

The history of the European oil and gas industry (1600s–2000s)

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Abstract: The history of the European oil and gas industry reflects local and global political events, economic constraints, and the personal endeavours of individual petroleum geoscientists, as much as it does the development of technologies and the underlying geology of the region. Europe and Europeans played a disproportionately large role in the development of the modern global oil and gas industry. From at least the Iron Age until the 1850s, the use of oil in Europe was limited, and the oil was obtained almost exclusively from surface seeps and mine workings. The use of oil increased in the 1860s with the introduction of new technologies in both production and refining. Shale oil was distilled on a commercial scale in various parts of Europe in the late eighteenth century and throughout the nineteenth century but, in the second half of the nineteenth century, the mineral oils and gas produced primarily from shale and coal could no longer satisfy demand, and oil produced directly from conventional oil fields began to dominate the European market. The first commercial oil wells in Europe were manually dug in Poland in 1853, Romania in 1857, Germany in 1859 and Italy in 1860, before the gradual introduction of mechanical cable drilling rigs started in the early 1860s. In the late nineteenth century, the northern part of the Carpathian Mountains in what is now Poland and Ukraine was one of the most prolific hydrocarbon provinces in the world. The Bóbrka Field in the Carpathian foothills of Poland, discovered in 1853, is still producing and is now the oldest industrial oil field in the world.

The 1914–18 and 1939–45 world wars were both major drivers in exploration for and exploitation of Europe's oil resources and in the development of technologies to produce synthetic fuels from the liquefaction of bituminous coal and the combination of carbon monoxide and hydrogen as the Allied and Axis governments struggled to maintain adequate supplies of fuel for their war efforts. In Britain, the first 'accidental' discovery of gas was made in 1875 in the Weald Basin, but it was not until 1919 that Britain's first oil field was discovered at Hardstoft, in Derbyshire, as a result of a government-funded exploration drilling campaign, triggered by the need to find indigenous supplies of oil during World War I. The period of reconstruction after World War II was also critical for the European oil and gas industry with further successful exploration for oil and gas in the East Midlands of England resulting in Britain's first 'oil boom', and the discovery and development of deep gas fields in the Po Valley in northern Italy fuelling the Italian economy for the next 50 years.

Drilling technologies developed during Britain's first oil boom, together with the extrapolation of the onshore geology of the East Midlands oil fields and of the Dutch gas fields, led to the discovery of the huge oil and gas resources beneath the North Sea in the 1960s and 1970s, which enabled Britain, Norway, Denmark and The Netherlands to be largely self-sufficient in oil and gas from the late 1970s until production began to decline rapidly in the early 2000s. Today, oil and gas production in most European countries is at an historical low. Exploration for new sources of oil and gas in Europe continues, although increasingly hampered by the maturity of many of the conventional oil and gas plays, but European companies and European citizens continue to play a major role in the global oil and gas industry.

The establishment of petroleum as a tradable commodity, as well as a natural resource, triggered a paradigm shift in the history of civilization, introducing a

new set of values, opportunities and forces, shaping the course of social endeavours as diverse as science, technology, energy production and consumption, and

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leading to associated improvements in living standards throughout the world. Our 160 year-old hydrocarbon-based civilization is founded on this paradigm and, despite many criticisms and shortcomings, hydrocarbons will continue to be a key component of our lives for decades to come (Sertorio 2002; Smil 2017).

Europe is highly dependent on oil and gas as its primary sources of energy and as a basic feedstock for the chemical and manufacturing industries. Natural gas is widely used to generate electricity and for heating, while petroleum products derived from oil (petrol, diesel and kerosene) are essential fuels for transportation. Oil and gas are also used for domestic heating, and as the raw material for producing millions of items ranging from fertilizers, plastics, detergents, preservatives, life-saving medicines, clothing and cosmetics, through to appliances including computers, insulation, inks and toners, paints, glues, solvents and antiseptics to golf balls, CDs, bin bags, nail polish, and chewing gum.

The beginning of the mass consumption of oil was the result of a transnational and cumulative process of trial and error that lasted for centuries. The inception of the modern oil industry gained momentum in the first half of the nineteenth century as a result of the definition of some 'hydro-carbon' compounds obtained by heating oil given by the British scientist Michael Faraday in 1825, the introduction of fractional distillation to refine oil by the American Chemist Benjamin Silliman Jr and the systematic application of mechanized drilling by means of the cable tool system operated by steam power in NW Pennsylvania. After centuries of stagnation, discontinuous production and low consumption, the use of oil increased in the 1860s with the introduction of new technologies in both production and refining. In the second half of the nineteenth century, the mineral oils and gas produced primarily from shale and coal could no longer satisfy demand, and the oil produced directly from conventional oil fields in Eastern Europe, Russia, the USA and, eventually, the Middle East fairly rapidly began to dominate the global fuel market (Jevons 1865; Gerali 2012; Gerali & Gregory 2017a). Oil has been the world's most important source of energy since the mid-1950s, largely because of its high energy content, transportability and relative abundance.

Several European countries, among them France, Germany and Italy, have an important oil heritage, rich in invention and technology, despite the fact that they never achieved globally significant levels of conventional oil production. This lack of conventional oil resources influenced both their attempts to develop alternative sources of energy – France worked on oil shales, Germany on coal hydrogenation, and Italy had diversified strategies involving lignite and hydroelectric – and, in the second half of the twentieth century, the success of their citizens as 'oil finders' in

the oil fields of the world (Yanarella & Green 1987; Bardini 1998; Pozzi 2009; Beltran & Carré 2016).

Britain, Norway, Denmark and The Netherlands were largely self-sufficient in oil and gas from the late 1970s and early 1980s, following the discovery of oil and gas under the North Sea (Fig. 1) in the 1960s and the subsequent rapid build-up in offshore production, until offshore production started to decline rapidly in the early 2000s. There is, however, a much longer and much less well-known history of oil and gas exploration and production in Europe. In fact, natural seepages of oil and outcrops of oil-bearing shale across Europe have been exploited since the Iron Age, and shale oil was distilled on a commercial scale in various parts of Europe in the late eighteenth century and throughout the nineteenth century (Forbes-Leslie 1917; Strachan 1920; Gallois 2012).

According to the *BP Statistical Review of Energy 2017*, the world's proved oil reserves (excluding self-sourced shale plays) are 1.71 Ttbb (trillion barrels), of which Europe (except Russia) contains a 'mere' 11.6 Btbb (billion barrels). The five European countries with appreciable oil reserves today are, in decreasing order of reserves at end-2015, Norway (8.0 Btbb), the UK (2.5 Btbb), Romania (0.6 Btbb), Italy (0.6 Btbb) and Denmark (0.5 Btbb). Out of the world's total oil production of 92 MMBOPD (million barrels of oil per day) in 2016, these five European countries produced just 3.3 MMBOPD or 3.5% of global production.

The Western and Central European countries with the largest total proved gas reserves at the end of 2016 were Norway (1.8 Tcf (trillion cubic ft)), The Netherlands (0.7 Tcf), Ukraine (0.6 Tcf) and the UK (0.2 Tcf), while Turkmenistan (17.5 Tcf), Azerbaijan (1.7 Tcf) and Kazakhstan (1.0 Tcf) hosted the largest reserves of the countries belonging to the Former Soviet Union (FSU), outside the current Russian Federation. The largest European and FSU gas producers in 2016 were Norway (116.6 Bcm (billion m³)), Turkmenistan (66.8 Bcm), Uzbekistan (62.8 Bcm), the UK (41.0 Bcm) and The Netherlands (40.2 Bcm), but Europe and the FSU (excluding Russia) as a whole today accounts for only 11% of global gas production (British Petroleum 2017). Despite these figures, there is a long history of exploration, production and consumption of oil and gas in many parts of Europe, as well as of oil- and gas-related science and technology, much of which had a profound influence on the oil and gas industry worldwide. In the history of the oil and gas industry in many European countries, there are important episodes and players that influenced the course of events; some of these are already well documented, while others have gone unnoticed or even forgotten. Nevertheless, each episode is important because, beyond the well-known stories of successes and failures, there are various elements that enable us to gain

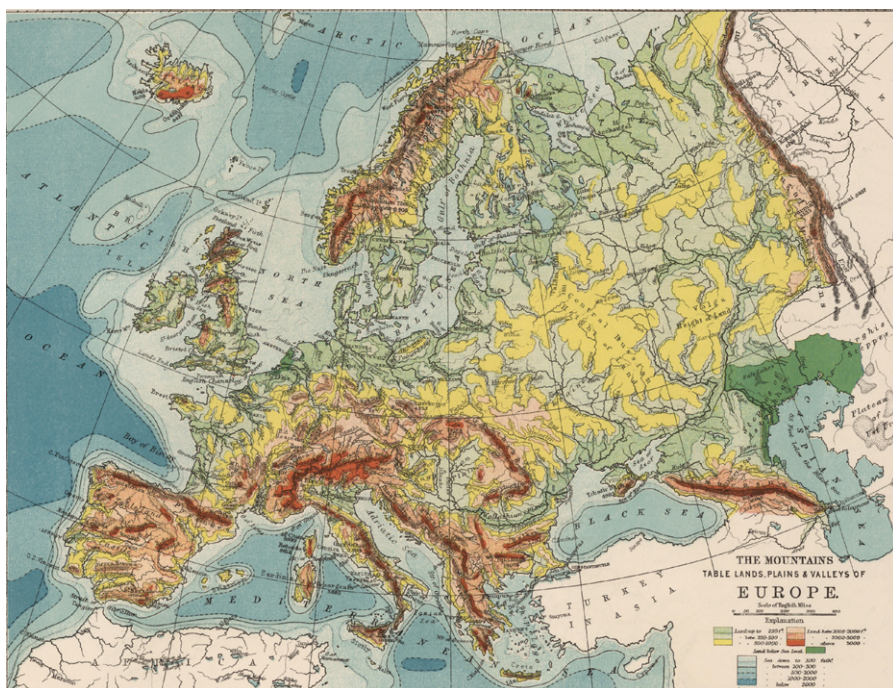


Fig. 1. Physical features of Europe. Published in 1906 by W. & A. K. Johnston Limited, Edinburgh and London. Available from the David Rumsey Historical Map Collection.

new insights into the process of the development of the oil and gas industry in Europe.

This Special Publication brings together a series of important papers dealing with different aspects of the history of the oil and gas industry in the UK, Norway, France, Spain, Italy, the Czech Republic, Hungary, Slovakia, Poland and Romania (Fig. 2), and examines the role of some of the key technologies and of the petroleum geoscientists who influenced the development of the European oil and gas industry between the sixteenth century and the present day.

A bibliography of selected published papers and books, primary and secondary sources, dealing with the history of the European oil and gas industry is provided at the end of this volume. It is not comprehensive, and is intended only as a source of further reading. There is also a comprehensive gazetteer of the main oil and gas industry museums in Europe at the end of the volume. These can be an invaluable source of additional information for those who wish to develop a deeper knowledge of the development of the oil and gas industry in specific parts of Europe.

Oil in the sixteenth, seventeenth and eighteenth centuries: an introduction

The manual gathering of petroleum from surface seeps, rock crevices or shallow shafts was recorded

in the chronicles of Europe during the late Medieval Age, but had been occurring since the classical age with oil obtained from such surface seeps being used by Greeks and Romans for several purposes. Although petroleum was used in Europe for many centuries, it was only during the sixteenth century that alchemists, natural philosophers and, later, chemists gradually developed scientific knowledge about the nature and potential uses of oil (Huguenet & Frojo 1856; Novelli & Sella 2009). In 1556, the German mining technologist Georges Agricola published *De Re Metallica*, in which he documented the use of heated petroleum. Forty years later, in 1601, Andreas Libavius, a German alchemist, published in the third volume of his *Singularium*, the most detailed account on every known occurrence of light and heavy oil in Europe at that time. In 1625, Johan Volck published a 30 page pamphlet, *Description of the Hanau earth balsam, petroleum and soft agate stone*, in which he detailed the advantages of refined oils. Many other contemporary scholars in Europe documented methods of refining petroleum, but these scientific advances had little impact on the socio-economic development of Europe at the time.

The methods used to produce petroleum in Europe remained almost unchanged between the sixteenth and the first half of the nineteenth century.



Fig. 2. General map of Europe showing the areas covered by the papers in this volume.

Basically, it was a craft activity, carried out without specific mining tools that yielded limited quantities of petroleum. Unlike coal, copper and iron, petroleum was not produced by a skilled labour force. Until the mid-nineteenth century, oil exploration was a premature concept; oil was not sought out, but simply found in the ground. Before oil products came into general commercial use during the last half of the nineteenth century, the exploitation of petroleum resources in Britain was restricted to a few surface oil seeps, such as those found in Shropshire, near Formby in Lancashire, in the coal mines of Nottinghamshire and along the south coast of England. For example, oil was distilled from oil-impregnated Carboniferous sandstone quarried at Row Brook in Shropshire during the seventeenth century (Plot 1684; Ele 1697). The use of 'seepage oil' in Britain increased considerably when it was found that

oil-soaked peat dug at Formby in Lancashire (Bunce 2018) made good fire-lighters, and the heavy tars from the seeps were excellent for caulking boats and for medicinal purposes on livestock. The waxy green oil that seeped steadily into some of the Nottinghamshire coal mines was even used to grease the axles of colliery wagons, but the production from these 'surface' sources was always, necessarily, extremely limited. Seeps of natural gas, both at the surface and in mines, have also been recorded in Great Britain for centuries. One particularly early example, near Wigan in Lancashire (Selley 2012), was recorded by Camden in his book *Britannia or a Chorographical Description of Great Britain and Ireland* published in 1586 and is often referred to colloquially as 'Camden's cooker' (Camden 1586).

One of the earliest attempts to produce indigenous oil in Britain occurred on the banks of the River

Severn in Shropshire. In January 1694, British Crown Patent No. 405 was granted to Martin Eele, Thomas Hancock and William Portlock of the British Pitch Works in Bentham, Shropshire who had found a 'way to extract and make great quantities of pitch, tarr and oyle out of a sort of stone' (Torrens 1994; Moody 2007). In 1716, another patent was taken out in Britain by one Talbot Edwards who claimed that, since the expiry of the 1694 patent, he had found a new and better way to extract these materials 'by fluxing with fire only ... the roch or rooffe stone' extracted from the local Shropshire coal mines. The market for the products was rather limited at the time and the oil was soon promoted as a medicine for 'the Cure of Rheumatic and Scorbutic Affections'. A third patent was issued in 1742, this one to Michael Betton, glazier of Wellington and his brother Thomas, shoemaker from Shrewsbury, again citing the medicinal use of the oil (Torrens 1994). The manufacture of this 'British Oil' later continued under the famous Darby family, the descendants of Abraham Darby who first introduced coke smelting at Coalbrookdale on the River Severn in 1709, thereby triggering the Industrial Revolution.

Elsewhere in Europe, a Russian-born Swiss doctor and Greek teacher called Eyrini d'Eyrinis (also spelt as Eirini d'Eirinis) discovered asphaltum at Val-de-Travers near Neuchâtel in Switzerland in 1710. He was the author of a landmark volume on the bitumen of the area, in which he presented all the possible uses of natural and refined bitumen. He established a bitumen mine called 'de la Presta' that operated until 1986. In France, the light and valuable oil called naphtha was collected in the region of Alsace, near the village of Pechelbronn (which means Pitch Spring). The locals had scooped up the oil from the water spring since the fifteenth century and exploitation of the local tar sands started in 1627. Then, in 1745, the mining of oil sands began in Merkwiler-Pechelbronn under the direction of Louis Pierre Ancillon de la Sablonnière, by special appointment of King Louis XV. In the 1810s, some wells were drilled to guide the location of the mine galleries. One of these wells penetrated a layer of sand containing oil at a depth of 77 m. However, the first important oil discovery was only achieved 135 years after the beginning of the oil mining in the area, when some wells dug mechanically in 1880 yielded oil in commercial quantities: 2860 wells had been drilled by 1916 and these produced 720 000 t (tons) of oil (Heritier 1994). The oil fields of Pechelbronn were active until 1970 and were the birthplace of present-day companies such as Antar and Schlumberger.

In 1786, a canal tunnel was driven into the side of the Severn Gorge, near Ironbridge in Shropshire, England, by a Quaker ironmaster, William Reynolds, to bring out coal from the local pits

(Fig. 3). The tunnel struck a spring of natural bitumen in Carboniferous sandstones about 300 yards from the entrance and seeps along the length of the tunnel yielded as much as 450 gallons of bitumen a day (Trinder 1981). Some was sold as medicine for the treatment of rheumatic and skin complaints, and some was processed for burning in lamps or converted into varnish. The rest was boiled in large cauldrons at the mouth of the tunnel to produce pitch that was used as a preservative for timber, for treating ropes and for caulking ships decks (Morton 2014).

Numerous oil and gas seeps were recorded in the Weald Basin of southern England during the nineteenth century, and gas was encountered during the sinking of a water well at Hawkhurst in Sussex in 1836. The gas was ignited by a lantern, causing an explosion that killed the two labourers who were sinking the well (Evans 2009; Wigley 2015).

In the territories of present-day Germany, petroleum production in the eighteenth century was mainly concentrated in the vicinity of Hannover, Brunswick, Wietz and Celle (Rinehart 1930). In France, thick and sticky asphalt was mined in the vicinity of Gabian, near the city of Clermont-Ferrand, in the region of Auvergne. The town of Gabian was also renowned for La Font de l'Oly (the oil spring), which produced light naphtha. Oil was recovered from La Font from 1608 onwards and the average production was 36 quintals per year. There was another seep, associated with a mineral water spring and a volcanic intrusion, at Le Puy de La Poix (the pitch mount) in the Limagne Basin. Gummy bitumen was collected in the region of Guyana (Schmitz 1938; Heritier 1994; Smith 2006). In Italy, the largest oil provinces were located in the territories of the duchies of Parma and Piacenza, and Modena and Reggio Emilia – stretching from NW to SE along the Northern Apennines (Fig. 1; Fairman 1868; Bonariva 1869; Cazzini 2018; Gerali *et al.* 2018).

Further scientific studies at this time paved the way to a better understanding of oil as a mineral and as a source of energy. In France, in the *Dictionnaire de Chymie* (1769), Pierre Joseph Macquer (1718–84) provided new evidence for the organic origin of oil. George Balthazar Sage (1740–1824) set out a classification of the different types of bitumen with reference to their density in *Éléments de Minéralogie Docimastique* (1772) while, in 1784, the Irish mineralogist Richard Kirwan (1733–1812) proposed a category of substances called 'inflammables' in his treatise *Elements of Mineralogy*. In 1796, Kirwan also published a study on the composition of coal and bitumen in the essay *Of the Composition and Proportion of Carbon in Bitumen and Mineral Coal*, in which he supported the idea of the major commercial utilization of petroleum.



Fig. 3. The Coalport Tar Tunnel, Ironbridge, Shropshire. (a) The Tar Tunnel with a drainage pipe on the left and wells cut into the tunnel walls. (b) Bitumen oozing out of the brick-lined walls. (c) A pool of bitumen in one of the wells (<http://geotopoi.wordpress.com/2012/09/13/coalport-tar-tunnel/>).

In the Austro-Hungarian dominions, petroleum was produced along the northern slope of the Carpathian chain (Fig. 1), in the vicinity of the village of Boryslaw, in the region of Galicia – today in Ukraine. In Romania, the core production of oil was concentrated near the city of Ploiești, in the foreland basin of the Southern Carpathian chain, in the principality of Wallachia. The earliest written accounts of natural occurrences of hydrocarbons in the Carpathians date back to the sixteenth century, but in the eighteenth century and the early nineteenth century accounts of the practical uses of oil, based on its occurrence in the Carpathians, were published by Rzączyński, Kluk, Hacquest and Staszic. Stanisław Staszic, a Polish priest, philosopher, statesman, geologist, scholar, poet and writer, produced a geological map of the region, dated 1806, showing the numerous oil seeps and different rock types containing hydrocarbons (Krzywiac 2018) – probably the first map to specifically document surface hydrocarbon occurrences in Europe.

In the SE part of what is today Moldova, ozokerite, or earth wax (a kind of natural paraffin), had

been mined for centuries (Pearson 1971), and ‘mineral resin’ was collected on the banks of some rivers. In Tsarist Russia, oil production was a burgeoning activity in the Trans-Caucasian area straddling Europe and Asia corresponding to today’s Azerbaijan. The economy of the port city of Baku, on the Caspian Sea, was largely based on oil production and trading (Henry 1905).

The nineteenth century: the beginning of the modern age of oil

In 1816–17, the Swiss naturalist Nicholas Theodore de Saussure made a comparative analysis of the composition and properties of petroleum samples collected in several European countries (Saussure 1816, 1817). Other scientists had previously carried out similar work, but Saussure’s work has the merit of delivering a comprehensive study that went further than the mere annotation of physical characteristics of the different petroleum samples. Instead, his work highlighted the chemical properties and

commercial applications of petroleum depending on its quality.

During the late eighteenth century and the nineteenth century, Scottish chemists were foremost in the development of British coal-gas, coal-tar and shale-oil industries. William Murdoch (1754–1839) and Archibald Cochrane (1749–1831), ninth Earl of Dundonald, carried out pioneering work on the destructive distillation of coal and shale oil. Archibald Cochrane developed, and in 1871 patented, a method ‘for extracting tar, pitch, essential oils and cinders from pitcoal, whereby the coals are made to ignite without flaming’ (Conacher 1938b) and in 1782 he lit Culross Abbey with gas from produced from tar. Cochrane was a brilliant chemist, but a poor businessman. He foolishly failed to repay massive loans made to his wife and died in poverty in Paris in 1831 (Tomory 2012).

Dr James ‘Paraffin’ Young, the founder of the Scottish oil industry, was much more astute. He rose from a humble background to become a noted and very successful chemist and entrepreneur. Young was born in Glasgow and trained as a chemist (Conacher 1938a). He was the manager of an alkali works in Manchester when, late in 1847, he was approached by James Oakes, the owner of the ‘New Deeps’ coal mine at Riddings in Derbyshire, to help him find a use for the thick, black crude oil that was seeping into his colliery workings from a small ‘petroleum spring’ (Fowler 1940; Lea 2018). In the autumn of 1848, Oakes and Young signed a partnership agreement and set up the first plant to produce paraffin oil for lamps. Oakes provided the crude oil from the mine and the plant to refine it, while Young was responsible for the manufacture and sale of the products (Beaton 1959). The crude oil production from the mine was only about 300 gallons a day and by 1850 the supply of oil had run out. Young returned to Scotland in 1851 having patented methods to extract paraffin from bituminous coal and oil shale, treating the extract and purifying the solid paraffin wax. He built a large plant to process the Carboniferous oil shales of West Calder, establishing an industry that was to dominate the West Lothian region of Scotland for much of the next century, and his patented technology was eventually adopted by many early commercial oil refineries worldwide (Carruthers *et al.* 1927; Conacher 1928; Dean 2018). Over the next 100 years, an estimated 75 MMbbl (million barrels) of oil and 500 Bcf (billion cubic ft) of gas were produced from Scottish shales.

In the early nineteenth century, small artisanal refineries with low, and variable, yields were scattered across Europe. Romania in the 1840s was the only European country with documented and consistent commercial-scale refining activity. Romania has a long oil industry history (the use of bitumen in the

country dates back to the fifth century AD), and it has the best-preserved official records of oil production, refining and trade in Europe. These confirm the importance of the oil business both for the country and for European oil industry heritage (Tulucan *et al.* 2018). In 1840, a refinery with the capacity of 300 t per year was active in Lucăcești, Bacău (at that time still included in the principality of Moldavia) to produce lamp fuel and greases; in 1856, a 2710 t per year plant was operating in Rafov, in the area of Prahova, and between 1857 and 1862 four more refineries opened in the area of Bacău, with a capacity ranging from 873 to 2446 t per year (Pizanty 1947; Forbes 1958).

During the second half of the nineteenth century, oil and gas produced primarily from shale and coal could not satisfy the increasing demand in the European fuel market, and new technologies for oil production (and, later, gas production) developed rapidly (Jevons 1865; Gerals 2012). In 1853, the Polish chemist Ignacy Lukasiewicz discovered how to make kerosene from crude oil. On the night of 31 July 1853, Lukasiewicz was called to his local hospital in the then Polish town of Lvov (now in Ukraine) to provide light from one of his new kerosene lamps for an emergency surgical operation. The hospital authorities were clearly impressed with his invention because they ordered several of his lamps and 500 kg of kerosene. Soon after, Lukasiewicz travelled to Vienna, the capital of the Austro-Hungarian Empire, to register his distillation process in the Vienna patent office with his co-worker, J. Zeh, on the 31 December 1853. After Lukasiewicz adapted Gesner’s distillation method in 1852 to refine kerosene from more readily available ‘rock oil’ seeps, Lukasiewicz and his business partners, Titus Trzcieski and Mikolaj Klobassa, established the first rock oil mine in Bobrka, near Krosno in Central European Galicia (Poland/Ukraine) in 1853. This led to the rapid growth of the oil industry in the Carpathians, with many shallow wells (30–50 m) dug manually on oil shows associated with the major anticlines in the region. Then, in 1856, Lukasiewicz set up the world’s first crude oil refinery at Ulaszowice in Poland.

The world’s first commercial oil wells were dug in Bibi-Heybat (Bibi-Eibat) near Baku in Azerbaijan in 1846, in Poland in 1853 and in Romania in 1857 (still 2 years before the drilling of the seminal ‘Drake well’ in NW Pennsylvania). In the late nineteenth century, the northern part of the Carpathian Mountains between Limanowa (Poland) and Kosów (Ukraine) was one of the most prolific hydrocarbon provinces in the world (Krzywiac 2018) (Fig. 4). The Bóbrka Field in the Carpathian foothills of Poland, discovered in 1853, is still producing and is now the oldest industrial oil field in the world (Koszarski & Bally 1994).

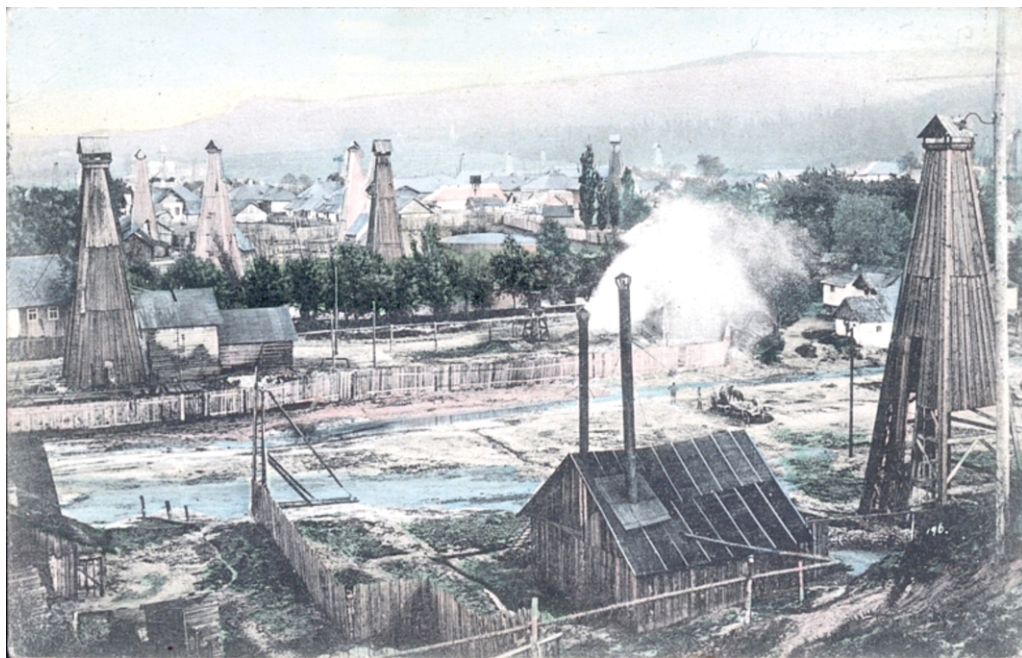


Fig. 4. Postcard showing an early oil field in the Northern Carpathians (from [Krzywiac 2018](#)).

Romania was the first country in the world to have its crude oil output officially recorded in international statistics with an amount of 275 tonnes recorded for 1857. Oil production in Romania had started in the middle of the nineteenth century, mainly from primitive hand-dug and wood-lined wells. An oil refinery was already in operation in Ploiești in Romania in 1856 and one year later its product illuminated the capital city, Bucharest, with 1000 oil lamps placed along the main streets ([Schleder *et al.* 2016](#)) – the first use of refined oil for street lighting anywhere in the world. The first oil discovery in NW Europe was made when the Wietze oil field near Hannover in Germany was discovered in 1859 ([Fig. 5](#)), followed soon after by a discovery near Ozzano in the Parma region of northern Italy in 1860 ([Cazzini 2018](#)).

From the 1860s onwards, the Majella oil district of Abruzzo in Italy played a key role in the development of the Italian oil industry through the first detailed analysis of the associated petroleum systems and the introduction of mechanized drilling ([Gerali & Lipparini 2018](#)). In 1863, Merzoeff built the first modern refinery in the town of Sourachany, close to the mature oil fields of Baku in Azerbaijan, at a time when they supplied about 90% of the oil used in Europe. Only a year later, the area of Baku had 23 fully equipped refineries ([Forbes 1959](#)). At about the same time, in Spain there was early exploitation of oil from bituminous shales, asphalt impregnations

or tar sands by subsurface mining and distilling, but with limited economic success ([Navarro Comet 2018](#)). Also in 1861, the sailing ship *Elizabeth Watts* carried a cargo of 1329 bbl of oil for lamps from Philadelphia to London – the first recorded shipping of Pennsylvanian oil to be sold in Europe.

Exploration for oil started again in the Gabian area in France in the early 1860, and numerous shallow wells were drilled around the old oil spring. In 1884, a well drilled 300 m from the old oil spring hit an oil reservoir at a depth of 68 m but, with the exception of two other dry wells, no further exploration work was undertaken in the area until 1923 ([Heritier 1994](#)).

Four of the first 10 giant oil fields to be discovered in the world were found in the late 1880s in what was then the Russian Empire, three of them (Balakhany, Surakhany and Bibi-Heybat) within 25 km of Baku in Azerbaijan ([Halbouty 2003](#); [Sorenson 2014](#)) ([Fig. 6](#)). The Balakhany Field on the Apsheron Peninsula in Azerbaijan was the largest producing oil field in the world in the 1870s and had 375 producing wells in 1883. It was succeeded as the world's largest producing field by the Bibi-Heybat Field on the south side of the Apsheron Peninsula in the mid-1880s, although this had certainly been in production since 1803 ([Sorenson 2014](#)).

The first deep well to encounter gas in Britain was drilled on the crest of the Battle Anticline at Netherfield in West Sussex by the Subwealden Exploration Company in 1875. The first well was abandoned at



Fig. 5. The first commercially productive oil well drilled in the Wietze Field, Hannover, Germany. Drilled by the Hannoverian government in 1859, the well yielded a small amount of oil at a depth of about 100 m. Until the 1930s, it was occasionally pumped by hand. From [Rinehart \(1930\)](#).

a depth of 1018 ft for mechanical reasons, but a second well was drilled nearby and reached a total depth of 1905 ft. While measuring the bottom-hole temperature of the well, a ‘naked light was injudiciously lowered down the hole’ ([Selley 2011](#)) which resulted in an explosion ([Willet 1875](#)). There was another accidental discovery of natural gas in 1895 when a 228 ft deep ‘artesian bore-tube’ was sunk in the stable yard of the New Heathfield Hotel at Heathfield in East Sussex ([Dawson 1898](#)). The first commercial discovery of gas in Britain occurred in

August 1896, when gas was again encountered, accidentally, close to Heathfield Railway Station by the London, Brighton and South Coast Railway while searching for an underground supply of water for its locomotives ([Dawson 1898](#)). The Heathfield discovery set off a widespread search for gas in commercial quantities during the years to 1910. Six more wells were drilled at Heathfield, and by 1903 some 70–80 houses and the railway station in Heathfield were lit by gas. The station continued to be lit by gas until 1930.



Fig. 6. A Baku ‘spouter’. The derrick is almost buried in sand ejected from the well (from [Beeby-Thompson 1904](#)).

In the late nineteenth and early twentieth centuries, most domestic gas was produced by the destructive distillation of bituminous coal (so-called ‘town gas’). The gas was driven off by heating the coal in air-tight chambers, storing it in ‘gasometers’, and distributing it through a network of pipes to houses and other buildings where it was used for lighting and, much later, for cooking and heating. Gas manufacturing also produced a range of by-products which later became important feedstock for the chemical industry. Manufactured gas allowed the development of what was the first integrated utility network, and its success in Britain led to its rapid spread across Europe (Thomas 2018).

The early twentieth century and World War I

In February 1899, Paul Dvorkovitz (1857–1929), a Russian petrochemist in the service of Britain’s Petroleum Storage Tanks and Transportation Co. Ltd, published the first issue of *The Petroleum Industrial Technical Review* in London, with the support of British oil entrepreneurs. This was the first European technical journal devoted entirely to the oil industry and soon had a worldwide distribution. Similar editorial initiatives were also active in the USA, but were focused mostly on business and the national industry. Dvorkovitz’s journal introduced a new way to communicate the latest oil insights to industry practitioners. It led the market in oil information until the early 1910s and affirmed itself as the ‘voice’ of the European oil industry. Dvorkovitz and his firms were also the major promoters of the first four International Petroleum Congresses held in Paris (1900), Liège (1905), Bucharest (1907) and Lvov (1910). Prior to this, oil was discussed as a ‘branch’ discipline in general geology, engineering

and chemistry conferences. Dvorkovitz’s Congress was the first international forum for global oil industry representatives organized in Europe.

By 1906, there were more than 7000 people working in the oil industry in the Prahova District of Romania (Fig. 7), the first area in the country to power oil rigs with electric engines fed by the local hydroelectric plant. Oil production exceeded 1 Mt (million tons) per year (Schleder *et al.* 2016).

Oil production in Austrian Galicia (an area stretching from present-day Poland to present-day Ukraine) peaked in 1910 at 2 Mt of crude oil (Krzywiec 2018), making this the third most prolific oil province in the world after Russia and the USA (Krzywiec 2016). Exploration drilling in Spain started in 1900, but the wells were usually simply located in the vicinity of surface oil seeps and impregnations with little or no geological input (Navarro Comet & Puche Riart 2018).

Among the many individuals who contributed to the development of the oil and gas industry in the late nineteenth and early twentieth centuries, Sir Thomas Boverton Redwood (1846–1919) stands out as, perhaps, the greatest petroleum engineer and scientist of his generation (Sorkhabi 2018). Redwood, together with his many collaborators and co-authors, contributed, either directly or indirectly, to petroleum exploration and production in many parts of the world where Britain had colonial and commercial interests, and played a leading role in the development of petroleum technology and its application to Britain’s oil operations around the world from the 1880s to the 1910s. He established one of the first and most successful petroleum consulting companies, trained generations of petroleum geologists and engineers, served as a technical advisor on many government committees and to many oil companies, and played a key role in securing Britain’s oil supply during World War I.

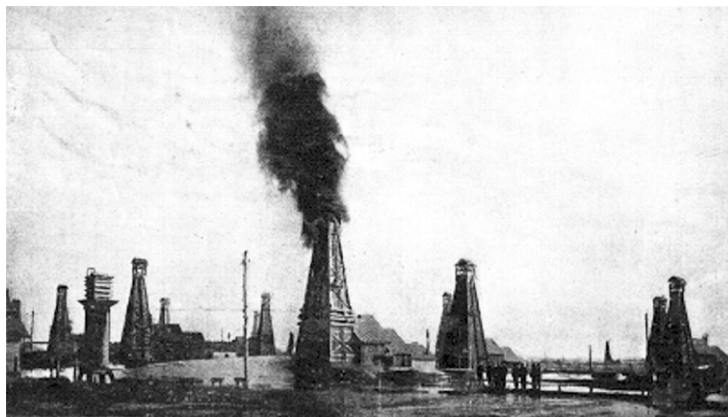


Fig. 7. ‘Gusher’ in the Campina Field, Prahova District, Romania (from Suciú & Luzzati 1923).

At the beginning of the twentieth century, Britain was importing nearly all of its oil from America and Iran. The Scottish oil-shale industry was making a modest, but important, contribution to meeting the domestic oil demand but, by 1918, Britain was importing over 100 000 BOPD (Hallett *et al.* 1985). Oil imports had increased by over 250% since 1913, in large part due to the increase in consumption required by the Allied Forces during World War I (Giffard 1923), but only about one-seventh of the oil imported in 1918 came from countries within the British Empire.

Access to oil was a major strategic factor in World War I (1914–18). The German invasion of Russia during World War I had as one of its objectives the capture of the Baku oil fields so that these could provide much-needed oil supplies for the German military. By the start of World War I, approximately 1335 km of pipeline had been laid in Romania to transport oil, and Germany's invasion of Romania in 1916 was driven by the desire to have access to the country's rich oil fields. The Romanians, following a request from Britain, destroyed more than 1500 wells to prevent them falling into German

hands and, as a result, Romanian production dropped from 1 783 947 t in 1914 to 518 460 t in 1917 during the German occupation (Tulucan *et al.* 2018). However, after the conclusion of the war, the damaged fields were quickly recovered and in 1918 the production had already recovered to 1 222 582 t. From 1857 to 1918, Romania produced 21 376 295 t of oil (Suciu & Luzzati 1923). The Gbely oil field in Galicia also played an important role in supplying oil to the German military during World War I (Benadová 2016), which was much more accessible because of the alliance between Germany and the Austro-Hungarian Empire.

Britain's first oil discovery at Hardstoft in Derbyshire in 1919 (Giffard 1923; Brentnall 1995) was made during a government-funded exploration programme to find indigenous oil supplies as a direct result of difficulties encountered in obtaining supplies from overseas during World War I (Craig *et al.* 2013; Corfield 2018). The exploration programme actually began shortly after World War I, but it was prompted by the concerns of the British government about the German submarine threat to imported supplies of essential petroleum products.



Fig. 8. The Hardstoft No. 1 well, Tibshelf, Derbyshire (© Devonshire Mss., Chatsworth, Tibshelf/Hardstoft Oilwell papers).



Fig. 9. View of a hilly oil field in Sarata, Romania, 1899 (source: *Petroleum Industrial and Technical Review*, vol. 1, 30 March 1899).

Between 1918 and 1922, 11 wells were drilled (nine in England and two in Scotland), two of which proved commercial volumes of oil (Lees & Cox 1937; Brentnall 1995). The first well was drilled on a prominent faulted surface anticline at Hardstoft, near Bolsover in Derbyshire (Fig. 8), and produced some 29 000 bbl of oil before it was finally abandoned in 1945 (Craig *et al.* 2013). The second discovery, at D'Arcy in Lothian, 10 miles SE of Edinburgh, produced only 50 bbl of waxy oil before it was abandoned. Two wells were drilled in Staffordshire – one on the western side and the other on the eastern side of the Staffordshire Coalfield – and the other seven English wells were drilled in a roughly north–south line along the east side of the Pennines in Derbyshire, but all these except the Hardstoft well were dry (Corfield 2018).

Oil was struck at Hardstoft on 27 May 1919 and production commenced in June 1919. Powers to enter onto land for the purpose of drilling for oil (but not ownership of any oil found) were provided under the Defence of the Realm Act of January 1918 and

the government used these powers to take the land necessary for the nine well sites. These powers lapsed on the cessation of hostilities at the end of World War I (Hallett *et al.* 1985), with rather embarrassing consequences for the government.

The inter-war years

Although modern rotary drilling techniques were first introduced in Texas in the early 1890s, most wells in Europe were still drilled using the older, slower and potentially more dangerous 'cable tool' method until the 1930s. Cable tool drilling did not allow the pressure in the well to be controlled, and the first indication that a high-pressure productive reservoir had been penetrated was usually the appearance of oil and gas jetting through the rig floor, which often then ignited causing dramatic oil field fires. One such spectacular 'blowout' occurred on 27 May 1929 at Moreni in Romania (Fig. 9) when the Romano American well No. 160 blew-out

after encountering high-pressure gas (Spencer & Furcata 2016). The entire 662 m drill string was ejected from the well and sparks produced by the friction ignited the gas escaping from the well. The derrick was thrown 300 m by the explosion. Numerous attempts to extinguish the fire and cap the well, including drilling a tunnel 60 m below the casing head, were ultimately unsuccessful. The light from the burning well was visible from Bucharest, 70 km away and the blowout became internationally famous as the ‘Torch of Moreni’ (Spencer & Furcata 2018). The fire finally went out naturally in November 1932, after burning for 2 years and 4 months, by which time the blowout and the subsequent attempts to extinguish the fire, including by the pioneer of oil-well firefighting, Myron Kinley (Spencer & Furcata 2018), had resulted in the death of 14 workers and the injury of more than 100 others.

After World War I, interest in exploring for oil in Britain declined when an Act of Parliament (the Petroleum Production Bill) in 1918 conferred on landowners the rights of ownership of any minerals found on their land. This discouraged oil companies from exploration. Cheap supplies of foreign crude oil also reduced the incentives to search for oil in Britain. Oil was produced at Hardstoft at an average rate of 6 BOPD until December 1927 (Craig *et al.* 2013). The well was prone to waxing and silting, and never flowed freely. Production increased to 14.6 BOPD during a pumping test carried out by the government in 1921, but the pumping was not continued because the government did not own the oil it produced. Several of the other wells drilled during this campaign on other structures encountered gas (Veatch 1923) but, ultimately, not in commercial quantities (Corfield 2018). On 23 March 1923, the Hardstoft well was taken over by the Duke of Devonshire, who owned the mineral rights and the land on which it was drilled. Eventually, the Petroleum Prospecting Act of 1934 gave the Crown the rights of ownership of any future discoveries of naturally occurring oil or gas and made it possible for companies to acquire exploration licences in the UK for the first time. With the new legislation, interest in exploration was renewed. The Petroleum Prospecting Act was not retrospective; the Duke of Devonshire retained ownership of the oil discovered at Hardstoft and he remains the only individual in the UK today who owns the rights to the oil under his land.

Initially, applications for licences to carry out exploration were concentrated mainly over parts of southern England, particularly Sussex and Hampshire. The first deep oil exploration well to be drilled in Britain, Portsdown No. 1, was spudded by D’Arcy Exploration Co. Ltd (the exploration subsidiary of the Anglo-Iranian Oil Company Ltd) in January 1936 on a site on a hill overlooking Portsmouth Harbour on the south coast (Fig. 10), but it found only a

small quantity of oil. Several other wells were drilled in Hampshire, Berkshire, Dorset and Sussex in the following years (including wells at Henfield in Sussex, which encountered a small amount of gas, and at Kingsclere near Newbury in Berkshire), and a little oil was found, but all the wells were abandoned due to the poor quality of the reservoir (Lees & Cox 1937). In 1937, the D’Arcy Exploration Co. Ltd (later to become BP) found gas at Eskdale in North Yorkshire (Anglo-Iranian Oil Company Ltd 1947; Haarhoff *et al.* 2018).

In 1937, the Anglo-American Oil Company (a subsidiary of Standard Oil) made an unsuccessful attempt to find oil at Hellingley in Sussex (Anon 1937). The search for oil then moved to the Midlands and the north of England, and particularly to southern Scotland, where, during 1937, D’Arcy made significant gas discoveries (with minor amounts of oil) in the northern culmination of the D’Arcy–Cousland Anticline at Dalkeith, SE of Edinburgh and at Cousland (Longhurst 1959). The gas was piped to the local gasworks during World War II and BP developed the field in the late 1950s. Also in 1937, Anglo-American re-drilled the southern culmination of the D’Arcy–Cousland Anticline, close to the original 1922 D’Arcy discovery well. This led to the later development of the Midlothian oil field (Underhill *et al.* 2008). Steel Brothers & Co. Ltd, whose association with the oil industry was primarily as the managing agents in London to the Attock Oil Company operating in India, completed an exploration well at Edale in Derbyshire in 1938 and, when this was unsuccessful, they carried out a general investigation of areas in Yorkshire, Derbyshire, Cheshire and Lancashire. Further wells drilled in the East Midlands, at Gun Hill, north Staffordshire and at Alport in the Peak District also gave disappointing results (Anglo-Iranian Oil Company Ltd 1947), but a small oil accumulation was discovered at Formby in Lancashire, at a depth of only 18 ft, in 1939 (Bunce 2018). Shortly after the Formby discovery, the D’Arcy Exploration Co. made much more significant discoveries in the Carboniferous succession at Eakring (in 1939), Kelham Hills (in 1941), Dukes Wood (in 1941) and Cauntton (in 1943) in Nottinghamshire, and at Nocton (1943) in Lincolnshire (Lees & Taitt 1946) (Fig. 7). In 1940–41, Gulf Exploration (Great Britain) drilled a deep exploration well at Penhurst in Kent and then a second well in the Cleveland Hills of Yorkshire, with unsuccessful results in both cases.

World War II

During World War II, oil facilities were a major strategic asset and were extensively bombed. German U-boats again threatened British oil supplies from Persia and this led to the rapid, and top secret, development of domestic oil fields at Eakring and

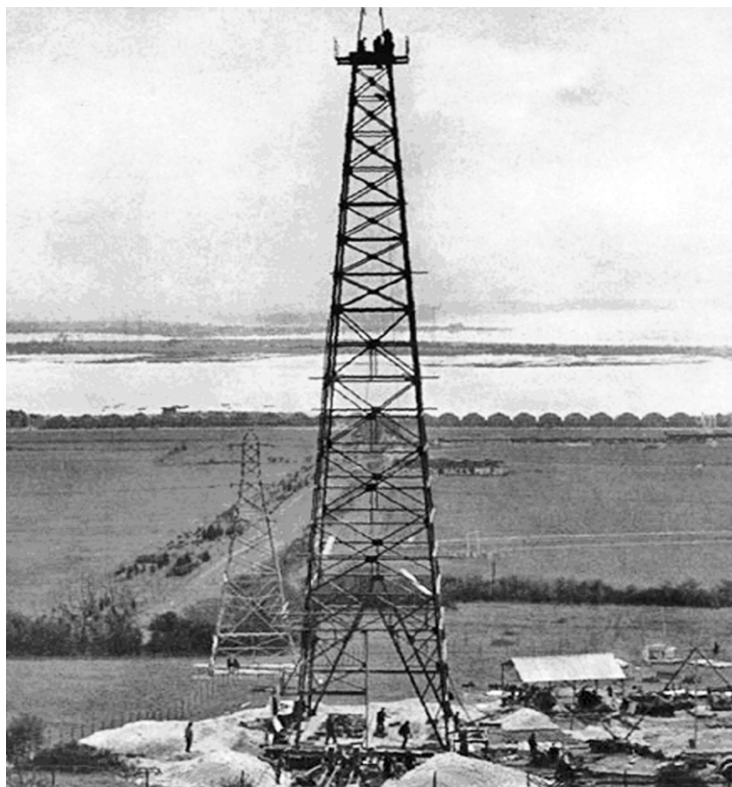


Fig. 10. Portsdown No. 1 Well. *Source:* BP.

Duke's Wood in the East Midlands of England. Given the critical need for an indigenous supply of oil during World War II, the D'Arcy Exploration Company decided that, in the national interest, it would suspend further speculative exploration drilling in order to focus on developing the two fields in Nottinghamshire. The development of the fields under wartime conditions was hampered by the lack of available labour because the majority of skilled and able-bodied men had been 'called-up' and by the lack of steel, which was required for munitions and shipbuilding. Delays were also incurred because of the restricted lighting conditions permitted during black-out hours and, in the early stages, by periodic air-raid warnings during which drilling had to be suspended. The development of the Duke's Wood Field was further hampered by the shortage of labour and of road-building equipment need to construct access roads in the hilly and wooded area. The various drilling rigs operated by D'Arcy Exploration were moved to Eakring to begin development work, but these heavy-duty rigs proved unsuitable (Southwell 1945). Although improvements were made, by August 1942 the situation was critical – Britain had just 2 months' stock of oil remaining and supplies

from overseas were being repeatedly disrupted by German U-boats. Britain turned to its American ally, importing, in great secrecy, American rigs and American drilling crews to drill up the Eakring and Duke's Wood fields. The new American Unitized rigs with jackknife portable derricks were designed to give maximum mobility (Day 1946). What 44 American roughnecks were doing in the middle of Sherwood Forest was kept a secret – apparently, by the simple expedient of spreading a rumour that they were making a Western film starring John Wayne! The new rigs and their American drilling crews greatly reduced the time taken to drill the wells and to move the rigs between drilling locations. The average time taken to rig-up, drill and complete a production well was reduced to 7 days (Southwell 1945) and, with experience and changes in drilling practices, it became possible to drill 800 ft with a single drill bit, thereby reducing the average number of drill bits (which were in short supply) required to drill a production well from 13 to six. By the end of the war, the crews had drilled 380 wells of varying depths (amounting to 735 000 ft of drilling) resulting in 250 successful production wells, which together had produced more than 2.25 MMbbl of oil. When

refined, this oil was particularly suited to power the Rolls Royce Merlin engine used in most of the Royal Air Force's high-performance fighters and bombers like the Supermarine Spitfire and the Avro 683 Lancaster. This provided Britain with a distinct advantage when compared with the low octane content of the synthetic aviation fuels produced in Germany by the synthesis of coal through the Fischer–Tropsch process. Before World War II, the German oil industry consisted of a weak upstream sector, mostly run by small- to medium-sized companies with limited financial resources, and a strong and competitive downstream sector. Because of the relatively small number of wells and the outdated technology (wooden rigs and manual gathering of the oil), the Wietze fields, in the Hannover district which is the richest oil area of Germany, produced only 11 773 567 t of crude between 1873 and 1929; while, in contrast, in the 1930s Germany had 27 efficient refineries that refined and re-sold foreign oil. It was this lack of domestic oil resources and the pressing war needs that motivated Germany to turn to the production of very expensive synthetic fuels to sustain their war effort (Rinehart 1930; Dewey 1946).

As the war progressed, supplies of oil to the 'Axis' troops also became increasingly vulnerable as the Allies mounted numerous attacks on German, Italian and Japanese oil resources. In 1943, some 35% of all 'Axis' oil supplies came from the Ploiești

oil fields in Romania, seized by the Germans in late 1940. Attacks on the oil refineries at Ploiești culminated in the infamous 'Operation Tidal Wave', launched on 1 August 1943, during which 54 out of the 117 B-24 Liberator bombers that flew the low-altitude mission from Benghazi in Libya were shot down with the loss of 532 men (Al-Ani 2015). Several more raids on the Ploiești oil fields in 1944 were more successful, resulting in substantial damage (Fig. 11) and making the refineries inoperable by August 1944, thereby substantially weakening the German war effort. At the end of the war, Romania was occupied by Russia, and the Russian influence on the Romanian oil industry remained for decades, even lasting until the fall of the Soviet Union in 1991 (Tulucan *et al.* 2018).

Near the end of the war in 1944, during the 'Italian Civil War', the Caviaga gas field was discovered in the province of Piacenza, near Milan in the Po Valley area of northern Italy (Fig. 1), following a seismic survey that started in 1940 with American personnel and machinery, but was stopped temporarily in 1941 when the USA entered the war. Italian technicians replaced the Americans on the seismic crew and the survey was completed (Cazzini 2018). Caviaga was one of the largest gas fields in Europe at the time, second only to the Deleni Field in Romania, and it played a key role in the rejuvenation of the Italian industrial economy after the war.



Fig. 11. 5 April 1944, B-24 Liberators in formation, bombing the Ploiești oil installations in Romania.

Pioneering petroleum geologists from Europe

Although the majority of European countries are not major producers of oil and gas, many have produced world-class petroleum geologists, explorers and engineers. Cesare Porro (1865–1940) was the first modern oil geologist in Italy. In contrast to his senior colleagues Giovanni Capellini (1833–1922), Antonio Stoppani (1824–91) and Dante Pantanelli (1844–1913), who focused on oil exploration for just a small part of their careers, Porro worked consistently in the oil sector from 1898 to 1931. He started his career with Royal Dutch Shell in Sumatra and eastern Europe. A few years later, he was hired by Deutsche Bank to work in what was then called Mesopotamia. In 1905, he documented the oil potential of the Mosul region for the first time. Hired by a Dutch private consulting firm in 1906, he was sent to explore areas of Wyoming and Oklahoma. In the early 1920s, he returned to Italy to work on oil exploration in the peninsula and then became a member of the Technical Committee of the newly-formed AGIP. He left in 1931, but was asked again in 1937 to explore the territories of Libya. Porro refused and the task was then offered to Ardito Desio (1897–2001), who between 1938 and 1939 discovered oil for the very first time in the oil formations in the province of Fezzan (Desio 1941; Candela 2014; Gerali & Lipparini 2018).

Three German geologists, Alfred Benz (1897–1964), August Moos (1893–1944) and Karl Krejci-Graf (1898–1986), made particularly important contributions to petroleum geology and exploration in the 1930s and 1940s (Kölbl-Ebert 2018). Benz and Krejci-Graf offered their expertise to Hitler's regime, whereas Moos, because of his Jewish background, was murdered. Their biographies shed new light on how German petroleum geologists lived and worked during the span of two world wars in the first half of the twentieth century.

Switzerland has also produced many excellent petroleum geologists, including Carl Schmidt (1862–1923), Josef Erb (1874–1934), Hans Hirschi (1876–1965) and Arnold Heim (1882–1965) (Gisler 2014, 2018; Gisler & Trümpy 2016). Schmidt and Erb worked for Royal Dutch Shell, mainly in SE Asia, while Hirschi and Heim were both students of Albert Heim (1849–1937), Arnold Heim's father, at Zurich. For a while, Hirschi also mentored Arnold Heim. Arnold Heim, who could not succeed to his father's position at Zurich because of a conflict of interest, led an almost 'nomadic' life, working in various parts of the world. His only permanent position came in 1949 (at the age of 70) when he put together a group of Swiss geologists to work in Iran. Among these were Jovan Stöcklin (1921–2008) and Heinrich Huber (1917–92) who later led the mapping work at

the Geological Survey of Iran and the National Iranian Oil Company, respectively, until the 1970s.

Another well-known Swiss geologist during the pre- and post-war period was Augustus Gansser (1910–2012). He worked for Royal Dutch Shell in South America during World War II, was another student of Arnold Heim at Zurich and later was a colleague of Albert Heim while working in the Himalaya in the 1930s and Iran in the 1950s (Sor-khabi 2012). The Swiss petroleum geologists working for Shell in South America during World War II, including Gansser and the two brothers Daniel Trümpy (1893–1971) and Eduard Trümpy (1903–66), remained in the region because of the war and undertook extensive geological mapping. Josef Theodor Erb (1874–1934) was the Chief geologist for Royal Dutch Shell, where he introduced rules and suggestions to standardize the writing of petroleum geological reports (Wannier 2018). Erb's 'Uniformity in Geological Reports' was written as an internal Shell report in 1917 and it eventually formed the basis of the 'Shell Standard Legend'.

Another pioneering European petroleum geologist during and after World War II was Simon Papp (1886–1970), who is regarded as the Father of petroleum exploration in his country, Hungary. Papp was an internationally renowned petroleum geologist, who contributed enormously to oil and gas exploration in Hungary. In 1948, soon after the end of World War II, the communist regime in Hungary imprisoned Papp; nevertheless, needing his expertise, the regime arranged for him to continue his geological work from his prison cell (Tari & Bérczi 2018).

Developments in the post-war period

The Eakring Field in the East Midlands was the first of 25 onshore discoveries made in Britain over the next 30 years (Falcon & Kent 1960) (Figs 12 & 13), a period that defined what was, effectively, Britain's first 'oil boom'. After World War II, both D'Arcy Exploration Co. Ltd and Anglo-American Oil Co. Ltd resumed their oil exploration efforts in Britain, but production declined to 5500 bbl per year by 1948. The search for other oil fields continued and, in 1953, BP found oil at Plungar in the Vale of Belvoir in Leicestershire – the first post-war oil field discovered in Britain. Following this, new fields were found in Nottinghamshire at Egmont in 1955, Bothamsall in 1958 and South Leverton in 1960 (Fig. 11). The search in Lincolnshire also proved fruitful, and four discoveries were made between 1958 and 1962.

In 1952, the Gas Council (GC) joined forces with BP in the search for natural gas and for structures suitable for the storage of peak-load gas. In 1958, gas from a discovery at Calow in Derbyshire was

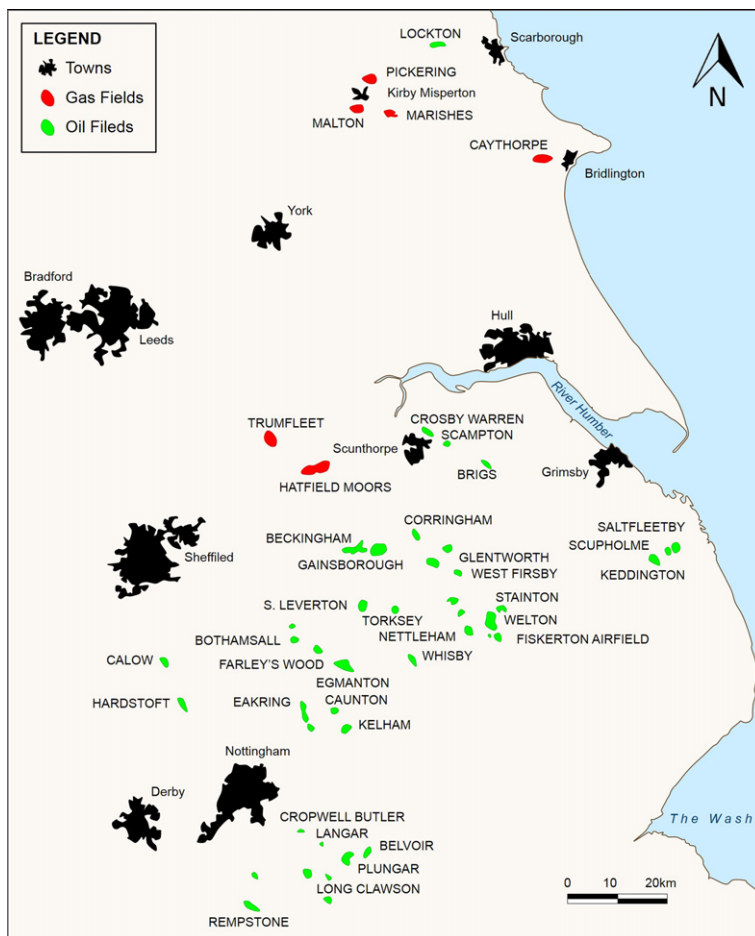


Fig. 12. Oil and gas fields in northern and eastern England (modified from [Gluyas & Bowman 1997](#); [Craig et al. 2013](#)).

fed to the Chesterfield gas works, and a similar link was made from the Eskdale gas field to the Whitby gas works in 1960.

Elsewhere in Europe, the widespread use of seismic data from the 1950s onwards triggered an intense period of exploration. The first significant oil discoveries in Italy were the Ragusa heavy oil field, discovered in 1954 and the Gela Field, discovered in 1956, both in Sicily ([Cazzini 2018](#)). By the mid-1950s, the first offshore seismic survey had started in the Adriatic Sea ([Fig. 1](#)) and, in 1959, the drilling of the Gela 21 well, the first offshore well in Europe, boosted further exploration possibilities in Italy. In Spain, despite systematic exploration in 1940, it took more than 20 years to find a commercial hydrocarbon discovery. The Castillo gas discovery in the onshore Basque–Cantabrian Basin in Spain was later complemented in 1964 by the oil discovery at Ayoluengo (Burgos) in the southern part of the

same basin, which today, more than 50 years later and after intense drilling activity during the 1960s, still remains as the only commercial oil field discovered onshore Spain, with production varying between 100 and 150 BOPD and a total cumulative production of 17 MMbbl of oil ([Navarro Comet 2018](#)).

Some exploration activity continued onshore in Britain during the late 1950s and the early 1960s ([Fig. 13](#)). BP made significant commercial oil discoveries at Kimmeridge in 1959 and subsequently at Wareham in 1964. However, in 1964, the British government ended the preferential tax treatment for producers of indigenous light oils in order to meet an obligation entered into under the European Free Trade Agreement. This had a devastating effect on the economic viability of Britain's onshore oil fields. BP's oil production from the East Midlands fell by a third and development work on several significant

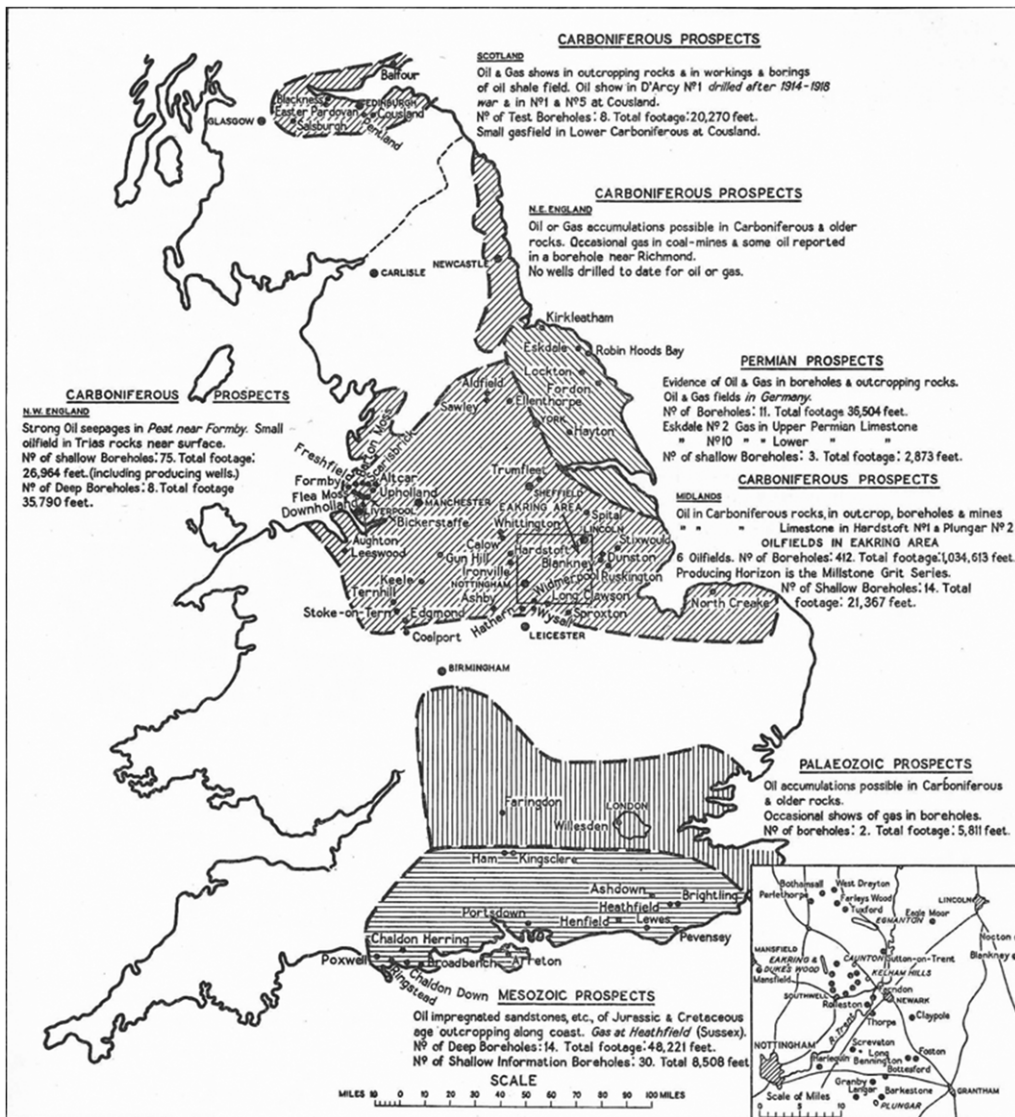


Fig. 13. General map of areas of Britain explored to the end of 1957 (from Falcon & Kent 1960).

discoveries ceased. In 1965, Home Oil drilled Lockton 2a in the North Yorkshire Moors which tested gas at very impressive rates. Subsequent wells, Lockton Nos 3, 4 and 5, all proved dry, but Lockton was still the most important onshore gas discovery of the decade in Britain. It came on stream commercially in 1971. Gas was later also discovered in the same horizon at Ralph Cross, west of Eskdale, and at Malton to the SW of Lockton (Haarhoff et al. 2018).

In the late 1950s and the early 1960s, gas was discovered onshore at Trumfleet in Yorkshire and at

Ironville in Nottinghamshire. The former was found to contain some oil during subsequent appraisal drilling in 1965. Esso made a further gas discovery at Bletchingley in Surrey in 1966, but the field was not developed commercially due to its low calorific value. All of these discoveries were small, and interest in exploring further for oil and gas onshore waned. There followed a period of inactivity while attention switched to the North Sea.

In 1958, a United Nations treaty divided the North Sea into economic zones by country and from this point onwards exploration gradually moved

from onshore to offshore. The first discovery in the North Sea, the Ekofisk Field, was made in the Norwegian sector in 1969 (**Jakobsson 2018**), while the first discovery in the UK sector, the Forties Field, was made the following year. Oil was first produced from the UK North Sea from the Argyll Field in June 1975 (**Gluyas et al. 2018**).

With the increased focus on the North Sea, interest in onshore exploration declined rapidly during the early 1970s and might have faded entirely but for the events of 1973–74, when the oil supply crisis led to a sharp rise in oil prices, thereby improving the economics of exploration and development onshore in Britain. It was against this political and economic background that, in 1973, the Gas Council discovered Wytch Farm; Britain's largest, and eventually Europe's largest, onshore field, with estimated initial reserves of 500 MMbbl of oil (**Morton 2014**). In 1998, when it was at peak production, the Wytch Farm Field produced 110 000 BOPD.

However, it was the steep rise in prices in 1979–80 following the Iranian revolution when the price of oil again rose that really rejuvenated exploration for oil and gas in Europe, and elsewhere in the world. In 1980, 10 exploration/appraisal wells were drilled onshore in Britain, compared to five during the previous 3 years. In 1981, a gas discovery was made at Hatfield Moor in Yorkshire, and Carless Capel made an oil discovery in the Weald Basin at Humbly Grove near Basingstoke. Hatfield Moor came on stream in December 1985 with the gas transported to the nearby Belton Brickworks, and Carless Capel made two further oil discoveries at Herriard and Horndean during 1982–83. The success at Hatfield Moor was followed by another discovery at Godley Bridge in Surrey during 1983. Also in the early 1980s, another oil field was discovered near the village of Scothern in Lincolnshire and this eventually led to the development of Britain's second largest onshore oil field, at Welton. In addition to the discoveries at Horndean and Herriard, other oil discoveries were made at Farleys Wood in the East Midlands, and at Hemswell and Nettleham No. 2 in Lincolnshire. The onshore exploration success continued in 1984, with further discoveries at Cropwell Butler, Broughton and Stainton. In addition, an oil discovery was made at Larkwhistle Farm in Hampshire, a find that confirmed the attractions of the Wessex Basin as an oil-bearing area, and adding to existing discoveries in the area at Kimmeridge, Arne, Wareham and Wytch Farm, and also at Stockbridge, Hampshire and Palmers Wood in Surrey. Taylor Woodrow made another gas discovery at Kirby Misperton in North Yorkshire in 1985 (**Haarhoff et al. 2018**).

Further onshore exploration success came in 1985, with discoveries at Whisby in the East Midlands, and of heavy oil in the Carboniferous at Milton of Balgonie in the Midland Valley of

Scotland. There was also an encouraging start to 1986 with finds at Rempstone, Kirklington and Kinoulton in the East Midlands. BP's Eakring Field in Nottinghamshire, discovered in 1939, produced more than 7 MMbbl, before it was abandoned in 1986 (**Fig. 14**).

In October 1987, a group headed by RTZ was awarded the very first new-style Development Licence to develop the Crosby Warren Field on the north side of the Humber estuary.

With the discovery and subsequent development of North Sea oil, Britain became self-sufficient in oil from the early 1980s and a net exporter of oil in 1981. Exports peaked in 1985 and production peaked in 1999. With declining North Sea production, the UK became a net importer of oil in 2004. As a result of the discovery and subsequent development of vast gas reserves offshore, mainly in the North Sea and in Liverpool Bay (**Bunce 2018**), the UK became a net exporter of gas in 1997, but, as these reserves declined, the UK became a net importer of gas in 2004. Overall, domestic gas production in the UK (onshore and offshore combined) began to decline in 2000 and by the early years of the second decade of the twenty-first century it was declining at a rate of about 6% per year, resulting in the UK importing 45% of the gas needed to meet domestic demand via pipeline and liquefied natural gas (LNG). In contrast, exploration in Norway continued to spread from the early discoveries in the Norwegian North Sea to the Norwegian Sea (**Jakobsson 2018**), where exploration started in 1980, and the Norwegian Barents Sea (**Jakobsson 2018**), where the first exploration licences were also awarded in 1980, with continuing success.

The development of the retail petrol industry in the UK followed a similar pattern of expansion followed by progressive contraction as oil exploration and production (**Ritson et al. 2018**). In 1939, there were approximately 37 000 service stations in the UK, a figure which grew to just over 41 000 in mid-1965, before the industry began a downwards trend, with about 26 500 stations in 1980, under 17 000 in 1995 and 8600 to the end of 2014. Sales of petrol in the UK peaked in 2007 and diesel sales peaked in 2011 (**Energy Institute 2015**).

This decline of UK gas production and the consequent implications for Britain's national energy security focused attention on the possibility of developing domestic unconventional gas resources, primarily shale gas and coal-bed methane (**Dean 2018**), despite the significant impediments to developing such resources in a highly populated country. The decline in UK oil production throughout the early years of the twenty-first century as the fields in the North Sea became increasingly mature also led to renewed interest in the possibility of redeveloping some of the early fields, such as the Argyll



Fig. 14. The Eakring No. 1 well, Nottinghamshire in June 1964, when it was still producing.

Field (then re-named the Ardmore Field), in an attempt to produce additional previously untapped reserves (Gluyas *et al.* 2018).

The successful exploitation of tight oil and tight gas resources in the USA, coupled with concerns about future energy security, also led to an increased focus on the potential for such ‘unconventional’ oil and gas resources in many European countries in the first decade of the twenty-first century. Poland, in particular, took a leading role in the evaluation of its potential shale-gas resources and, from 2007 onwards, the Polish government started to assign shale-gas exploration licences to both national and foreign companies in the hope of reducing Poland’s dependence on Russian gas. Unfortunately, due to a combination of less than favourable geological, legislative and macroeconomic conditions, this early phase of shale-gas exploration in Poland was less successful than initially hoped (Cantoni 2018).

Exploration for new sources of oil and gas in Europe continues, but is increasingly hampered by the maturity of many of the conventional oil and gas plays in onshore areas such as in Britain, France and Italy that already have a long history of exploitation since the mid-1800s, the increasing maturity of some offshore areas, notably the UK sector of the North Sea, that have been explored extensively since the early 1960s, and increasing public

opposition to the perceived environmental impact of the oil and gas industry in general, and of the technologies required to produce new tight oil and tight gas resources in particular.

Conclusions

The quest for oil and gas has generated geological insights and driven technological innovation since the beginning of the modern oil industry in the mid-nineteenth century. Oil and gas are natural resources, but their exploration and production are only partly controlled by the geology. Exploration is ignited by the demand for these resources, and is regulated by careful evaluations of the costs and likely revenues that will be generated. The rigorous application of petroleum geoscience reduces the risk inherent in oil and gas exploration and production, and so provides investors with improved financial returns.

Europe and Europeans played a disproportionately large role in the development of the modern global oil and gas industry. From at least the Iron Age until the 1850s, the use of oil in Europe was limited, and the oil was obtained almost exclusively from surface seeps and mine workings. The use of oil increased in the 1860s with the introduction of

new technologies in both production and refining, but, in the second half of the nineteenth century, the mineral oils and gas then produced primarily from shale and coal could no longer satisfy demand, and oil produced directly from conventional oil fields began to dominate the European market.

The papers in this volume clearly show how the history of the European oil and gas industry has been controlled as much by political and economic conditions as it has by geology, and the historical insights they provide have important implications for current petroleum resource evaluations. In 1902, the State Geologist of Western Australia, Andrew Gibb Maitland, received a letter from a man interested in entering the oil business who wrote: ‘Sir, may I ask if you would kindly tell me something of the geology of petroleum and the best means of prospecting for it?’. Maitland answered that the knowledge on the topic was so vast that a library would not have enough space to contain it (Gerali & Gregory 2017b). Today, the same question would illicit an answer, not in terms of library shelves and stacks, but in terms of thousands of terabytes of petroleum geoscience data, and in the knowledge and expertise of thousands of petroleum geoscientists.

The discovery of the huge oil and gas resources beneath the North Sea in the 1960s and 1970s enabled Britain, Norway, Denmark and The Netherlands to be largely self-sufficient in oil and gas from the late 1970s until production began to decline rapidly in the early 2000s. Oil and gas production in most European countries is now at an historical low, but exploration for new sources of both conventional and unconventional oil and gas in Europe continues, although increasingly hampered by the maturity of many of the conventional oil and gas plays. Despite the decline in domestic oil and gas production in Europe – or, perhaps, because of it – European companies and European citizens continue to play a major role in the oil and gas industry worldwide.

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