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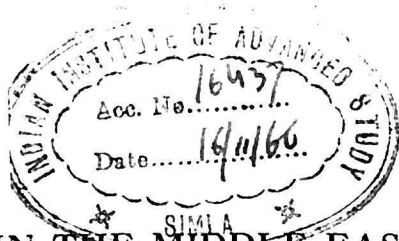
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OIL IN THE MIDDLE EAST

By G. M. LEES, M.C., PH.D.

Report of a lecture given on Wednesday, July 18, 1945.
Captain E. H. O. Elkington, M.C., in the Chair.

The CHAIRMAN: It is a privilege and a great pleasure to introduce Dr. Lees; in fact, he needs little introduction because he is a geologist of international reputation, and was largely responsible for the discovery of oil in Great Britain. Although Dr. Lees has travelled extensively in many parts of the world his interests have caused him to make a special study of the oil resources of the Middle East. Oil—what tremendous significance attaches to that simple little word! It describes a substance which touches our lives so closely wherever we go and almost whatever we do. Is it surprising, then, that a substance which produces such energy, fuel, light and power should also give rise to political and strategic considerations of the utmost importance? The Middle East is, as you are aware, already richly endowed with political and strategic problems, and we hope that its oil resources will lubricate them and not aggravate them further. Dr. Lees is going to tell us about those oil resources, their extent and their possible potentialities, and we hope that he will also tell us the manner in which they fit into the world-wide oil picture.

I HAVE been asked to lecture on the general nature of the oilfields of the Middle East in order that you may be able to understand something of the background of what is called in journalistic circles "oil politics." We in this country have long realized the importance of the Middle East in general and of Persia in particular as a source of substantial oil reserves. During the inter-war period other nations, following our lead, took an increasing share in the search for and development of oilfields in the Middle East, but the process was gradual and relatively unobtrusive until suddenly in the autumn of 1943 the full glare of world publicity was given to the immense importance of the region, by American official and unofficial statements and by extravagant estimates. You may ask what had suddenly happened, and had some new and enormous discovery been made to give rise to such a burst of publicity and planning and schemes and discussions. The answer, strangely enough, is in the negative. Nothing had happened; at least, nothing in the Middle East. The reasons for it all arise from a stocktaking process of the oil reserves of the world as a whole and of the United States in particular, and the results of this have shown that the Middle East is relatively of much greater importance than had been generally realized hitherto. Before commencing a description of the Middle East oilfields I shall therefore discuss very briefly the present opinions on the potentialities of various oil-producing areas and give, before that, a short introduction on the very nature of oilfields.

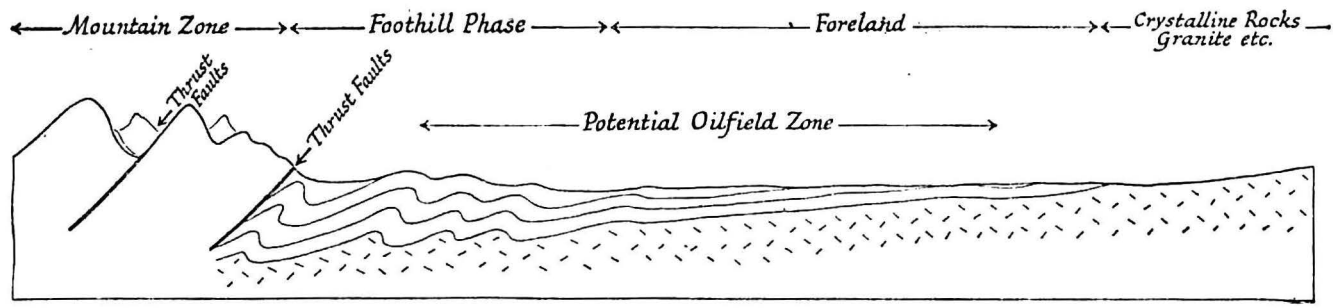
We in Great Britain are well aware of our coal-mining problems, and even the public in general appreciates that our coal seams are fossilized accumulations of tropical forests buried beneath more recent strata. But we are less well educated on the nature of oilfields; an oil man is to us a stranger, almost lacking in respectability, and until recently we have had

no contact with oilfields in our own country. Oil is a fossil organic product formed by the chemical or biochemical decomposition of seaweeds or other algal growths, or of lowly forms of animal life entombed with sediments forming on the bottom of the sea or of estuaries. At first, small globules of oil and gas were dispersed through thick accumulations of shales, but later compaction of these shales squeezed these globules into adjacent porous strata, either sandstones or porous limestones. The oil globules were still in a dispersed state in such water-bearing strata, and the next phase was a concentration of the oil and a separation from its attendant water. This is effected by gravity. In many zones of the earth's crust the mountain-forming movements have thrown strata, originally horizontal, into a series of giant waves and troughs, geologically known as anticlines and synclines (see Fig. 1). The result of this was to incline the porous water-bearing strata containing widely dispersed oil globules, and these globules gradually moved up such a porous bed by flotation, accumulating in the crestal part of an adjacent anticline, sealed against further upward rise by impervious strata. If excess gas were present it would occupy a position above the oil (see Fig 2). This is called the anticlinal type of oil accumulation, and is the simplest, the most common and the most easily discovered. Other types are governed by a lensing-out of an inclined sandstone bed, called a stratigraphical trap, by salt domes, where the tilting of the porous strata is caused by intrusions of rock-salt, by fault-structures and by various other circumstances.

The essential conditions which govern the occurrence of concentrations of oil are therefore very complex; original richness of the oil-forming organic material, suitable porous strata, inclination of the strata to allow separation of oil from water, and adequate cover rocks to prevent too great a leakage of oil to the surface by seepage—all these must occur in favourable conjunction. The zones of possible oilfields throughout the world can thus be defined by geological structure as shown in Fig. 1. The high mountain zones may once have contained oil accumulations, but they have been bled to death by deep erosion and exposure. The areas of granite and other crystalline rocks lying in front of such a system can, by their nature, never have contained oil. The intervening "foothill" and "foreland" zone contains the surviving oil prospects. The breadth of this zone varies from a few miles where the mountain ranges have been extremely compressed, as, for example, along the Bavarian Alpine front, to several hundred miles in the sector of Persia and Iraq.

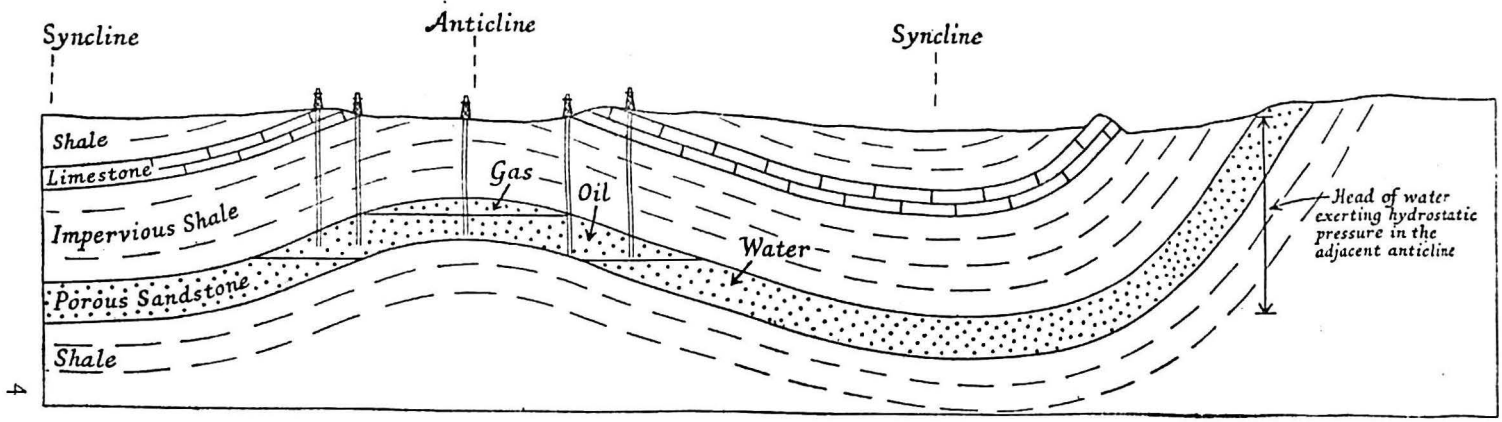
The distribution of oilfields throughout the world is limited by these factors. They are aligned along the front of definite mountain systems—the Rockies and the Appalachians of North America, the Andes of South America, the Alps, Dinaric Alps, Caucasus and Urals of Europe, the Persian Zagros ranges, the Himalayas, the ranges of Burma, of the East Indies, and of Japan and Sakhalin. Elsewhere some local circumstances may cause locally favourable conditions, but they may be regarded as exceptional and outside the general rule.

No estimate is possible of the total petroleum reserves of the world, as so many potentially oil-bearing countries are as yet inadequately explored, and geological science cannot predict the size of oil accumulations



Generalised cross section of a mountain system from high mountains to crystalline foreland

Fig. 1



Geological vertical section through a typical anticlinal oilfield

Fig. 2

without the practical test of drilling. Experience, however, has shown that the average oilfield in the world is small and that large fields are exceptional and groups of large fields even more so. The only country in the world which has been really intensively explored is the United States of America, and here certain estimates are possible, although, as usually set out, they are most misleading. About 3,500 separate oilfields have been discovered in the United States and a total of 4,250 million tons produced, or 63 per cent. of the total world production up to date. The total oil in any given oilfield can be measured by calculations of areal extent of the reservoir rock, its thickness and porosity, but the proportion of the total which can be extracted by present-day producing methods is a variable quantity, less easy of estimation. It varies from 25 per cent. to perhaps 75 per cent. of the total. The total known and producible reserves of the United States can therefore be calculated within limits, and a yearly stocktaking on these lines is carried out. The current estimate is approximately 3,000 million tons, or, at the present rate of production of 240 million tons per year, twelve years of supply. This figure is, however, most misleading, as it takes no account of the possibility of new discovery, and it is frequently quoted without this qualification. For a number of years the yearly total of new discoveries has exceeded the yearly production, giving an increasing total to the remaining proved reserves, and it would be illogical to assume that this process will not continue for some years. The total reserves of the United States—*i.e.*, proved plus unproved—may well be several times as great as the proved reserves alone. Also, improved recovery methods may even increase the recoverable reserves of the present known fields. And the natural gas reserves of the United States are approximately equal in thermal value to the crude oil reserves.

This may all sound very complicated, and it is so in fact. The United States public has been fed on alarmist statements based on an over-simplification of the position by which proved reserves have seemed synonymous with total reserves, and occasional sober statements like those of Wallace Pratt have had relatively little circulation, as they are less good as "news." Nevertheless, the total reserves of the United States, even by the most generous estimate, are short enough to occasion serious concern. They may represent thirty years' or even fifty years' supply at the present rate, and, to a nation accustomed to abundant cheap liquid fuel, this is a short life, and other means of extending the supply, such as by distillation of oil shale or hydrogenation of coal, would increase production costs substantially; they would, however, assure the continuance of supply for hundreds of years.

This, then, is something of the background of the awakening of American public opinion to the importance of oil reserves outside their own country; and when an enquiry is made into the distribution of potential oil reserves of major magnitude throughout the world it becomes clear that only four oil provinces can be classified as of major importance. They are: Central America and the northern countries of Southern America, known as the Caribbean province; the Russian province; the Middle East; and the East Indies. Many oilfields are known

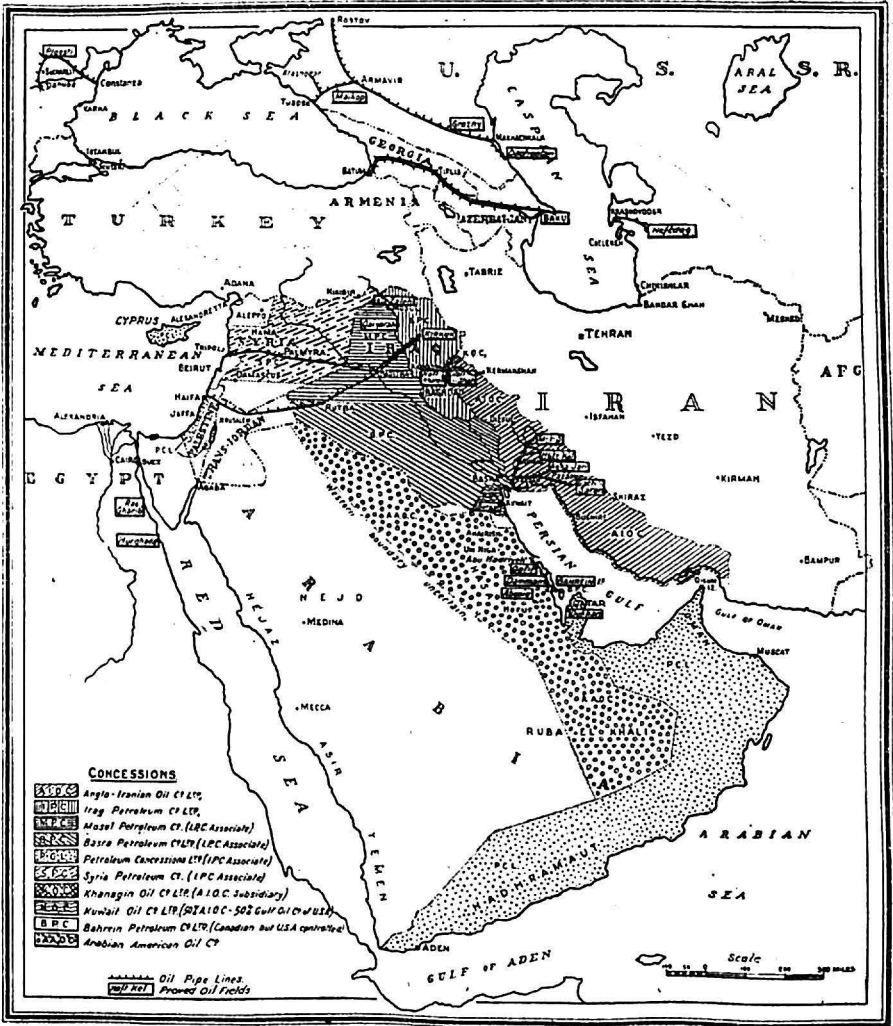
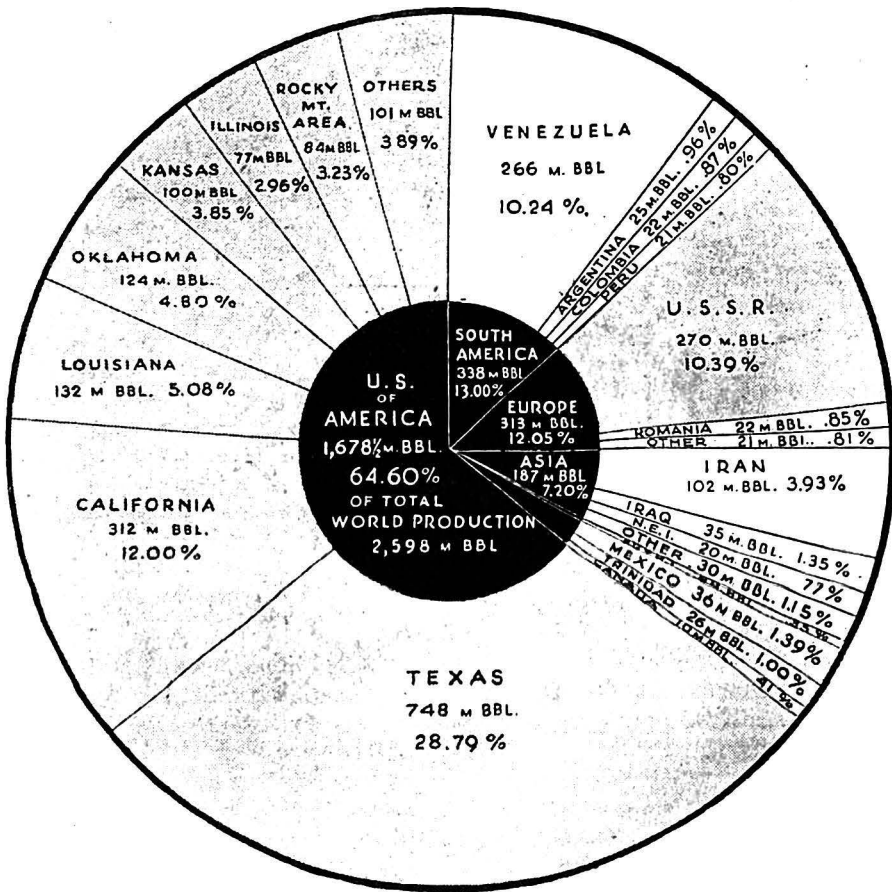


Fig. 3



or may yet be discovered outside these four provinces, but they are not likely to be of major importance from a long-term point of view.

The diagram (Fig. 3) which I have taken from *World Petroleum* of March, 1945, shows the distribution of production by countries and by continents estimated for 1944 (the figures are in millions of barrels: 7 barrels equal 1 ton approximately). The United States of America produced 64.60 per cent. of the world's production in that year and has produced 63 per cent. of the world's total up to date, but there is no manner of doubt that her future reserves bear a very much smaller ratio to the world's total reserves than her past performance.

It is quite impossible to hazard a guess at the order of magnitude of the oil reserves of the four major oil provinces mentioned above. The present production gives a very uncertain indication, as the development of oilfields has been very slow in countries which are greatly handicapped geographically in respect of the world's markets and which have negligible internal consumption. Thus the tropical forest areas and the llanos plains of Eastern Peru, Eastern Ecuador, Colombia and Venezuela may yield many new and important discoveries, but the process will be slow and costly. The Middle East has a great advantage in that the terrain is open and allows of easier development, but in the case of the Persian Gulf area it has a disadvantage of position relative to the world's markets compared to the Caribbean area. The East Indies oilfields are all on or very close to seaboard, but the total extent of potential oil territory does not permit an expectation that the reserves of this province will be on a scale comparable with those of the Caribbean or the Middle East provinces.

In 1942 the United States Government financed a company called the Petroleum Reserves Corporation, whose functions were to take such action as might be necessary to ensure that the United States had control over oil reserves in any part of the world on a sufficient scale to safeguard their future supply position, and by a process of elimination the attention of this company was directed primarily to the Middle East. Schemes were considered for constructing a large diameter (perhaps 24-inch) pipeline from the Persian Gulf across Arabia to the Mediterranean coast, and at first this project was considered as a possible necessity for war-time supply. The Petroleum Reserves Corporation proposals were not acceptable to the United States companies already operating in the area, and it soon became clear that the magnitude of the enterprise was such that it could not be a factor during the war by any reasonable expectation of its length. An American technical mission to the Middle East, under the leadership of Dr. Degolyer, surveyed the geological conditions of the countries concerned, and reported that the proved reserves in the Middle East probably exceed the total proved reserves in the United States of America. The number of exploration wells which have been required to discover such an immense quantity of oil is, he stated, only about 150, or less than 5 per cent. of the number of exploration wells drilled regularly year by year in the United States. The Petroleum Reserves Corporation in the end withdrew from any active participation in the Middle East and left the future development in the hands of the various American companies already operating and holding concessions.

It is difficult to explain in simple terms the geological reasons for the exceptional richness of the Middle East oil province and for the immense size of its individual fields. It is the product of a favourable conjunction of a number of important factors: first, continuous marine sedimentation persisted through a very long period of geological time, from Permian to Lower Miocene; secondly, organic matter was entombed with the limy muds accumulating on the sea-bottom in sufficient quantity to form, after later chemical or biochemical change, rich source rocks of petroleum of great thickness and lateral extent; thirdly, the folding movements produced a system of long anticlines and synclines; fourthly, porous reservoir rocks were well developed, into which the oil migrated and became concentrated in the crestal zones of the anticlines; and fifthly, these oil reservoir rocks are sealed above by impervious strata which function as effective cap rocks.

The dimensions of the Iraq and Persian oilfields are on a giant scale compared with most oilfields elsewhere in the world. The Kirkuk oilfield is over 50 miles in length, Masjid-i-Sulaiman about 15, Haft Kel 20, and Gach Saran about 15 miles in length. The reservoir rock is a porous limestone named the "Asmari" in Persia and the "Main Limestone" in Iraq. It is overlain by a series composed of alternating gypsum and grey and red marl beds, with, in some areas, great thicknesses of rock salt. These strata, called the Lower Fars Series and of Miocene Age, are the cap rocks which seal the oil accumulations underground.

The thousand-foot-thick reservoir limestone owes its high productivity to numerous small cracks or fissures which have developed as a consequence of the acute bending imposed on it by great mountain-forming movements. The greater part of the oil is held in small pores in the rock, but the fissures are the channels which feed the oil to the individual wells, and should a well fail to encounter any such fissure it may be quite unproductive. On the other hand, wells which do strike good fissures may be capable of producing at a rate of one million gallons per day, or exceptionally even more, but it is not possible to allow wells to flow at their full capacity without upsetting the balance of the reservoir fluid as a whole. By excessive local production it is possible to cone up the bottom water unevenly, and for this reason producing wells must be evenly distributed along the flanks of the anticlines with a spacing interval of one to two miles, depending on local conditions.

The structural conditions on the Arabian side of the oilfield belt are in striking contrast to those in the Iraq and Persian foothill zone. The anticlines are broad and flat; in some cases they can be defined by surface outcrop, in others they are poorly exposed or not at all. The producing rocks are considerably older in geological age than in the foothill zone, being Cretaceous and Jurassic, and the oil reservoirs include both sandstones and limestones.

In the north in Syria, east and west of Palmyra, and east of the Euphrates several promising-looking anticlines have already been tested to considerable depths, but so far without positive result. In North-Western Iraq in the Euphrates area the large pitch lakes in the desert area west of Ramadi and the active bitumen springs on the outskirts of Hit point

to the probable existence of underground oil accumulations, but extensive test drilling between Anah and Ramadi has yielded disappointing results. Some of the test wells were completely negative, others proved oil in substantial quantity but of a quality which renders it impossible to exploit under present-day conditions. Its high asphalt content makes it virtually unpumpable, and its high sulphur content imposes a prohibitive refining handicap even if it could be transported to seaboard.

In the Tigris area, north and south of Mosul, a number of promising anticlines and oil seepages along the Tigris valley indicate underground oil richness. Qaiyarah anticline and several others in the area have been tested and substantial yields of oil have been proved, but it is of the same heavy sulphurous character as that in the Euphrates area. At Ain Zaleh, north of Mosul, exploration drilling was in progress before the war, but was later suspended on account of the threat of enemy invasion.

The area lying between Ramadi and Basra lacks outward and visible signs of oil richness, but it must be accorded a prospective value. So far its exploration has not progressed beyond the geological and geophysical phase, and until test wells are drilled no quantitative prediction on its value can be made. In addition, the uncertainty on quality cannot be resolved by any theoretical deduction; such oil as it may contain may belong to the Euphrates-Tigris heavy oil province or to the Kuwait-Arabian coast zone of better-grade oil.

The Burgan oilfield in Kuwait territory was discovered in 1937, but its development to production has been delayed by war-time conditions. The number of wells drilled up to date is insufficient to allow a firm estimate of its size to be made, but it is unquestionably an important oilfield. Farther south, four oilfields have been proved on the Arabian mainland—Abu Hadhriya, Qatif, Dammam and Abqaiq, and one on Bahrein Island, but of these only Dammam and Bahrein have so far been developed to the stage of commercial production. On Qatar Peninsula an oilfield has been discovered, but its development has been retarded by war-time conditions. Various concessions are held over the territories of the Shaikhs of the Trucial Coast and in Oman territory, but exploration is still in its initial phase and no test drilling has been carried out.

Another Middle East area has been prominently in the "news" recently—namely, Central and Northern Persia. This area lies behind the Zagros Mountains, which form the north-east backbone to the Iraq-South-Western Persian oil belt, and Central and North Persia therefore lie in a distinct geological and structural province, the Caspian littoral being probably more related to the Russian oil-bearing conditions. Seepages are known at a number of localities, and while there may be a reasonable expectation of oil discovery it is quite impossible to predict whether it will be on an important scale. It is of interest to recall that an American company called the Amiranian Oil Company carried out extensive exploration in North-Eastern and Eastern Persia in 1936 and 1937, but finally relinquished their concessions, presumably because they were unable to anticipate oil discovery on a sufficient scale to justify the cost of a pipeline to the seaboard to the south. So far the only drilling in Central Persia was by a joint Russian-Persian oil company called the

Khurian Company, which drilled two wells near Semnan, but without success.

In conclusion, I feel that this paper would be incomplete without a short description of the various oil concessions now held in the Middle East and of the different oil companies operating these concessions.

PERSIA

The only existing oil concession is that held by the Anglo-Iranian Oil Company, Ltd., derived from that obtained by Mr. Wm. Knox D'Arcy in 1901, now covering 100,000 sq. miles of South-West Persia.

Oil was first discovered in commercial quantities in 1908, and in 1914 H.M. Government acquired a majority interest in the Ordinary share capital of the company in order that they might obtain some security of fuel oil supplies for the Admiralty. The company's refinery at Abadan has become one of the largest in the world, and a further increase in its production capacity is now in hand, with the corresponding increase in production and pipeline capacity from the several oilfields. Pre-war production approximated 10 million tons per annum. Production of 100 octane aviation spirit at Abadan, now at the rate of about 1 million tons per year, has been the outstanding war-time achievement of this great refinery. A small refinery at Kermanshah (capacity 100,000 tons per year) is operated to serve the markets in Northern Persia. It receives its oil by pipeline from Naft-i-Shah, adjacent to the Naft Khaneh field in Iraq. The total Persian production to end of 1944 is approximately 170 million tons.

IRAQ

The Khanaqin Oil Company (an Anglo-Iranian subsidiary company) holds a concession over a small area in the north-east of Iraq, which was formerly part of the Anglo-Iranian Persian concession, but was transferred to Iraq in consequence of certain frontier adjustments in 1914. The production of the Naft Khaneh oilfield is refined at the Alwand refinery, near Khanaqin, the products from which serve the local Iraq market.

The remainder of Iraq is covered by three concessions held by the Iraq Petroleum Company, the Mosul Petroleum Company, and the Basrah Petroleum Company, but to date commercial oil has only been obtained from one field—viz., Kirkuk, in the Iraq Petroleum Company's concession. This field produces at the rate of approximately 4 million tons per year and has produced to date about 40 million tons. The oil is delivered by two pipelines to the Mediterranean coast, one terminal being at Tripoli and the other at Haifa. An important refinery, belonging to the Anglo-Iranian and Shell Groups, was completed at Haifa during the early war years, and its operation has played an important part during the Mediterranean campaigns. Plans are now being developed for the construction of a third pipeline, of 16-inch diameter, between Kirkuk and Haifa.

The concession held by the Mosul Petroleum Company was originally granted in 1932 to a British syndicate termed the "B.O.D. Co., Ltd.," in which by 1935 Italian and German interests had acquired control. These

and other interests were bought out by the groups forming the Iraq Petroleum Company, who constituted the Mosul Petroleum Company to hold and operate the concession. So far, large reserves of heavy and sulphurous oil have been discovered in this concession, but no method of economical exploitation of this low-quality oil has been devised.

The shareholding in the Iraq, Mosul and Basrah Petroleum Companies is as follows :

Anglo-Iranian Group	$23\frac{3}{4}$ per cent.
Royal Dutch Shell Group	$23\frac{3}{4}$ " "
French Group	$23\frac{3}{4}$ " "
American Group ...	$23\frac{3}{4}$ " "
Mr. C. S. Gulbenkian	5 " "

KUWAIT

The territory of Kuwait is under concession to the Kuwait Oil Company, Ltd., a British company owned 50/50 by the Anglo-Iranian interests and the Gulf Exploration Co. (U.S.A.). After a suspension of operations during the war years, work on the development of the Burgan oilfield has recently been recommenced, and export of crude oil will begin during the coming year. At a later date a refinery may be constructed within the Kuwait territory.

SAUDI ARABIA

Concessionary rights over the whole of the easterly part of Ibn Saud's territory is held by the Arabian-American Oil Company, jointly owned by the Standard Oil Company of California and the Texas Corporation. Oil production up to the present has been drawn from one oilfield—namely, Dammam—but two other fields, Abqaiq and Qatif, will shortly be developed to the productive state. A small refinery has been operating at Ras al Tanura, but the bulk of the crude produced, about 2 million tons per year, has so far been delivered to the Bahrein refinery. A large new refinery, with a capacity of $2\frac{1}{2}$ million tons per year, is at present under construction at Ras al Tanura. A pipeline route from this group of fields to the Mediterranean has already been surveyed, and doubtless the line will be constructed within the next few years.

BAHREIN ISLAND

The Bahrein Petroleum Company (Canadian registered) holds a concession purchased from the original British concessionaire company. It is owned jointly by the Standard Oil Company of California and the Texas Corporation. A refinery on Bahrein Island treats both the crude oil from the Dukhan oilfield in the island and also crude oil from the Dammam field on the adjacent Arabian mainland, with which it is connected by pipeline. The Bahrein field has already produced $9\frac{1}{2}$ million tons, but its reserves are not expected to be on a scale comparable with those of the Arabian mainland. Its current production is about 1 million tons per year.

QATAR, TRUCIAL COAST, MUSCAT, OMAN AND ADEN

Concessions over these territories are held by the Petroleum Concessions, Ltd., a company with similar shareholding to that of the Iraq Petroleum Company. In Qatar an oilfield was discovered and was at an early stage of exploratory drilling during the early war years, but work was later suspended for the duration. Exploration in the other concessions under this heading has not yet progressed to the stage of determining whether or not exploration drilling is justified.

SYRIA

The Syrian Concessions, Ltd., a company with similar shareholding to the Iraq Petroleum Company, holds extensive concessionary rights in Syria and has already completed a number of deep borings, but without result. Some smaller French companies have also been interested in concessions.

PALESTINE

Exploration for oil in Palestine has extended over many years, but the prospects have always been regarded as borderline in attractiveness. In 1914 the Standard Oil Company of New Jersey decided to bore at Kurnub, south of Hebron, but the war overtook their intentions, and their piping, which had reached Port Said, was commandeered by the British Army. After 1918 the company reconsidered the decision to drill as a result of later surveys. In 1939 the Palestine Development Company (a company of similar composition to the Iraq Petroleum Company), after exhaustive geological and geophysical surveys, decided to drill a test well near Gaza, but again this intention was overtaken by the outbreak of war. The intention, however, still remains, and will be carried out as soon as post-war circumstances permit. Concessions held by the Palestine Development Company are mostly in the coastal area and in Southern Palestine. Other concessions in the Dead Sea area are held by the Palestine Potash Syndicate.

EGYPT.

The Anglo-Egyptian Oilfields, Ltd., control the only oil production from Egypt. The two fields, Ras Gharib and Hurghada, together produce at the rate of about 1,225,000 tons per year, the crude oil being shipped to the company's refinery at Suez. Active exploration and test drilling was in progress before the war, and has recently been resumed, in the Western Desert, in the Suez Canal and Gulf of Suez area, and in Sinai, but no further success has been registered. In addition to the Anglo-Egyptian Oilfields, Ltd., three American companies have been active—the Standard of New Jersey, the Standard Vacuum and the Standard of California, and the Texas Corporation, the last two in co-operation.

I am afraid that in the compass of a short lecture it has been quite impossible to do justice to all aspects of the important problem of Middle East oil. The impact of the oil industry on the various countries concerned is like mercy: it blesses him that gives and him that takes. The

countries whose adventuresome enterprise has been responsible for the development of the great oilfields have had their share of the reward. The British interests have been the pioneers, but American enterprise has also won a share large enough to satisfy; French and Dutch interests are also substantially represented.

Immediately to the north of the area which I have described, and really forming an integral part of it, lies the rich oil-bearing province of the Caucasus, where Soviet enterprise has achieved immense success, and by all indications will continue to do so for many decades to come; but Soviet oil is outside the scope of my present essay. The two "have-not" countries, Germany and Italy, failed to achieve a place through lack of courage. German interests held concessions in Persia in 1896 and onwards, but lost heart after two unsuccessful wells and withdrew. Again in 1932 both Germany and Italy entered the race, but failed to make the grade and withdrew in 1935.

The effect of this great industrial enterprise on the countries of the Middle East cannot be exaggerated. In addition to the great sums received as royalties, the benefits to the general welfare by reason of large-scale employment have been very great. A large-scale demand for skilled technicians, artisans and labour has been created, with all the concomitant advantage of greater opportunities and improved standards of life. As the supply of educated nationals of the countries concerned increases, so will their share in the development of their national resources.

The Middle East oil province contains reserves on a scale which places it perhaps first among the petroliferous areas of the world, and its relative importance will increase in the years to come as other oil-bearing areas, notably those in the United States of America, gradually pass into a decline. This great oil wealth is shared between Persia, Iraq, Koweit, Saudi Arabia, Bahrein and Egypt, and future discoveries are possible in the Shaikhdoms of the Trucial Coast, Oman, Syria, Palestine and Trans-jordan. Existing concessions are held by oil companies of British, American, French and Dutch nationality; in other words, the United Nations are well represented, and we are justified in looking forward to a harmonious and equitable development of this great oil wealth.

