

Mexican Raw-Materials Development: A Case Study

Barney Paul Popkin*

Tucson, Arizona USA

Abstract

For over 500 years, Mexico depended on foreign capital for its commercial capital-intensive raw materials development. Mexico still depends on international cooperation from foreign investors, managers, technologies, and markets. Cooperators include its northern, wealthy entrepreneurial U.S. and Canadian neighbors, its historical Spanish colonial masters, and more recently, more modest cooperators from European, Japanese and Chinese organizations. Raw materials were developed for local use, export, political and social reasons, resource independence, as well as investment. For the past 90 years, political and social reasons led Mexico to vacillate between resource nationalization and privatization. Sweeping government reforms in 2015 allow for private and international investment in its energy sector. This encourages more international cooperation.

Introduction

The United Mexican States is located below the southern border of the USA (Figure 1). It covers 2 M sq km of high and rugged mountains, low coastal plains, high plateaus, and deserts with tropical to desert climate. Towards its southern border, the country's climate becomes tropical. Its several geologic provinces are rich if not abundant in natural raw materials: oil and gas, coal, silver, gold, copper, lead, zinc, minerals and gems, construction sand and gravel, salt, biogenetic pool, timber, and sea water. Mexican sea water is a long-term raw-water source for future desalination activities for its coastal cities and perhaps for southern Arizona.

Mexico delivers petroleum resources by pipeline, ship, truck and rail. According to CIA [1] in 2014 Mexico produced an estimated 45.4 B cu m of natural gas in (19th in world), and 2.549 M bbl/d in (11th in world) of its estimate 9.812B bbl crude oil proved reserves (January 2015; 17th in world). Mexico exports about \$430.9 B of goods (2015); \$398.3 B (2014) 12th in the world. Approximately 80.2% of its exports go to the U.S. (2014) as manufactured goods, crude oil, oil products, silver, fruit, vegetables, coffee and cotton. Sweeping government reforms in 2015 allow for private investment in oil, gas and energy sectors and this can attract international cooperation.

Table 1 compares the Mexican petroleum and mining sectors. Table 2 provides information from the Ministry of the Economy mining insights and shows the sectors importance and trade agreements. Table 3 compares mineral and petroleum exploration and development. The purpose of Tables 1 and 3 is to illustrate the resources required for these sectors. Table 4 is a strengths, weaknesses, opportunities and threat (SWOT) analysis of Mexico's raw materials sector. The SWOT analysis is a standard business-type evaluation of strengths, weaknesses, opportunities and threats. Table 5 provides a personal account of recent Mexican mining inefficiencies. A personal account of recent Mexican petrol station bribery has also been provided.

A shorter, more succinct version of this article was submitted to the European Geologist journal for publication in its September 2016 issue on international cooperation in raw materials development. Its title is "International Cooperation in Development of Mexican Raw Materials."

Geologic Thumbnail

My late British, New York University petrology professor Leslie Spock was fond of saying, "Quartz is ubiquitous, but gold is where you find it." There are many geological settings to account for igneous,

sedimentary and metamorphic conditions that can lead to gold and other metals being trapped in rock. For example, porphyry intrusions vent into existing bedrock, often limestone, and release pressurized gases to produce ore-body lined tubes or chimneys of metal sulfide. These chimneys are typically, galena, anglesite, wulfenite, smithsonite, covellite and cerrusite in the form of lead-silver-zinc deposits. Commodity ores often are in association with each other, such as lead (galena), zinc (sphalerite), silver, copper, gold and molybdenum. Tourists and mineral collectors can enter open and abandoned mines to collect such peculiarities as black wulfenite crystals resulting from manganese inclusions.

Most of the conventional crude oil and natural gas reserves are located in three main areas: onshore along the eastern coast, within the deep sea exploration area of the Gulf of Mexico, and at the Yucatan Platform. There are several different types of petroleum deposits based on various sedimentary and structural traps ranging from overlying salt domes, buried coral reefs, deep marine deposits such as turbidites, and traps related to sedimentary facies changes, faults, interfingering, lithologies and similar sedimentological arrangements. Current economic conditions prevent development of shale gas and other unconventional petroleum resources. If the price of a barrel of oil increases two to three times, Mexico may enjoy production from unconventional resources as well as conventional oil and gas reserves.

Benefits, Management and Finances

Extraction sector benefits

The extraction, processing and marketing of raw materials is an ancient human activity, though fraught with risks to human health including its workers and nearby public, the environment including habitats, and its invested capital, operations and markets. The benefits are vast, beyond simply meeting the demand for construction materials, fuels and metals, as well as providing economic development through

*Corresponding author: Barney Paul Popkin, Consultant, Tucson, Arizona, USA, Tel: 16917334860; E-mail: bpopkin@yahoo.com

Received July 19, 2016; Accepted March 30, 2017; Published March 31, 2017

Citation: Popkin BP (2017) Mexican Raw-Materials Development: A Case Study. J Geogr Nat Disast 7: 194. doi: [10.4172/2167-0587.1000194](https://doi.org/10.4172/2167-0587.1000194)

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Figure 1: Location map of Mexico.

Oil and Gas Sector	Mining Sector
<p>The government monopoly Pemex dominates the sector and also runs Mexico's retail gas stations either directly or through small but growing private concessionaires like Grupo Hidrosina, La Gas, and more recently, U.S.-based Gulf Oil. Mexico is the world's 11th largest oil producer, 13th largest oil exporter, with the 17th largest oil reserves, and 4th largest producer in the Western Hemisphere behind the USA, Canada and Venezuela (Wikipedia, 2016). Oil generates 10% of Mexico's export income and generates about 33% of collected taxes. Ending a 76-yr largely unprofitable monopoly, Mexico kept 83% of its petroleum reserves within its Pemex bureaucracy, but in an effort to boost declining income and dwindling productivity, government auctions for foreign firms were announced for new shale gas and offshore oil and gas exploration and development. This unknown reserve is estimated at 20% of future production (Parker, 2014). Exxon-Mobil, Shell, Chevron, Petrobras, BP, Russia's Lukoil, Japan's Mitsui, Toronto's Pacific Rubiales, Dallas' Talos, London's Premier, Italy's Eni are among over 30 firms chasing this market.</p>	<p>Mexico's main foreign investment countries include USA, Spain, Canada, Netherlands, Germany, Japan, Belgium and France with about 8.8% invested in the mining sector in 2014 (Ministry of the Economy, 2016). Gold, silver and copper dominate the Mexican mining sector with over 60% of annual mining production value; Canada represents 75% of the total foreign investment related to the mining sector in Mexico (Deloitte, 2012). Much of Mexico's mining sector is controlled by oligopolies, wealthy families and associations. Grupo Mexico of Cananea, Sonora, holds vast mining interests in Mexico, as well has interests in Minera Mexico, Ferrocarril Mexicano, Condumex, Southern Copper Corporation, Mexican Railway Group and Ferrosur, Asarco, and International Copper Association Banamex.</p>
<p>As crude oil prices dropped to almost one third of their previous price over the past several years, Pemex has been under pressure to cut its costs and increase foreign investors. Petroleum producer Pemex seeks at least a sustained price of USD 25/bbl to at least cover its heavily subsidized costs (Domm, 2016), compared to a 2008 peak of USD 120/bbl.</p>	<p>As copper prices slump, dipping below USD 2.00/lb in January 2016, or less than half its 2000 high, it has traded at a spot price of USD 2.30 most of the year. Copper prices had been on an upswing during autumn and early summer 2016 on signs of more demand from China, but fell to USD 2.11 on news of Britain's vote to leave the EU on June 23, which also adversely impacted copper firms' share price by more than 10% on the New York Stock Exchange. Copper miners seek at least a sustained price of USD 2.15 to consider making future expansions (POT, 2016).</p>

Table 1: Comparison between the Mexican petroleum and mining sectors.

Mining in Mexico and the World	Foreign Trade/Countries with Treaties and Agreements signed by Mexico
<p>The mining-metallurgical sector in Mexico contributes 4% of national GDP.</p> <p>Mexico in the world</p> <ul style="list-style-type: none"> Ranked first place in silver production worldwide. It ranks among the top 10 world producers in: bismuth, fluorite, celestite, wollastonite, cadmium, molybdenum, lead, zinc, diatomite, salt, barite, graphite, gypsum, gold and copper. It is the first destination in investment in mineral exploration in Latin America and the 4th in the world according to the report released by SNL Metals & Mining 2015. It is the 5th country in terms of being the best environment for mining businesses, according to a report by consultancy Behre Dolbear published in August 2015. <p>Mining-metallurgical sector in Mexico</p> <ul style="list-style-type: none"> As of July 2015, it generated 352,666 direct jobs and 1.6M indirect jobs, according to the report by the Mexican Social Security Institute. 	<p>Mexico has signed bilateral investment treaties with over 30 countries. Mexico has a network of 12 Free Trade Agreements with 46 countries, 32 Agreements for the Promotion and Reciprocal Protection of Investments with 33 countries and 9 agreements of limited scope (Economic Complementarity Agreements and Partial Scope Agreements partial) within the framework of the Latin American Integration Association. In addition, Mexico is actively involved in multilateral and regional organizations and forums such as the World Trade Organization, the Asia-Pacific Mechanism Economic Cooperation, and the Organization for Economic and Cooperation and Development.</p>
<p>Ministry of the Economy (2016)</p>	<p>Ministry of the Economy (2015)</p>

Table 2: Mexico Ministry of the Economy Mining Insights.

employment, taxes, royalties and concessions, indirect benefits, and resource self-sufficiency. A single, large mine may employ several hundreds to thousands of people, impact several hundreds more people in the local economy, and pay out hundreds of millions of

dollars to its employees and indirect beneficiaries. It is often the single local employer if not a significant one. A large metals mine may pay millions of USD in taxes, wages and spending by the company and its employees.

Oil and Gas Exploration	Oil and Gas Development
Review of historical and anecdotal information and surveys; magnetic, gravity and seismic geophysics; soil, water, vegetation and thermal surveys; onshore/offshore drilling, sampling, testing and assays; mapping, krigging and statistical data and factor analysis; extended mapping/projections; conceptual and numerical modeling.	Permitting; land purchasing or leasing; extended onshore/offshore drilling; pumping and storage; refining; oil distillation; gas compression and liquefaction; water and steam injection; hydraulic fracturing; oil/water separation; natural gas scrubbing; marketing, distribution and transportation to markets; monitoring and evaluation.

Table 3: Comparison of mineral and petroleum exploration and development.

Minerals Exploration	Minerals Development
Review of historical and anecdotal information and surveys; magnetic, IP and EM geophysics; soil, water, vegetation and thermal surveys; trenching, drilling, sampling, testing and assays; detailed mapping, krigging and statistical data and factor analysis; extended mapping/projections; conceptual and numerical modeling.	Permitting; land purchase or leasing; resettlement and compensation; surface extraction or open-pit mining; tunneling; quarrying; blasting; shallow shafting; subsurface mining; overburden and tailings resource recovery; crushing; ore concentration and floatation; metals smelting and refining; minerals leaching and recovery; marketing, distribution and transportation to markets; monitoring and evaluation.

Table 4: SWOT Analysis of international cooperation in Mexican raw materials.

SWOT	Analysis
Strengths	<ul style="list-style-type: none"> • Extensive natural resources for the development of all types of industry at competitive costs • Rising middle class with discretionary income, wanting to invest and that is demanding better and more goods and services • Growing economy • Good labor laws • Basic education, training and literacy in English and Spanish • Awareness of challenges among public sector operators, generous international donors; well-informed academics, researchers and private sector advisors, consultants, and engineering firms; successful non-governmental organizations • Strong maquiladoras (duty-free manufacturing operations) and shelter companies • Liberalized and favorable US/Mexico trade policies • Good quality highways, roads, bridges, rail, trucking and shipping • Vibrant young, educated and skilled labor force • Expedited USA/Mexico customs services and growing and new ports of entry • Weak regulations and enforcement
Weaknesses	<ul style="list-style-type: none"> • Nation-wide and government corruption, poor public management in which there are institutional and political constraints threatened press and media, criminality, heavily centralized decision making, embezzlement, bribery, corruption, nepotism/cronyism/favoritism, poor governance, and the unavailability of trained and motivated personnel • Labor shortages and rising labor costs • Non-transparent contracting and bidding regulations and processes • Ports of entry need more trained staff and efficient and fast manning in customs, and national protection and security • Bank interest rates remain comparatively high • Economy is highly tied to the well-being of the U.S. economy • Socioeconomic and class stratification • Violence involving criminal organisations that present a risk in parts of Mexico (particularly some of the areas along the U.S.-Mexico border) • Some sectors are reserved exclusively for the Mexican State or for Mexican nationals • The country's large size presents distribution or supply chain challenges • Public management, implementation, and efficiency in Mexico are weak and non-sustainable without donor funds and extensive outsourcing to the private sector, due to: institutional and political constraints, criminality, non-competently based appointments, heavily centralized decision making, corruption and cronyism and favoritism, unavailable trained, experienced and motivated personnel, inadequate capital and operations and maintenance capacity, old or failing and incomplete physical infrastructure, and poor financial practices. • Government restrictions on certain foreign investment; the investment climate suffers from red tape, corruption, arbitrary licensing decisions, high taxes (some specific to mining), tariffs, and fees, archaic legislation, and weak intellectual property rights. • Claims for government reform may be oversold. • Transparency International (2015) ranked Mexico a score of 35 of 100 from 168 countries, where 0 is most and 100 is least corrupt.
Opportunities	<ul style="list-style-type: none"> • Growing demand for low-cost, high-quality raw materials • Labor costs comparable to Asia-based manufacturing, extensive trade agreements and a strategic location between North and South America; Mexico is well-positioned to enter these markets or expand their supply chains • Government is very positively oriented to foreign investment with efforts to make economic reform and new investment opportunities
Threats	<ul style="list-style-type: none"> • Growing national and local movements in environmental protection; threats by indigenous peoples and their labor rights; and materials reduction, reuse, recycling and substitutions; the suggestion of phasing out fossil fuels; competition from less developed countries with abundant raw materials; fluctuations in demands and exchange rates • Unanticipated adverse event

Table 5: Mexican mining inefficiencies.

Extraction sector management

Careful monitoring and evaluation, and analysis of and acting upon operating results and market conditions are critical to the financial health of extractive industries. When oil and metals prices fall, industry owners and managers typically struggle to remain in business, often needing to survive a short-term financial loss, by cutting costs and selling or leasing out assets. Cost cutting includes reducing work hours, lying off labor, reducing benefits, renegotiating debts and other financial agreements together with postponing expenditures.

Selling and leasing out assets include physical as well as lease-holding contracts, permits, royalties, concessions, options and commitments.

Not all raw materials development activities are profitable, and several may be established for non-profit or even cost-covering objectives. This is especially true in socialist or nationalist economies where governing authorities deem it important to employ or at least pay personnel to improve social and economic stability and attain some autonomy, national pride and resource independence through government intervention. This has been prevalent in Mexico's early mining operations and especially for its oil and gas development.

Extraction sector finances

Raw materials development is a capital intensive industrial sector with highly variable incomes. Mining, for example, requires expensive generally non-liquidable physical assets from land to equipment. Cash flows and profitability fluctuate considerable due to chances in commodity prices, foreign currency exchange rates, and international demand. If an operation pays dividends to investors or equity holders, this may come from operational revenue, asset sales, borrowed money or combinations. An increase in its assets is not necessarily good if there is an increase of inventory or financing, or a decrease in dividends. Nonetheless, raw materials firms tend to seek increases in market share, assets and profitability, and tend to be tempted towards overexpansion.

Oil and Gas Historical Background

Oil and gas in Mexico became modernized through its national monopoly Pemex [2]. From its founding in 1933, and the quick expatriation of foreign oil company facilities, it was and continues to be heavily subsidized by the Mexican government. Pemex consistently lost money until 1962, at a time when imported crude oil and oil products decreased. This financial breakthrough occurred a year after Pemex obtained international credits from the British Board of Petroleum Equipment (10M £) and other US financial institutions (\$50 M), including Chase Manhattan Bank, to stimulate oil company programs. However, over its long history, Pemex depended heavily of foreign subcontractors to provide technology and service expertise.

The history of the last 78 years of Mexico has been fed by the presence of the most important company our country has had. To talk about Pemex is to talk about effort, sacrifice, and dedication, but also about development, success and progress. In this chronology some events that marked the growth of the petroleum industry are presented, through it you may understand a little more of how *Petróleos Mexicanos* has struggled and has merged with the Mexican economy to become the development engine that, for several generations, has been and remains the pride of the Mexican people.

For political, social and economic reasons, the Mexican government began to reform its monopoly of its oil and gas sector through: a PRI-PAN alliance which enabled the December 2013 approval of constitutional reforms on energy; December 2013 Constitutional Reforms; and Secondary Laws Approved in August 2014 [3].

Mining Historical Background

There is extensive and interesting literature on the mining history of Mexico, going back to the diaries and reports of colonial Spanish missionaries and noblemen. This legacy illustrates extensive international cooperation through funding, management and technology and the Mexican government's capacity to adapt and improve the terms of contracts to garner interest from foreign investors.

Couturier [4] discusses the nature of colonial entrepreneurship in the mid-18th century. He notes the high cost of new mining technologies, the extent of capital transferred to fixed mining works, the improved silver refining methods, the policies of the Spanish crown and its constant need for money, and the foreign control over the mines. At that time, the government favored large enterprises and monopolies in the hands of wealthy Spanish merchants.

Taylor [5] discusses the mid-to-late 19th century Mexican gold mining boom. He notes the boom energized Mexican-U.S. trade,

economic development of Southern California, and the then Mexican government's attempts to control the mines and their foreign investors.

Hart [6] discusses the pre-Mexican Revolution period's silver bonanza where American investors began purchasing mines and expanding their hold on natural resources outside the U.S. between the mid-19th century and 1910. He notes the technology, industrialization and the politics tied local Mexican mining communities to the U.S. and China, and led to Mexican development programs which relied on foreign investments, foreign managers and foreign technology.

Shepherd [7] discusses silver mining difficulties in Copper Canyon, State of Chihuahua, from 1880 to the early 20th century. He notes the challenges of supervision, accounting, ore treatment and transportation, extraction of silver, smelting and refining into bullion bars, and shipping to markets from the viewpoint of the vice president and general manager of an American silver mining company.

Calderón [8] discusses the hand-loading coal mining era from the late 19th century to 1930 which gave way to the new era of advancing mining. He notes the complex matrix of mining, investment capital, labor markets, railroad construction and racial ideology during economic growth and social disruption in both Mexico and the western U.S.

Lowell [9] recounts his experience as an American mineral exploration geologist working in Mexico from the mid-20th to early 21st century. He applied successful classic geologic mapping, sophisticated geophysical and geochemical exploration, and statistical methods to generate the scientific data which, in turn, allowed discover and then created the financial structures to develop the mines.

Gómez discusses the massive confrontation between the Mexican National Miners' Union and the transnational corporations through a mining blast which trapped 65 miners underground 2006. Gómez notes this event as a "senseless tragedy stemming from an insatiable hunger for profits."

Today, Mexico ranks as one of the world's top metals producers [10]. Money collected from mining royalties will go to the fund for sustainable regional development in mining municipalities. In May 2008, building on a 100 years legacy of Cornish miners in Mexico, the Mexican mining industry issued an Initial Public Offering as Fresnillo, the world's largest producer of silver, on the London Stock Exchange. The enterprise, the first truly Mexican company to be listed in London, raised some USD 2 B, but its initial public offering had broader ramifications implying that London dominates international mining finance. However, though Mexican mining contributed 8% to its Gross Domestic Product (GDP) in 2014, there were also more than 37 disputes over land, water, environmental and social issues [11-14].

Investments and international cooperation

Investment in Mexico's raw materials is funded by wealthy, traditional land and property rich families, as well as consortia and concessionaires, and of course by foreign investors, donors and the federal government.

USAID (2016) notes: The U.S. and Mexico have strong social, cultural and economic ties; common security concerns; and a shared border. Mexico, as an upper middle income country with a high level of institutional capacity, is also a strong development partner for the USA. While Mexico is a modern democracy with a thriving economy, challenges related to crime and violence, rule of law, human rights, climate change, economic competitiveness, and workforce development remain. To address these challenges, USAID works with



a broad array of public, private and non-governmental partners to support Mexican initiatives and priorities [15-17].

U.S-Mexico cooperation includes: Bilateral Framework on Clean Energy and Climate Change (2009); North American Development Bank loan of over USD 577 M since 2011 for wind and solar energy development; USAID’s Mexico Global Climate Change (GCC) program, a 5 y, USD 70 M greenhouse gas reduction and low emissions program (2011-2014); U.S.-Mexico Trans-boundary Hydrocarbons Agreement, a Gulf of Mexico energy partnership (2012); and USAID environmental and water/wastewater initiatives. An earlier USAID pre-2000 “Partnership to promote Clean Technology in the Mining Sector in Latin America and the Caribbean” included pollution prevention in Mexican mining.

Additionally, EU-Mexico cooperation includes: EU-MEX INNOVA (2013-2016) which includes clean energy development; EU-Mexico Global Agreement (2015) which includes renewable energies; EU-Mexico GEMex (2016-2020) 3 years renewable geothermal energy where each party is contributing €20 M.

Mexico’s government, led by President Enrique Peña Nieto, emphasized economic reforms during its first 2 years in office, passing and implementing sweeping education, energy, financial, fiscal and telecommunications reform legislation, among others, with the long-term aim to improve competitiveness and economic growth within the Mexican economy. Mexico began holding public auctions of exploration and development rights to select oil and gas resources in 2015 as a part of reforms that allow for private investment into the oil, gas, and electricity sectors. The second and third auctions demonstrated the capacity for the Mexican Government to adapt and improve the terms of the contracts to garner sufficient interest from investors amid low oil prices [18-22].

The country has several constraints to development. These include low GDP and GDP growth rate, high poverty, democracy and governance challenges, debt and budget deficits, illicit and organized criminal activities including drug cartels which are intertwined with Mexico’s mining sector, recently weakened oil prices and budgetary overdependence on its petroleum exports. There are several structural issues limiting progress, such as high migration and brain-drain rate, low productivity, high inequality, a large informal sector employing over half of the workforce, weak rule of law, and corruption.

The Mexican Government has taken on substantial economic reforms that aim to help ensure the security of investment operations, despite uncertainty in the global investment environment. Its 2014

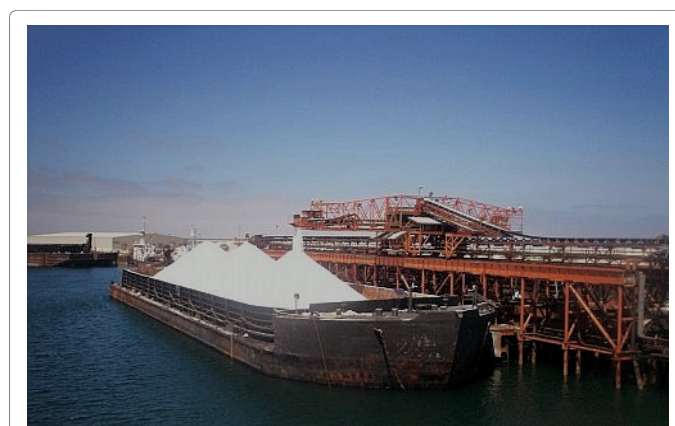


Figure 3: In 2014, Mexico exported slightly over 9 million tons of salt from its Exportadora de Sal facility in Baja California Sur, jointly owned by the Mexican Government and Japan’s Mitsubishi, worth USD 164M, making it the world’s seventh largest world producer and fifth largest salt exporter, after the Netherlands, Canada, Germany and Chile (Geo-Mexico, Why is the world’s largest salt-works in Baja California Sur? 12 Feb 2015).

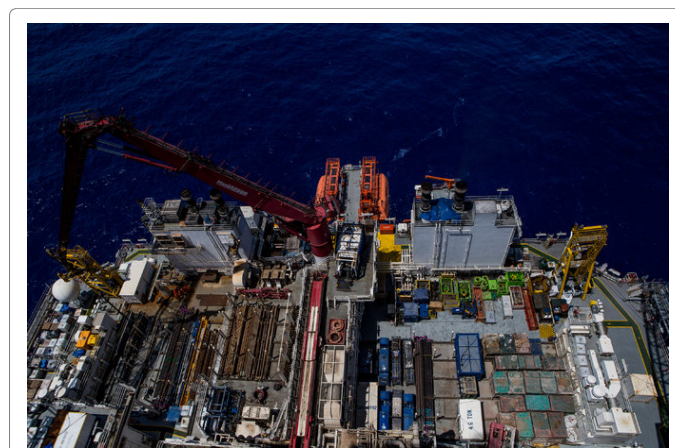


Figure 4: La Muralla IV, an off-shore drilling rig working for Pemex, the Mexican state-owned oil company, in the Gulf of Mexico near Veracruz (NYT, 2012).

national infrastructure plan focused on transportation, water, electricity, health, energy and urban development. The large scale of this plan will not only improve infrastructure for future investment operations, but also provide investment opportunities in sales to or subcontracting with the federal government [11].

Personal account of recent Mexican mining inefficiencies by a mining geologist

On the basis of my year spent at Compania Minera Dolores, State of Chihuahua:

a) Inadequacies and unhelpfulness of the Mexican police in upholding the rule of law.

b) Need for expatriates to be given extra protection (i.e. flying between the Chihuahua city and the mine site) to avoid possible kidnap by drug runners.

c) Inability of senior Mexican mine management to show an example to their subordinates by adhering to normal work/leave rotation rosters. The general manager (and his assistant) at the Dolores mine would work from Monday morning to Friday morning every week, flying in and out from/to Chihuahua city and spent three days over every weekend with their families at home. Everyone else working at the mine was required to work two weeks continuously at the mine followed by a one week leave.

We had an incident at the mine where the vehicle that brought in food was stopped from progressing to the mine. Certain villagers put up barricades which they refused to pull down unless the mine paid them USD 100,000. The mine manager tried to call in the police but they said that they didn't want to get involved! The matter was finally resolved by getting local politicians involved who insisted that the barriers be pulled down.

Personal account of recent Mexican petrol station bribery

In July 2016, a Mexican-American neighbor planned a touristic and shopping visit to Puerto Peñasco, Sonora, Mexico from Tucson, Arizona, USA. She plans to take her estranged former husband along with her as his Spanish is better and he is better equipped to bribe the Pemex petrol station operators for a lower fuel price. Bribery is common at border, customs, police and other stations and public facilities in Mexico (Figures 2-6).



Figure 5: Grupo Mexico's Cananea mine in Mexico holds the second biggest copper reserve in the world. Image courtesy of Lokomen123.

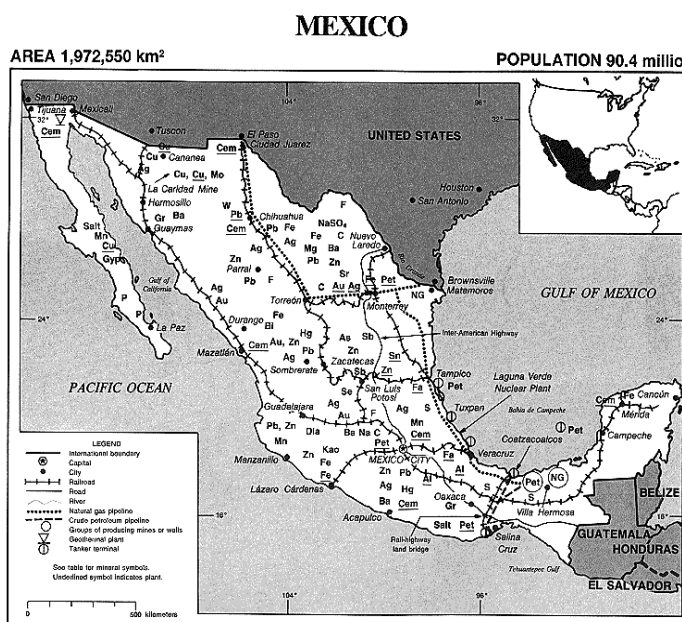


Figure 6: USGS Mexican minerals map (January 13, 2013).

Acknowledgements

I gratefully acknowledge the helpful resources of the CNN, Congressional Research Service, Economist magazine, Geo-Mexico, HORIZON 2020, Inter-American Development Bank, Mexican Ministry of the Economy, Mexico Mining Center, New York Times, Open Universities Australia, Pemex, Pima County Public Library, Port of Tucson, Santander, University of Arizona, USA Today, Wikipedia, Wall Street Journal, and the ubiquitous Internet. I am especially indebted to the wisdom and guidance provided by Bruce Raymond, Chuck Josephson and Mina Goldberg of Tucson; David Pollard of Loughborough; Emeka Ezeh of Abuja; Igor Ziderer of Dushabe; Ihor Nikiteno of Dnipro; Jim Jacobs of San Francisco; and Omar Barrios of Lima.

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