

## HISTORY OF PETROLEUM AND PETROLEUM ENGINEERING

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### Summary

Petroleum in its various natural forms is known and utilized by mankind since immemorial times. However, its industrial development at a large scale came only in the late XIX century, first as a raw material to produce lighting oil and lubricants, and then, at the turn of the XX century, as a powerful source of energy that partially substituted for coal within a few decades and characterized the entire evolution of the contemporary society. The present paper highlights the valuable documentation on petroleum substances of the pre-industrial era, and illustrates the early studies that paved the way to the modern petroleum industry, addressing in particular the pioneering and empirical technology of the XIX century, the application of scientific methodologies of the early XX century that contributed to the foundation of petroleum engineering, and the intensification of high technology standards at the turn of the XXI century that ensure the ever growing supply of energy necessary to sustain life on earth.

### 1. The Pre-industrial Period: From Antiquity to Drake's Well

Petroleum and petroleum related substances were already known by the ancient civilizations of the Fertile Crescent and Egypt. In the late bronze age, solid hydrocarbons (known as bitumen and asphalt) found many applications as waterproof

construction materials, as confirmed by several archaeological finds, inscriptions and mentions in the Bible, while the liquid ones (known as naphtha) were sporadically used for lighting, and never became a substance of large consumption. It must be recalled that “Petroleum” is a late Medieval Latin term (*petroleum*, or *oleum petrae*, *i.e.*, Rock oil) and hence it was not used until the XV century.

In Ancient Egypt petroleum products were used as a liniment and in curative preparations for eye infections, while bitumen was used for embalming practices. Herodotus states that in Persia there were many wells producing asphalt, salt and oil. Diodorus, Josephus Flavius and Vitruvius report that the people living along the banks of the Dead Sea (*Lacus Asphaltites*) collected the *bitumen judaicus*, and obtained great profits from trading it to the Egyptians. Strabo in his *Geographia* reminds that the Dead Sea was full of asphalt, which surfaced from the centre of the lake, as though the waters were boiling.

In antiquity the richest hydrocarbons seepages occurred in Persia and next to the Tigris and Euphrates valley. The importance of this region was highlighted by various authors, who mentioned the oil springs of Babylonia and the eternal fires of Persia, *i.e.*, emanations of natural gas burning spontaneously. It is known that the Zoroastrians transformed these fires into the symbol of their religion. Natural deposits of bitumen and asphaltic rocks were known along the southern coast of Asia Minor (Turkey). Dioscorides and Pliny the Elder recall that at the river Akragas, near modern-day Agrigentum (Sicily), there was a spring from which an oily liquid floated on water which the local inhabitants collected to use in their lamps instead of olive oil, and also to treat animal scabies.

In the Mediterranean basin, oil springs still exist in the island of Zante (Ionian Sea), in Southern Italy and in Sicily. Again, Pliny recalls that in the north-east of Persia there were wells producing naphtha, and Plutarch recounts that an officer in Alexander the Great’s expedition discovered oil springs by the river Oxus, in present day Turkmenistan. However, at that time the lack of distillation techniques did not allow the use of liquid hydrocarbons as a lighting and energy source. In fact, natural naphtha is often highly inflammable, making its use for lighting very difficult. Later, the Byzantines and the Arabs developed some distillation techniques, and utilized naphtha for the preparation of the so-called Greek fire, an inflammable mixture used as a strategic weapon, in the form of incendiary projectiles.

During the expansion of Islam, after the downfall of the Persian Empire, the ancient oil springs of the Middle East had not been forgotten, but were indeed exploited regularly, while others had been further explored, such as those of Baku, along the coast of the Caspian Sea. At the turn of the millennium, the Sultans of Egypt formulated a legislation to discipline these mineral rights, and imported oil from Persia and Syria to supply the torches of his personal sentinels. From the earliest centuries of the Common Era, first in Alexandria and then in Syria, light oil distillates were produced and used for lighting, silk cleaning, or to produce the Greek fire. In the following centuries, the process called *destillatio per descensum* (downward distillation) was devised to extract lighting and lubricating oil from asphaltic rocks. The liquid that resulted was a mixture of hydrocarbons obtained through a process of roasting, distillation and cracking.

Distilling techniques were not fully developed until the mid-XIII century in the Mediterranean areas of Arabic culture, and then migrated to Europe thanks to the spread of the alchemical culture. In Medieval Europe the knowledge of petroleum products and the tradition of their use were not lost, and were revitalized by the information reported by merchants traveling to the East and by the Crusaders returning from the Holy Land, who told stories of burning fountains, oil springs and of the Greek fire. Marco Polo, in his *Il Millione* (1270) describes the oil springs of “Armenia”, probably the present-day Baku area.

Medical manuals and the medieval pharmacopoeia reported Greek, Roman and Arabic knowledge on the virtues of petroleum, based on Dioscorides and Avicenna, favoring the spread and the trades of these products that were offered in every pharmacy, as witnessed from the XVI century literature. Numerous documents testify that in the XV century Europe small quantities of oil were produced in many sites. Oil springs were known in the Italian Northern Apennines between Bologna and Piacenza (the oil of Modena), in Bavaria (at Tegernsee), in Alsace (the Pechelbronn mine), in France (the oil of Gabian) and in the vicinity of Hanover (Brunswick and Wietze). Over these centuries, oil was used as well as a substance for waterproofing, lighting and lubricating purposes, in the preparation of paints and occasionally as a fuel. In fact, due to its scarcity and cost of transport over long distances, the applications of oil were confined on its alleged medicinal virtues.

Important among the descriptions of the Italian oils is the one by the German scientist G. Agricola in *De re metallica* (1556), the first mining handbook, in which oil and bitumen production and refining techniques are described and illustrated by splendid woodcuts. The German Jesuit A. Kircher left many indications on natural fires in his *Mundus Subterraneus* (1665), while in other writings he describes the Chinese “hydropyric” wells (probably gas wells), obtaining descriptions from reports of Jesuit missionaries. Italian oil is also mentioned by A. Barba in his mining treatise *El arte de los metales* (1640) and in the work by P. Pomet *Histoire general des drogues* (1694). In 1671 P. Boccone published *Recherches et observations naturelles* in which are described the main occurrences of oil and natural gas in Italy. In 1698 the Italian physician B. Ramazzini edited a 1440 manuscript regarding the oil of Modena, and considered that this oil was valuable as an ointment for skin diseases, as a cure for scabies and as a purgative.

A milestone in the study of petroleum products in the XVIII century is the Encyclopedia of Diderot and d’Alembert (1751-72). Here, mention is made of the oil produced from the Middle East, Sumatra and Europe (France, and Italy). With regard to the nature and origin of petroleum, a subject already debated, the hypothesis was that an underground fire distilled and sublimated the bituminous parts of certain rocks within the earth, and that petroleum migrated to the surface through fractures. In the same period, petroleum studies were given a considerable boost by M.E. Eyrini d’Eyrinis, the pioneer of the application of asphalt products as waterproofing, construction and road paving material.

A few decades later, the Italian physicist A. Volta discovered the methane, which he called “inflammable native marsh air” (distinguishing it from “inflammable air”, the modern hydrogen) that he collected in some springs near Milan, and from emissions in

shallow marshes of Lake Maggiore (Italy). He devised methods for on-site gas sampling, and carried out laboratory analyses, recognizing that it contained carbon and produced water in the combustion process. The discovery earned numerous recognitions for Volta by contemporary scientists. He also made considerations about its origin, concluding that it came “from plants and animal bodies decomposing in water”. Shortly afterwards these researches inspired also L. Spallanzani, an Italian naturalist who studied numerous oil and gas seepages in the Northern Apennines, and proposed the term “natural gas” still in use today; he considered it to be of inorganic origin, and used a different name to distinguish it from “marsh air”, in contrast with Volta’s more precise deductions.

Concerning the geology and the underground behavior of petroleum, specific studies were not carried out until the XX century. Earlier, the only case studied was that of water, which furnished the scientific basis for subsequent studies on hydrocarbons. B. Ramazzini (1691) was the first to recognize the nature of the artesian wells of Modena (Italy), and he identified the flow of water through sands. A few years later, A. Vallisnieri (1715) completed Ramazzini’s observations and formulated the cycle of underground water in modern hydrogeologic terms. The earliest mention to the measurement of the flow rate of liquids in porous media dates back to 1856, when the French engineer H. Darcy published the results of his experiments on the flow of water through sand. Commissioned to construct the water supply system for the city of Dijon, Darcy proposed the empirical law that regulates the flow of water through sand layers used as cleansing filters. The results were generalized in the empirical law which was named after him. Darcy’s law correlates the rate of flow with the hydraulic gradient by means of a constant which he calls “permeability”, probably using the terminology already in use among contemporary hydraulic engineers. The validity of Darcy’s law was then confirmed by experiments conducted on a wide range of natural and artificial porous media, while further studies, in the first half of the XX century, revealed that it could be also extended to describe the multiphase flow occurring in petroleum reservoirs.

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### Biographical Sketches

**Paolo Macini** is Associate Professor of Petroleum Engineering at the University of Bologna (Italy). Prof. Macini holds a M.S. Degree in Mining and Petroleum Engineering from the University of Bologna. He is a Registered Professional Engineer in Italy. Before joining the University, he worked for a Service Company supplying tools and services to the oil and gas industry, with experiences in Italy, North Sea, Africa and USA. He joined the University of Bologna in 1992, and his present appointment is Associate Professor at the Chemical, Mining and Environmental Engineering Department. Prof. Macini has taught a number of classes at the University of Bologna. Principal among them are Underground Fluid Mechanics, Drilling Engineering, Reservoir Engineering and Petroleum Production, which are also the main areas of his research activity. He has authored or co-authored more than 80 papers and three books. Prof. Macini is a member of the Society of Petroleum Engineers (SPE), where he served for more than 10 years in the Board of the Italian Section and as Chairman of the Ravenna Subsection, of the American Society of Mechanical Engineers (ASME), of the Russian Academy of Natural Sciences (US Section) and of the Italian Society of Mining Engineers (ANIM).

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During his teaching activity at the University of Bologna, Prof. Mesini covered almost all the classes offered to Petroleum Engineering students at the College of Engineering.

He is member of the following scientific and professional associations: Italian Society of Mining Engineers (ANIM), Society of Petroleum Engineers (SPE), Pi Epsilon Tau (National Petroleum Engineering Honor Society, University of Southern California); International Hall of Fame (IHF Los Angeles); Russian Academy of Natural Sciences. In addition, he is member of the Editorial Board of the Journal of Petroleum Science and Engineering, Elsevier, Amsterdam.

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