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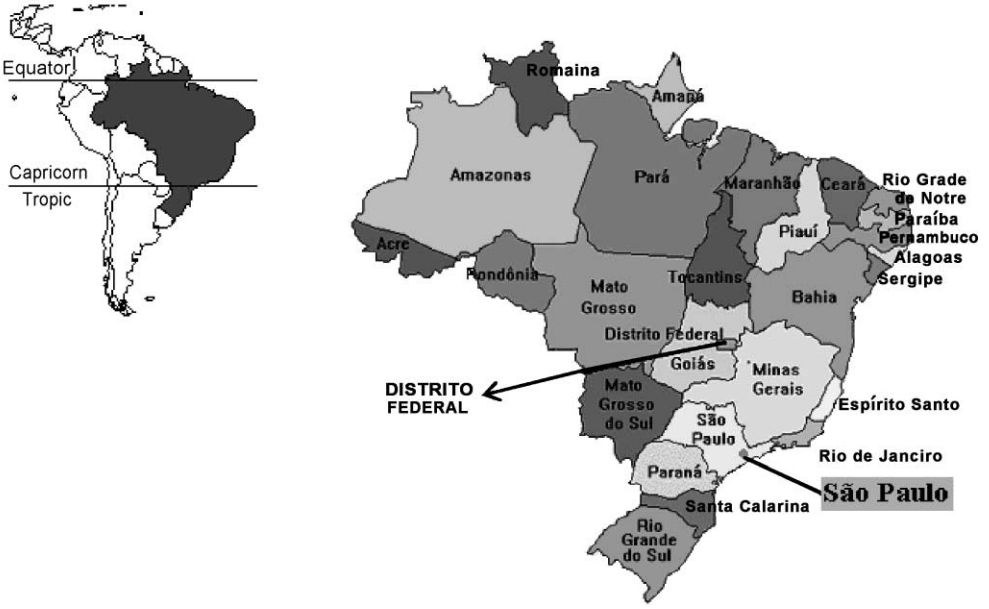
Editorial

An introduction to petroleum production research in Brazil



1. History

Brazil is made up of diverse population and a vast land. The Natives who were the original inhabitants of Brazil included the Carib and Arawak groups in the north, the Gas in eastern and southern Brazil, the Tupí-Guaranís in the East Coast of Brazil and in the Amazon River valley, and the Panos in the west. For the most part these groups of natives were essentially semi-nomadic, who subsisted by hunting and gathering and simple agriculture. Those groups in the more remote areas of the interior of Brazil maintained their traditional ways of life until the late 20th century, when their existence was threatened by the advancing frontier. The Spanish navigator Vicente Yáñez Pinzón is the first known European who visited the region now constituting Brazil. He landed near the site of present-day Recife on January 26, 1500. He subsequently drifted northward as far as the mouth of the Orinoco River. In April 1500, Pedro Alvarez Cabral, a Portuguese navigator, arrived in what today is known as the state of Bahia. He officially dedicated the land to god and the king of Portugal. Brazilians consider him the discoverer of Brazil. In 1530 the Portuguese King John III initiated a program of systematic colonization of Brazil. In 1555, the French founded a colony on the shores of what they

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named Rio de Janeiro Bay. The Portuguese destroyed the French colony in 1560, and in 1567 they established on its site the city of Rio de Janeiro.

Present-day government of Brazil consist of a federal republic divided into 26 states and the federal district of Brasília. There is an elected National Congress divided into a Senate, with three members from the states elected for eight-year terms, and a Chamber of Deputies, elected for four-year terms, both, on the basis of population. Political power is divided among the executive, legislative and judiciary branches of the government of Brazil.

2. Background

Stretching 4000 km from east to west and 4300 km from north to south in the South America, Brazil is the world's largest tropical country and also the largest South American country. Brazil is the ninth largest economy in the world and the fifth most populous country of the world. It is the third largest country of Americas in terms of area and the second largest country in terms of economy and population.

From the energy consumption point of view, Brazil is the largest energy consumer in South America, consuming 8.1 quads of commercial energy in 1998, and the third largest in the Western Hemisphere behind the United States and Canada. While total energy consumption statistics place the country as prominent in the region, Brazil's per capita energy consumption of 50.0 million Btu is comparable to the average per capita energy consumption for all of the Central and South American countries.

According to the U.S. Energy Information Administration, it is a proven fact that Brazil contains the second largest oil reserves in South America (after Venezuela), at 7.4 billion barrels. Brazil continues to strive for self-sufficiency in petroleum production. PETROBRAS produced an estimated 1.4 million barrels of oil per day (bbl/d) in 1999, up 0.2 million bbl/d from 1998 production. Brazil's oil imports come mostly from Venezuela and Argentina. Also according to the U.S. Energy Information Administration the discovery of petroleum in Brazil dates back to the beginning of the twenties century. Following many frustrated and unsuccessful attempts in many parts of the Brazilian territory, dating back to 1892, petroleum was discovered in 1939 in the State of Bahia. With this discovery, the National Petroleum Council of Brazil was created to regulate and supervise all petroleum exploration, production, transportation, and refining activities in the country. Petroleum reserves were nationalized and petroleum-related activities were restricted to Brazilian citizens. Originally, petroleum production began in the Candeiras Camp in 1941, with activities extending rapidly to other states. PETRÓLEO BRASILEIRO (PETROBRAS), founded in 1953 by President Getúlio Vargas, is Brazil's largest industrial company. It engages in exploration for oil and gas and in production, refining, purchasing, and transportation of oil and gas products. Today, PETROBRAS has proved reserves of 10.1 billion barrels of oil equivalent. PETROBRAS Internacional operates the company's worldwide exploration, production, and marketing services. Other products include petrochemicals and natural gas. The Brazilian government owns a controlling stake in PETROBRAS. In 1997, the National Petroleum Agency (ANP) of Brazil was created when President Cardoso signed the Petroleum Investment Law. As outlined in the law, ANP is responsible for overseeing the process of opening up Brazil's petroleum industry to other domestic and foreign players. PETROBRAS currently imports some petroleum products for its domestic market.

The creation of the PETROBRAS Research Center (CENPES), in Rio de Janeiro, in the early 1970s has added a new dimension in providing an environment for research, innovation and development. The center is currently engaged in research activities in almost all areas of petroleum production operations and is widely known for its innovations in petroleum drilling in deep water reaching record depths of 1845 m. Some of the contributions in this special issue are authored or co-authored by researchers of the CENPES. Petroleum research activities are expected to expand to new frontiers with the creation of the National Petroleum Agency (ANP), and the opening up of Brazil's petroleum industry to other domestic and foreign players.

Federal, state and private educational institutions in Brazil have long been active players in petroleum production activities as they contribute to the preparation of competent technicians, engineers and managers and to the implementation of research and development in petroleum production operations. Universities with a tradition in petroleum activities in collaboration

with PETROBRAS and also respectable academic record in Brazilian high education include the three public universities of the state of São Paulo: The University of Campinas-Unicamp, The University of São Paulo-USP and The State University of São Paulo-Unesp; the Federal University of Rio de Janeiro; The Federal Universities of Rio Grande de Norte; The State University of North Fluminense; The Federal University of Santa Catarina; The Federal University of Bahia; The University of North Fluminense and the Federal University of Para, among others. In these universities, we find research groups that contributed to this special issue.

The University of Campinas-Unicamp offers the only graduate level in petroleum science and engineering offering masters and PhD programs. The areas of research include petroleum geology, petroleum geoengineering, reservoir engineering, drilling, production, among others. This program is an example of the partnership that PETROBRAS has established with state universities in Brazil. This graduate course was created in 1988, basically to satisfy the need of the company for more qualified researchers in the field. The program started with heavy financial support of PETROBRAS and continues to have this support. It is important to mention in this sense also the existence of the center of petroleum studies (CEPETRO), an almost virtual center that includes researchers from many disciplines all have in common interest in petroleum research activities. This center is the backbone of the petroleum program.

The new Petroleum Investment Law for which implementation and overseeing the ANP is responsible, allocates large portions of the funds obtained from petroleum royalties on all new concessions for scientific research on petroleum in universities and research institutes in the public and private sectors. These funding programs which could be obtained through the submission of research projects which pass through a peer-review process is underway since the year 2000 and is expected to have important and significant impact on petroleum research activities in Brazil.

3. This special issue

The presentations in this special issue represent the wide range of current petroleum research activities in Brazil, with papers in the areas of exploration, reservoir and fluid characterization and production operations. The first contribution after this introductory remark authored by Simões-Filho and Castro illustrates how to combine seismic and well data through seismic modeling and geostatistical simulations as a useful tool for the characterization and management of petroleum reservoirs. The paper by Suslick and Furtado demonstrates how to improve the quality of investment decision when evaluating new petroleum ventures through a mathematical model based on a Multi Attribute Utility Theory. The proposed method provides a rational tool in decision making through a sensitivity analysis of options and alternatives and the consideration of the interaction of technological advancement and financial and market factors. The contribution ''Value Assessment for Reservoir Recovery Optimization'' discusses the advantages of the real option approach in comparison with discount cash flow method for the evaluation of oil reserves. The paper concludes that the concession time and divided yield are the most sensitive parameters for the evaluation of oil reserves.

In the paper entitled ''Characterization of deep bed filtration system from laboratory pressure drop measurements'', a mathematical model with two empirical parameters: a filtration coefficient and a formation damage coefficient, is formulated for the simulation of the resultant increase in hydraulic resistance to flow due to the entrapment of solid particles in the porous media during the injection of sea/produced water in petroleum reservoirs. The paper also concludes that the proposed method for the evaluation of the parameters furnishes unique values for the two coefficients with the solution being stable with respect to small perturbations in pressure data. Monte Carlo simulation of a three-dimensional network model to represent porous media was carried out by the authors of the paper ''Scaling Laws in Network Models: Porous Medium Property Prediction during Morphological Evolution''. It was possible to relate network parameters to macroscopic properties of the network through some power low correlations that are inferred from percolation theory. Macroscopic property evaluation this way required less computational effort and permitted the incorporation of the developed model into oil flow simulators. Relevant aspects with respect to the use of discrete Markov Random Fields in the

simulation of Rock properties in petroleum reservoirs are discussed in ''The Use of Discrete Markov Random Fields in Reservoir Characterization''. The spatial correlation of binary Markov images were confirmed experimentally by relating the properties of flow in porous media, applying the percolation theory.

For research contribution in petroleum production, Rosa, França and Ribeiro describe the development of cyclone gas–liquid separators undertaken in a joint program involving the Multiphase Flow Laboratory at the State University of Campinas-Unicamp and PETROBRAS. Results showed that cyclone separators, besides having a small footprint and operating with adequate levels of phase separation, are also able to process intermittent gas–liquid flows and three-phase gas, liquid mixtures and solid particulate flows. The paper by Pires et al. addresses the correlation of vapor–liquid equilibrium data for mixtures containing associating molecules such as water or alcohol using a modified equation of state suitable for complex water/hydrocarbon and alcohol/hydrocarbon systems which could be encountered in enhanced recovery processes involving the injection of fluids in petroleum reservoirs. Annular flow patterns of two immiscible liquids of different viscosities in pipes, commonly known as core-annular flow and its application as an attractive alternative for the transportation of heavy oils is discussed in the paper ''Modeling Aspects of Oil–Water Core Annular Flows''. Phenomenological models, based on mass and momentum balances are developed for both horizontal and vertical oil–water core flow. The conclusion drawn by the authors is that core flow technology might be even more attractive for heavy oil production in vertical wells.

The application of microemulsion systems to breakdown water-in-oil emulsions is discussed in the paper entitled ''Microemulsion systems applied to breakdown petroleum emulsions''. The results revealed interesting relationships between breakdown efficiency and co-surfactant–surfactant ratios.

Recent advances in the use of artificial intelligence techniques in petroleum drilling and production operations in Brazil are described in the paper entitled ''Development of Intelligent Systems for Well Drilling and Petroleum Production''. Intelligent system techniques were applied to injection water quality evaluation, water production control as well as production with progressive cavity pump and proved to be successful as evidenced by the resultant increase in petroleum production.

A numerical model to assess the behavior of gas-lift design options is presented in ''Study of the Dynamics, optimization and selection of Intermittent Gas-Lift Methods—A comprehensive model''. The model presented in this paper can be used to carry out simulations under various reservoir conditions and for different sets of operating parameters. The results of the model allow the determination of optimum conditions for the design of gas-lift systems.

This special issue also brings four different papers on the heavy fraction in Brazilian petroleum fluids, the characterization and prediction of the behavior of this fraction and the problems associated with the presence of this fraction in crude oils. The paper ''Poly (Ethylene–Co–Vinyl Acetate) (Eva) as Wax Inhibitor of a Brazilian Crude Oil: Oil Viscosity, Pour Point and Phase Behavior of Organic Solutions'' deals with the paraffinic fraction and the effect of the continuous addition of copolymers on the viscosity and pour point of a Brazilian crude oil that contains such a fraction. The authors conclude that the performance of these copolymers as pour point depressants is strongly dependent on the copolymer composition, with the existence an optimal concentration at which one can obtain the best efficiency. Questions associated with presence of an aromatic heavy fraction, composed mainly of asphaltenes and resins, and consequences on oil production operations is dealt with in the paper entitled ''Interfacial and Colloidal Behavior of Asphaltenes Obtained from Brazilian Crude Oils''. The authors examine aggregation mechanisms, precipitation inhibitors, and surface-related phenomena, through surface tension, viscosity as well as adsorption isotherm and emulsion formation tendency measurements. In the paper entitled ''Asphaltene Flocculation and Collapse From A Petroleum Fluid'' the mechanism of asphaltene deposition, which is the major cause of most organic deposition cases, is modeled based on statistical mechanics of polydisperse polymer solutions joined with the kinetic theory of aggregation and its predictive capability is discussed. Utilization of statistical mechanics of polydisperse polymer solutions joined with kinetic theory of aggregation enables the investigators to develop a realistic model which is able to predict, both, reversible and irreversible heavy organic depositions. Their model is capable of describ-

ing several reversible and irreversible situations, such as the phenomena of organic deposition, growing mechanism of heavy organic aggregates, the size distributions of precipitated organics, and the solubility of heavy organics in a crude oil due to variations in oil pressure, temperature and composition. As an example, the model is applied for heavy organics deposition prediction of two different Brazilian crude oils for which experimental data are available. It is shown that the prediction results of the present model are in good agreement with the experimental data. The last paper ''The Combination of Thermal Analysis and Supercritical Extraction as Tools for the Characterization of Mixed Deposits and Sludges'' explores supercritical CO_2 extraction technology in the classification of deposits from petroleum fluids. Quantitative analysis and classification of paraffinic, asphaltenic and inorganic material are obtained.

The wide spectrum of the topics dealt with in this special issue reflect the wide spectrum of research activities in Brazil. Production of this special issue took almost one year to complete. In response to a call for contributions, 41 manuscripts were submitted and 15 were chosen for publication in this special issue after a lengthy review process. The editors of this special issue would like to thank the Elsevier Earth Sciences Editorial Office in the Netherlands for their cooperation and encouragement in publishing this special issue.

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