The transition from continental extension to seafloor spreading marks the separation of continents and the development of conjugate passive margin systems. It causes major restorations of the regional tectonic conditions, with wide implications for basin evolution, and affects the formation of petroleum systems. In restricted environments, the continental break-up commonly occurs somehow close to the period of salt deposition, such as in the South Atlantic basin or the Gulf of Mexico. Unsurprisingly, it is widely debated whether salt deposits postdate or predate the continental break-up. Depending on the timing, salt basins might have formed either separately on each conjugate margin including scenarios with salt deposited on newly formed oceanic crust, or as a large salt basin that has been subsequently split during break-up.

Analysis on extensional faults near the base of salt allows us to narrow down the critical time interval of continental separation and provides insights into the condition during reservoir formation of the pre-salt plays. Key prerequisites for such investigations are high resolution regional-scale seismic products offering reliable and accurate imaging of the base of the salt and the reservoir-bearing sequences below, including their fault-controlled morphology. PGS implement a focused and integrated velocity model-building process, including refraction and reflection Full Waveform Inversion over the entire depth section, rigorously constrained by geological compatibility. High resolution broadband seismic imaging and Least-Squares Migration (LSM) provide high fidelity images of the pre-salt sediment geometries and fault architecture.

Comparing Santos Basin, Brazil... The pre-salt São Paulo Plateau is a rift-related basement high which contains the regional fairway for the prolific hydrocarbon play associated with pre-salt carbonate build-ups. Based on the salt and post-salt architecture (Figure 1), the plateau region is divided into three tectono-stratigraphic domains. The north-western Albian Gap domain is an approximately 40 km-wide zone of roll-over structures that displaced most of the Aptian layered evaporite sequence (LES) and largely lacks the post-salt Albian carbonates. A system of extensional faults (Cabo Frio Fault) delineates the Albian Gap from the adjacent mini basin domain of thick layered evaporite sequences bounding mini basins filled with post-salt sediments. Highly reflective layers of anhydrite and other evaporites within the LES indicate complex internal folding, while rather transparent sections refer to accumulations of intra-formational mobilized halite. The dominance of mini basins diminishes towards the adjacent fold belt domain, which reveals increasingly well imaged folding and diminishing complexity towards the distal section of the São Paulo Plateau. The São Paulo Plateau is bound by normal faults, such as the Merluza Graben system, with fault throws in excess of 3,500m. On the plateau, similar north-east to south-southwest trending faults form the basis of major pre-salt hydrocarbon reservoirs. Displacement along these fault systems continued during the deposition of the LES, which accumulated up to 4,000m in thickness at the graben systems, while the São Paulo Plateau received about 1,150–1,500m of evaporite deposits (Figure 2).

A key objective of the PGS regional-scale imaging project Santos Vision, which encompasses more than 49,000 km² of broadband 3D seismic, is the reliable and accurate imaging of the base of salt and the reservoir-bearing sequences below, including their fault-controlled morphology. The latter is a major element in play fairway analysis, and a useful guide to define hydrocarbon leads and prospects within the pre-salt play. Constructing an accurate model of the heterogeneous seismic velocity signature within the LES and its cover sequences is essential not only for imaging the pre-salt structural and depositional geometries, but also for assessment of the seal risk for the pre-salt reservoirs.

…to Kwanza Basin, Angola... The West African margin is conjugate to the Brazilian margin and reveals similar architectural elements for the rifted pre-salt section. However, separation of the continents was rather asymmetric and left a significantly wider portion at the Santos Basin than at the West Africa counterpart, including the Kwanza Basin of Angola. These differences are reflected in the visible post-salt architecture. The Kwanza Basin is dominated by a basinward gravitational gradient that causes up dip extension (Figure 3), which is balanced by downdip compression via the salt layer serving as the kinematic detachment. The Santos Basin lacks such a gradient at...
the São Paulo Plateau, where lateral salt movement due to displacement loading is caused by propagating Upper Cretaceous sedimentary wedges (Figure 4).

**Timing is Everything**

Timing and tectonic context of fault activity at the base of the Aptian salt in the South Atlantic basins affects the development of the pre-salt petroleum system. It has a direct impact on trap formation and hydrocarbon charge, while the prolific carbonate reservoir facies are associated with the fault-controlled paleo-relief, besides using sub-salt faults as proxy for the continental break-up. Rift-related faulting affects the development of the pre-salt reservoir carbonates and the shallow marine to lagoonal paleo-environment on the São Paulo Plateau. Fault movement continued at least into the early stages of the Aptian evaporite deposition as clearly indicated by the displacements of the salt base (Figures 4 and 5). Well-imaged volcanic layers interbedded with the pre-salt reservoir section were initiated at the deep grabens and later reached the São Paulo Plateau. Pre-salt faulting actually affects the salt sequence and the imprint on its top might be the result of salt withdrawal. Faulting was active during the pre-salt deposition and certainly affected the depositional (erosional) environment for the hydrocarbon reservoirs. Fault activity continued at least during the early stages of salt deposition and initiated in the graben structures and local depressions, while paleo-highs were eroded and subsequently covered by the evaporite sequence. Faulting ceased sometime during the deposition of the Aptian salt restoration of the rifted margins falls into this period.

**High Quality Imaging Critical**

The success of hydrocarbon exploration and production demands high quality seismic images that provide critical subsurface insight into prospective petroleum systems, enable an improved classification of play types, and mitigate the overall prospect risk. Both Santos Vision and high quality GeoStreamer data from Kwanza provide a high level of detail in post and pre-salt imaging. These datasets are ideally suitable for exploration efforts, including prospect maturation and hydrocarbon risk assessment of the pre-salt reservoirs. Innovative technologies such as LSM offer a further leap in enhanced image quality that help to delineate pre-salt fault patterns at very high detail and support confident seismic stratigraphy analysis.