

## COMMONWEALTH OF AUSTRALIA

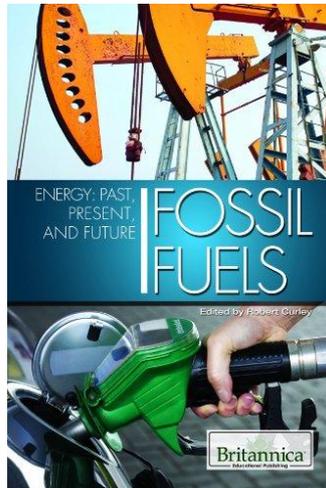
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Curley, R. (Ed.) (2012). *Fossil fuels*. New York: Britannica Publishing.

# CHAPTER 2 OBTAINING PETROLEUM

After petroleum has formed underground, a great technological and human effort must be made before it is used in daily life. Workers must find the substance at its most accessible points, which can be anywhere on the planet, and then extract it from below Earth's surface.

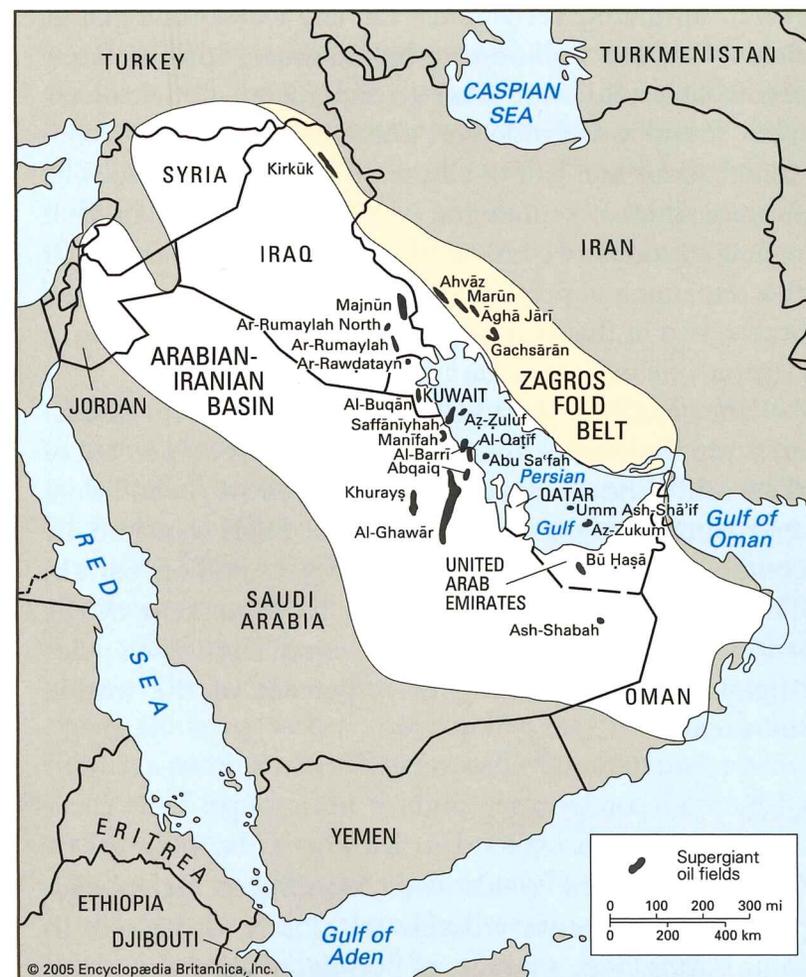
## WORLD DISTRIBUTION OF PETROLEUM

Petroleum is not distributed evenly around the world. More than half of the world's proven oil reserves are located in the Middle East (including Iran but not North Africa)—that is to say, the Middle East contains more oil than the rest of the world combined. Following the Middle East are Canada and the United States, Latin America, Africa, and the region occupied by the former Soviet Union. Each of these regions contains less than 15 percent of the world's proven reserves.

The amount of oil a given region produces is not always proportionate to the size of its proven reserves. For example, the Middle East contains more than 50 percent of the world's proven reserves but accounts for only about 30 percent of global oil production (though this figure is still higher than in any other region). The United States, by contrast, lays claim to only about 1.5 percent of the world's proven reserves but produces about 10 percent of the world's oil.

## OIL FIELDS

Two overriding principles apply to world petroleum production. First, most petroleum is contained in a few large fields, but most fields are small. Second, as exploration progresses, the average size of the fields discovered decreases, as does the amount of petroleum found per



Major oil fields of the Arabian-Iranian basin region. Encyclopædia Britannica, Inc.

unit of exploratory drilling. In any region, the large fields are usually discovered first.

Since exploration for oil began during the early 1860s, some 50,000 oil fields have been discovered. More than 90 percent of these fields are insignificant in their impact on world oil production. The two largest classes of fields are the supergiants, fields with 5 billion or more barrels of ultimately recoverable oil, and world-class giants, fields with 500 million to 5 billion barrels of ultimately recoverable oil. Fewer than 40 supergiant oil fields have been found worldwide, yet these fields originally contained about one-half of all the oil so far discovered. The Arabian-Iranian sedimentary basin in the Persian Gulf region contains two-thirds of these supergiant fields. Of the remaining supergiants, there are two in the United States, two in Russia, two in Mexico, one in Libya, one in Algeria, one in Venezuela, and two in China.

The nearly 280 world-class giant fields thus far discovered, plus the supergiants, account for about 80 percent of the world's known recoverable oil. There are, in addition, approximately 1,000 known large oil fields that initially contained between 50 million and 500 million barrels. These fields account for some 14 to 16 percent of the world's known oil. Less than 5 percent of the known fields originally contained roughly 95 percent of the world's known oil.

### SEDIMENTARY BASINS

Giant petroleum fields and significant petroleum-producing sedimentary basins are closely associated. In some basins, huge amounts of petroleum apparently have been generated because perhaps only about 10 percent of the generated petroleum is trapped and preserved.

The Arabian-Iranian sedimentary basin is predominant because it contains more than 20 supergiant fields. No other basin has more than one such field. In 20 of the 26 most significant oil-containing basins, the 10 largest fields originally contained more than 50 percent of the known recoverable oil. Known world oil reserves are concentrated in a relatively small number of giant fields in a few sedimentary basins.

Worldwide, approximately 600 sedimentary basins are known to exist. About 160 of these have yielded oil, but only 26 are significant producers and seven of these account for more than 65 percent of total known oil. Exploration has occurred in another 240 basins, but discoveries of commercial significance have not been made.

### GEOLOGIC STUDY AND EXPLORATION

Current geologic understanding can usually distinguish between geologically favourable and unfavourable conditions for oil accumulation early in the exploration cycle. Thus, only a relatively few exploratory wells may be necessary to indicate whether a region is likely to contain significant amounts of oil. Modern petroleum exploration is an efficient process. If giant fields exist, it is likely that most of the oil in a region will be found by the first 50 to 250 exploratory wells. This number may be exceeded if there is a much greater than normal amount of major prospects or if exploration drilling patterns are dictated by either political or unusual technological considerations. Thus, while undiscovered commercial oil fields may exist in some of the 240 explored but seemingly barren basins, it is unlikely that they will be of major importance since the largest are normally found early in the exploration process.

## TAR SANDS

Tar sands are deposits of loose sand or partially consolidated sandstone that are saturated with highly viscous bitumen, a solid or semisolid form of petroleum. Oil recovered from tar sands is commonly referred to as synthetic crude and is a potentially significant form of fossil fuel.

Deposits of bitumen, like those of other heavy hydrocarbons, are thought to be degraded remnants of accumulations of conventional (light-to-medium) oil. Degradation occurs when conventional oil migrates toward the surface and encounters, at temperatures below 93 °C (200 °F), descending rainwater containing oxygen and bacteria. This leads to the formation of a tarlike substance at the oil and water contact that eventually invades the entire oil pool. The lighter crude-oil fractions are removed by solution, while the paraffins are removed by the bacteria in the water.

Open-pit techniques can be used to mine thick deposits of tar sands when they occur near the surface. After the tar sand has been excavated, the bitumen has to be separated from the sand and then concentrated and cleaned. This crude bitumen is upgraded in a special coking unit, which produces a blend of lighter hydrocarbon fractions to yield synthetic crude, naphtha, kerosene, and gas oil. Deeper deposits are extracted by so-called in situ methods, in which steam is injected into the deposits to liquefy the bitumen, which flows closer to the surface where it can be pumped out.

The largest known deposits of tar sands occur in the Athabasca River valley of Alberta, Canada. The world's largest commercial projects for synthetic oil production from tar sands are being carried out in the Athabasca region. Synthetic crude represents approximately half of Canada's total liquid petroleum production.

The remaining 200 basins have had little or no exploration, but they have had sufficient geologic study to indicate their dimensions, amount and type of sediments, and general structural character. Most of the underexplored (or frontier) basins are located in difficult environments, such as polar regions or submerged continental margins. The larger sedimentary basins—those containing more than 833,000 cubic km (200,000 cubic miles) of sediments—account for some 70 percent of known world petroleum. Future exploration will have to involve the smaller basins as well as the more expensive and difficult frontier basins.

## STATUS OF THE WORLD OIL SUPPLY

On several occasions in recent history—most notably, during the oil crises of 1973–74 and 1978–79 and during the first half of 2008—the price of petroleum has risen steeply. Because oil is such a crucial source of energy worldwide, these rapid rises in price spark recurrent debates about the accessibility of global supplies, the extent to which producers will be able to meet demand in decades to come, and the potential for alternative sources of energy to mitigate concerns about energy supply.

How much oil does Earth have? The short answer to this question is, “Nobody knows.” In its 2000 assessment of total world oil supplies, the U.S. Geological Survey (USGS) estimated that about 3 trillion barrels of recoverable oil originally existed on Earth and that about 710 billion barrels of that amount had been consumed by 1995. The survey acknowledged, however, that the total recoverable amount of oil could be higher or lower—3 trillion barrels was not a guess but an average of estimates based on different probabilities. This caveat notwithstanding, the USGS estimate was hotly disputed. Some experts said

that technological improvements would create a situation in which much more oil would be ultimately recoverable, whereas others said that much less oil would be recoverable and that more than one-half of the world's original oil supply had already been consumed.

There is ambiguity in all such predictions. When industry experts speak of total "global oil reserves," they refer specifically to the amount of oil that is thought to be recoverable, not the total amount remaining on Earth. What is counted as "recoverable," however, varies from estimate to estimate. Analysts make distinctions between "proven reserves"—those that can be demonstrated as recoverable with reasonable certainty, given existing economic and technological conditions—and reserves that may be recoverable but are more speculative. The *Oil & Gas Journal*, a prominent weekly magazine for the petroleum industry, estimated in late 2007 that the world's proven reserves amounted to roughly 1.3 trillion barrels. To put this number in context, the world's population consumed about 30 billion barrels of oil in 2007. At this rate of consumption, disregarding any new reserves that might be found, the world's proven reserves would be depleted in about 43 years.

By any estimation, it is clear that Earth has a finite amount of oil and that global demand is expected to increase. In 2007 the National Petroleum Council, an advisory committee to the U.S. secretary of energy, projected that world demand for oil would rise from 86 million barrels per day to as much as 138 million barrels per day in 2030. Yet experts remain divided on whether the world will be able to supply so much oil.

Some argue that the world has reached "peak oil"—its peak rate of oil production. The "peak-oil theory" suggests that once global peak oil has been reached, the rate of oil

production in the world will progressively decline, with severe economic consequences to oil-importing countries. The controversial theory draws on studies that show how production from individual oil fields and from oil-producing regions has tended to increase to a point in time and then decrease thereafter. For example, oil production in the continental United States increased steadily through the early and mid-20th century until it peaked in 1970. By 2008 it had declined by almost 50 percent from its peak.

A more widely accepted view is that, through the early 21st century at least, production capacity will not be limited by the amount of oil in the ground but by other factors, such as geopolitics or economics. One concern is that growing dominance by nationalized oil companies, as opposed to independent oil firms, can lead to a situation in which countries with access to oil reserves will limit production for political or economic gain. A separate concern is that nonconventional sources of oil—such as tar-sand reserves, oil-shale deposits, or reserves that are found under very deep water—will be significantly more expensive to produce than conventional crude oil unless new technologies are developed that reduce production costs.

### MAJOR OIL-PRODUCING COUNTRIES

As is mentioned earlier, petroleum resources are not distributed evenly around the world. Indeed, according to estimates published for 2006 by the U.S. Department of Energy, as few as 15 countries account for 75 percent of the world's oil production and hold 93 percent of its reserves. Significantly, these countries are projected to have a correspondingly large percentage of the world's remaining undiscovered oil resources.





*Sedimentary basins and major oil and gas fields of North America.*  
Encyclopaedia Britannica, Inc.

the country's total proven oil reserves to approximately 175 billion barrels, second only to oil giant Saudi Arabia. Canada's largest oil field is Hibernia, discovered in the Jeanne d'Arc Basin off Newfoundland in 1979. This giant field began producing in 1997 and was soon joined by two other fields, Terra Nova (first production 2002) and White Rose (first production 2005).

The Middle Eastern countries of Iraq, Kuwait, and Iran are each estimated to have proven oil reserves in excess of 100 billion barrels. Together they account for more than 25 percent of all proven reserves in the world.

These countries have a number of supergiant fields, all of which are located in the Arabian-Iranian basin, including Kuwait's Al-Burqān field. Al-Burqān is the world's second largest oil field, having originally contained 75 billion barrels of recoverable oil. Iraq possesses a significant potential for additional oil discoveries.

## DRILLING FOR OIL

Drilling engineering was among the first applications of technology to oil-field practices in the early 20th century. Today the drilling engineer is responsible for the design of the earth-penetration techniques, the selection of casing and safety equipment, and, often, the direction of the operations. These functions involve understanding the nature of the rocks to be penetrated, the stresses in these rocks, and the techniques available to drill into and control the underground reservoirs. Modern drilling involves organizing a vast array of machinery and materials, investing huge funds, and acknowledging the safety and welfare of the general public.

## CABLE TOOLING

Early oil wells were drilled with impact-type tools in a method called cable-tool drilling. A weighted, chisel-shaped bit was suspended from a cable to a lever at the surface, where an up-and-down motion of the lever caused the bit to chip away the rock at the bottom of the hole. The drilling had to be halted periodically to allow loose rock chips and liquids to be removed with a collecting device attached to the cable. At these times the chipping tip of the bit was sharpened, or "dressed" by the tool dresser. The borehole had to be free of liquids