Unifying Threads of Southeast Mexico's Discovery Processes*

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Introduction

Southeast Mexico's petroleum region extends from the Isthmus of Tehuantepec to the Mexico- Guatemala border (Figure 1). It is home to four world-class petroleum provinces: the Isthmus Saline Basin, Comalcalco Basin, Reforma-Akal Trend, and Macuspana Basin (from west to east in Figure 1). These provinces have yielded 80 percent of Mexico's cumulative production, contain 60 percent of Mexico's remaining reserves and host 53 percent of Mexico's prospective resources.

The discovery processes of these provinces were forged through different political, economic and legal frameworks, imprinted indelibly by the history of Mexico. Their development was decisive not only for Mexico's economic progress, but also for the growth of major international oil companies and for that of Mexico's own state oil company, Pemex.

Therefore, knowing about the petroleum exploration history of southeast Mexico is a must for petroleum geologists wishing to find new exploration targets in this territory, and also for those seeking to unveil the unifying threads of a significant chapter of Mexico's petroleum industry history.

The pace at which reserves were discovered in four distinct periods in southeast Mexico provides clues to identifying and drawing on their unifying threads, as well as of the declining or impasse phases that followed each discovery period.

Each period shows that the prime and crucial unifying thread for success has been an intellectual tool; namely geological reasoning, marked by a great deal of imagination, study, hard work, willingness to take risks, persistence, patience, cooperation and competence, all within a business environment of operational autonomy. Geological reasoning has been the beacon to question dogmas and has been expressed in three historical phases: inductive, deductive and through an inductive-deductive hermeneutic circle.

Induction: Discoveries at the Cap Rock of Salt Domes

This first period, as well as the period to follow, was outlined by closely linked landmarks that blended the petroleum account of the Isthmus of Tehuantepec and the legendary story of the Texas and Louisiana coastal plains.

After the Pennsylvania oil rush in 1874, Agustín Barroso, a Mexican geologist commissioned to find an interoceanic route across the Isthmus of Tehuantepec, published the “Memoir on the Geology of the Isthmus of Tehuantepec.” In this report, he described sulfur brines and oil seepages on some mounds located in the northern part of the Isthmus of Tehuantepec, east of the Coatzacoalcos River. He predicted that these oil occurrences would be exploited soon.

Barroso very likely knew that in 1862 the search for salt deposits had led to the discovery of the first salt dome in Louisiana, and that commercial production in Pennsylvania was related to the occurrence of oil seepages on anticlinal structures.

The remarkable commercial meaning of Barroso’s harbinger became tangible on the Louisiana and Texas coastal plains. In 1890, Patillo Higgins and Anthony Francis Lucas started prospecting there for oil on the basis of the relationship between sour water springs, oil and gas seepages, and mounds. Their visionary enterprise led them, in 1901, to the famous first great Texas oil strike: Spindletop.

This Texas gusher spurred British contractor Sir Weetman Pearson, who had built the Tehuantepec National Railway, to hire Lucas to assist him in acquiring some coastal plain land next to the railroad. Thus, between 1902 and 1904, Pearson & Son Ltd., which later became Royal Dutch-Shell Group’s Mexican Eagle Oil Company, drilled six wells on salt domes located west of the Coatzacoalcos River. The results were meager and Lucas returned to the United States in 1905 - but his initial efforts were seminal.

From 1905 to 1917, four small light oil fields were discovered east of the Coatzacoalcos River, in the mounds described previously by Barroso, at depths between 40 and 800 meters. The San Cristobal-Copoacan, Soledad-Concepcion and Tecuanapa fields produced from dolomites of the salt domes’ cap rocks; the Ixhuatlan field produced from Miocene sands overlying the salt domes.

By 1908, the maximum daily production from the largest field (San Cristobal- Copoacan) had increased to 1540 barrels per day, but by 1915 it was down to 55 barrels per day. In 1915, in the midst of the Mexican Revolution turmoil, cumulative total production from the four fields had reached 2 MMb, the reserves by then being almost exhausted.

During this first period, offshore exploration in the Gulf of Mexico was overlooked, despite the fact that in 1917 Mexican geologist Fernando Urbina had published a report titled “The Submarine Petroliferous Reservoirs” in which he emphasized the economic significance of oil seepages in the Gulf of Mexico continental platform.

Induction-Deduction: Discoveries on the Flanks of Deeper Salt Domes

By 1918, oil production in southeast Mexico was negligible. However, the legendary discoveries made in the Ebano-Panuco and the Golden Lane areas led Mexico to play a crucial role in World War I, and by 1921 it was the world's second largest producer, with a historic output of 530,000 barrels per day – one quarter of the world's production.

Between 1862 and 1911, several hypotheses had been formulated to account for the origin of salt domes, but they were not thought to be reliable deductive arguments useful to find new oil reserves in Texas and the Isthmus of Tehuantepec. In 1913 and 1916, Everett L. DeGolyer, together with a group of geologists from the Mexican Eagle Company headed by Paul Weaver, visited the Isthmus of Tehuantepec to examine the salt domes, especially the occurrence of oil in Miocene sands overlying the Ixhuatlan salt dome and the oil shows found in two wells drilled on the flanks of the Soledad-Concepcion salt dome.

The field observations in the Isthmus of Tehuantepec, the inspection of similar deposits in Texas and Louisiana, and a critical reading of literature led DeGolyer and his co-workers to new geological thinking that soon proved decisive in overcoming the standstill. They reasoned that lateral sands, like those found on the flanks of the Soledad-Concepcion salt dome, were promising. This inductive argument was backed by the intuition of other European and American geologists who, between 1916 and 1920, thought that refinement of physical instruments could be helpful in mapping oil-bearing subsurface structures.

Suffice to say that, following DeGolyer's recommendation, torsion balances arrived in 1922 in Texas and in 1923 in the Isthmus of Tehuantepec. Seismic refraction and reflection crews began to work in the Isthmus in 1928 and 1933, respectively.

Henceforth, between 1923 and 1935, geological and geophysical methods led to the discovery of oil pools in Miocene sands on the flanks of four deep salt domes located at the western margin of the Tonala River: Filisola, Tonala-El Burro, El Plan and Cuichapa. By 1938, these fields had become the backbone of oil production in southeast Mexico, with total reserves of around 160 MMbls, a cumulative output of 92 MMbls and by then remaining reserves of 67 MMbls. A geological map of Yucatan and Guatemala traced by J. Tercier in 1932, showing the location of oil seepages offshore the State of Campeche, is a testimony of the attention given to the hydrocarbon potential of the continental shelf.

The Hermeneutic Circle: Discoveries on the Flanks of Deeper Salt Domes and in Extensional Tertiary Basins

At the time of the Mexican petroleum nationalization in March of 1938, when the world was about to confront the outbreak of World War II, the landscape of Mexico's petroleum industry was not favorable. Daily production had dropped to 105,000 barrels and the only reliable oil pool was the Poza Rica field. Areas within sight were not promising, especially those in southeast Mexico.

In 1939, a group of no more than 10 young geoscientists with Pemex, with solid track records and operating autonomy, faced the challenge of organizing the exploration activities throughout the whole country: selecting the most promising areas for exploration, finding new reserves to increase and sustain hydrocarbon production, and recruiting and training the most suitable graduates from different geological schools within the country. By 1950, this exploration body had grown to about 100 geoscientists and had the cooperation of renowned former Mexican professors like Ezequiel Ordoñez and that of international consultants. Pemex exploration leaders Santos Figueroa Huerta, Manuel Rodriguez Aguilar, Jorge Cumming, Antonio Garcia Rojas and Guillermo Salas made the titanic assignment possible by giving general guidelines to the newcomers, such as to keep reading vintage data, conduct limited surface geological mapping in order to familiarize themselves with the geology of key areas, and build or become familiar with the geophysical instruments left by the ousted foreign companies.

Pemex's exploration activities in Mexico were formally launched in 1943 and aimed to understand the essential regional geological framework in order to identify the most promising areas. In southeast Mexico, attention was especially focused on the remote Tabasco areas and the Sierra de Chiapas foothills, where oil seepages and previous geological studies had led to drilling exploratory wells with disappointing results.

By 1947, two northeast-southwest-trending minima gravities had been delineated on both sides of the Jalpa High that had been defined by the El Aguila Company, and deeper salt domes were imaged at the easternmost part of the Isthmus Saline Basin. The two minima were interpreted as the Macuspana and Comalcalco Tertiary basins.

The new hydrocarbon laws enacted in 1949 allowed Pemex to grant risk contracts to several American independent companies in order to perform geophysical surveys and exploration drilling offshore, between southern Veracruz and Ciudad Del Carmen, and onshore, in some areas of Veracruz, Tabasco and Campeche. Between 1947 and 1962, Pemex discovered 35 fields in southeast Mexico. Three of them held proved oil and gas reserves of more than 100 million bboe in Miocene sands associated with salt domes in the easternmost part of the Isthmus Saline Basin (Sanchez Magallanes, Cinco Presidentes and Ogarrio fields). Another found gas and condensate reserves greater than 2 Tcf in Miocene sands in the downthrown blocks of normal faults in the Macuspana Basin (Jose Colomo-Chilapilla Field).

Meaningful discoveries were made in 1958 in Upper Miocene sands of the Comalcalco Basin (Mecoacan and Tupilco fields), and a small but significant oil strike was made in 1960 in Upper Cretaceous carbonate rocks in the Cerro Nanchital Anticline, in the Sierra de Chiapas foothills. Offshore Coatzacoalcos, the independent company CIMA discovered three small oil fields in Miocene sands associated with salt domes between 1949 and 1959 (Tortuguero, Rabon Grande and Santa Ana fields).

The Hermeneutic Circle Renewal: Discoveries in Mesozoic Carbonate Rocks of the Reforma-Akal Trend

By the mid-1960s the positive results of the exploratory efforts were deemed insufficient for the country's successful industrialization process. By 1965, the national energy consumption had doubled that of 1955. From 1961 to 1965, annual oil consumption had averaged 820 million barrels. The forecast annual consumption for the 1966-70 period was 1064 million barrels, and for the 1971-80 period it was 3617 million barrels. Since no meaningful discoveries had been made by 1966, Mexico had to suspend oil exports and Pemex, and the independent companies decided not to extend the risk contracts.

The study of the accumulated data, with a mix of imagination, technological creativity and scientific analyses, became of paramount importance.Field mapping in the Sierra de Chiapas had identified porous Upper to Mid-Cretaceous rudist-bearing limestones and dolomites, which showed numerous oil seeps at the crests of thrust-faulted anticlines plunging to the northwest into the Reforma area in the Tabasco

Coastal Plain. There, a refraction survey had sketched a high velocity layer that might be correlated with the carbonate rocks exposed at the Sierra foothills.

By 1969, common-depth-point reflection data and new techniques in processing had improved the image of the high velocity layer. Three on-trend thrust faulted anticlines were seismically mapped in the subsurface beneath a section of sealing shales. Well engineering had by then progressed to enable drilling through the geopressured basal Tertiary shale.

Alternative interpretations were ineluctable. Well results in nearby areas with Mesozoic targets had been disappointing to the extent that some geoscientists thought the high-velocity layer to be Eocene sandstones and conglomerates cut in nearby wells and exposed in the Chiapas Mountains. Others thought this layer could correspond to Cretaceous evaporites seen in some wells in Chiapas to the south.

By mid-1970, sound geological arguments had persuaded Pemex's top management to approve investment for three wildcats in the Reforma area. In 1972, two out of those three wells – Sitio Grande and Cactus – yielded high oil and gas production rates from Upper Cretaceous carbonates. Further wildcats on structures to the north were equally successful in discovering pools in a complex that was later named "Bermúdez."

The Reforma success allowed updating and refining of the paleogeographic maps and encouraged offshore seismic surveys in Tabasco and Campeche waters, where oil slicks had been previously reported. In 1976, the Chac-1 well came in as an oil producer in thick, porous and very permeable Upper Cretaceous breccias. Adjacent pools, like Akal, flowed at average rates up to 33,000 bopd and were later combined to become the Cantarell Complex, the largest offshore oil field in the world.

Javier Meneses de Gyves, Pemex's exploration manager, acknowledged the discovery of this field as the crowning accomplishment of his generation and of his 10 predecessors, the founders of Pemex's exploration activities. Hence he proposed commemorating the success with an act of kindness: Cantarell is the surname of Rudesindo, a fisherman who in 1971 showed up at the Pemex general exploration superintendent's office in Coatzacoalcos to report "an oil stain" at the Campeche Bay.

That sequence of successes was followed by vigorous exploration and development drilling campaigns. By 1974, production from this new trend had increased sufficiently to ford the 1973 oil shock and renew exports. And, once again, Mexico had become a key player on the international oil scene. This geological success was the cornerstone of the country's fiscal revenues for these last three decades.

Corollary

This history shows that in a business environment in which creativity and operational autonomy are encouraged, geological reasoning and diligent exploration strategies are crucial for questioning dogmas. Such questioning must be based on past exploration experiences, actual knowledge and technological breakthroughs, all within the existing regulatory framework.

Geological experience tells us that southeast Mexico still conceals diverse hydrocarbon leads that will demand the talent, technical skills and persistence of a legion of future geoscientists.

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Author

Javier J. Meneses-Rocha (Figure 2) worked for Pemex for 32 years in positions that included manager of geological and geophysical integration and interpretation and exploration manager of the southern region. He is past president of the Asociación Mexicana de Geólogos Petroleros (AMGP) and a member of Mexico's Academy of Engineering. He was awarded the AMGP Prize in 2012 for distinguished professional achievements.

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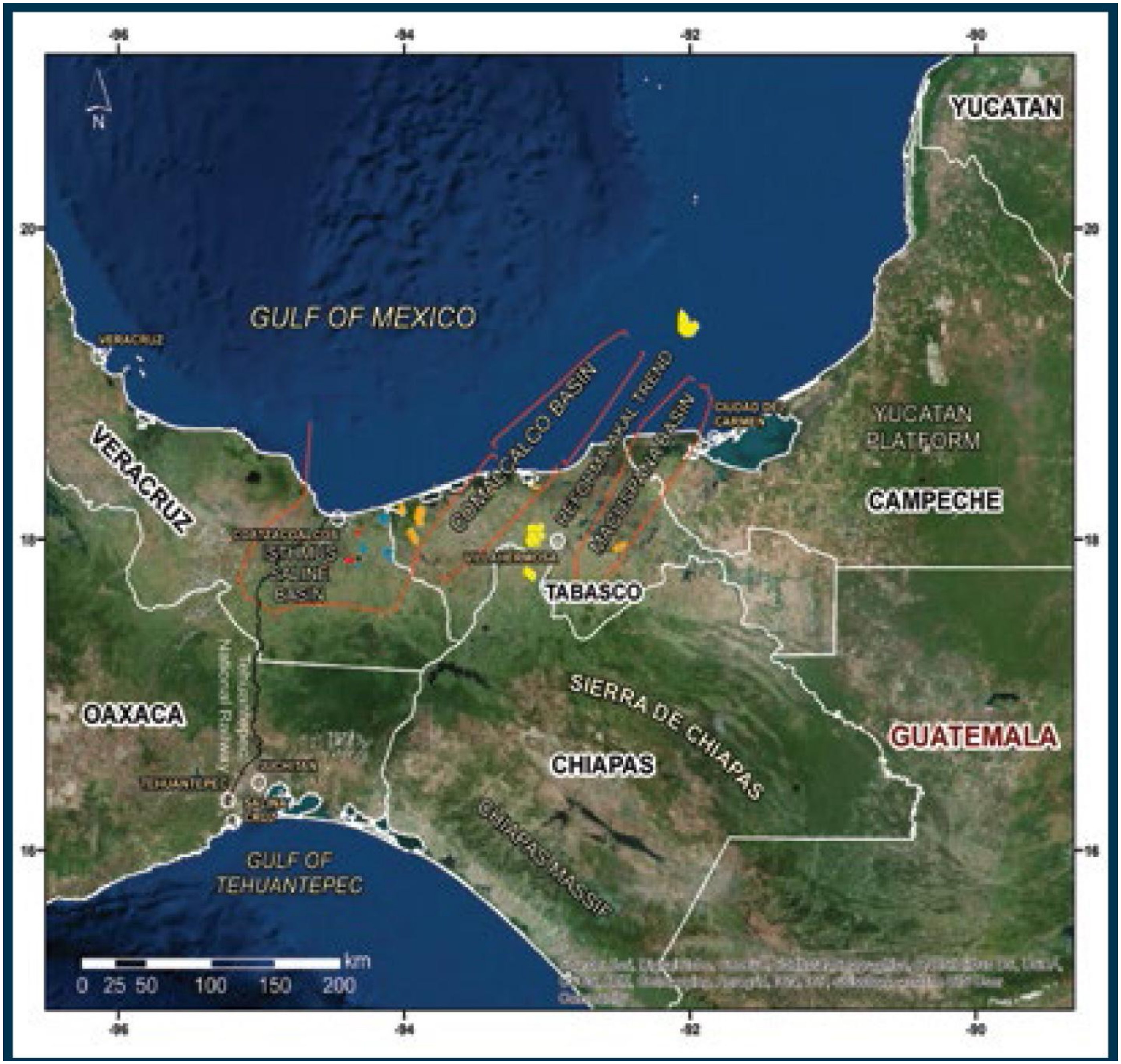

Figure l. Index map of Southeast Mexico, with identification of key geologic provinces.

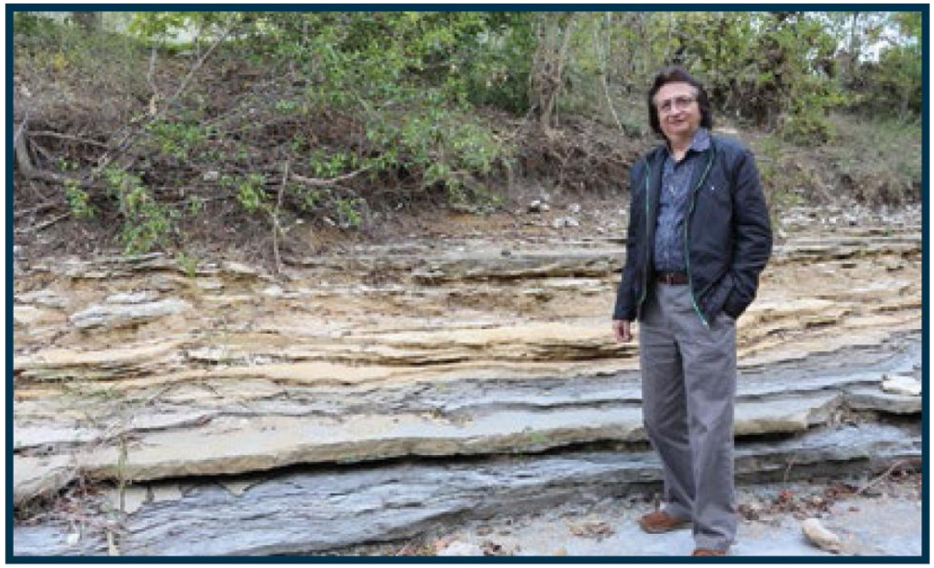

Figure 2. Javier J. Meneses-Rocha, author and past president of AMGP.