properties and de-risk exploration. It uses detailed earth models, created using Full Waveform Inversion (FWI) and geological constraints, to iteratively obtain an optimal image of the earth's subsurface.

LSM has emerged as a new standard in high-end imaging, providing the level of resolution and amplitude fidelity necessary for prospect risk mitigation, reservoir characterization and well planning. A recent application of PGS LSM to data from the Buzios Field in the Santos Basin of Brazil proves the benefit of the technology at all stratigraphic levels, but most importantly in the presalt plays.

PGS' Santos Vision program covers 18,919 sq miles (49,000 sq km) of the prolific Santos Basin and delivers on the industry's demand for accurate seismic imaging of presalt hydrocarbon plays offshore Brazil. While existing products, based on conventional imaging solutions such as Kirchhoff Prestack Depth Migration (KPSDM) and Reverse Time Migration (RTM), provide a level of seismic detail that helps outline prospects and capture the hydrocarbon reservoirs, LSM has taken the imaging and characterization of reservoirs to new levels.

Superior image from good velocity model

Reservoir targets in the Santos Basin are primarily presalt carbonate buildups underneath a heterogeneous section of salt. The major industry focus on the presalt hydrocarbons requires precise seismic imaging to minimize uncertainties in reservoir definition. Therefore, building an accurate and detailed velocity model for the reservoirs is key to the Santos Vision program. A unique implementation of FWI utilizing the complete seismic wavefield generated an accurate and geologically consistent velocity model down through the presalt section. An understanding of the Layered Evaporite Sequence (LES, salt) complexity and the heterogeneity of the postsalt carbonate layers was incorporated in the model building process. The final velocity model successfully captured the variability in the postsalt sediments, including the Albian carbonates and the LES.

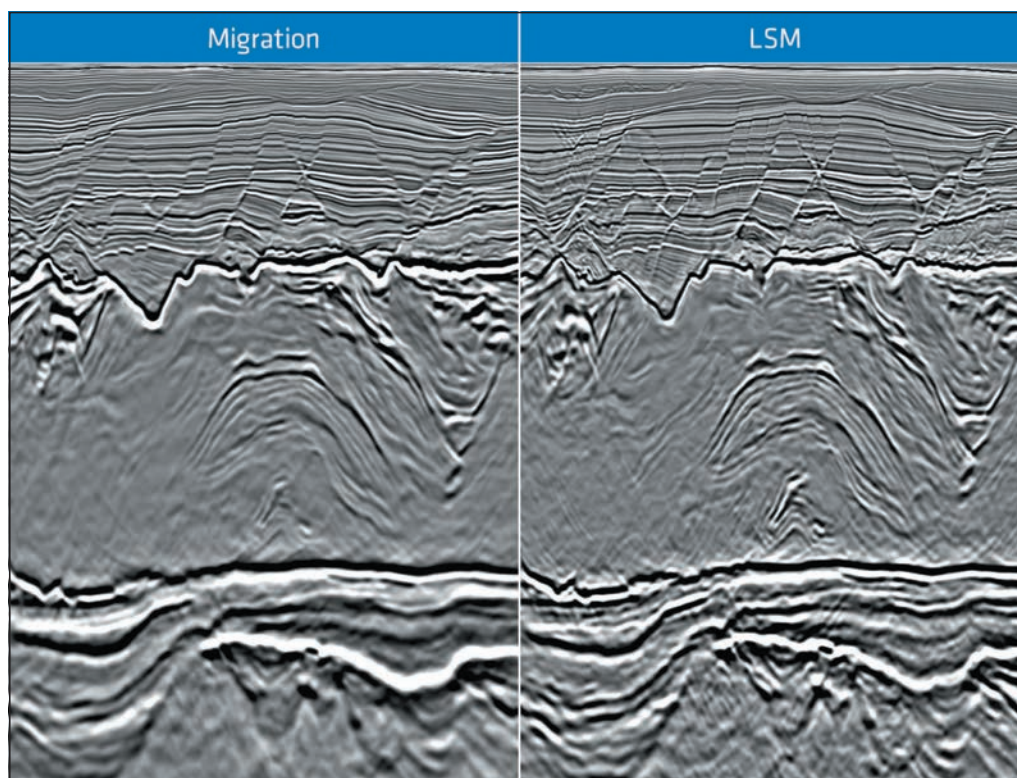
Imaging by inversion

Even with an accurate velocity model, conventional depth migration only produces an approximation of the earth's true reflectivity. The main limitations are attributed to incomplete acquisition and variable illumination beneath a complex overburden (e.g., salt or carbonates). Therefore, migrated images often suffer from limited wavenumber content and reduced granularity, especially in the presalt. LSM, on the other hand, tackles the limitations by posing the seismic imaging problem as an inversion process seeking optimal images closely representing the earth's reflectivity.

While most commercial LSM algorithms are implemented as multidimensional deconvolutions in the image space, the PGS data domain LSM algorithm solves for the earth's reflectivity by means of an iterative data-fitting workflow similar to FWI. More than one iteration of data modeling and migration is often necessary to obtain the optimal image. The engine of PGS LSM efficiently propagates high-frequency seismic data using the detailed earth models derived from FWI and in-depth interpretation. The results are high-resolution images with balanced amplitudes and reduced illumination variations. The reflectivity models have more reliable amplitudes and are more suitable for quantitative reservoir characterization.

Improve target definition and mitigate risk

The PGS iterative, data domain LSM was applied over the Buzios Field in the Santos Basin to exemplify the inversion approach on presalt reservoirs. The results highlighted how fault patterns and stratigraphic geometries are better resolved with LSM. They provide significant uplift for prospect maturation and reservoir characterization. The PGS LSM enhances image resolu-



The comparison between KPSDM and PGS LSM highlight the stunning improvement in postsalt and presalt sequences. The resolution and fault recognition at the presalt reservoir section on the LSM image enables detailed analysis in seismic stratigraphy and reservoir characterization. (Image courtesy of PGS)

tion, mitigates compartmentalization risk, resolves depositional signatures and limits uncertainties in seismic stratigraphy characterization of reservoir facies varia-

tion. PGS LSM technology proved to be beneficial at all stratigraphic levels of the Santos Basin, but most importantly in the prolific presalt play. ■

Don't Miss These Near-Surface Activities at Annual Meeting

In seeking to advance and promote the science, technology and professional practice of applied near-surface geophysics, the Near-Surface Geophysics Technical Section has organized the following technical and educational components throughout the week of the Annual Meeting.

Day	Time	Room	Title
Monday	1:50–5:10 p.m.	217C	NS 1: Dynamic Coastal Environment: Crossing the Land/Sea Interface
		303B	SS 2: Geoscientists <i>Without Borders</i> ® and Humanitarian Geophysics
Tuesday	8:30–11:50 a.m.	217C	NS 2: Engineering Geophysics
		301B	SS 3: SEG/AGU Hydrogeophysics
	9:20–11:50 a.m.	Poster Station 7	NS P1: Machine Learning and Airborne Geophysics
	12:05–1:05 p.m.	221A	Panel: Solving Near-surface Problems with Geophysics and Engineering
	1:50–5:10 p.m.	217C	NS 3: Imaging and Modeling 1
Wednesday	7–10 p.m.	Iron Cactus	Near-Surface Geophysics Technical Section Reception
	9:20–11:50 a.m.	Poster Station 6	NS P2: Novel Methods
	1:50–5:10 p.m.	221C	NS 4: Applications for Archaeology, Void and Target Detection
		225C	NS 5: Imaging and Modeling 2
		304B	SS 8: Surface Wave Method Applications
1:50–4:10 p.m.	Poster Station 7	NS P3: Seismic Processing and Applications	
Thursday	8:30 a.m.–5 p.m.	217D	Summit: Near-surface Geophysics for Archaeological and Forensic Applications
Friday	8:30 a.m.–noon	225B	Workshop W-21: Ambient Noise Imaging and Monitoring for High-resolution Spatial and Temporal Near-surface Characterization and Exploration Seismology