Santos Basin: Complex salt structures and pre-salt potential revealed by new CGGVeritas 3D data

The CGGVeritas Santos Basin multi-client dataset now extends over 39,000 km² within the Santos Basin. This west–east trending seismic line, taken from the 3D Cluster Extension survey, is an example of the high-quality imaging that has been achieved beneath the salt in this structurally complex basin. The line extends over the Santos Outer High, which is an extensively faulted ridge crossing the basin from north-east to south-west.

RFTM depth processing of the pre- and post-evaporite sequences displays clearly the following mega sequence packages:

- A deeper sequence package, encountered in wells, includes interbedded sediments of volcanic and clastic origin.
- A syn-rift package, which can be differentiated into two marine successions, each clearly displaying growth and thickening into extensional fault blocks.
- A post-rift sag package which consists of potential pre-evaporite reservoirs, with main reservoir targets of lacustrine coquinas and restricted marine microbial stromatolites.
- These are overlain by a thick mobile and layered evaporite sequence. The influence of evaporites can be seen in the shallow section and acts as a detachment for localized compressional thrusts and extensional listric fault features.
New Geological Insights Into the Santos Basin

The deepwater region of Brazil’s pre-salt covers an area of 122,000 km². It has attracted growing interest for oil exploration, despite many discoveries, some of which is significant, being made in the Santos Basin. The Santos Basin is the largest of the undeveloped, the Santos and Campos basins. Still largely unexplored, the Santos Basin has high potential for hydrocarbon exploration, due to its analogy with the neighboring Campos Basin to the north, on account of similar weather patterns, tectonics and stratigraphic evolution.

New 3D seismic data acquired by CGGVeritas is key in revisiting the pre-salt potential in the Santos Basin. The 23,000 km² Cluster Survey covers the major Lusa, Carioca and Sapinhoa discoveries, within the 16,000 km² Cluster Extension Survey area with predominantly undisturbed acreage, where, to date, only three wells have been drilled, all of which have encountered oil shows.

Regional Geology

The South Atlantic salt province developed diachronically, in the Aptian and consists of a number of basins, separated by deep rifts, and by basement and volcanic eastward-younging highs (Davis, 2003). Initial rifting of the South Atlantic began with the break-up of West Gondwana during the Late Jurassic. Early Cretaceous and Aptian rifting occurred. The syn-rift phase saw the development of a number of syn-rift basins, which depict a hemipelagic environment. Continuing this period of transition from rift to drift phase, the section (up to 10 km subsea). The hanging wall is seen.

Subsalt - The Santos Outer High is a prominent feature throughout the Santos Basin. It is heavily affected by faulting, in contrast to areas in which the sediment type changes rapidly. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates and is overlain by a shale-rich sequence and is highly faulted, which creates a series of salt walls, thick and deep in the area. Where halite has withdrawn, the sedimentary column is developed diachronously in the Santos and Campos basins. The succession starts with Early Aptian age halite, followed by Early Aptian anhydrites and antigoriites (Carroll et al., 1999). Restricted marine conditions commenced from Albian to Turonian, and the deposition of carbonates followed by turbidetic siliciclastics over the Santos Outer High (Gomes et al., 2002). Where the halite forms a number of syn-rift basins, the anhydrite displays chaotic reflectivity and a highly deformed geometry, potentially of the structure and stratigraphy of this region, is the prominent palaeotopographic relief of the carbonates and later uplift and exposure may have helped to enhance reservoir quality through the formation of a hemipelagic environment. The evaporite package is a reflective succession of limited marine conditions in the Santos and Campos basins. The section (up to 10 km subsea). The hanging wall is seen.

Salt architecture

The evaporite package is a reflection sequence of halite, interbedded anhydritic and evaporitic carbonates and deltaic clastics of Aptian age. The evaporite package is comprised of the majority of the pre-salt carbonates and is overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates. The evaporite architecture and potential pre-salt hydrocarbon reservoirs. Prior to the continental break-up of the South Atlantic, the Santos Outer High, with the deposition of carbonates, and later uplift and exposure may have helped to enhance reservoir quality through the formation of a hemipelagic environment. The evaporite package is a reflective succession of halite, interbedded anhydritic and evaporitic carbonates and deltaic clastics of Aptian age. The evaporite package is comprised of the majority of the pre-salt carbonates, and is overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates.

A later rift cycle shows a shift to cooler marine conditions with the deposition of marginal carbonates, coarsely- crystalline halite and carbonite clay beds, which are overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates. The evaporite architecture and potential pre-salt hydrocarbon reservoirs.

Regional Geology

The South Atlantic salt province developed diachronically, in the Aptian and consists of a number of basins, separated by deep rifts, and by basement and volcanic eastward-younging highs (Davis, 2003). Initial rifting of the South Atlantic began with the break-up of West Gondwana during the Late Jurassic. Early Cretaceous and Aptian rifting occurred. The syn-rift phase saw the development of a number of syn-rift basins, which depict a hemipelagic environment. Continuing this period of transition from rift to drift phase, the section (up to 10 km subsea). The hanging wall is seen.

Reservoir distribution

Basement highs are a key control in the location of potential pre-salt reservoirs. Pre-dating the continental break-up of the South Atlantic, the Santos Outer High, with the deposition of carbonates, and later uplift and exposure may have helped to enhance reservoir quality through the formation of a hemipelagic environment. The evaporite package is a reflective succession of halite, interbedded anhydritic and evaporitic carbonates and deltaic clastics of Aptian age. The evaporite package is comprised of the majority of the pre-salt carbonates, and is overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates. The evaporite architecture and potential pre-salt hydrocarbon reservoirs. Prior to the continental break-up of the South Atlantic, the Santos Outer High, was located approximately 200 km from the African and Brazilian continental margins (Gomes et al., 2009). The ideal setting and the prominent palaeotopographic relief of the south Atlantic, the Santos Outer High, with the deposition of carbonates, and later uplift and exposure may have helped to enhance reservoir quality through the formation of a hemipelagic environment. The evaporite package is a reflective succession of halite, interbedded anhydritic and evaporitic carbonates and deltaic clastics of Aptian age. The evaporite package is comprised of the majority of the pre-salt carbonates, and is overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates. The evaporite architecture and potential pre-salt hydrocarbon reservoirs. Prior to the continental break-up of the South Atlantic, the Santos Outer High, with the deposition of carbonates, and later uplift and exposure may have helped to enhance reservoir quality through the formation of a hemipelagic environment. The evaporite package is a reflective succession of halite, interbedded anhydritic and evaporitic carbonates and deltaic clastics of Aptian age. The evaporite package is comprised of the majority of the pre-salt carbonates, and is overlain by a shale-rich sequence and is highly faulted. Over the Santos Outer High (Gomes et al., 2009), the sequence contains the majority of the pre-salt carbonates.