Optimizing Exploration and Development Opportunities in Brazil's New Regulatory Scenario

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PROGRAM BOOK

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Optimizing Exploration and Development in Brazil’s New Regulatory Scenario

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Production decline in mature oil and gas fields is a natural phenomenon. To reverse this decline, an integrated approach between many different areas is necessary, resulting in a more reliable reservoir characterization and field development. This presentation will describe the workflow applied to the redevelopment (first workover campaign) of Macau Cluster fields (Potiguar Basin – RN - Brazil), and how the well production optimization led to an increase of 34% of the production in 11 months. One of the most important premises when studying a reservoir, is to begin with a good static model; hence, a high-resolution stratigraphy and facies model were applied to better assess the reservoir connectivity and flow units. The forementioned effort allowed the definition of different oil-water contacts for each zone, with the construction of robust HcPv 3D models. Also, the integration between petrophysics and reservoir engineering played a crucial role in establishing reservoir depletion levels and in estimating current water saturation and oil-water contact displacement. In this case, the usage of resistivity-independent water saturation estimation techniques (such as pulsed neutron logs) to monitor the reservoir through casing significantly reduced risks and aided in the identification of bypassed oil zones. Finally, the methodology for workover definition consists in (1) searching for bypassed oil zones in well logs; (2) checking the cement integrity; (3) looking at the well in the static model; (4) observe production of neighbor wells; (5) selecting perforating intervals based in cutoff parameters. Static and dynamic models, as well as examples of executed workovers will be presented, with the comparison between planned and executed and between former and late productions observed after intervention.

The Reservoir-to-Wire (R2W) business model is currently the best way to monetize gas fields reserves in unexplored Brazilian onshore basins, mainly those located in remote areas without a gas pipeline infrastructure, but with access to an electric power network connecting all the country. R2W was the business strategy assumed to acquire exploratory blocks at the Parnaíba Basin during the ANP 9th round bid 2007.

Since then, 150 wells have been drilled, being 62 exploratory wells, with a success rate higher than 30%, 88 production development wells with almost a hundred percent success. All these efforts resulted in a discovery of 54 billion cubic meters of non-associated gas distributed in ten adjacent fields, known as the Parque dos Gaviões.

Five of these fields are already in production with a potential gas rate higher than 8.4 million cubic meters per day, which is the gas rate demanded when all four thermal power plants are dispatching energy,
generating 1.4 GW now and 1.8 GW in the near future. Five gas fields are still in the production development phase. Gas production in Parnaíba Basin began in 2013 and so far, 13 billion cubic meters of gas has been produced. The current reserves in Parnaíba Basin add up to 31 billion cubic meters.

The development strategy in terms of timing and number of wells, associated to excellent rock properties for a dry gas, resulted in an average estimated ultimate recovery factor of 82%, already confirmed by mature areas performance. An integrated production management also plays a major role in the overall success of the Parnaíba Basin project, focusing on an adjusted incremental investments timing achieved by a detailed analysis on the energy future dispatch scenarios and production forecast of each field.

1.III Improved Reservoir Characterization of a Mature Field Through an Integrated Multi-Disciplinary Approach: Lagoa Parda Field, ES, Brazil
Miguel Nuñez (presenter), Lidiane Garcia, Erick Moreno, Karoline Conti, Kesley Melo, Leandro Lubiana and Jhonny Marquez, IMETAME Energia

The LP-10 reservoir from Lagoa Parda Field is located at the mouth of Doce River, in the Espirito Santo Basin, Espirito Santo State, Southeastern Brazil. Since its discovery in the early 1978's, this reservoir has produced over 57.8 MM bbl of oil from shallow (<1,700 meter), canyon filled with deep water sediments during Late Cretaceous of the Urucutuca Formation. Production is complicated by the heterogeneous nature of the sediments, water drive mechanism and water coning and channeling. A multidisciplinary team consisting of engineers, geologists, geophysicists, and petrophysicists was assembled to characterize and simulate the field. The objective of the team was to develop a reservoir management plan for the Lagoa Parda Field that would increase daily production and ultimate recovery. Available data included 3-D seismic, openhole logs from over 90 wells, four cores, and some production and pressure measurements. All available data will be used and honored in the interpretation process. Reservoir pressure data and production history were integrated with the seismic interpretation, log analysis, core descriptions, log correlations, and deterministic mapping to define the reservoir compartments. Seven reservoir regions were defined. The daily production was increased by 144% as a result of this first stage of this study. Also, 32 workovers/recompletions candidates were identified.

1.IV Rock Physics Modeling for Quantitative Seismic Characterization of Tight Sandstones in the Neuquén Basin, Argentina
Atílas Meneses da Silva (presenter), Petrobras; Ali Tura, Colorado School of Mines

The Basin-centered gas accumulation (BCGA) from the Lajas and Punta Rosada formations is composed of a stack of low porosity sandstones (4% to 10%), overpressurized and with continuous gas saturation, with thicknesses up to 1000 meters. The low porosity of these reservoirs results in low seismic sensitivity to the fluid variation. Therefore, traditional approaches used in conventional accumulations might not provide an accurate assessment for this type of reservoir.

A Hybrid rock physics modeling, which considers the shape of pores and grains as input, is used to predict the properties of these tight sandstones. The proposed workflow combines the inclusion models of Kuster-Toksoz (KT) and Differential effective Medium (DEM) with the Gassman theory. The model allows the individualization of the effects of fluid, porosity, and mineralogy on the elastic properties of the rock, being able to predict scenarios for areas where there are no wells available.
From the rock physics model and the corresponding templates, we formulate attributes that have a high correlation with water saturation, porosity, and clay content. The attributes are validated with the well-logs available in the area and provide quantitative information, allowing the prediction of rock properties as a function of the VP/VS ratio and Acoustic impedance. Finally, rock physics templates and the formulated attributes are applied to the elastic seismic inversion to better delineate the anatomy of this gas field and determine which factors control the migration and accumulation of gas in this complex petroleum system.

BCGA usually implies large areas pervasively filled with gas, resulting in massive reserves. However, because of the low number of analogs, lack of critical knowledge about this petroleum system, and low seismic sensitivity, the exploration of BCGA is highly risky. Therefore, establishing a workflow able to predict gas in tight sandstones and improve knowledge about BCGA has great value, both in the exploratory and production stage.

SESSION II: EXPLORATION POTENTIAL AND NEW OPPORTUNITIES IN POST-SALT AND EQUATORIAL MARGIN BASINS

2.I Rift-Associated Magmatism in the Sergipe-Alagoas Basin and its Influence on Local Petroleum Systems
Mariana Meirelles (presenter), Celso Jardim, Fabio Mendonça, Delzio Machado Jr., Petrobras

Since 2010 a new exploratory frontier in ultradeep water of Sergipe-Alagoas Basin was discovered related to gas and light oil bearing turbidites reservoirs of Maastrichtian and Campanian ages. These discoveries resulted in almost 30 new wells, drilled by Petrobras and partners. The crustal framework upon which such discoveries were made is extensively debated since 90’s works. The wildcat well 1-SES-158 brought more clarity to this question, when a sequence of eoalbian pillow basalts (104Ma) was drilled and indicated alkaline composition. This information inspired a new interpretation about the rifting evolution in this region. Recent works incorporating these data proposed that Sergipe-Alagoas basin has been affected by multi-phased rifting processes, presenting different characteristics in both onshore and offshore regions. Whereas in onshore portion an amagmatic rift occurred, offshore showed evidence of a magma rich terminal event during albian age. This magmatic event resulted in a variety of volcanic geometries covering a hyperextended continental crust, whose development culminated on the oceanic crust formation. These geometries provide interesting information about the rifting dynamic as well as the environment conditions in which they were formed. Additionally, the resulting relief has an important role in the petroleum system of ultradeep portion of this basin, either by forming the depocentres for marine source rocks deposition or traps development for hydrocarbon in turbidites through differential compaction process.

2.II Upper Cretaceous Turbidite System in the Deep Water of the Pará-Maranhão Basin
Eduardo Faria (presenter), Márcia Karam, Felipe Nascimento, Daniel Canellas, Alexandre Souza, Ronaldo Baldi, Enauta

The Pará-Maranhão Basin, located on the Brazilian Equatorial Margin, is seen as a new exploration frontier. Recently, new 3D seismic surveys enabled to identify and characterize a well-developed Upper Cretaceous sand-rich channel-lobe turbidite system in deep water.
Three basic depositional architectural elements have been identified in this system: 1) erosional surfaces featuring - cut, bypass and fill - on the shelf; 2) canyon systems in the slope and 3) channel-lobe complex from the base of the slope toward the distal part of its basin.

The complex cut and fill channelized features characterized by coarse grained sediments interbedded with shales, siltstones and diamictites have occurred on the platform area. They are seismically characterized by chaotic pattern with elongated orientation. Also, canyons and distributary channels show low sinuosity and incipient development of overbank deposits. They were developed between the shelf break and the base of the slope. They have become unconfined evolving into a series of frontal lobes. Amalgamation and compensation of the lobes has shown lateral pinch outs and high amplitude contrast with shaly background sediments on the seismic data. Its channel margins are very well defined on seismic amplitude maps.

The stacking pattern of sedimentation shows a progradation of channels over the lobes which are characterized by high amplitude channelized features on the top of high amplitude subparallel to parallel reflectors. These features can be identified as continuous reflectors with high amplitude contrast as well.

Volcanic guyots could have acted as topographic barriers to the high-density turbidity flows inducing the pounding of sand-rich lobes at the base of the slope, creating a perfect setting for accumulation of thick and good quality reservoir rocks.

The announcement of new discoveries offshore Guyana points out to an estimated recoverable oil around 8 BBOE. This reinforces the high potential of the petroleum system of the Upper Cretaceous in the region. The same play is expected for deep water in Pará-Maranhão Basin.

2.III Exploration Potential in Ultradeep Waters of the Pará-Maranhão Basin: Geology and Petroleum Systems
Pedro Zalán (presenter), ZAG Consulting; Eric Newman, Mike Saunders, TGS

As newly discovered reserves increase continuously in nearby Guyana and Suriname, the Equatorial Margin of Brazil arises as the natural next potential area to be explored by the petroleum companies. From North to South, the Foz do Amazonas, Pará-Maranhão and Barreirinhas Basins present geology and petroleum systems very similar to those found not only in Guyana/Suriname but also in Ghana/Ivory Coast/Sierra Leone/Liberia, the homologous margins of the Brazilian Equatorial Margin.

All these margins present oil (dominant) and gas discoveries in their deep and ultradeep waters, consisting of Late Cretaceous (predominantly) and Cenozoic turbidites held in mostly stratigraphic traps. The source rocks are organic rich marine shales of Late Albian/Cenomanian/Turonian ages, deposited during global oceanic anoxic events that coincided with the early stages of the continental drift in these areas. These geological elements form what is termed as the Late Cretaceous petroleum system.

The Pará-Maranhão Basin presents so many leads and prospects in this petroleum system that it ranks today as the third (after the Pre-Salt of Santos/Campos and the Late Cretaceous of Sergipe Basins) most promising area in Brazil in terms of capacity of replenishing its reserves of hydrocarbons in the near future
with billions of barrels of oil equivalent. In this aspect, papers shedding light on the geological aspects of this basin are a must in any event dealing with exploratory opportunities in Brazil.

2.IV Sergipe Surprises and Suppositions: Deepwater Test Area for Source, Reservoir and Trap Development
William Dickson (presenter), Dickson International Geosciences; Mark Odegard, GrizGeo; Craig Schiefelbein, Geochemical Solutions international (GSI); David Rajmon, Geosophix; and Seva Egorov, GeoExpera

One group holds all Sergipe Basin licenses outboard of the continental-oceanic crust boundary (COB). We ask what attractive possibilities could lie within this ultra-deepwater area and where else success could be replicated.

We have elsewhere discussed two likely reservoir/trap plays, being contourite-enhanced turbidites and, growing atop the syn-rift volcanic elements along and parallel to the COB, isolated carbonate buildups (ICBs). The key risk is sourcing, relating to adequacy of maturity and existence of migration pathways that link source to trap. Migration requires an interplay with volcanic intrusions in this well-sealed, mud-dominated system. We argue for existence of a deep (intra-SDR) source which only requires normal heat flow for maturity. The otherwise too-shallow A-C-T intervals across most of this outboard acreage can only reach maturity with elevated heat flow inconsistent with our crustal interpretation.

We also present an explanation for the related presence of extremely high levels of oleanane in both wells of the undeveloped Barra Field. Sherlockian logic says eliminate the impossible to arrive at the improbable. Published seismic across wells 1-SES-158 & 3-SES-174 shows volcanics that pierced the Barra reservoir immediately downdip of -174, reaching upwards into the early Tertiary level. At depth, magmatic intrusions opened incipient fractures above the COB trend to provide migration pathways into each deepwater field; but high oleanane is only seen in Barra. We infer periodic volcanic eruptions that formed a (Barra) caldera in which Tertiary organic matter (OM) accumulated. Small volumes of OM were withdrawn with retreating magma, during a series of lava advances and withdrawals. Following Tertiary burial, high API fluids were expelled from deep marine source layers. These condensate-like fluids followed the magmatic paths, entraining oleanane from the downward-migrated Tertiary OM and depositing it in Barra. Escape to surface was prevented by the sealing Oligo-Miocene muds, consistent with the lack of surface seepage verified by piston coring.

Exploration success in the most outboard region requires sourcing from organic-rich intervals within thick local restricted SDR sequences. An SDR source would charge both the adjacent ICB trend and Upper Cretaceous - Eocene contourite drifts. Migration from source to trap will most likely follow magmatic flow paths. Validation of these play elements will spark activity around the South Atlantic.

2.V Structural Reconstruction and Kinematic Evolution of the Campos Salt Basin, Offshore Brazil
Hongjiao Yu (presenter), Paula Brazao, Matteo Molinaro, Long Ma, Mitchell Prante, Shell

This work developed a customized workflow that integrated observations from extensive 3D seismic surveys across the Campos basin with palinspastic reconstructions to explore the kinematics of the salt
evolution. The 2D reconstruction incorporated thermal and flexural subsidence from basin modelling, high resolution sequence stratigraphy, and paleo bathymetric profiles calibrated with well data.

Two main competing models, extension vs salt expulsion, have been proposed to describe the kinematic evolution of the salt basin and the development of the so-called Albian Gap. Differentiating between these models is a key element to understand the timing of salt related traps, migration pathways and trapping mechanisms in different structural domains. Based on observations from high resolution seismic data and our structural reconstruction results, we suggest that there are two phases of salt flow. The first flow happened during Albian time. Albian carbonate was rafted up to 40 km during the first salt flow, creating the Albian Gap. The outboard salt was thickened through internal thrusting and collapsed basinward responding to regional tilting and linking to the updip extension. The second salt deformation event was triggered by Late Cretaceous sediment progradation and was dominated by salt expulsion: salt bodies were withdrew inboard, diapirs rose nearby, with limited extension by normal faulting in post-Albian sediments. The structural reconstruction indicates that there was pre-existing topography before salt deposition, controlling the original salt basin thickness and thus accommodation space for post-salt sediments.

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**DAY 2 – JUNE 23, 2021**

**SESSION III: RECENT ADVANCES AND CHALLENGES IN PRE-SALT BASINS**

**3.1 Petroleum Systems Evolution in the Outboard Atlantic Margins of the Campos and Santos Basins, Offshore Brazil: A Regional 3D Basin Modelling Study**

Antonio Martín-Monge (presenter), Ángel Carrasco, Massimiliano Masini, Antonio J. Olaiz, Keith Buck, Jose Guilherme de Castilho, A. Vayssaire, Repsol

With more and more petroleum exploration focused on the outboard parts of passive margins, our understanding of the evolution of petroleum systems in these settings has been greatly enhanced over the past two decades. New plays have emerged in several basins along the southern Atlantic margins. Basin and petroleum systems modelling has played a very valuable role in the assessment of petroleum systems related risks in these new plays. The prolific Atlantic margins of the Campos and Santos basins, offshore Brazil, have been no exception in this outboard push to unravel the complexities of passive margins in the quest to unlock new exploration plays. Here we present a regional 3D basin model constructed and calculated for an extensive area across the two basins. The model integrates regional interpretation of seismic data with a meticulous mapping of crustal domains along the margin. A thorough compilation of present-day temperature and thermal maturity data was used for calibration purposes. Sensitivity of several input parameters was tested, including different thermal scenarios and variations in source distribution, organic richness, and petroleum generation kinetics. This modelling exercise, which incorporates the emerging views of the development of passive margins, allowed us to move forward and become predictive in the assessment of the petroleum prospectivity of the area of study, being able to identify new exploration opportunities, especially along the pre-salt play.
Natural open fractures have recently been reported in several pre-salt lacustrine carbonate reservoirs in both the Santos and Campos Basins offshore Brazil. Open fractures are also frequently observed in borehole image logs from wells in block BM-C-33, and fracture densities are in general high. Open fractures are also present in sidewall cores and in whole core samples.

The highest density of open fractures is seen in the damage zones developed above and below larger cavities called amalgamated cavern damage zones (ACDZs). Increased fracture density is also found near faults in fault damage zones. Other controls on fracture density are mineralogy and porosity. The fracture density is high in silicified carbonates, where it tends to increase with decreasing porosity. Clean dolomite is less fractured while the less brittle argillaceous dolomites have the lowest fracture density. Fractures tend to be present in vuggy intervals, and borehole image data also show that many of the fractures have local enhancement of aperture (i.e. vuggy fractures). The positive correlation between fractures and vugs is suggested to be caused by flow of dissolving fluids through open fractures in addition to fracturing at local stress concentrations around vugs and other cavities. DST’s in wells on BM-C-33 show much higher productivity than suggested from core plug measurements. This excess permeability is attributed to open fractures which together with vugs and caverns are believed to form a connected pore system that provides both productivity and significant storage.

Regional and detailed seismic stratigraphic analyses of Early Cretaceous (Aptian) presalt carbonate sections from offshore Brazil reveal the complex stratigraphic architecture of late- and post-rift lacustrine carbonate systems. The lateral and vertical distribution of calibrated seismic facies within this framework highlights the evolution through time of the carbonate system and bathymetry of the host lacustrine basin. Despite the simple, largely abiotic and microbial components, lacustrine carbonate accumulations formed complex geometries that closely resemble those observed from marine systems, suggesting that a downward-tapering carbonate production profile must have occurred. The complexity of the stratigraphic architecture reflects lateral variations in subsidence patterns combined with the interference of the basement topography, palaeowind directions and basinal filling patterns. Well-imaged clinoforms several hundred metres high attest to both the existence of significant lake-bottom topography, locally in excess of 800 m, and the occurrence of deep water at time of deposition. Platform margin trajectory and vertical and lateral architecture of clinoform packages through time reveal distinct sequence boundaries that can be correlated in detail only locally, demonstrating the impact of syndepositional tectonics, and possibly recurrent isolation of smaller lakes during lowstands. Depositional models from this study fill a gap in current understanding of lacustrine carbonate systems and offer a template for exploration and appraisal of the presalt play.
3.IV Relation Between Tectonic Domains and Hydrocarbon Prospectivity in Campos and Santos Basin

Antonio Olaiz (presenter), Massimiliano Masini, Laszlo Benkovics, Jose Guilherme de Castilho, Diana Sineva, Ángel Carrasco, Keith Buck, Rubén Loma, Antonio Martín-Monge, Matthieu Pontet, Repsol

In the last decades, hydrocarbon exploration in passive margins has been highly extensive, revealing them as prolific in discoveries. However, the success or failure of the drilled wells, although balanced with other factors, is closely correlated to their locations on the corresponding tectonic domains.

Despite the significant tectonic complexity of the Campos and Santos basins, exacerbated by the presence of evaporites that prevent an accurate identification of the structural domains and, consequently, a reliable evaluation of the hydrocarbon prospectivity, important discoveries have been recently reported in the region.

To shed some light on conventional research, we analyzed gravity and magnetic data, which are particularly well suited to deal with evaporite-bearing basins; thus, satellite and shipborne data can assist in the identification of tectonic domains, estimation of crustal thickness and modeling the presence of salt.

Examples will be discussed of different applications of potential fields data consisting of: 1) qualitative interpretation while stripping off salt gravity response; 2) 2D forward gravity and magnetic modelling along selected profiles supported by iterative seismic interpretation in order to locate areas of interest for oil and gas exploration; 3) 3D inversion to help extend the findings to those areas with poor seismic coverage allowing to test hypothesis regarding the margin configuration.

SESSION IV: TECHNOLOGICAL ADVANCES AND APPLICATIONS

4.I 3D Stratigraphic Principles as Prior Knowledge for 3D Seismic Facies Segmentation

Elton Trindade, Petrobras

Technological advances in oil and gas reservoir characterization, such as 3D seismic and seismic attributes, enriched the subsurface’s description made by specialists. The manual labeling of seismic facies heavily lies on the theoretical information and experience of the geoscientists, which are often left aside in deep learning applications, rather used merely on the dataset sampling and/or results interpretation. In order to more efficiently manage big seismic data and establish whether the accuracy of facies segmentation tasks improve, this work explores the impact of innate knowledge supported by a heuristic based on geological principles. The results show a performance increase compared to a naive counterpart, also showing that such performance increase may benefit from several kinds of innate knowledge. Compared to other models in the same benchmark, the proposed networks, with a geological heuristic, obtained better results than other architectures of literature with a very feasible computational cost in both datasets. The results suggests that such approach is a promising one and of easy replication since it can be seamlessly applied to any network architecture.
4.II Using Geophysically-Derived Mechanical Properties to Constrain Fracture Intensity and Distribution in Pre-salt Carbonate Reservoirs
Mário Santos and Astrid Fernandez, GALP E&P

From a reservoir management point of view, naturally occurring fractures (NOF) play a significant role during the development and production stages of hydrocarbon fields as they impact to a great extent the movement of fluids in the subsurface. The existence of naturally occurring fractures could either have a positive or negative impact on the overall field performance, on the one hand increasing the hydrocarbon production rates in producer wells at an early stage; and on the other hand, facilitating early water/gas breakthroughs from injectors to producers and consequently decreasing the reservoir sweep efficiency. Well placement optimization, on either producers or injectors, needs to be carefully assessed in order to maximize hydrocarbon recoveries (EUR) during the project full life cycle.

In order to better assess the behavior of a reservoir containing naturally occurring fractures, the elaboration of a reliable 3D discrete fracture model (DFM), which integrates all the subsurface knowledge is paramount in order to get a better understanding of subsurface fluid dynamic behavior. This presentation will address the workflow that currently is being applied by Petrogal for modeling naturally occurring fractures in pre-salt carbonate reservoirs of the Santos Basin. The workflow comprises several dimensions and integrates data from several sources, including regional geological framework and characteristics, seismic QI and processing, artificial intelligence analysis, borehole image analysis, and injection/production data.

4.III Reservoir Management using Water Alternate Gas Injection in the Lapa Pre-Salt Field
Serugue Santiago (presenter), Julien Couchard, TotalEnergies

Water-Alternate-Gas (WAG) injection is one of the promising EOR techniques in enhancing oil recovery factor over secondary recovery. It is widely used as recovery mechanism in the pre-salt fields in Brazil, as it uses two readily available resources: sea water and produced gas. WAG injection combines the improved microscopic displacement efficiency of the gas flooding with an improved macroscopic sweep by water injection. Nonetheless, WAG recovery mechanisms are complex processes that require comprehensive understating of factors governing its performance. A dedicated reservoir monitoring program is key to achieve success in a such challenging context with very high capital expenditure, ultra-deep waters, thick salt cap rock, varying CO2 content in the reservoir fluid, etc. This presentation aims at discussing how production optimization may be achieved by properly managing a reservoir with WAG Injection, using the case of Lapa field.

4.IV ANP Pre-Salt Round 7: 3D Seismic Data demonstrate Esmeralda and Água Marinha Block Prospectivity
Andrew Hartwig, James Deckelman, Kyle Reuber, ION

Brazil’s 7th Pre-Salt Licensing Round features highly anticipated acreage in the deepwater Santos and Campos basins, Brazil. 3D seismic data demonstrate that two Blocks offered in the 7th Pre-Salt round, Água Marinha and Esmeralda, have considerable hydrocarbon potential.
The Campos basin Água Marinha Block is bordered on three sides by producing fields: Marlim to the north, Pão de Açúcar to the south, and the Espadarte complex to the east. 3D seismic data suggest that the Block is highly prospective at both pre-salt and post-salt levels. With respect to the pre-salt play, the base-salt seal is possibly thin over a possible basement paleo-high of volcanic nature. A thinning sag section to either side of a prominent 4-way-dip structural closure could be either a microbialite pinch-out or mounded feature. Attribute analysis also provides deeper insight into potential post-salt turbidite plays.

The Santos basin Esmeralda Block has similar, if not greater, potential depending on risks relating to salt seal and proximity to shallow crustal structures. The southern Santos basin is uniquely positioned near rifted crustal highs, in which the sag section and autochthonous salt do not exist. In context, the opening of the south Atlantic basin from south to north suggests that the salt deposition was slightly earlier in the southern Santos and Campos basins than it was to the north, complicating the development of widespread source rock deposition, as observed in the northeast Santos basin (i.e. Lula and Buzios fields). As rifting continued northward, southern Santos crust remained shallow while rift blocks slumped to either side. This is displayed by substantial base-salt topography and steep normal faults at depths ranging from 4.8km to 11km. Nonetheless, updated seismic images clearly display parallel bedding of Aptian age sag section fetching a thermally mature source kitchen, down dip to the west of potential reservoir facies, with >1 km of closure inside the Block.

4.IV How it Started, How It’s Going: Quantifying The Impact Of Tupi Field Development Strategies Over Time
Jason Eleson (presenter), Jared Kugler, Oma Wilkie, Enverus

The discovery of Tupi field in 2006 garnered global attention as one of the largest, most productive oil finds in decades. With nearly 30 Bboe of discovered resource, the pre-salt play stabilized NOCAR (non-OPEC, non-Canadian, non-American and non-Russian) production and, at ~2MMbbl/d, comprises half of the growth from new projects that could hold production flat through the decade. A Petrobras-led consortium took a flexible approach towards field development, including extended well test pilot programs in two different parts of the field, a complete reconfiguration of the development plan to alleviate CO2 processing challenges, changing locations of producer/injector pairs based on new well results, gas/water/WAG injection pilots to increase sweep efficiency and dispose of waste gas, and intelligent completions to ensure zonal isolation and prevent early gas/ water breakthrough.

Our evaluation indicates Tupi’s producing wells yield globally competitive EURs of20-96 MMbbl and robust single-well, ½-cycle breakevens below $30/bbl. However, there are indications of development challenges, potentially impacting ¼-cycle economics at Tupi and other pre-salt developments. Examples include limited size of FPSO gas-processing capability, poor reservoir quality in the lower flank positions of the field, thin or absent reservoir near the crest of the field and tighter injector-producer spacing than originally proposed. Developing such reservoirs may be more challenging and expensive than initially thought, potentially negatively impacting pre-salt production growth expectations and sanctions. If the pre-salt fails to meet current expectations and production growth is delayed, NOCAR production could begin to roll over sooner than the initial forecast.
KEYNOTE PRESENTATIONS

KP.I Keynote Presentation: The E&P Sector in Brazil
Rodolfo Saboia, General Director, National Agency of Petroleum, Natural Gas and Biofuels (ANP)

An overview of Brazil’s Exploration and Production Sector, provided by the director of the National Agency of Petroleum, Natural Gas and Biofuels (ANP).

KP. II Keynote Presentation on the Brazilian Pre-Salt
Thiago Pessoa, General Manager for Reservoir and Flow Assurance – Búzios Field, Petrobras

An overview of Petrobras activities in Búzios Field, a giant ultra-deepwater oil and gas field located in the Santos Basin, approximately 200 km off the coast of Rio de Janeiro.
BIOGRAPHICAL SKETCHES

WELCOME AND OPENING REMARKS

Sylvia Anjos, ABGP
Sylvia holds a bachelor’s degree in geology from the Federal University of Rio de Janeiro and a master’s and a PhD in geology from the University of Illinois in the United States.

Anjos has worked in the energy industry since 1979 and has dedicated her years of service to Petrobras in Rio de Janeiro. She served as manager of Stratigraphy, Sedimentology, Petrology and Biostratigraphy and manager of Rock Technologies at the Petrobras Research Center, then moved to Petrobras Exploration in 2005. She started as manager of the Petroleum Systems Modelling before being named general manager of geology for Petrobras Exploration, a position she held for 10 years.

From 2016-2019 Anjos served as deputy general manager for the Libra Joint Project Team, representing Petrobras and overseeing applied technologies projects for the Libra field in the Brazilian pre-salt. She also pioneered the E&P Digital transformation in Libr@Digital Program. Since then, she served as Petrobras business advisor for the Gas & Energy director supporting the company to face the new gas market in Brazil and left the company in April 2021.

Sylvia was a founding member of the Brazilian Association of Petroleum Geologists (ABGP) and served two terms as president. She has been an active member of AAPG since 2001 and served as Latin America and Caribbean Region vice president from 2017-2019. Since 2018, she has served as member and co-founder of the Diversity Committee at the Brazilian Petroleum Institute (IBP).

Victor Vega, Shell
Victor received a bachelor’s degree in Geology from National University of Colombia and a Master’s in Geophysics from the University of South Carolina, Columbia.

He worked in Colombia, Venezuela and the United States, assuming positions of increasing responsibility with Amoco Production Company; BP Amoco Corporation; BP America, BP Andes and Equion Energia between 1993 and 2015. Victor has been with Shell since 2015 and is currently working as Regional Exploration manager for Caribbean and South America based in Houston, Texas.

Victor’s professional affiliations include memberships in the Colombian Association of Petroleum Geologists and Geophysicists (ACGGP), the American Association of Petroleum Geologists (AAPG) and the Argentine Association of Petroleum Geologists and Geophysicists (AAGGP).

Victor served President of the Latin American and Caribbean Region from 2015-2017 and Advisory Counselor for the Region from 2017-2020. He has participated on numerous AAPG committees and has helped to organize Geoscience Technology Workshops in several countries. He served as General Vice Chair of the AAPG/SEG International Conference and Exhibition (ICE), held in Cancún in 2016 and AAPG ICE Buenos Aires in 2019. He also served as General Chair for the Inaugural Energy Opportunities Conference, Exhibition and Business-to-Business Session held in Cartagena in 2018 and will hold the same position for the next AAPG International Conference and Exhibition to be held in Cartagena in April 2022.
Marta Vieira Abrao, General Manager of Exploration Planning, Business and Operations, Petrobras

SESSION I: OPTIMIZING DEVELOPMENT IN ONSHORE BASINS AND MATURE FIELDS

Session Chair: Ricardo Savini, CEO, 3R Petroleum
Ricardo has a degree in Geology from the University of Brasilia and holds a MSc in Stratigraphy from the Universidade Federal do Rio Grande do Sul (UFRGS).

He has 34 years of experience in the industry and is he is Founder and Chief Executive Officer of 3R Petroleum, a Brazilian oil & gas field operator focused on revitalizing mature fields in Brazil. 3R has 36 different oil and gas fields, onshore and offshore in Brazil and is among the 10 largest producers of hydrocarbons in the country.

Before joining 3R Petroleum, Ricardo worked in companies including Georadar (CEO Brazil, 2015-2018), Deloitte (Director of Oil & Gas Center of Excellence, Brazil, 2013-2014), Petrobras (Upstream Strategy and Risk Management Manager at Rio; E&P Technical Services Manager at Buenos Aires and Caracas, 2004-2012); Pérez Company (Reservoir Manager; Geology & Geophysics Manager at Caracas, 1998-2003); and Petrobras (Geologist - Rio and Salvador, 1987-1997).

Ricardo is a member of ABGP and SBP.

Session Chair: Frederico Miranda, Exploration Director, ENEVA
Head of Exploration at Eneva and a professor in the FGV MBA Program for Oil & Gas, Frederico Miranda, worked extensively over 15 years in the Paleozoic onshore basins in Brazil, such as Parnaíba, Amazonas, Solimões, and more recently Paraná.

Mr. Miranda holds an Msc. in Geology and Stratigraphy from the Federal University of Rio de Janeiro, focused on Parnaíba's unconventional resources. Also, hold specializations in Basin Analysis from the State University of Rio de Janeiro and in Petrophysics by Petrobras Corporate University.

Bruno Valle, 3R Petroleum
Bruno Valle earned a BSc in Geology at Federal University of Rio de Janeiro (UFRJ); a MSc in Petroleum Engineering at University of Southern California (USC); and a MSc in Geology at Federal University of Rio de Janeiro (UFRJ).

With six years of experience in the industry, he currently works at 3R Petroleum as Petrophysicist, where he performs complete petrophysical evaluation, quantifying and characterizing reservoir properties such as shaliness, porosity, permeability and saturation for net pay estimation and to be used as inputs in the static and dynamic modeling. Also, identifies bypassed oil zones and estimates remaining oil saturation in mature wells and evaluates intervals for workovers and production stimulation. He also analyzes oil-water contacts in stratigraphically complex reservoirs with fresh water.

His previously worked as a project manager for the Pre-salt project at Lagesed (UFRJ), leading more than 60 people from different areas (sedimentology, geochemistry, volcanics, stratigraphy, petrophysics, geophysics, geologic modeling). Also coordinated and performed petrophysical activities, implementing
multidisciplinary workflows for reservoir characterization and applying advanced techniques such as rock types, FZI, borehole images, NMR and saturation height modeling.

**Armando Ferreira, ENEVA**
Armando earned a BSc in Engineering at Universidade Federal do Rio de Janeiro, and a MSc in Petroleum Engineering at Universidade Federal de Ouro Preto.

With 40 years of experience in the industry, he is General Advisor Manager at ENEVA, where he is responsible for reservoir management of Paranaiba and Amazonas Basins. Before ENEVA, he worked as Asset Manager at Petrobras.

Armando is a member of SPE.

**Miguel Nuñez, IMETAME Energia**
Miguel holds a MSc in Geophysics from the University of Oklahoma. With 27 years of experience in the industry, he currently is E&P Director at IMETAME Energia, Aracruz, Espirito Santo, Brazil, where he leads the technical team, undertakes the development for 21 Exploration Blocks and 13 Oil &Gas fields in Brazil onshore, including Reconcavo, Potiguar, Espirito Santo. He is also co-responsible for revenue growth and P&L results, and to establish and maintain strong relationship with all partners.

His previous experience includes working as Technical Advisor-Americas and Country Manager at Geoteric, Technical Director at Geoquasar, Senior Consultant Geocientist at Emerson Colombia (Paradigm Geofisical), International Exploration Manager and New Venture Manager at PDVSA, and Geoscientist at Fusion Petroleum Technologies.

Miguel is a member of AAPG, SEG, SBGf, ABGP, EAGE and SPWLA.

**Atilas Meneses da Silva**
Atilas earned his BS in Geology at the University of Brasilia (2008) and holds a MSc in Geophysics from the Colorado School of Mines (2020).

With 12 years of experience in the industry, he is Exploration Geophysicist at Petrobras, Rio de Janeiro, Brazil, where he is responsible for the assessment of the petroleum potential of mature and frontier areas, and volumetric assessment of prospects. Currently, he is working with deepwater and ultra-deepwater provinces of the Espirito Santo and Sergipe basins.
SESSION II: EXPLORATION POTENTIAL AND NEW OPPORTUNITIES IN POST-SALT AND EQUATORIAL MARGIN BASINS

Session Chair: Decio Oddone, CEO, Enauta
Decio Oddone has an electrical engineer degree from the Federal University of Rio Grande do Sul. He has attended the Advanced Management Program at Harvard Business School and the Advanced Management Programme at Insead. He was awarded an honorary PhD in Education from Universidad de Aquino.

With 35 years of experience in the industry, he currently serves as CEO at Enauta, where he is responsible for making major corporate decisions and managing the overall operations and resources of the company.

Before joining Enauta, Decio was CEO of Petrobras Bolivia, President and CEO of Petrobras Energia, Vice President of Braskem, Director of Prumo Logística and General Director of the National Agency of Petroleum, Natural Gas and Biofuels (ANP).

He was a member of the Board of Directors of the Institute of the Americas, in the USA, and chaired the Bolivian-Brazilian Chamber of Commerce and the Argentine Chamber of the Petroleum Industry.

Decio is a member of the Board of Directors of the Brazilian Petroleum and Gas Institute (IBP), a member of the Board of Directors of the ABEP, and member of the Advisory Board of the FGV Energia.

Session Chair: Hywel Upshall, General Manager Exploration, Murphy Oil
Hywel earned a BSc in Geology and Geophysics at the University of Durham, UK, and holds a PhD in Geophysics from the University of Birmingham, UK.

With 32 years in the industry, he is General Manager Exploration at Murphy Oil, Houston, USA, where he is responsible for managing Brazil exploration portfolio and new ventures in the Atlantic Margin. His experience includes 10 years with BP and 20 years with Murphy.

Hywel is a member of AAPG.

Mariana Meirelles, Petrobras
Mariana earned a BSc in Geology from the Universidade Federal do Rio de Janeiro (UFRJ) and has a MSc in progress at the Universidade do Estado do Rio de Janeiro (UERJ).

With almost 11 years of experience in the industry, Mariana works as Geologist at Petrobras, Rio de Janeiro, Brazil, where she is explorationist in Sergipe-Alagoas Basin.

Eduardo Faria, Enauta
Eduardo holds a PhD in Geophysics from The University of Texas at Austin.

With 39 years working in the industry, he is Executive Manager of Exploration at Enauta, Rio de Janeiro, Brazil, where he manages and coordinates the exploration of the company. His previous experience includes working for 33 years at Petrobras; between 2011 and 2013 he held the position of Executive
Manager at Georadar Levantos Geofísicos SA and Technical Director at Oceangeo. He was Technical Director of GXT Tecnologia-Data Processing in 2014.

Eduardo is a member of SEG and SBGf.

Pedro Zalán, ZAG Consulting in Petroleum Exploration
Pedro earned a BSc in Geology from the Federal University of Rio de Janeiro and holds a MSc and a PhD both from Colorado School of Mines.

With 43 years in the industry, he is the President at ZAG Consulting in Petroleum Exploration, Rio de Janeiro, Brazil, where he analyzes, maps and defines the petroleum potential of sedimentary basins worldwide; and identifies exploration opportunities. Previously, he worked at Petrobras for 34 years.

Pedro is a member of AAPG, SBGf and SBG.

William Dickson, DIGs (Dickson International Geosciences)
William earned a bachelor’s degree from the University of Manitoba.

He has more than 40 years of experience in the industry, working at majors and independents and, since 1998, at DIGs, Houston. He has worked in frontier and producing basins around the Atlantic margins, EAME region, SE Asia & Canadian arctic; coordinated projects with subject matter experts across multiple disciplines and regions; and build and deliver non-exclusive studies based on these projects. William is a member of Datapages Board (AAPG Subsidiary), and peer-reviewed publications primarily on petroleum systems analysis of Atlantic margin basins.

Currently, he is Owner & Chief Scientist at DIGs (Dickson Int'l Geosciences), where he is in charge of R&D, project coordination and fulfillment.

William is member AAPG, EAGE, SEG, SPE and local societies in Houston, England, SE Asia & Australia.

Hongjiao Yu, Shell
Hongjiao holds a PhD from the Louisiana State University.

With 6 years of experience in the industry, she is Exploration Geoscientist at Shell Exploration & Production Company, Houston, USA, where she works in frontier exploration.
SESSION III: RECENT ADVANCES AND CHALLENGES IN PRE-SALT BASINS

**Session Chair: Ana Serrano, Vice President Subsurface, Equinor Brazil**
Ana holds a BSc and a MSc both in Geology.

With 38 years of experience in the industry, she currently serves as Vice President Subsurface for Equinor in Rio de Janeiro, where she is responsible for subsurface work exploration, development, production and IOR projects. Before joining Equinor, she worked for a number of companies, including Gessal and Repsol.

Ana is a member of AGGEP.

**Session Chair: Vanessa Kertznus, Business Opportunity Manager, Shell Brasil**
Vanessa is a Geological Engineer graduated from the Universidad Central de Venezuela and holds a PhD in Geology from the University of Aberdeen.

With more than 15 years of experience in the industry, she is Business Opportunity Manager at Shell Brasil, Rio de Janeiro, Brazil, where she manages the team responsible for developing and accessing growth opportunities in the Santos and Campos basins.

Vanessa has held a variety of leadership and individual contributor roles at Shell, working in the Mexican Gulf of Mexico, as well as New Ventures and Business Development in Latin America, Europe, Africa and Asia.

She gained experience in sedimentology doing reservoir characterization of fields with Integrated Reservoirs Solutions.

Vanessa is a member of AAPG.

**Antonio Martin-Monge, Repsol**
Antonio earned a BSc in Geology and a MRes/DEA in Isotope Geochemistry, both from the Universidad de Salamanca, Spain.

He has more than 15 years of professional experience, 12 of them in the petroleum industry. During his career, he has worked as research technician at the Servicio General de Análisis de Isótopos Estables (SGAIE) of the Universidad de Salamanca in Salamanca, Spain and at the Scottish Universities Environmental Research Centre (SUERC) in East Kilbride (UK).

Currently, he is Petroleum Systems Analyst at Repsol Exploración, SA in Madrid, Spain, where he is working in the central subsurface function to provide specialized technical support in petroleum systems modelling and organic geochemistry to units across the E&P division.

Antonio is a member of the European Association of Organic Geochemists (EAOG) and EAGE.
Ole Petter Wennberg, Equinor
Ole Petter holds a PhD from the University of Bergen, Norway.

With 25 years of experience in the industry, he works for Equinor ASA, Bergen, Norway, as Specialist Geology, responsible for fractured reservoir characterization.

Ole Petter is a member of EAGE and the Norwegian Geological Society.

Alessandro Cantelli, Shell Brasil
Alessandro holds a PhD, and with 15 years of experience in the industry is Senior Exploration Geologist at Shell Brasil, Rio de Janeiro, Brazil, where he develops exploration focused on Brazil pre-salt plays. He previously worked at the University of Minnesota.

Alessandro is a member of AAPG.

Antonio Olaiz, Repsol
Antonio holds a PhD from the Universidad Complutense de Madrid, where he started his career as researcher (8 years).

Currently, with 10 years of experience, he works for Repsol, Madrid, Spain, where he is Geoscientist responsible for non-seismic acquisition methods, processing, and interpretation.

Antonio is a member of AAPG, EAGE, SGE (Spanish Geological Society) and AGGEP (Spanish Association of Petroleum Geologists and Geophysicists).

SESSION IV: TECHNOLOGICAL ADVANCES AND APPLICATIONS

Session Chair: Antonio Velásquez, Development and Production Manager, Ecopetrol Brasil
Antonio is a geoscientist and QI geophysicist with 18+ years of experience in the oil and gas industry and academia. He BSc and MSc degrees in Geology from the Universidad Nacional de Colombia and holds a second MSc degree in Geophysics Seismology from the Colorado School of Mines, USA.

He also graduated from the executive management program for High Potentials offered by Ecopetrol and the Universidad de Los Andes. Antonio has worked as adjunct professor of seismic exploration, structural geology and tectonics, while serving as editor of well-known scientific journals and volunteering as board member in different professional associations, including AAPG, SEG, EAGE and ACGGP.

Over his 17 years in Ecopetrol, Antonio has participated in diverse exploration and development projects in both onshore and offshore basins, including important hydrocarbon discoveries and appraisals. He developed his technical career first as seismic interpreter and structural geologist, then as a geophysicist, supporting the subsurface teams in variety subjects like borehole geophysics, synthetic well-seismic tie, velocity modelling and depth conversion, gravity and magnetics, seismic inversion, AVO and reservoir characterization.
Antonio was founder and technical lead of the Ecopetrol’s Geophysical Technologies team and was geophysics technical authority on the QA/QC team that reviewed the exploration and new ventures opportunities in Colombia and overseas.

After two years leading the Pre-salt exploration assets in Brazil, Antonio recently was appointed Development and Production Manager of Ecopetrol Brasil.

Currently, Antonio also serves as BoS member of Ecopetrol USA Inc., Ecopetrol Permian LLC and Ecopetrol America LLC. He is an active member of AAPG, EAGE and ACGGP.

Session Chair: Lorena Dominguez Espido, COO, Repsol Sinopec Brasil

Elton Trindade, Petrobras
Elton earned his BSc in Geology from the University of Sao Paulo.

With 8 years of experience in the industry, he is Exploration Geophysicist at Petrobras, Rio de Janeiro, Brazil.

Mario Santos, GALP E&P
Mario earned his BSc in Geology at the Faculty of Sciences of Lisbon University.

With 15 years of experience in the industry, he works as Reservoir Geologist at Galp Exploration and Production, Lisbon, Portugal, focused on the Tupi-Iracema reservoir and pre-salt assets since 2014.

Before Galp Exploration and Production, he worked in different companies, as Mudlogger and Data Engineer in Geolog International BV, working in oil fields; Geologist for NAER, Novo Aeroporto, SA, working in LNEC (National Laboratory of Civil Engineering); Geologist, Project Manager and Member of the Board of Trangás Armazenagem SA for the planning, solution mining and connection of underground caverns in Carriço site/Monte Real salt diapir.

Mario is a member of SPE.

Astrid Fernandez, GALP E&P

Serugue Santiago, TotalEnergies
Serugue earned his BSc in Petroleum Engineer at the Universidade Federal do Rio de Janeiro, and a MSc in Reservoir Engineering at IFP School.

With 2 years of experience in the industry, he started his career working at PetroRio (internship). Currently, he is Junior Reservoir Engineer at TotalEnergies, Rio de Janeiro, Brazil, where he is responsible for daily production and injection monitoring, pressure transient analysis, support in reservoir simulation, tracers and surface fluid analysis.
Serugue is a member of SPE.

Andrew Hartwig, ION Geophysical
Andrew earned his BSc in Geophysics from The University of Texas at Austin and holds a MSc in Petroleum Geophysics from the University of Houston.

With 11 years of experience in the industry, he is Team Lead, Multi-client Interpretation Services at ION Geophysical, Houston, USA, where he leads team through regional interpretation of relevant geologic surfaces within ION’s Multi-Client 3D datasets for imaging and mapping purposes; drives innovative business development through client interactions, data presentations, and industry research.

Andrew is a member of AAPG, SEG and EAGE.

Jason Eleson, Enverus
Jason earned his BSc in Geology from the University of Nebraska and holds a MSc also in Geology from the University of North Carolina.

He has worked in the oil and gas industry since 2000 and has diverse experience in international and US Onshore basins for ExxonMobil in Houston, & Koch Exploration Company, Neos GeoSolutions and Caerus Oil and Gas in Denver. During that time, he focused on carbonate reservoir characterization in Kazakhstn and Brazil oil fields, as well as unconventional reservoirs, prospect evaluation and drilling campaigns in Rocky Mountain, Texas and Argentina, with a focus on Bakken, Niobrara, Eagle Ford, Austin Chalk and Vaca Muerta plays.

Currently, he works as the Manager of Technical Sales at Enverus, Denver, USA, and leverages his deep technical background and the company’s rich data and comprehensive solutions to provide value to the customers. He also provides regional insights for the Enverus International groups, regularly advises on tough technical questions related to conventional and unconventional reservoir exploration and development, and is developing subject matter expertise in ESG-related topics, such as geothermal, CCU, etc. He also serves as an advisor the Enverus International Intelligence team.

Jason is a member of AAPG, SEPM and RMAG.

KEYNOTE PRESENTATIONS

Rodolfo Saboia, General Director, National Agency of Petroleum, Natural Gas and Biofuels (ANP)
Rodolfo Henrique de Saboia holds a bachelor’s degree in Naval Sciences from the Brazilian Naval Academy (1978), as well as a Master’s degree in Command and Staff (1995), and a Ph.D. in Naval Policy and Strategy (2005), both from the Naval War College. He also holds a specialization in International Management by Coppead-UFRJ (2005).
Admiral Saboia held several positions with Brazilian Navy, including Deputy Chief of Organization and Naval Affairs with the Naval Operations Command (2008 to 2010), Commander of the Surface Force (2010 to 2011) and Coordinator of the Navy Refitting Program (2011 to 2012).

After serving more than 40 years, he was transferred to the Naval Reserve in 2012, as a Rear Admiral. In the Naval Reserve, he served as Environment Superintendent with the Ports and Coastal Department, from 2013 to August 2020.

Admiral Saboia has served as ANP's Director-General since December 2020.

Thiago Pessoa, General Manager for Reservoir and Flow Assurance – Búzios Field, Petrobras