NATURAL OIL AS SOIL POLLUTION SOURCE: GENESIS, EXPLOITATION AND PROCESSING

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Abstract

In this paper, the actual problems of oil geology and technology are presented, mainly for specialists in environmental sciences. After a short historic introduction, the genesis of natural hydrocarbons, the process of oil and gas accumulation, the conservation in traps and the geological and geophysical methods of the discovery of the productive structures and their exploration are discussed. The terms like mother rock, reservoir rock, hydrocarbon trap and gas or oil productive structures are explained, too. After presenting the methods and the tools for drilling the oil and gas wells, the way of oil from the production well to the consumers of the oil products – fuels, chemical products – is described: the well head installations, the pipelines, the separation parks, the refineries and the deposits of the oil-derived products. Finally, the "hot spots", where the oil and the oil-based products may cause soil contaminations are discussed.

Key words: mother rocks, reservoir rocks, traps, drilling engines, crude oil, paraffin, soil pollution

Összefoglalás

A tanulmány az olajkutatás jelenlegi állapotát vázolja, főleg a földtan szempontjából, a földtani tudományokban kevésbé jártas környezeti szakértők számára. Rövid történelmi áttekintést követően a természetes szénhidrogének keletkezését mutattuk be, abból kiindulva, hogy ezek képezik a Föld (rég)múltjában bolygónkat érő napenergia szénben és hidrogénben "konzervált" anyagát. Követtük a szerves anyagokat tartalmazó üledékek anyakőzetként való betemetését, a betemetést követő átváltozásokat, amelyek során, megfelelő hőfokot elérve a komplikált szerves molekulákból szubmikroszkópos méretű olajcseppek és gázbuborékok keletkeztek. Ezek vándorolnak (migrálnak) előbb ki az anyakőzetből, majd a pórusos vagy üreges-repedezett (karbonátos) tároló kőzetben, nem egyszer több száz kilométert, addig, amíg kedvező csapdát találnak. Ezekben, elegendő agyagos-márgás rétegek védelmében halmozódnak fel a szénhidrogének és itt keletkeznek a földgáz- illetve olajtelepek. A következőkben részletesen bemutattuk az olajfeltáró kutak fúrásának, és a kutak üzemeltetésének technológiáját, valamint a kőolaj-telep termelékenység szinten tartásának a módját. A finomítókban a nyers olajból kinyerhető párlatok (desztillátumok) felsorolása után követtük az olaj útját a kúttól a felhasználóig és ezzel kapcsolatban rámutattunk a talajszennyezés szempontjából a lehetséges kockázatokra.

Kulcsszavak: anyakőzet, tároló kőzet, csapda, fúróberendezés, nyersolaj, parafin, talajszennyezés

Introduction

It is generally known that natural hydrocarbons such as oil and gas are the most important energetic and chemical raw materials. The modern life style is impossible without them. Therefore, their extraction, processing, transport and distribution in all developed countries represent an important branch of the industrial activity; while on the other hand, it also represents a serious environmental risk factor including soil level pollution.

That is why we believe that introducing some aspects of the genesis, the exploitation and the processing of natural hydrocarbons with their possible environmental consequences would be useful even for those who are not specialists of environmental problems.

1. Short history

The oil seeps and spontaneous gas emissions have been known from ancient times. Herodotos (484–425 BC) mentions the Mesopotamian naphtha sources and the holy fires of Colkhia (Caucasus). The Athenians used flaming naphtha against besiegers during the storming of the city (657 BC). The role of the Colossus of Rhodes was not only lighting the entrance of the port, but to burn the invaders' ships with hot naphtha. In the ancient times and in the Middle

Ages such military use of natural hydrocarbons were common, but it does not exclude the "civil" uses of them; as medical potions, unguents or as cosmetics and — mainly in the Carpathian region – as cart-grease ("dohot").

By discovering petrol as lighting oil in the first half of the 19th century, research for natural sources started. The Carpathian, Caucasian, Middle Eastern and American oil fields were discovered and studied step by step. By the invention of the internal combustion engine and in the beginning of the 20th century by the serial automobile production the oil industry was busted. By the extension of the known fields, in newly discovered oil belts herds of oil wells appeared and now they invaded the offshore area. Giant refineries were built and the continents were enmeshed by thousand kilometers of pipelines. Now, the oil production is close to 10 billion barrels/year.

2. Oil in the history of Earth: genesis, migration and conservation.

Natural hydrocarbon accumulations along with coal deposits represent the "conservation" of ancient solar energy, hidden in C- (and H-) bearing natural substances. Over more than three billion years, the photosynthesis of some organisms has converted the carbon of the carbon-dioxide and the hydrogen of water into organic components such as hydro-carbonates, synthesized complexes such as N, S, P, K and Mg and other element-bearing macromolecules. After the death of the organisms, these compounds followed a reverse process: they were oxidized, mineralized and the process released CO_2, N, water and mineral salts; with the exception of the buried ones: under favorable P and T conditions natural hydrocarbon formation started in them.

2.1. Oil source rocks

As a consequence, the source of the gas and oil is the organic material that has been buried and preserved in sedimentary rocks. But which organisms are responsible for such a large mass of organic matter? In contrast to the terrific images of sci-fi stories, the main sources of C and H accumulation were microscopic unicellular organisms, e.g. the *Cyanobacteria* group, not Dinosaurs or other giants that were killed by catastrophic Earth events and volcanic eruptions. Now, in each cm^3 of the seawater thousands of such organisms are floating. In some black rocks, other Plankton rests as *Diatomaea, Radiolaria, Infuzoria, Flagellata* etc. (Photo 1) were identified – just like fish scales, bones and whole skeletons as well. The latter is present only as few pieces, without notable contribution to oil genesis, only as "gifts" for oil researcher paleontologists.

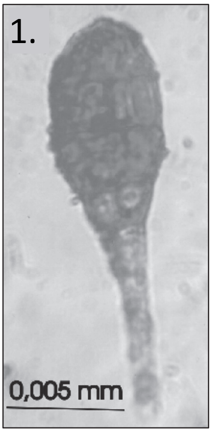

Photo 1.

Photo 2.

The most common organic-rich sediment is “black mud” on the bottom of isolated, anoxic basins (e.g. in the Black Sea below 200 m depth). By the burial and by a wide range of bacterial and diagenetic processes, these sediments were transformed into black shales (disodyle schists, hot shales, phtanites, Photo 2), i.e. as the mother rocks of the oil. These rocks contain hydrocarbons in the form of submicroscopic drops (Figure 1) and bubbles. The content of the CCl_4-soluble organic matter varies between 0.1–5%. Exceptionally, it can reach 15–20% (e.g. Anina-Steierdorf Liassic oil shale in Romania, exploited between 1930–1957 for polar oil extraction (Bucur, 1975)).

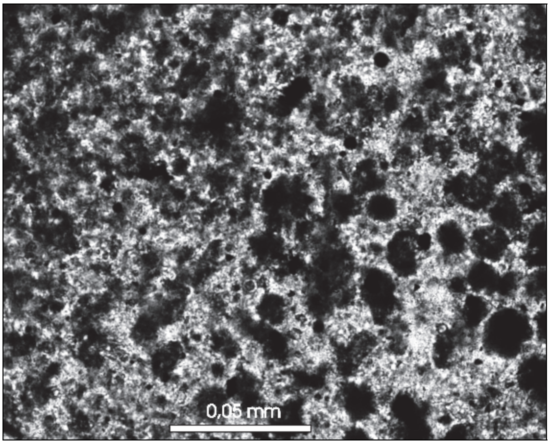

Figure 1.

In the subsurface region, the temperature is the most important factor for turning organic matter into oil. The minimum temperature for breaking the complex hydrocarbon and protein molecule, i.e. for the formation of oil components is ca. 65°C in the depth about 2800 m (Figure 2). Oil is generated from there and is down to about 150°C and up to 5500 m depth of burial. If the source rock is buried deeper, where the temperature is higher than 150°C, the remaining organic matter generates natural gas (Hyne, 2001).

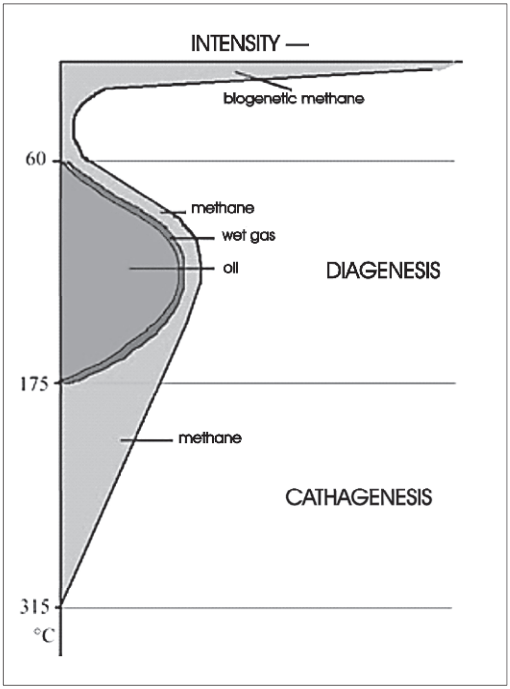

Figure 2.

2.2. Migration: the "birth-way" of the hydrocarbon deposits

The heat-generated hydrocarbon drops and bubbles may follow three ways: (i) by the tectonic and erosion processes the back shale rises to the surface and its organic content oxidizes; (ii) the shale sinks to deeper regions, to metamorphic zones and recrystallizes as mica-schists or black quartzites with a part of carbon being converted into graphite; and (iii) in the optimal zone (see 2.1. sub-chapter) the fluid content of these rocks migrates. At first, it leaves the mother rock, following the submicroscopic pores, micro-fault tracks, strata surfaces, crystal imperfections and dissolution voids. For the second step of the migration permeable rocks are required: sands, porous sandstones, spongeous or vacuolar limestones etc. In these rocks, the hydrocarbon particles unify, forming mobile drops and lenses (Figure 3), which percolate between the voids of these rocks. The mobility of them is assured (i) by the motion of the groundwater in which they are floating; (ii) by the ascension force due to the difference between the density of the water (γ=1.00–1.05) and the oil (γ=0.63–0.86); and (iii) by the "pumping" effect of associated gas. The way of migration can vary from a few hundred meters to hundred kilometers (e.g. from the Tanezuft Silurian hot shales, South Sahara to the Cretaceous sandstones and chalk in Sirte Basin, (Lüning et al., 2000)).

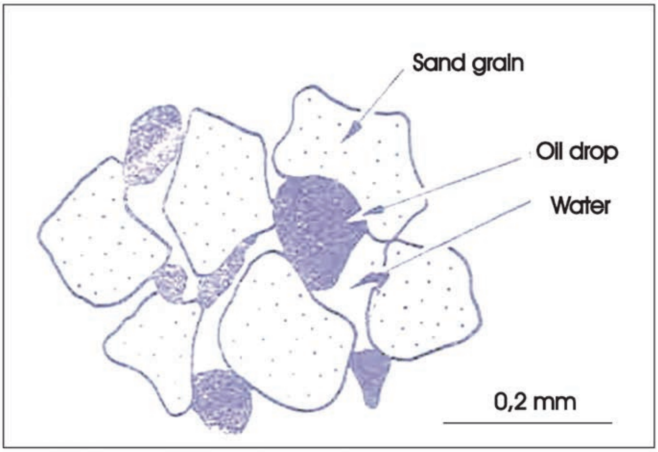

Figure 3.

During its migration, the oil can change its composition and rheological properties, it can loose some undesired compounds (as sulphur), or getting close to the surface, loose the light fractions, resulting in natural wax (ozokerite) and/or pitch (bitumen) seal of the outcropping sandstone level (Derna, NW Transsylvanie; Matița, Eastern Carpathians, Romania).

2.3. Conservation of hydrocarbons in traps

The hydrocarbon deposit, following a more or less long way in permeable sediments as reservoir rocks can be conserved for our use only in case it meets a favorable, closed geological structure, in which it can be accumulated for million years without notable losses (Selley, 1998).

The main property of the reservoir rocks is the permeability both for hydrocarbons and water. We can distinguish two reservoir rock types: porous and vacuolar rocks. To the first category different (dunar, shortline, river and delta) sands, sandstones, less frequently gravels (Figure 4), pyroclastic rocks (Farmos) or weathering crust breccias (Algyő, Ásotthalom, Szank, Hungary; Berettyószéplak – Suplacul de Barcău, Romania (Nicorici, 1974)) belongs.

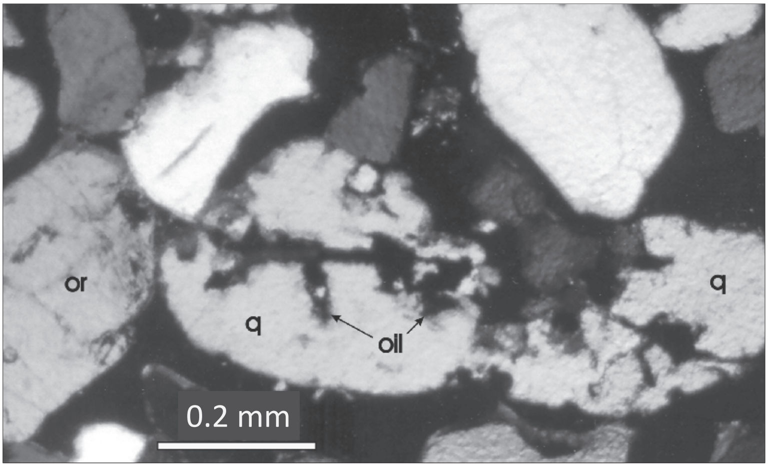

Figure 4.

To the second category mainly carbonate reservoir rocks belong: old reefs, limestone platforms, buried karst, chalk and dolomite deposits, oolitic limestones. They are the most productive reservoirs: the oil fields in Texas, Alberta – Canada, North Sea, Middle East and Indonesian – and in Hungary, the Pusztaföldvár, Hahót and Nagylengyel deposit belong to these rock types.

The main condition of the traps is the presence of an impermeable level that protects the upward hydrocarbon-bearing reservoir rocks (Figure 5). The structure must be closed downward, too with an impermeable bed or by the water table.

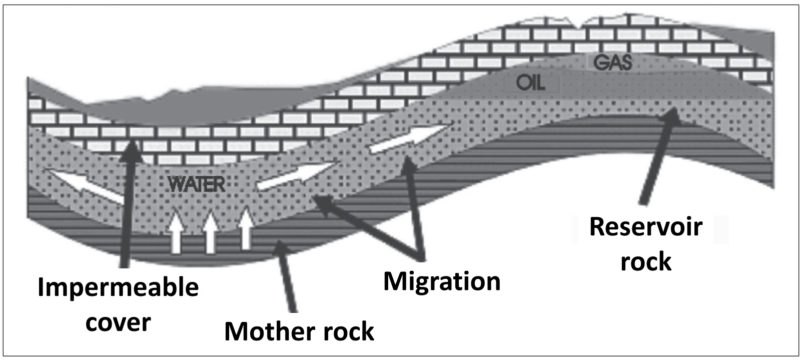

Figure 5.

By surface mapping, by geophysical (mainly seismic) measurements and by the interpretation of well logs, a few hundred trap types were justified. They are classified into three main types: structural traps, stratigraphic traps and combined ones (Chapman, 2004). In the Carpathian area, mainly structural trap types were recognized. Out of the Carpathian belt, the anticline structures, often with diapir salt plugs appear in which the oil and the associated gas are located in Pliocene, Miocene and Oligocene sand and sandstone reservoir rocks. In the Pannonian Basin, large anticlines (with or without fault lines) contain small oil and gas accumulations in Miocene (mainly Pannonian) sandy deposits. Triassic and Miocene carbonatic reservoir rocks and breccias of the Proterozoic-Paleozoic basement (Nicorici, 1972), protected by thick Pannonian marls and clayey levels (Dank, 1985) occur in the Transdanubian, Northern Slovenia (Peklenica) and Eastern Romania (Érábrány, Selénd, Nagyszalonta, Pécska) areas (Figure 6).

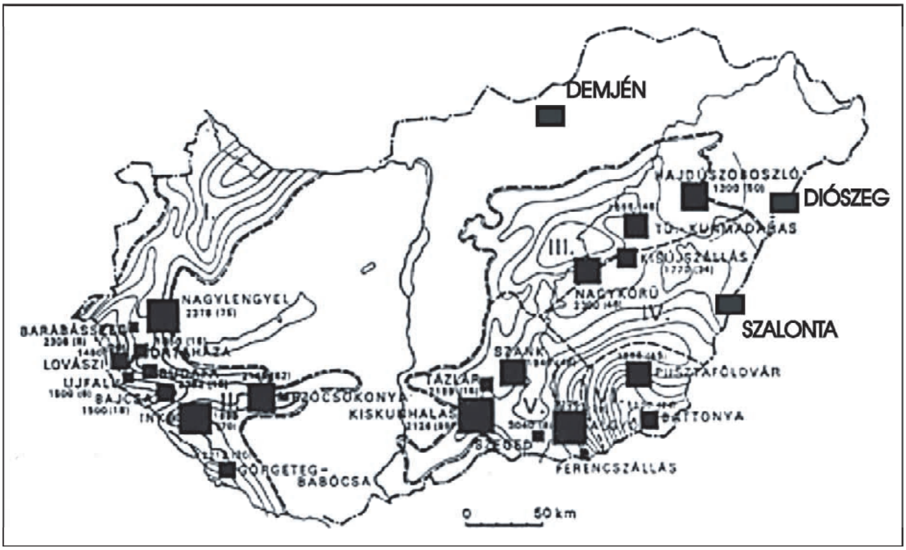

Figure 6.

3. Identification and extraction of oil from the depths

3.1. How were hydrocarbon-bearing structures discovered?

For put in exploitation, the first step is to localize the presumed hydrocarbon accumulation and to estimate their quantitative and qualitative parameters (Emmons, 1931).

As we presented in Chapter 2.3., the hydrocarbon accumulations are situated in structural and/or stratigraphic traps. Because these geological bodies are often hidden under thousand meter thick sedimentary rock formations, geophysics measurement is the main tool for their identification.

The gravimetry method that is based on the density of natural rocks mark the so-called gravimetric anomalies where the gravimetric field of the Earth is smaller (–) or greater (+) than the normal value in the given area. The negative anomalies mark presence of light rocks (e.g. salt domes or diapir plugs), while the positive ones mark increased density, for example when older, heavy rocks rise from the depth, i.e. in nuclei of an anticline structure. Hungarian geophysics played a pioneer role in this matter: the first application of the torsion balance that was invented by Loránd Eötvös indicated the structures of Transdanubia, where industrial oil accumulation was found later.

The position of the strata and the geometry of the presumed structure is determined by the interpretation of seismic profiles. Seismic methods are based on the reflection and/or refraction of elastic deformation waves along lithological boundaries (as stratification, faults etc).

Because the geophysical methods mark favorable structures without any information about their hydrocarbon content, they are combined with geochemical measurements. In air samples that were collected in shallow pits, the presence of volatile hydrocarbons (mainly methane) could be detected by gas chromatography. By this method, a large gas field was contoured by Soviet geochemists in Emba Basin (Northern Russia).

The positive result of the first exploration wells are the justification of the productivity of the proven structures. The presence of hydrocarbons is justified by borehole geophysics and by open well joint tests.

The well geophysics is a system of measurements of some geophysical parameters along drilled wells. The results are presented in geophysical (electric, radioactive, thermal) logs.

The most common logs are the electric ones: a long, depth proportional diagram where in the left side the spontaneous potential, while in the right side the continuous line of resistivity and the dotted line of the gradient are represented. The interpretation of these values make it possible to distinguish the oil, gas or (salt and/or fresh) water content of the permeable rocks as well as the impermeable ones without fluid phase content.

Another method is the radiometric log. In this case the natural gamma activity, the induced gamma, the neutron-gamma and the neutron-neutron radiations are measured.

Because an essential component of the oil is the hydrogen, the spectrum of the neutron activation and the deflection indicate the presence (and the approximate concentration) of oil in the sediment.

The thermometric logs in barren wells put in evidence the inflow of hot or cold fluids, and the back of the casing, the level of the cement ring. Periodic temperature and pressure measurements are made during the exploitation of the oil. The P-T variation in time offers diagnosis about the "health state" of the well and its environment.

3.2. The way of the oil from the depth to the surface

In the beginning, the naphtha was gathered from natural sources (called seeps) or from shallow trenches. In the Extra-Carpathian oil zone, the first lighting petroleum refineries brought the crude oil from 10–30 m deep pits, with grooved pine board liner together with a horizontal oil gallery as it can be seen in Sărata Monteoru oil park, a unique productive oil mine in Europe (Photo 3).

Photo 3.

The first boreholes, drilled for American oil structures, were realized by the Pennsylvanian drilling system. In this engine the rock of the well was broken by a percutant bit and the debris was extracted by a tubular spoon. The protection of the walls was assured by sheet iron casing. Reaching the oil bearing level, the oil was expulsed to the surface by the gas pressure, and was collected close to the well in small trenches and pits. It is evident, that the use of this method involves large soil pollution and, not at least, a high risk of well fires.

Nowadays, for well construction, Rotary method is used. The rock of the structure is loosened by rotating bits, and the debris comes up by the stream of the drilling mud. All of the circulation systems is safe, their rapid closing is possible by an assemble of ventils and valves.

The Rotary drilling equipment consists of the derrick, the rotary table, the drillpipes and the bit (Man. ing. petrolist, III. 1954).

The derrick is a vertical lathwork that moves all the objects that are used by the drawing out procedure of the borehole: the drillpipes, the casing and the tubing of the well by a system of steel cables, pulley blocks and the mechanic winch.

The rotary table is an engine, which turns the drillpipes by the quadrate pipe. At the upper part of the quadrate pipe, the hydraulic head is emplaced, by which the drilling mud is pumped in the well.

The drillpipes are 5–12 m long, strong steel tubes, with rapid screw-thread to bind each other together. The role of the drillpipes is to transmit the drilling force to the bit and to the lead in order to pass the drilling mud towards the working space of the bit. The first drillpipes that are directly up to the bit are the drill collars: heavy, massive pipes with thick walls that assure the verticality of the well.

The oil wells are dug by various types of bits. The simplest bit has a shape of a fish tail, with two, opposite cutting blades, often reinforced by hard metal alloy pellets. It is used by relative soft rocks: clay, shale, marl or friable sandstone levels. These rocks are cut in snail-like slices and disaggregated by the mud jet.

For the traverse through harder rocks, the rolling bits are used, which crush the rock and mill them to fragments, which can be removed to the surface by the mud.

The drilling mud is a suspension of clay minerals, mainly composed of smectites, in which during the rotation of the drillpipes and the pumping engine the solid particles are transported towards the surface. It coagulates, when the flow stops, the particles rest in suspension. This feature of the mud is called tixotropy. To meliorate the tixotropy and other rheological properties, the mud is treated with chemicals. In order to traverse through high pressure oil or water levels, the density of the mud is increased by adding barite or iron oxide powder. The appropriate properties of the drilling mud have high importance; thus, inside the drilling unit, a complete mud and water laboratory functions.

The drilling of a well comprise two or more stages (Figure 7). First, the near-surface, 10–50 m thick, soft sediments are traversed, and the first casing column, 16–22” in diameter is fixed and cemented. It is called the anchorage casing column.

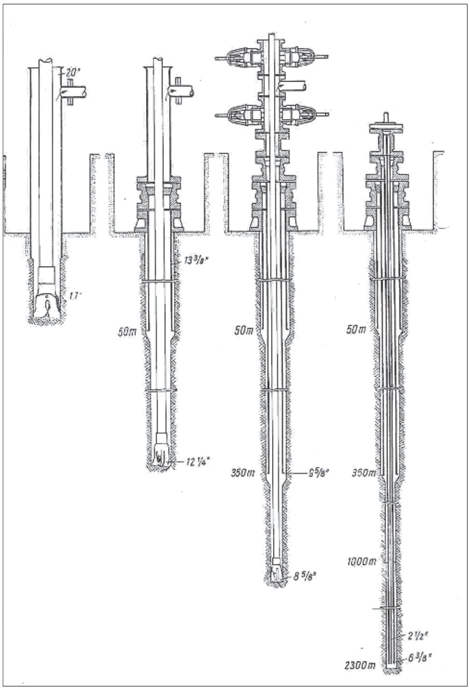

Figure 7.

The next stage is the drill until the head of the cover of the productive level. The hole is lined by a technical casing column, 8 5/8–10 1/2” in diameter and cemented up to the surface. At the head of this casing the prevention valve is assembled. By closing this engine around the drillpipes, the spontaneous eruption of fluids can be stopped in time.

The last stage is due to the traverse of productive levels. The well is lined by the production casing, 6 5/8–5 3/4” in diameter and cemented up to the foot of the technical casing.

In all of situations, the cement ring fixes the casing by filling the space between them and the wall rock. It also isolates the several fluid containing levels.

After the hardening of the cement ring, the casing is perforated in place of the traversed productive level(s), which was (were) established by geophysical logs. A column of tubing 2 1/2 –2” in diameter is introduced in the well, by which the mud is replaced by water. Decreasing the pressure, the oil or the gas (or the salt water) begins to flow towards the surface, in a so called controlled eruption.

In case of low pressure strata, or at the advanced stage of the exploitation, the uplift of the oil must be helped, pressing gas in the space between the casing and the tubing: the oil and/or the water flows out, like soda from the siphon-bottle.

During the exploitation, the pressure of the oil reservoir decreases in time. For a predictable and continuous oil production, it is important to "break" this loss of pressure using recovering procedures. In the gas cap, for the shallow deposits, methane gas, steam, carbon dioxide or thermo-central coal smoke injection is made – or to fluidize the heavy oil, it is heated by electric resistance (like tea electric kettle) or by the local burning of the oil with air injection (Berettyószéplak, Romania).

After the natural reservoir drive has been depleted, water flood and enhanced oil recovering can be attempted to extract some of the remaining oil. The recycled salt water is pumped under pressure down to the injection wells to force a part of the remaining oil through the reservoir towards the producing wells. At the Țicleni oil field (Romania), the pumping of salt water into a depleted block of Helvetian 1 level, (three wells, called 74 SRP, 75 SRP and 76), the first line produced 500–600 m^3/day/well fluids with 3–5% oil content, in fact total 75 t/day crude oil (and 10–25 thousand m^3 wet gas). It seems, that the injected salt water "cleaned out" the pores of the sandstone, so all of the mobile oil drops could be extracted.

Photo 4.

Step by step, the natural pressure decreases and the hydrostatic level sinks under 500–800 m in depth. In this case, only the pumping of the oil is a rentable method for the extraction (Photo 4). The deep pump is fixed at the end of the tubing column and it is moved up-down by pumping pipes, 1 3/4 – 1/2" in diameter. At the surface, the pumping unit is formed of an electric motor, which actions the balanced fly-well, a pair of slide-bars, moving the balance bar ended by a parabolic piece called horse head. The pumping pipes are fixed to the horse head by a pair of short steel cables, called "horse traces". Traveling to Eger along the highway No. 25, leftwards, between the vineyards, two small pumping units may be seen. They produce oil from Oligocene sandstone, which forms the reservoir rock of the small Demjén structure. From the weakly oil production, two tank cars are filled.

After a well has been depleted, it is plunged and abandoned. Cement must be poured down the well to seal the depleted reservoir and to protect any subsurface fresh water reservoirs. Now, the appropriate sand levels of the abandoned wells are re-utilized as commercial gas reservoirs – or as fresh water sources.

3.3. From the well to the refinery

All fluids from the depth reach the surface through a complicate assemble of taps, pipes and measuring instruments, called "Christmas tree". The main piece of the Christmas tree is the block valve, a steel or ceramic cylinder, with a calibrated orifice (from 5 mm to 1.2 cm in diameter). The debit and the pressure of the gas, oil or water stream is regulated by the block valve.

An other important piece is the pipe through which the paraffin crust is scrapped out from the tubing. It is known, that when the paraffinic (waxy) crude oil is in the subsurface reservoir where is very hot, the wax occurs as liquid. As it is being brought up by the well, it cools and the waxes solidify. This clogs the tubing in the well and the flow (mixture) lines on surface. The well and the pipeline than has to be shut in for a moreover to clean out the wax – an important oil-based raw material for lubricants, lacquers and paraffin candles.

Several pieces of the Christmas tree are heated with steam or with electric hot oil heaters because of cooling by gas détente and during cold weather.

The fluid from the exit tap of the Christmas tree is collected by a tank in case of exploration wells while for the productive wells it flows towards the separator park through a so called mixture pipe (4–8" in diameter). There is a short cylinder at their heads, which permits the paraffin scraper to be introduced into the mixture pipe called "godevill-car".

The fluid which is flowing out from the wells is a multi-phase system, a mixture of gas, oil, water and sand particles. They are separated in an installation called separator park. Here the mixture is jetted to a ceramic plaque, which disperses them into small drops. Thus, both the solved gas and the salty water is separated: the "wet" gas is collected in gas pipes or burned, the oil and the salty water is pumped in tanks in which the water and the mineral particles are released by the bottom taps and the pure, crude oil is pumped into the main pipeline of the oil field.

The crude oil of the entire oil field is collected in a central park from which is transported toward refineries. The production of a few tone/day is transported by tank cars or by railway tanks. Three wells had produced four tank wagons of oil each month till 1957 from the Oligocene sandstones in Săcel-Iza field (Maramureş county, Romania). They were transported and discharged in Câmpina refinery. Afterwards, to finish the pipeline of 8” in diameter, all of the oil of Ţicleni field (6–7000 t/day) was transported by long oil tank wagon trains to Ploieşti and Piteşti. Thus, the Bărbăteni charge station close to Gilort river was the main pollution source for the whole hydrographic basin.

There are many hundred – a few thousand km long oil pipelines, traversing mountainous and desert regions as the pipelines between the Persic Gulf and the Eastern Mediterranean Coast or the newly lied pipeline of 36” in diameter, from the giant Elefantina oil field (Murzuq Basin) to Adjabiya refinery, Libya, crossing Sahara.

3.4. From the refinery to the consumers

The crude oil is not useful: containing light fractions, it is highly inflammable and containing heavy ones, it is improper to be used as motor fuel. It is necessary to separate these components by fractionated distillery (Man. ing. petrolist, IV.1954).

Five types of crude oil may be distinguished: *paraffin bearing*, *aromatic rich* and *asphaltic based crude oil*. The fourth category is represented by *heavy, oxidized oil*, which had lost the volatile components. It is characterized by high content of lubricant and electric (polar) oil fraction. Last, but not least, some oil wells produce a *colorless, volatile product* with pleasant, aromatic smell: it is the so called casing head gasoline, the natural condensed light fractions of the deep situated oil bearing zone.

All of these oil types must be refined for obtain commercial oil products. From lighter to heavier ones, in increasing order of the boiling temperature, these fractions are the following:

1. Low pressure gas. It is obtained by conditioning of the crude oil first to introduce in the fractionation column. It is ~90% methane, about 5% other hydrocarbons, water (steam), nitrogen and carbon dioxide. It is the main fuel for heating the furnaces of the distillery columns.

2. Light fraction: from C2 to C4: the LPG or PB gas. It is obtained mainly in the treatment of the wet gas, in so called degasolinizer stations, by adsorption on porous charcoal pastilles and desorption with steam. In refinery, it is a by-product of low pressure gas.

3. Gasoline ("benzin") fraction: from C5 to C10 one, having as main component the octane C8H14. The Octane Number of the gasoline-type fuels is the main characteristic of their quality.

4. Kerosene or lighting petrol fraction (C10–C16) gives the fuel of planes and of reactive engines; in the past, it was the fuel of the old, nostalgic paraffin lamps.

5. The Diesel fraction (C16–C24) is the fuel of powerful trucks, locomotives and ships. Now, the Diesel oil-rich crude oils are the most useful ones, because the price of this fuel is increasing continuously.

6. The "black oil" (up to C25) is the liquid fuel of central-heating, and in the past, for steam locomotives ("pacura"). Now, it is the raw material for synthetic (cracking) fuel: by pyrolize, with or without hydrogen injection, the long hydrocarbon ranges are brooked to obtain lighter, useful oil fractions. The paraffin (see Chapter 3.3.) and the black bitumen for running cover of the sealed ways are also obtained from this heavy fraction.

The different fractions of refineries are transported out of the localities by pipelines toward fuel deposits in cylindrical or spherical tanks, with high level of security. Other pipelines, floats of tank-cars and tank wagons serves the consumers: gasoline stations, railway terminals, airports and chemical plants. The long way of hydrocarbons ends in the cylinder of the internal combustion engine or in reaction tanks of certain synthetic lacquer plant.

4. The hot-spots of oil pollution

Under optimal conditions, the oil and its products do not see the blue sky only as exhaust pipe smoke — but the reality is much worse: there are a lot of escape points though which they can invade the environments, including the fertile soil levels. Following the way of the oil from the depths till the consumers, we suggest these "hot points" (Figure 8).

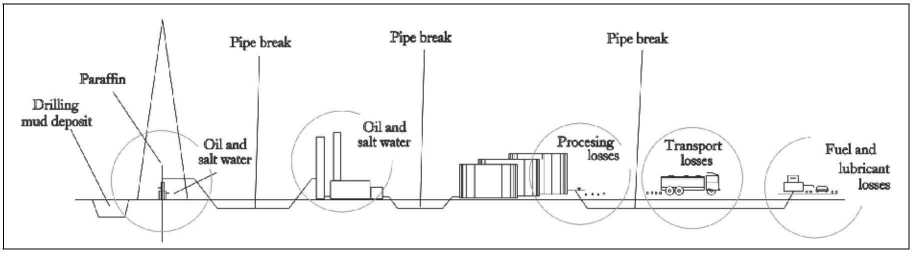

Figure 8.

4.1. The well

Drilling of oil, gas or water wells bear the risk of pollution.

During the drilling operation, the mud is the main pollution agent. The natural, clay containing mud is rather a fertilizer, having high content of smectite clay minerals and silica-gel, with neutral or slightly basic pH. But introducing some chemicals (tensio-active and/or anti-coagulants), and as well barite powder, the mud becomes pollutant. Therefore, the abandoned mud-filled trenches pollute the soil, mainly those having traversed productive levels with oil content or water-bearing levels with high salt concentration.

The successive essay of the presumed oil or gas-bearing strata in the exploration wells is another pollution source: the spreading of the oil-gas-water mixture, before it is transported to the tanks or pipes. Finally, in the depleted oil fields, in case of improper cementation of the casing system, the abandoned wells may lead to local pollution by oil or salt water escapes.

As for the stage of exploitation, the main sources of oil pollution around the wells are the oil jets that escape during such interventions as temperature and pressure measurements, valves and tapes changing of Christmas trees and the deep pump of pumping wells, as well as the launch of the paraffin scrapers into the tubing and into the mixture pipeline. These “small” amounts of the pollutants accumulate in the course of time: in 30–50 years or more, the whole area of the oil field became a semi-desert environment, with rare, sick vegetal cover and sterile soil level (Photo 4).

The uncontrolled, “free” well outbreaks that spread oil and salt water on large areas present major catastrophic pollution events affecting hundreds of hectares and in case the jet goes up in flames (Figure 9), the whole vegetation of the affected area can be burned down.

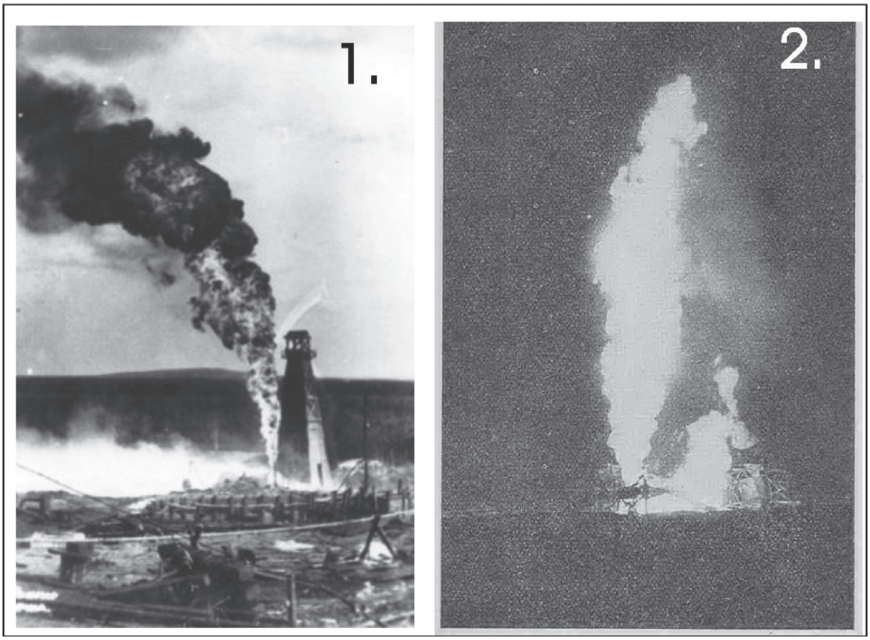

Figure 9.

4.2. The separator parks and the pipelines

In the separator parks, the whole courtyard is insulated by concrete cover. Unfortunately, there is no absolutely impermeable or fissure-free concrete. As it has already been mentioned, during the exploitation of the oil field, even half a century later, small quantities of oil and salt water can filtrate into the soil of the surrounding areas.

Despite the anti-corrosive (cathode) protection, the steel pipelines may be perforated over time. The fluids can escape through the records and the damaged soldering seams. Landslides, as well as unauthorized excavations on the track of the pipelines can crush the pipes so that the fluid content gets into the environs.

4.3. The refineries and the deposits

In these industrial objects, the soil is protected against the filtering of the oil products by thick concrete floor and by high earth and concrete walls. High level of fire safety and counter-terrorist measures assure their protection. However, unexpected natural events (typhoons, earth quarks, tsunamis) and technical accidents may occur followed by serious environmental consequences. For example, in 1978, in a high-pressure cracking unit of the Piteşti refinery (Romania), due to an inadequate pressure control an all-destroying explosion occurred. Hundreds of workers lost their lives and the environment was highly polluted.

4.4. Fuel pipelines, truck tanks and deposits

Apart from the risks presented for crude oil (and gas) pipelines (chapter 4.2.), the fuel pipelines are presumed pollution sources, not because of the natural or technical damages, but because of the fuel stealers. In despite of active, air borne and land patrols, in despite of sensible pressure and debit measurements, they dug long subsurface galleries and “milk” hundred tones of fuel from the pipeline, without problems of environmental pollution.

During the transport of the fuel and other oil-based chemicals, pollution may occur at the charging and discharging stations of the tank trucks and wagons, as well as in case of route and railway accidents.

Finally, some gasoline stations and other consumers release more or less hydrocarbons to the environment. For example, large areas of the former Soviet air bases show high level of kerosene pollution.

The detailed physical and chemical processes within polluted soil particles and in their pore space will be presented in the next papers of this volume.

Conclusions

In order to recognize the origin and the nature of oil pollution, we presented the genesis, the evolution and the geological condition of oil (and gas) accumulations. We described the mother rocks, the reservoir rocks and the hydrocarbon-bearing stratigraphic and structural traps, the diagenesis of the organic matter, the migration of hydrocarbons within the mother rock and out of them through porous or fractured rocks till they accumulate in productive structures.

The geologic research and the technical means to find an oil field and to start its exploitation are described, too. The well drilling techniques and tools, the phase of the exploitation of oil fields and the way of the crude oil from the well to the fuel consumers are shown, pointing out the “hot-spots” of oil pollution along this way. The risk factors of the oil pollution of the soil level involve natural (geological), technical and antropogene, accidental ones.

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