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CONSERVATION OF THE OIL AND GAS RESOURCES OF THE AMERICAS. PART I.¹

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ACKNOWLEDGMENTS.

In preparing a paper of so wide a scope as the title of this one implies, it becomes necessary to seek information from first-hand sources if one wishes to make his data at all complete. The writer has been fortunate in having the hearty coöperation of many whose personal work is adding day by day to our general knowledge of the gas and oil fields of the Americas. Among those to whom he is particularly indebted are Dr. George Otis Smith, director of the United States Geological Survey; Dr. Eugene Haanel, Dr. R. G. McConnell, and Mr. Wyatt Malcolm, of the

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INTRODUCTION.

It is the purpose of the present paper to show the status and possibilities of the oil industry in each country of the Americas, and to discuss briefly some of the ways in which the oil resources of these countries can best be conserved. Gas will be mentioned only as it is incidental to the oil.

Before beginning the discussion it will be well to enumerate some of the factors that govern the production of oil and gas in all countries. These factors may be divided into two groups—natural factors and artificial factors. In the group of natural factors are rock pressure, or pressure under which the oil and gas exist in their underground reservoir; viscosity of the oil; and thickness, extent, porosity, and structure of the reservoir rock. In the group of artificial factors are the price of oil or gas, which is the dominant factor, and such others as depth of wells; time required to complete wells; distance separating wells; condition of wells, pumps and other equipment; improvements in methods of development and recovery; water complications; discovery of new fields; distance of fields from markets; transportation facilities; and relative cost of production in the several fields. These condi-

² *Petroleum World*, Vol. 12, February, 1915.

tions have all been briefly discussed in a paper³ by the writer appearing in a recent number of this journal.

The relative rank as oil producers of the countries of the Americas with respect to one another and to the countries of other continents is shown by the following table, compiled by the United States Geological Survey.

TABLE I.

WORLD'S PRODUCTION OF CRUDE PETROLEUM IN 1914, AND FROM 1859 TO 1914, WITH PERCENTAGE OF PRODUCTION, BY COUNTRIES, IN BARRELS OF 42 GALLONS.

	Country.	1914.		1859-1914.	
		Production.	Per Cent.	Production.	Per Cent.
1	United States.....	265,762,535	66.36	3,335,457,130	59.63
2	Russia.....	67,020,522	16.74	1,622,233,845	29.00
3	Mexico.....	21,188,427	5.29	90,359,860	1.62
4	Roumania.....	12,826,579	3.20	117,982,474	2.11
5	Dutch East Indies.....	^a 12,705,208	3.17	138,278,392	2.47
6	India.....	^b 8,000,000	2.00	73,979,919	1.32
7	Galicia.....	^b 5,033,350	1.26	131,873,601	2.36
8	Japan.....	^c 2,738,378	.68	27,051,158	.48
9	Peru.....	1,917,802	.48	14,306,972	.26
10	Germany.....	^b 995,764	.25	12,965,569	.23
11	Egypt.....	777,038	.19	1,086,728	.02
12	Trinidad.....	643,533	.16	2,069,430	.04
13	Argentina.....	600,000	.15	600,000	.01 ½
14	Canada.....	214,805	.05	23,493,610	.42
15	Italy.....	39,548	.01	802,229	.01
16	Other countries.....	20,000	.01	722,000	.01 ½
		400,483,489	100.00	5,593,262,936	100.00

^a Includes British Borneo.

^b Estimated.

^c Includes Formosa.

As nearly three fourths of the world's supply comes from North and South America, the tremendous influence they wield in this great industry is obvious, and in view of the fact that petroleum is a fundamental necessity of modern civilization, the strength of the new world's position becomes manifest. The countries of North and South America now hold relative positions in this industry indicated by the following order: United States, Mexico, Peru, Trinidad, Argentina, Canada, Venezuela, Colombia, Bolivia and Ecuador.

³ Arnold, Ralph, "Petroleum Resources of the United States," *ECON. GEOL.*, Vol. X., p. 695.

OIL FIELDS OF NORTH AMERICA.

Indications of petroleum are found in most of the countries of North America. The United States and Mexico are the largest producers, and Canada yields a small quantity, but the other countries are non-productive at present.

NEWFOUNDLAND.

Petroleum was first discovered in Newfoundland in 1812, but no effort was made to develop it for over half a century. The petroleum-bearing area of Newfoundland is confined to its west coast, the principal localities, according to Redwood, being at Port au Port Bay and from Bonne Bay to Sandy Bay. The reservoir rocks are the porous Lauzon limestones and Levis sandstones of the Quebec group, of Ordovician age. The oil is of brown color, light gravity, and paraffin base and ranges from 36° to about 46° Baumé (0.843 to 0.798 specific gravity). Development has consisted in the sinking of four or five wells at Parsons Pond, 100 miles northeast of Port au Port Bay. The deepest well attained a depth of 1,500 feet but found only a fair showing of oil. Other wells put down at Port au Port Bay yielded small quantities of a light paraffin-base oil. No commercially important deposits of petroleum are believed to exist in this island.

CANADIAN OIL FIELDS.

General Features.—The oil-producing territory of Canada is confined at present to the province of Ontario, where an area of about 25 square miles of proved land yields the total annual output of a little over 200,000 barrels of oil. Extensive areas in western Canada, however, offer indications suggesting the presence of oil in commercial quantities, and it is believed that the future will see the Dominion take its place as an important producer of petroleum. The oil-yielding formations are of Ordovician to Carboniferous age in the east and of Cambrian, Devonian, and Cretaceous age in the west. The oil is usually found in sandstones, limestones, or dolomites, associated with anticlines and domes. It ranges from the heavy oil of asphaltic type in

Athabasca to the high-grade refining oils of 36° to 46° Baumé (0.8434 to 0.7955 specific gravity) of the Ontario field. The initial production of individual wells has never gone above 7,500 barrels daily; the present average per well is only a few gallons. The product is used entirely within the country.

Nova Scotia.—Oil seepages occur in the Carboniferous shale and sandstone around Lake Ainslie, on Cape Breton Island, in Nova Scotia, but shallow borings made here have not been rewarded by production. This evidence and the paucity of indications elsewhere in the province leads to the conclusion that it will never yield oil in commercial amounts.

New Brunswick.—The proved oil territory of New Brunswick occupies an area of about two and one half square miles. It lies on the west bank of Petitcodiac River, between Stony Creek and Weldon Creek in Albert County. The oil occurs in sandstone beds, which are possibly in the nature of lenses in the shales of the Albert series of the Carboniferous system. The oil has a paraffin base, is free from sulphur, and ranges in gravity from about 32° to 37° Baumé (0.862 to 0.838 specific gravity). The production of the wells is small. Considerable quantities of gas accompany the oil. Indications of petroleum have also been found along anticlines in Kings and Westmoreland counties. To judge by the results of drilling in this province it does not seem probable that large deposits of petroleum will be found here.

Quebec.—Discoveries of gas in commercial quantities and indications of petroleum have stimulated prospecting in Quebec over a long period of time. Gas is found at St. Hyacinthe, St. Grégoire, Beauséjour, and in insignificant quantities elsewhere; evidences of petroleum occur on the Saguenay, Dartmouth, York, St. John and Malbey rivers. The area chiefly explored lies in the basin of York River as far west as Falls Brook. The hydrocarbons are found at one place or another through the entire geologic series from the Trenton limestone (Ordovician) to the lower Devonian, but the upper formations yield the most favorable evidences for commercial deposits. The oil indications are usually associated with anticlinal structure. The oil is mostly of

high grade, ranging between 18° and 46° Baumé (0.948 to 0.795 specific gravity). Development has been carried on intermittently for a period of over forty years in the Gaspé field, but no uniformly commercially successful results have been realized, although some deep wells have been sunk. It does not appear probable that the province will ever yield more than very small quantities of oil.

Ontario.—The petroliferous fields of Ontario, the most important oil-producing province of Canada up to the present time, form a northeastward continuation of the Ohio-Indiana field of the United States. The producing oil fields are limited to that section of the province lying south of a line drawn from the west end of Lake Ontario to the foot of Lake Huron, and most of the oil produced comes from Lambton, Kent, Elgin, and Brant counties. The Oil Springs pool covers two square miles, and the Petroleo field covers 26 square miles. None of the others cover more than a few square miles, and the total proved area of the district probably does not exceed 50 square miles. The formations yielding oil and gas range from the Trenton (Ordovician) to the Chemung group (Devonian). The chief source of oil is the Onondaga limestone of the Devonian, and the principal deposits of gas are found in the Medina sandstone and Trenton limestone. The Tilbury field derives its oil from the Salina formation and Guelph dolomite of the Silurian. The rocks as a rule are nearly horizontal and are covered by a great thickness of drift. Domes are the principal structural features affecting accumulation in these fields, although locally porous lenses or pockets and crevices afford sites for commercial deposits of oil. The wells range in depth between 300 and 500 feet and in production from an individual initial yield of 7,500 barrels daily, in one of the wells drilled in the sixties, down to the average of a fraction of a barrel a day now maintained by the wells of the district. The Ontario petroleum is rich in lubricating oils and give good yields of paraffin; those of Lambton County run as high as 2.5 per cent. in sulphur. The Lambton County oils range in gravity from 31° to 35° Baumé (0.8696 to 0.8485 specific gravity); those

of Tilbury from 38° to 41° Baumé (0.8333 to 0.8187 specific gravity). The relative importance of the Ontario pools is shown in the following figures of production furnished by Mr. Wyatt Malcolm, of the Canadian Geological Survey:

TABLE II.
PRODUCTION OF PETROLEUM IN ONTARIO.

	1906.	1910.	1914.
Lambton County.....	377,286	205,456	154,186
Bothwell field.....	44,827	36,998	33,961
Tilbury and Romney.....	106,992	63,058	18,530
Dutton.....	19,376	7,752	1,190
Onondaga.....		1,005	2,437

There are a few other fields of small yield, and a few that have produced small quantities of petroleum but are now exhausted. The total production of Canada in 1914 was 214,805 barrels, practically all of which came from Ontario.

In view of the facts that all the favorable localities in the Ontario field have been pretty thoroughly prospected and that the decline of the present pools suggests that the production will sink to rather insignificant quantities within a comparatively short time, it is evident that this province, like all of the others in eastern Canada, is destined to play but a very minor part in the oil industry of the future.

Calgary or Foothill Field.—The Calgary or Foothill field received more attention and gained more notoriety during 1914 than any other oil region in North America. It includes the narrow belt of sharply folded and faulted Cretaceous rocks that extends for 500 miles northwestward along the eastern foot of the Rocky Mountains from the international boundary into northeastern British Columbia, and the parallel wider belt of low, broad domes and folds, also developed in the Cretaceous rocks, in the plains country of southern Alberta and Saskatchewan. Oil has been found in noteworthy if not yet commercially remunerative quantities in shale formations above the Dakota sandstone along the crests of sharply folded anticlines in the narrow belt near Cal-

gary, and gas is being recovered in commercial quantities from beds at practically the same horizons in the broader folds in the plains region about Medicine Hat. The oil from the Calgary wells ranges from 38° to 62° Baumé (0.8333 to 0.7290 specific gravity), and the highest-grade oil is a very unusual natural product. The output of the few wells that have struck oil in the Calgary region has not yet been thoroughly tested, as the best wells have produced only a few hundred barrels in all. It is the writer's opinion that the area of commercial productivity will be confined to a few square miles along the crests of locally favorable anticlines and that the product, though small in quantity for individual wells, will for the most part be an oil of unusually high grade.

Athabasca or Tar Sand Field.—The Athabasca or Tar Sand field includes the area in northern Alberta extending from a locality a short distance north of Edmonton to the lower reaches of Athabasca River. Throughout portions of this region Devonian limestone is unconformably overlain by asphalt-saturated sands or tar sands of Cretaceous age. These sands are in places as much as 200 feet thick, and, according to Bosworth, cover an area of at least 2,000 and possibly 10,000 square miles. If uniformly saturated they would contain 200,000 million tons of oil, enough to satisfy the world's demand at the present rate for 2,000 years. A few wells, one at least 1,750 feet deep, have been put down in the Tar Sand region, and considerable gas and a little oil have been recovered. The oil is black and viscous and yields unusual percentages of gasoline, kerosene and lubricants for its relative specific gravity. Owing to the poor transportation facilities and the rather unfavorable structural conditions for the accumulation of oil in the localities so far examined, little will probably be done toward the immediate development of this region, but as a potential source of hydrocarbons it must certainly be taken into account. Those who are best acquainted with it are the most enthusiastic over its possibilities.

Northwest Territories.—According to Bosworth the region between Peace and Athabasca rivers and the Arctic Ocean, covering

200,000 square miles, is occupied largely by Devonian limestones and shales which at many points yield direct evidences of petroleum in the form of seepages, burnt shale, etc. The structure is locally favorable for the accumulation of oil, broad anticlines prevailing over extensive areas. The oil is apparently of light gravity and excellent quality. No wells have yet been drilled in the region to test its commercial possibilities, and although it is at present isolated from the markets of the world by hundreds of miles of trackless wilderness, it must, like the Tar Sand field to the south, be regarded as a possible source of future supply of oil for North America.

British Columbia.—The British Columbia or Rocky Mountain field, as at present known, occupies the extreme southeast corner of British Columbia and the extreme southern part of Alberta and extends across the international boundary into Montana. The region is that of the great overthrust fault which has forced the mountain-making mass of Cambrian rocks out over the Cretaceous strata of the plains province. On Sage Creek and other adjacent tributaries of Flathead River, on the west, and on Pincher Creek, on the east, well-defined anticlines in the Cambrian beds yield seepages of a light oil, and wells drilled at both localities have produced petroleum of approximately 40° Baumé (0.8235 specific gravity). The oil from Sage Creek is of a peculiar milky color and an unusual composition for a natural oil and supports the theory that it has been derived by filtration from the Cretaceous beds underlying the Cambrian in the area of the thrust fault. It is the writer's belief from personal examination that not more than four or five square miles of this field, at the most, may prove productive, and that this area will be made commercially productive only by the most careful management.

UNITED STATES.⁴

General Conditions.—The oil fields of the United States are fairly well distributed geographically, occupying areas from the

⁴Details concerning the oil fields of the United States were covered in the paper mentioned in the footnote on page 204, so that only a general statement will be included here.

Appalachian Range on the east to California on the west, and from the Canadian boundary on the north to the Mexican line on the south. They are usually classified as the Appalachian, Lima-Indiana, Illinois, Mid-Continent, Gulf, Rocky Mountain, California, and Alaska fields. Their proved area includes over 4,100 square miles; the prospective territory nearly 1,000 square miles. The production for 1914 was 265,762,535 barrels; the total production to 1914 was 3,335,457,130 barrels; the estimated future supply is 5,763,100,000 barrels. The oil is found in formations ranging in age from the Ordovician to the latest Tertiary and Quaternary, usually in sandstones or limestones. Practically all types of structure are present in the productive areas, but anticlines and domes predominate. In quality the oil ranges from the asphalt-base oils of California and Texas, whose gravity is from 10° to 35° Baumé (1.000 to 0.8485 specific gravity), to the lightest paraffin-base oils of the Eastern States, whose gravity is from 25° to 52° Baumé (0.9032 to 0.7692 specific gravity). The maximum production of individual wells for most of the fields is less than 10,000 barrels daily, although there have been daily records of 58,000 barrels in California and 75,000 barrels in Texas. The wells range in depth from 200 to more than 6,000 feet. Old pipeline transportation systems extend for hundreds of miles in certain parts of the country.

MEXICO.

*General Features.*⁵—The known oil fields of Mexico are included within two great regions, both of which are segments of the Gulf Coastal Plain—the Tampico-Tuxpam and Tehuantepec-Tabasco regions. The Tampico-Tuxpam region is the larger and better known and consists of that part of the Coastal Plain tributary to and depending mostly for supplies on transportation through the ports of Tampico, in the State of Tamaulipas, and Tuxpam, in the State of Vera Cruz. It covers approximately that part of the Coastal Plain between Soto la Marina and Tecolutla

⁵ This section is copied practically verbatim from statements kindly prepared for the writer by Mr. John S. McKenna, under the direction of Mr. V. R. Garfias, and by Mr. E. De Golyer.

rivers, an area of some 20,000 square miles. It includes parts of the States of Tamaulipas, Vera Cruz, San Luis Potosí, Puebla, and Hidalgo and embraces some fifteen oil fields. The Tehuantepec-Tabasco region consists of that part of the Coastal Plain included in and between the valleys of the Coatzacoalcos and Grijalva rivers and includes parts of the States of Vera Cruz, Tabasco, and Chiapas. This region embraces some four or five oil fields. A very rough estimate places the proved area in the two regions at 25 square miles; the prospective area at 500 to 1,000 square miles.

Exploration has advanced too little and the Mexican fields are too young to justify any but approximate estimates of the proved, probable, or possible oil territory in each field, nor are such estimates of much value, even for comparative purposes, without a full consideration of other factors that are as yet undetermined. Inasmuch as less than 700 wells have been drilled for oil in the entire Republic up to the present time and as almost two thirds of the entire quantity of oil produced has come from two wells, neither of which is more than six years old, it would be rash indeed to give too much weight to estimates of unit areas.

The principal oil-yielding rocks in the Tampico-Tuxpam region are the Tamasopo limestone, of Cretaceous age, and the overlying San Felipe series, of Cretaceous or Eocene age. The oil in the San Felipe rocks has apparently migrated from the underlying Tamasopo through faults, fissures, and broken contact zones between sedimentary and intrusive rocks. Some oil is found in the overlying Mendez shale, of Eocene age, and the Oligocene limestones which overlie the Eocene. This oil also is evidently derived from the Tamasopo limestone. The oil-bearing rocks of the Tehuantepec-Tabasco region are true quartz sands of Miocene (?) and Pliocene age.

The Tamasopo limestone, the principal oil-yielding rock, is a massive-bedded, fossiliferous, hard, porcelain-like limestone. It is locally porous or cavernous as a result of solution. It is not dolomitic but is somewhat siliceous. The overlying San Felipe beds are a series of alternating impure limestones and shales, in

which the oil occurs to some extent in porous limestone members but more generally, perhaps, in interstices in the shales. Many wells that are apparently finished in the San Felipe draw their major oil supply from the Tamasopo limestone through fissures. Potrero No. 4 was finished in the San Felipe, but a great number of blocks of Tamasopo rock were blown out when the well came in.

The fields of the Tampico region are generally anticlinal in structure, so far as is known; the San Diego, Casiano, Naranjos, Tierra Amarilla, Potrero and Alamo fields being markedly so. The structure of the Topila, Panuco, Ebano, Chijol and Chila Salinas fields is not determined, but it is probable that they are the result of the filling of porous beds in the San Felipe formation through fissures that extend to the Tamasopo, and that the structure is not a vital factor in the accumulation of the oil deposit. The Furbero field is structurally a laccolith or sill intruded into the Mendez shales on a preexisting anticline. The shales were metamorphosed by the intrusion and the igneous rock of the sill was subsequently altered, thus providing pore space. The oil evidently came from the Tamasopo limestone.

The oldest Mexican field dates as an important producer from 1906, the Isthmus fields from 1907, and the most productive fields from the later part of 1910. There are almost no data to be had regarding the life of a field or of a well. Laguna No. 2 of the Ebano field came in November 7, 1906, with an initial production of 500 barrels a day. Five years later, in December, 1911, it was producing 450 barrels a day. No information is available regarding the larger wells, for the potential production so far exceeds the actual production, because of a lack of transportation facilities, that for many wells the true capacity, initial, potential, or present, is unknown. The largest gaged production is that of Potrero No. 4, at some 110,000 barrels daily. Casiano No. 7 has yielded a total production to the present time of some 40,000,000 barrels, with no apparent sign of decline.

The following table shows the range in production of individual wells and the present daily production by districts.

TABLE III.

RANGE IN PRODUCTION OF INDIVIDUAL WELLS, AND DAILY PRODUCTION BY DISTRICTS.

District.	Range in Daily Production per Well. <i>Barrels.</i>	Net Present Daily Production for the District. <i>Barrels.</i>
Ebano	50- 5,000	5,000
Panuco	50-100,000	20,000
Huasteca	50-110,000	45,000
Tuxpam	50- 10,000	10,000
		<u>80,000</u>

The bulk of the oils at present produced commercially are heavy oils of mixed asphalt and paraffin base. The oils of the Tehuantepec-Tabasco region are the lightest, their gravity ranging from about 15° to 29° Baumé (0.964 to 0.882 specific gravity). The oils of the Tampico-Tuxpam region are somewhat heavier and fall into two general classes, the heavy oils of the Panuco River valley fields, with gravity of nearly 10° to 14° Baumé (0.896 to 0.972 specific gravity), and the lighter oils of the Casiano, Potrero, Furbero, and other fields, with gravity of 19° to 26½° Baumé (0.940 to 0.900 specific gravity). A very high grade oil, about 49° Baumé (0.783 specific gravity), has been discovered south of Valles, in San Luis Potosi, but revolutionary disturbances have precluded the development of this deposit up to the present time.

The oil is usually accompanied by and associated with a considerable quantity of gas, all "wet" so far as known. White estimates that 10,000,000 to 12,000,000 cubic feet of gas is produced daily by Casiano No. 7, and it is probable that a like quantity is produced at Potrero. A well in the Topila field came in last May with an estimated daily flow of 15,000,000 cubic feet of "wet" gas. The Alamo field is said to have a potential daily production of 4,000,000 to 6,000,000 cubic feet of "wet" gas.

The depth of the producing wells of the Tampico-Tuxpam region ranges from 113 feet, in Tanhuijo well No. 1, to 4,000 feet, in San Pedro well No. 1, though most of the large producers are between 1,600 and 2,500 feet deep. Exploratory wells 3,000

to 4,000 feet deep are not uncommon, and Furbero No. 19, the deepest well in Mexico, has reached a depth of 4,640 feet. The wells of the Tehuantepec-Tabasco region are relatively shallow.

The following table summarizes information about the operating companies and wells:

TABLE IV.
OPERATING COMPANIES AND WELL DATA, MEXICO.

District.	Com- panies.	Wells Pro- ducing.	Wells Being Drilled.	Dry Holes or Aban- doned Wells.	Idle Wells.	Depth (Feet).
Huasteca	11	28	27	40	24	1,700-3,000
Ebano	1	5			22	1,500
Tuxpam	1	2	5	1		2,000
Panuco (Topila)	16	^a 23	11	9		2,600
Panuco (Panuco)	46	^a 60	57	12		
Panuco (other fields)	4	2	1	1	11	770-4,000

^a Completed.

Both the rotary-hydraulic and standard cable systems of drilling are used. The former is particularly efficient and rapid in drilling through the great shale formation which overlies the oil zone; the latter is most efficient for drilling the alternating shales and limestones of the San Felipe series and the hard limestone of the Tamasopo, the producing formations. Though both systems are used for the entire completion of wells, a combination of the two is generally regarded as most efficient and is in general use. The Canadian pole tool and Fauck systems have each been tried in this region but, as they present no decided advantages and it is difficult to obtain repairs, spare parts, etc., they have been abandoned.

The first and most general use for Mexican crude oil, aside from supplying oil for refining, for local trade, has been as a fuel oil. More than half the oil produced in Mexico is exported to the United States, where it is used for the most part as fuel oil. Shipments are also made to Central and South American and European ports. Considerable quantities of refined oils, including fuel oil, are exported to Great Britain. Asphalts, road oils, and similar products are exported to Canada, the United States, and Europe. The present tendency, with the increased refining

facilities at Tampico and the better development of refining practice both in Mexico and in the United States, is to top the crude oil before using it for fuel and thus save the lighter and more valuable constituents.

Several American and European financial groups interested in the petroleum industry are represented in the Mexican fields.

The Mexican Petroleum Co., Ltd., and its subsidiaries (Doheny interests) are at present the largest producers and best equipped as regards camps and facilities for transportation and storage. Their product is sold mostly in bulk to American companies along the Gulf States. Of late this company has undertaken to market its products in the United States and has established distributing depots at New York and on the Mississippi River not far from New Orleans.

The Aguila Oil Co. and its subsidiaries (Pearson interests) have a larger nominal production than the Mexican Petroleum Co., but are somewhat hampered by insufficient pipe-line and storage facilities. The oil is refined at their Minatitlan plant, the products being sold in Mexico and exported to Europe. This company and the Mexican Petroleum Co. furnish practically all the oil used in Mexico and the greater portion of that which is exported.

The Waters-Pierce Co (Standard Oil) has a refinery at Tampico, where Mexican and American crude oils are treated, and producing wells in the Panuco district. This company and the Aguila control the market for refined oils in the Republic.

The Corona Oil Co. (Dutch Shell), East Coast Oil Co. (Southern Pacific), Pennsylvania Mexican Fuel Oil Co. (Standard Oil) and other concerns have strong affiliations and ample market facilities in the United States and Europe and thus are able to dispose of their Mexican products regardless of the local market. Most of the lands controlled by these companies are located in the Panuco and Tuxpam districts.

Besides the groups just enumerated there are several independent companies that have no affiliations with any of these groups and depend on small contracts and the local market for the dis-

posal of their products. The lands controlled by some of these companies are located in the Panuco and Huasteca districts, in comparatively small tracts, many of them scattered over large areas. The boom time for operators of this type is practically over, and the bulk of the oil industry in Mexico has passed into the hands of large financial interests.

The following figures of production of crude oil in Mexico were compiled by Miss Anna B. Coons of the United States Geological Survey.

TABLE V.
PRODUCTION OF CRUDE OIL IN MEXICO, 1904 TO 1914.
(In barrels of 42 gallons.)

1904	220,653
1905	320,379
1906	1,097,264
1907	1,717,690
1908	3,481,610
1909	2,488,742
1910	3,332,807
1911	14,051,643
1912	16,558,215
1913	25,696,291
1914	21,188,427
	90,153,721

Soto la Marina Field.—The northernmost oil field in Mexico takes its name from Soto la Marina River. It is in the State of Tamaulipas, 15 to 20 miles from the coast and 100 miles north of Tampico. The oil in this field is found in the porous limestone of the San Felipe series (Cretaceous and Eocene). Some oil may occur under laccoliths or lava flows above the main producing horizon. No well-defined structure other than the easterly monoclinical dip is observed in the field, the dominant structural factors of accumulation being basalt intrusions, laccoliths and faults. The oil averages about 18° Baumé (0.9459 specific gravity). Two wells are now being drilled in this field and have attained a depth of 3,000 feet, but oil in commercial quantities has not yet been encountered.

Tamasi Field.—The Tamasi field includes all the more or less

prospective areas between Los Esteros, on the Mexican Gulf Railroad, and the valley of Tamasi River, 20 to 30 miles northwest of Tampico. The oil comes from fracture zones in the lower Mendez marl (Eocene) and limestones in the San Felipe formation (Cretaceous and Eocene). Toward the northwestern part of the field anticlines appear to play an important part in the accumulation of the oil, but the southwestern part is more probably affected by fracturing and faulting. The oil is very heavy, ranging from 10° to 14° Baumé (1.000 to 0.9722 specific gravity). The production of the wells is so small and the oil so heavy that it is commercially worthless under existing marketing conditions.

Ebano Field.—The Ebano is the oldest of the fuel-oil fields and is on the Mexican Central Railway 40 miles west of Tampico. It includes about 4 square miles of proved ground, the few tests so far made outside of the producing area have not proved successful. The oil comes from the limestone and fracture zones in the San Felipe (Cretaceous and Eocene), the accumulations being largely determined by volcanic necks and fault zones. The oil ranges in gravity from 10° to 14° Baumé (1.000 to 0.9722 specific gravity). Wells yielding as much as 5,000 barrels a day have been recorded in the field; but the settled production runs from 25 to 5,000 barrels daily per well. La Paz No. 1 has averaged 1,500 barrels daily since April, 1904. The wells range in depth from 1,500 to more than 2,000 feet. The oil has been used principally for fuel on the railroads and for the manufacture of asphalt.

Panuco-Topila Field.—The most important of the northern fields is the Panuco-Topila, which extends along Panuco River from 20 to 30 miles west of Tampico. The proved area embraces about 4 square miles; the possible territory includes at least 10 square miles. The oil is obtained in the San Felipe (Cretaceous and Eocene) but probably comes from the underlying Tamasopo limestone (Cretaceous) through fissures. The range in gravity is 10° to 14° Baumé (1.000 to 0.9722 specific gravity). An initial flow of over 100,000 barrels daily has been recorded for one well; the settled production ranges from 50 to 100,000 barrels daily. The average daily production per well, for the wells now

being operated in the field, is about 250 barrels. The wells range in depth from 1,800 to 2,600 feet. The oil is all marketed through Tampico and is used largely for fuel and the manufacture of asphalt. On account of its great viscosity, which renders pipeline transportation unsatisfactory, the oil is sent down the river in barges. Transportation is the factor at present governing the production of this field.

Valles (San Pedro) Field.—The small Valles or San Pedro field lies in the belt of Tertiary rocks 80 miles west-southwest of Tampico. The proved area includes a quarter of a square mile; the possible territory 1 to 2 square miles. The oil comes from the crest of an anticline in alternating limestones and shales of the San Felipe (Cretaceous). It averages about 48° Baumé (0.783 specific gravity) and is light colored and extremely volatile. The daily production of individual wells ranges from 50 barrels initial to 10 barrels settled. The wells are about 4,000 feet in depth.

Huasteca District.—All the fields lying between the valleys of Panuco and Tuxpam rivers, southwest of Tampico, among which are the Tanhuijo, Tierra Amarilla, Juan Casiano, Cerro Azul, Potrero del Llano, and Los Naranjos fields, are included in the Huasteca district. This district occupies a belt about 80 miles in length and 30 miles in average width, or a total area of 2,500 square miles. The proved areas include about 15 square miles; the possible territory at least 500 square miles. The oil is obtained from beds at various horizons from the Tamasopo limestone (Cretaceous) to the Tuxpam impure limestones and sands (Miocene). The enormous producers, all of which yield medium-grade oil of 19° Baumé (0.9395 specific gravity), obtain oil from the porous and cavernous limestones at the lower horizons. The sandstones and limestones at the upper horizons yield smaller quantities of a higher-grade oil—26° to 29° Baumé (0.8974 to 0.8805 specific gravity). Broad anticlines with numerous faults and igneous intrusions of various types appear to dominate the commercial accumulations. The initial production of individual wells yielding the medium-grade oils reaches 110,000 barrels a day, the capacity for settled controlled production ranges from 50 to 110,000 bar-

rels daily, and the average daily production is at least 1,600 barrels per well. The production of the wells yielding high-grade oil ranges from 300 barrels initial down to 25 barrels settled. The oil is marketed through Tampico and Tuxpam and is used principally for fuel, with minor quantities being refined. The wells tapping the upper (Tertiary) beds range in depth from 100 to 500 feet; those reaching the lower horizon from 1,800 to 2,500 feet.

South Tuxpam Field.—The South Tuxpam field includes the areas south of Tuxpam River, such as Furbero and Alamo, covering about 800 square miles. The proved territory is less than 1 square mile; the prospective territory about 50 square miles. The oil at Alamo comes from the Tamasopo (Cretaceous) limestones, probably in an anticline, and that at Furbero from Eocene marls associated with a laccolith or sill. The oil ranges from 18° to 26° Baumé (0.9459 to 0.8974 specific gravity). The range in individual daily production is from 20,000 barrels initial (Alamo) to less than 100 barrels settled (Furbero). The wells are from 1,700 to 2,500 feet deep. The oil is marketed at Tuxpam for fuel and refining.

San Cristobal Field.—The San Cristobal field is about 40 miles inland from Coatzacoalcos, in the Isthmus of Tehuantepec, and includes some subsidiary fields, such as Jaltipan. Its areal extent is about 20 by 5 miles, or 100 square miles. The proved area is less than 1 square mile; the prospective area is rather small. The oil-yielding rocks are lower to middle Tertiary sandstones; the dominant structures are well-defined elongated domes. The oil ranges in gravity from 25° to 32° Baumé (0.9032 to 0.8642 specific gravity). The individual daily production runs from 500 barrels initial to 50 barrels settled; an average at the present time is about 50 barrels. The market for the oil is the Minatitlan refinery. The wells are from 300 to 1,000 feet in depth.

Macuspana-Chiapas Field.—The Macuspana-Chiapas field includes areas in south-central Tabasco to the borders of Chiapas. The petroliferous territory includes about 20 square miles, of which about a quarter of a square mile is proved. The oil comes from middle and upper Tertiary sandstones in monoclinical and

anticlinal structure. The range in gravity of the oil is 30° to 40° Baumé (0.8750 to 0.8235 specific gravity); the average daily production is about 10 barrels to the well. Little of the oil has been marketed, and the field is temporarily idle. The wells range in depth from 100 to 2,000 feet.

Campeche Field.—Recent test drilling at Rancho el Chapopote revealed promising indications of an oil field near Campeche in the State of Campeche.

Conclusions.—No one can read even the most moderate statement regarding the Mexican oil fields without being impressed by their wonderful potentiality. There are a dozen wells in Mexico which, if opened to their full capacity, could almost double the daily output of the world. Political disturbances and difficulties of transportation have governed the production in Mexico since the large wells were brought in, so that no adequate estimate of total capacity can be made. It is certain, however, that the Mexican fields are destined to control the fuel situation on this side of the Atlantic Ocean for a long time to come, and that it is simply a question of transportation facilities and markets that will determine whether these fields are to produce as much or more than the combined fields of the United States. As to the longevity of the wells, no one can predict with certainty. When a well or group of wells begins to drop in production its decline will probably be rapid, for all the evidence in hand leads to the conclusion that water surrounds and underlies the productive areas and zones, and when the oil is gone from any reservoir the incoming water will terminate its productivity forever.

(To be continued.)