

Ion Popescu-Voitești: the Romanian petroleum geology after ‘*belle époque*’

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Abstract. During the WWI the oil needs of the Romanian army became essential in the context of the retreats towards Eastern Romania, in Moldova. Geologist Ion Popescu-Voitești was asked to find solutions to increase the oil production and he proposed to deepen the wells of certain oilfields such as Solonț - Stănești or Zemeș, with excellent results. Based on this precedent, for a quarter of a century, the geological scientist turned professor at the University of Cluj, remained concerned with the issue of hydrocarbon fields in Romania. The results of that work were included in a series of publications, the last book published just one year before his sudden death being a synthesis on this topic. This paper exposes the main ideas which can be find in the publications issued between 1916 and 1943, which explain Voitești's proposed approaches to the professional challenges of the oil and gas fields in Romania.

Key-words: Ion Popescu-Voitești, petroleum, natural gas, genesis, accumulation, extraction, Romania.

Motto

‘Geologists, these detectives of the Earth's crust...’

Victor Stanciu

Introduction

The issues related to the genesis, migration paths, ways of accumulating oil and gas, as well as the prospecting, exploration and production of the sedimentary deposits hosting these resources have been and continue to be of peculiar interest because of the weight these resources have acquired in the energy balance of the needs of today's societies. For all the stubborn, principally justified insistence on 'decarbonization' as the goal of anti-pollution measures, giving up oil and gas seems

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to remain more of a wish than a reality, at least in the short term. Dependence on oil and gas will undoubtedly continue for at least the next two decades, and politically generated turbulence ending in armed conflict will only add more bricks to the wall of such dependence.

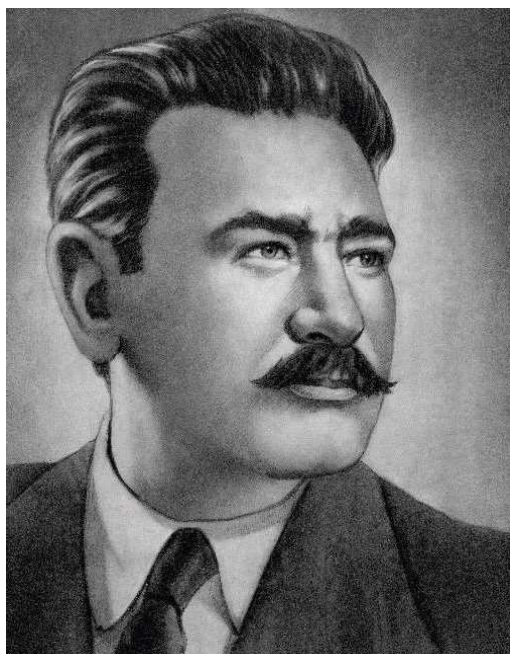


Fig. 1 – Professor dr. geologist Ion Popescu-Voitești (November 18, 1876 Voiteștii din Deal – October 4, 1944 Voiteștii din Deal).

In the context of such a state of affairs it is beneficial to look back to the beginnings of geological research for oil and gas, and in such a context the personality of geologist Professor Ion Popescu-Voitești (Fig. 1) stands out for the substance of his published contributions on these topics. Obviously, his contributions on oil and natural gas in Romania must be understood in the context of the level of knowledge of the times in which he lived.

A number of papers published by this geologist are extremely difficult to access, being untraceable in the vast majority of Romanian reference libraries, in universities or other institutions. In addition, as Popescu et al. (2018) pointed out Romania *‘is the only country with geological information still classified’* when the works refer to resources such as oil and gas. Since the publication of the

mentioned paper the situation has not changed, a secrecy weighs heavily on geological data, patronized by the governmental structure mentioned in the paper, NAMR (National Agency for Mineral Resources, in Romanian ANRM). Relevant unpublished data are still ‘captive’ inside files unavailable for open access, even long time after these reports were wrote. Such a philosophy even obstructs memoirist writings based on data more than a century old.

Fortunately, for Voitești's work we have available up to 1927, a memoir of titles and works written by the author himself (Popescu-Voitești 1928; Fig. 2), followed in 1937 by a more complete one (Popescu-Voitești, 1936; it worth to note that in this last one Voitești was



Fig. 2 – Title page of the memoir of titles of works issued in 1928 (Central University Library Cluj).



Fig. 3 - Title page of the memoir of titles of works issued in 1936 (Central University Library Iași).

wrong about the year, ending the list with the date ‘2.V.1926’, on page 32; Fig. 3). These memoirs have not been reported in many of the works that have issued concerning the work of this geologist (e.g., Ilie 1957, Mocioi & Huică, 2017 etc.). Where I did not have access to certain works (marked in the references by *non vidi*), I will refer to their contents starting from those summarized by the author himself.

I am no doubt aware that the following lines do nothing more than concentrate and summarize a scientific work which, in order to be understood, needs to be fully explored by the geologists and students directly interested in. Not in vain did Maxim (1944) rightly point out that: ‘/.../ “summaries” and “reviews” of works are less than torsos, they are simply cheap “surrogates” ‘ (p. 175). Having such a landmark in mind, we realize that this writing should not be understood otherwise than as an encouragement to study the Voitești’s scientific work concerning oil and all the issues related to the subject in

question, in all the richness of the details he formulated and left as a legacy of knowledge in Romanian geology.

I have not formulated in this writing anything about Voitești’ soul. I have no competence in this chapter as long as we were not contemporaries, so we had no way to meet and exchange ideas, opinions. On the other hand, he was extremely well characterized by people of his time such as Victor Stanciu (1936), Ioan Alexandru Maxim (1944, 1945) or Mircea Ilie (1957). We find other mentions in the many writings of the geologist Ilie Huică, all mentioned in his last book (Mocioi & Huică 2017 and references therein). Without claiming to be exhaustive, summarizing what others have written, I am able to appreciate that the Oltenian geologist born at the foot of the Carpathians was above all an authentic altruist, always willing to help anyone in need. He was an upright character who did not break under the miseries of others directed at him, he was a man without grudge, passionate to the extreme about his profession. At the same time, he was an example of appreciation for his wife Elena Popescu-Voitești (which he calls Luna), whom he loved until his last breath, which he took in the field near the Luna villa (so called as a sign of the love he bore her) in Voiteștii din Deal, on October 4, 1944, at the age of 68.

Voitești's legacy is also reflected in those he supported. It was not in vain that in January 1932 Emil Severin thanked him for setting up the chapter on geology in the monographic volume on petroleum (Severin 1931; Fig. 4): ‘*To my distinguished*

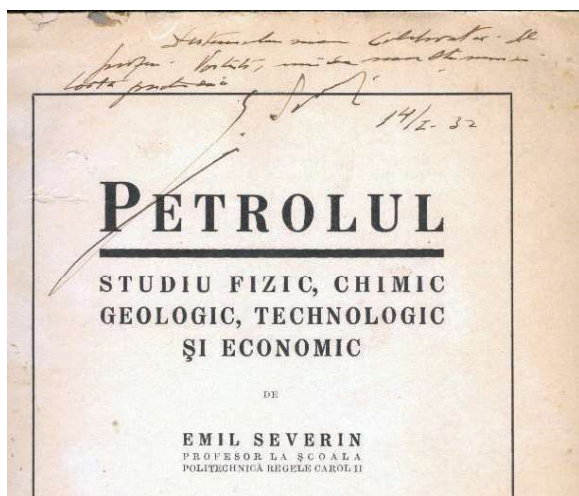


Fig. 4 - Title page of Emil Severin's book on petroleum with his dedication to Ion Popescu-Voitești dated February 14, 1932 (VAC personal library).

collaborator Mr. Professor Voitești many thanks and all friendship'. On the other hand, he trained geologists whose careers were decisive for the knowledge of oilfields and gas pools in Romania, such as his former student Augustin Vancea, which was later corresponding member of the Romanian Academy (Codrea & Popescu 2017).

Voitești and the Romanian petroleum

If we are to judge the evolution of the professional topics of the geologist with roots from Gorj County, we can without much doubt

consider that his interest concerning petroleum geology was not among the earliest in his career. In the early stages, he was rather concerned with paleontology - his first work was devoted to nummulites (Popescu-Voitești 1908a) - and regional geology. The work that brought him a well-deserved Hillel prize from the University of Bucharest in 1905, whose financial part (one thousand lei) provided him with training periods in Vienna and Paris is the one entitled *Geological study of the Argeș Valley, starting a little below Boteni to a little above Nămăești*, which was the nucleus of the one published subsequently under a different title and with reference to a wider territory (Popescu-Voitești 1908b), is a typical work of regional geology concerning an area located not very far from the school where he taught as a high school teacher in Câmpulung Muscel, between 1904 and 1909.

The published work is composed of a very brief introduction, a chapter on the history of geological knowledge (thoroughly documented) for the studied area, a section on stratigraphy (the sedimentary succession in the area starting from late Jurassic, in Tithonian, ending in Quaternary and 'Alluvium'), and then a chapter on tectonics. What is of interest for this approach, however, is the final section of the work devoted to geological resources (mineral waters, natural gas seeping, lignite and useful rock quarries). The author mentions methane gas seeping at Albești (the mouth of the Șchiopului stream) and Suslănești (Vică Luca's garden, which he says sometimes '*spontaneously ignite, scorching the vegetation*'), the origin of which he links to the considerable amount of organic matter in the Oligocene clay shales. This explanation is of considerable value if we are to judge that we were not very far in time from the issue of Cobălcescu's (1887) paper in which the inorganic (volcanic) origin of hydrocarbons was supported, and that adherents of this theory still persisted in the second decade of the last century (e.g., Murgoci 1928). It is worth noting, however, that in the discussion of the paper presented at the meeting of February 5,

1921 by I. Tănăsescu (Tănăsescu 1926), Murgoci stressed that ‘/.../ both hypotheses of the origin of oil must be pursued: organic and mineral’ (Murgoci, in Tănăsescu, p. 16).

In any case, Voitești's interest for the economic potential of certain useful mineral resources is worthy to be noted (Codrea & Fărcaș, 2023). What is worth pointing out is that until relatively recently, at the University of Cluj in Transylvania which trains geologists, such a structure that includes a distinct section of useful mineral resources was recommended for the preparation of the license thesis and it would not be excluded that it is in fact part of Voitești's legacy.

Consequently, his involvement in petroleum geology was, we believe, dictated rather by practical needs arising during Romania's involvement in the WWI and the immediately subsequent events among which it is worth mentioning the annihilation of Béla Kun's communist revolution in Hungary (Kirițescu 1922) which has been too little remembered in recent decades and which *de facto* prolonged the war for our country. During the phase of the war in which the Romanian army was forced to retreat to Moldova, the rest of the territory having been lost, the oil needed to support military operations had to be found first of all and then put to use. Consequently, the officer Voitești highlighted the potential of the Zemeș – Solonț - Stănești (Fig. 5) and Moinești oilfields, as well as some solutions offered by the geologist are noteworthy, such as the suggestion to deepen some of the oil wells

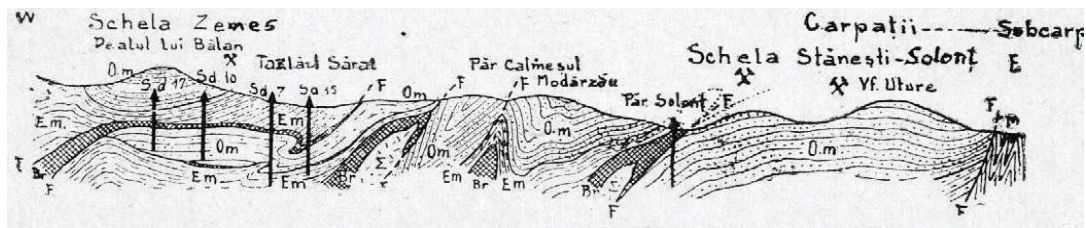


Fig. 5 – Cross section in Solonț-Stănești and Zemeș oilfields, East Carpathians (Popescu-Voitești, 1943).

already in operation, which increased production in a consistent way (Ilie 1957, Huică 1980, Mocioi & Huică 2017).

With the outbreak of the First World War, the European ‘*belle époque*’ came to an end, but new economic challenges following the armed conflict ignited Voitești's interest in petroleum geology.

The first issues focused exclusively on the oil can be considered those published in Annals of Mines in Romania (Popescu-Voitești 1918 a, b, c, d), a publication that unfortunately is difficult to access today, as many of its issues are missing from the collections of the major libraries in our country. For this reason, the works mentioned have remained relatively little known to professionals and consequently, little cited.

As summarized in the memoirs of works (Popescu-Voitești 1928, 1836), in the first contribution (Popescu-Voitești 1918a), *Some personal views on oil deposits are included here* (p. 16), for the second one (Popescu-Voitești 1918b) he does not formulate any specifications, for the third (Popescu-Voitești 1918c) he points out that

‘For the first time a study and a map of this region is given, based on data controlled in the field and by surveys, a study with which I was commissioned in Moldova in the last period of the war (1917-1918), for the needs of the army’ (p. 16), while in the fourth (Popescu-Voitești 1918d) *‘The new method of oil exploitation through mine galleries, introduced by the Germans at Pechelbronn during the war, is described for the first time in Romanian’* (p. 17). So, the experience dictated by practical war constraints, ended with the beginning of his interest towards the geology of the oilfields. The geologist resumes the last of the above-mentioned works concerning the method of oil extraction through mine galleries at Pechelbronn, in Alsace (Popescu-Voitești 1920a), which is also found in our country at Sărata Monteoru (Stoleru 2020). The method is effective when the viscosity of the oil is high and the flow to the borehole becomes slow and inefficient, bringing unprofitable quantities to surface. Much of that oil, however, remains trapped inside the rock voids.

Subsequently, he published a paper on *Romania's natural energies* (Popescu-Voitești 1920b). It is undoubtedly the result of post-war concerns, including the prioritization of channeling Romanian energies in order to restore industrial and economic potential. Visible in those days, however, *‘/.../ although special study circles were formed and commissions and sub-commissions were appointed to investigate all the problems connected with the rebuilding and reorganization of our industrial and commercial machinery, which were also influenced by the sterility of internal political turmoil, which seems to be stubbornly perpetuating situations that are not conducive to a thorough internal organization, the solution of these imperious problems seems to be still a long way off.’* (p. 82). The text highlights the exemplary patriotism and innate good sense of the scholar in the face of the challenges of the times. It also offers solutions to these challenges: *‘For the rebuilding and reorganization of our national economy, apart from money, which we will have in sufficient quantities, if we know how to use it wisely, and skilled men, which we do not lack, if we know how to use them, applying each of them only where their work will give the maximum yield; we need in the first line to create a modern industry of our own, which will sufficiently satisfy, for the time being at least, the current requirements of our country.’* (p. 82). An optimism bitterly contradicted decades after writing these lines...

The author emphasizes the organic origin of hydrocarbons in oil (*‘/.../petroleum came into being through a special transformation of animal and vegetable organic matter/.../’*; p. 88), but also the paths of migration that control the accumulations that he retained at the structural-tectonic level (*‘/.../the power of migration of this liquid, on the borders of fractures of the crust; thanks to which migration and under the impetus of the powers that have wrinkled and broken the strata. The oil has accumulated in large quantities in the porous rocks of the anticlinal vaults, forming the rich exploitable reservoirs of today.’*; p. 89) and whose role is also emphasized in terms of technical facilities in exploitation, particularly in the eruptive stage of a reservoir which is then continued by piston and pumping, underlining the need for appropriate positioning of well locations. It also highlights the undesirability of deliberately wells’ damaging including surface gears during the

war as intentional sabotage to slow the advance of enemy troops. Voitești anticipates the need to return to pre-war production performance, and even surpass the old production performance, given the needs of the country's increased territory.

A link is presumed between methane gas pools in Transylvania and some presumed oil accumulations, based on surface occurrences of crude oil such as those at Ocna Sibiului, Odorheiu Secuiesc, Cetea near Teiuș, Țaga, Someș-Odorhei etc. However, such connection could not be subsequently proven and those occurrences have other local explanations. At that stage, the role of geothermal gradients in the genesis and migration of oil was not yet understood. However, the bitumen occurrences in Bihor at Derna-Tătăruș correctly interpreted as altered oil are mentioned, and these were some of the clues on which the subsequent geological prospecting that identified and highlighted the oil on the western margin of the Pannonian basin were based.

The loss of reservoir energy as the gas associated with the crude oil dries up is reiterated, as is the possibility of enhanced recovery if underground mining galleries are used. Of course, such a method is only suitable for some of the oilfields, such as some in the Sub-Carpathians, and the reality has shown that this process has never been widely used in our country. With the exception of the crude oil mine at Sărata Monteoru dug by the *Steaua Română* Company (now, rather a mine-museum), a second one did not work in the Romanian area, and the *Drainage* company's similar attempt at Câmpina failed by flooding the mining dig (Stoleru 2020). On the contrary, for such viscous oil from Suplacu de Barcău in Bihor County, the *in-situ* combustion process was used, with satisfactory results (Paraschiv, 1975) between 1964 and present (Turta, 2021).

Finally, starting from the geological age of the salt massifs and their diapir tectonics, it is assumed the existence of rock deposits located at greater depths, with oil of older geological ages, a fact confirmed in the current geological knowledge of the territory of Romania (Paraschiv 1975). Here we see the mental model on which Voitești was based for increasing the production, as already underlined, a requirement of wartime needs.

Concerning the natural gas, he points to the special nature of the methane gas pools in Transylvania, but considers that they originated from deeper accumulations of crude oil. Later, based on this idea, a series of boreholes were drilled in the Transylvanian basin, but they did not confirm this presumed geological pattern. The methane gas accumulations are not related to the presence of deeper located crude oil, but are result of a process that is only at an early stage of maturation of the organic matter, a consequence of the meager heat flow values and related geothermal gradients specific for this structural unit of Romania. The economic value and the purposes of economic extraction in Transylvania (Turda, Sân-Martin) are underlined. Voitești glimpses the value of using natural gas from the Sub-Carpathians for various economic purposes and stresses how important it would be to separate the associated gasoline.

A year later (Popescu-Voitești 1921a) the relationship between the oil fields and salt diapirs is discussed (Codrea & Fărcaș, 2023). In fact, the paper in question

was intended as a reply to earlier observations by French geologists (Bertrand and Joleaud) on this subject. Voitești stresses his personal priority in interpreting the tectonic breccias that accompany salt masses. The assumption is clearly formulated that the age of the salt is old, being ‘/.../ *en dessous de toutes les formations du géosynclinal du Flysch /.../*’ (p. 48). The salt masses are thought to lie entirely in tectonic settings, which impedes to establish the geological age of the salt. According to the author's assessment, the determination of the age of the salt is of purely scientific interest, but it becomes important because of the interrelationships between the tectonic dislocations along which the salt moves to the surface and the associated accumulations of petroleum deposits, a fact already pointed out at that time by Mrazec (1910). The contribution issued in the French bulletin concludes by highlighting the unknowns: neither the age, nor the origin of the Romanian petroleum is exactly clear, and the salt is considered to come from very great depths, but without being able to say to what extent the two resources come from the same mother rock. What the author does say, however, refers to the fracture lines produced by the salt in its diapiric ascent to the surface, which are nothing more than migration paths of the petroleum from great depths to the surface.

In the extensive work on the geology of Romania (Popescu-Voitești 1921b) a separate section is devoted to the Romanian petroleum in which the knowledge already formulated is summarized. Part of this data is also presented in the editions of the didactic book on general geology (Popescu-Voitești 1921c, 1924c), each of which has a separate section on useful mineral resources.

At the International Geological Congress in Brussels, these ideas are taken up again (Popescu-Voitești 1922). The relationship between the amount of petroleum and the width of the salt fault layer is highlighted even more clearly, but this time the question of the origin of the salt and its geological age is no longer regarded as being only of theoretical importance, but also of practical one in the context of its association with petroleum. Insisting on the deep origins of both salt and crude oil, Voitești reiterates the need to go deeper than the ‘Mediterranean’ strata for wells in production in the Carpathians and Sub-Carpathians, as a solution to rise production, suggesting examples such as the Buștenari oilfield, or the one located further north, at Cosmina.

The age of the diapiric salt and by implication the associated petroleum and gas accumulations is given as being between the Late Pliocene and Early Quaternary (p. 1405). At the same time, the author highlights the importance of the folded structures such as domes and anticlines, as well as those derived from faults such as those in overlapping scales, the overlaps exceeding one kilometer horizontally at Moinești, Zemeș or Bacău. Starting from such a tectonic structure, the petroleum soaks are different, depending on their location on one flank of the structure or the opposite one, the more productive being the reversed flank. Traps of this type have been protected from degradation by their cover by impermeable rocks or salty aquifers, which have washed away the associated salt masses.

The pressures of crude oil in the reservoir are explained by the action of associated natural gas and salt water, but where degradation has occurred it alters the

flow qualities of the petroleum to the borehole. Finally, the Matia, Brusturi and Derna asphalt fields are given as examples of advanced degradation, and the Slanic-Moldova and Boryslaw fields are given as examples of paraffin formation. The paper concludes on an optimistic note, regarding the prospects in the Transylvanian and Pannonian (eastern margin) depressions, which the following decades have confirmed.

The article issued in London (Popescu-Voitești 1923) refers to ‘(...) *the scientific results of our studies on the presentation and genesis of oil and salt in the Romanian Carpathian regions, constituting the subject of the communication done on the occasion of this Congress in London, where to the study of the Carpathian oil was reserved a special chapter, for which I was also specially invited by the organizer of the Congress, the geologist Cunningham Craic.*’ (Popescu-Voitești 1928, 1937).

Same principles can be found in a lithographed course (Popescu-Voitești 1924a), never published in large print (Fig. 6). He taught this course to Timișoara polytechnic students for four years, from 1923 to 1926 (Popescu-Voitești 1928, 1937). But, the identical content of the course is repeated in an article (Popescu-Voitești 1925) issued in the first volume of the journal of the geological-mineralogical museum of the University of Cluj.

After a preamble on natural energies, in the section on the origin of petroleum Voitești points out the dichotomy between the conceptions of different chemists and geologists, namely inorganic vs. organic origin. In this context he mentioned Gheorghe Munteanu-Murgoci who was, as is well known, a proponent of the theory of inorganic origin, based more specifically on the scenario of the influence of volcanic processes (*‘volcanic theory’*). Murgoci was among the firsts to underline the influence on the heat flow in the hydrocarbon genesis.

Voitești stresses the importance of the oil migration processes that occur between the rocks in which it was generated and the so-called secondary deposits, and furthermore, he states that

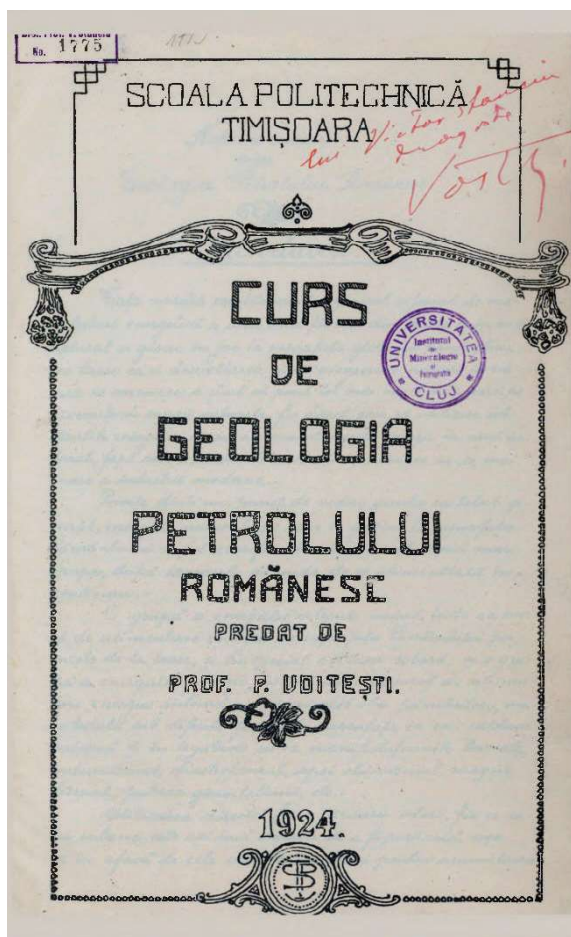


Fig. 6 - Title page of the course taught by Popescu-Voitești in 1924 at the Polytechnic of Timișoara (Central University Library Cluj).

'.../ I personally do not know of any oil deposits that would leave any doubt that they would be found in "secondary" deposits' (p. 7). The laboratory experiments on which the arguments of inorganic origin based on chemical reactions are based are devoid of the influence of one of the essential controlling factors of hydrocarbon formation, the geological time, so that *'.../ chemical laboratories cannot work under anywhere near the conditions under which phenomena can occur in nature'* (p. 8). A good opportunity to reiterate the widespread occurrence of petroleum or similar hydrocarbons in all geological formations, in all types of rock, both sedimentary and volcanic. Voitești dismantles the inorganic theories in an argumentative way, taking a radically different position from Murgoci, who was on the other side of the argument, conceptually speaking.

Summarizing, he concludes that petroleum occurs in secondary deposits in porous-permeable rocks with geological ages from the Early Cretaceous to the Quaternary in the *'geosyncline of the Carpathians and Subcarpathians'*, mentioning rock deposits both in Romania and abroad; rocks with reservoir features become petroliferous only *'.../ along more or less completely fractured anticlinal dislocation lines and along large flakes /.../ and the richer the reservoir, the more these fractures have been widened by salt masses'* (p. 11-12); in his opinion, nowhere in the Carpathians and Sub-Carpathians there are any Cretaceous-Cenozoic rocks that can be considered source rocks, the entire quantity of oil coming from greater depths, under the influence of geotectonic pressures, following the path open by the large fractures. This synthesis of ideas is important because it summarizes the fundamental concepts of this geologist at that stage of his professional life. And not only those about petroleum, but also his estimation of the geological age of the Romanian salt, which he considered to be pre-Cenozoic. The exclusively deep source of the petroleum, where the mother-rocks are located, as well as the structural values of the traps are the result of field experiences during the war, when the deepening of the boreholes on the structures already mentioned gave results. By disputing the reservoir rock capacities of the rocks of the Eastern Carpathian flysch, but also of the Cenozoic rocks of the areas mentioned, he was in opposition to a number of geologists from abroad, but also to Mrazec (1907a, b, 1910), whose conceptions were opposed, he admitting the quality of parental rocks for those having the mentioned geological ages.

In terms of source rocks for hydrocarbons, at the beginning of the third decade of the last century he agrees that various sapropelites, cinnamon-coal, torbanite and bituminous shales, but subject to incipient regional metamorphism related to geosyncline dips, fall into this category. It is important to reiterate here that these conceptual patterns for crude oil formation and accumulation were not strictly mental exercises, but were reflected in the prospecting and exploration strategies for hydrocarbons, implicitly in their costs.

Various hydrocarbon deposits are then presented, with case studies from the Romanian Carpathian regions. In this chapter, Romania has been and remained a generous territory in oilfields and gas pools, part of the country's structural units remaining relevant also in summaries at European or world level (e.g., Perrodon

1985). This paper, which has a didactic purpose, starts from the definition of a reservoir, for which the *sine pro quo* conditions are the interbedding of porous-permeable and impermeable rocks over a wide area and enough significant depths, the existence of reservoir rocks (the porous-permeable rocks are considered to be dominant, with limestone being given strictly secondary importance), and profitable quantities of hydrocarbons. He divided the host rocks into two main categories, primary and secondary ones. In the first category he included reservoirs where petroleum is accumulated in rocks belonging to complexes that also include the parental rocks, such as those mentioned by Mrazec (in the profile course taught to students of polytechnics in Bucharest) at Colibași-Reșca (Dâmbovița County), Tescani and Pârjol-Câmpeni (Bacău County), which Voitești considers secondary, not primary. In the second category, in which the petroleum is allochthonous, migrated from elsewhere, he included all the Romanian deposits then in production.

The course further presents a classification of the deposits according to the tectonic structures occurring in various areas of the Carpathians and the Carpathian foredeep, accompanied by drawings of some illustrative geological sections. Regarding the geology of the oil-bearing areas, he classified them into: the Carpathian regions proper (in which he emphasizes the term he himself introduced, that of '*Dacide Chains*', which would subsequently become Dacides in the geotectonic of Săndulescu, 1980) and regions outside the Carpathian areas ('*Podolico-Russian Platform*', '*Variscan-Kimmerian Chain of Northern Dobrogea*' and '*Prebalkan Platform*', in the structural meanings of the time). Visibly, it was a good opportunity to highlight the structural models he designed himself and published in the first post-war extensive geology of the whole Romania.

In his view, the oil-bearing zones fall into two categories: i. those of the Cretaceous-Paleogene Carpathians and ii. those of the Mio-Pliocene Sub-Carpathians. For each of these, illustrative reservoirs, or simply petroleum seepages occurring during drilling works or just in natural occurrences, are specified. It is worth noting the particular professional intuition of the author, who for the western portion of the Getic Depression specified two alignments of interest for petroleum, with related potential deposits. After his passage into eternity, the area in question fully confirmed this potential, with structural traps hidden by the horizontality of the upper Cenozoic overlying the older folded series. In Transylvania, he recalled the petroleum seepages in the Ocna Sibiului salt breccia, in the Eocene sandstones of Rodna or those in the uppermost Cretaceous-Paleocene deposits, in the basal section of the Jibou Formation outcropping north of Jibou, and west of the Apuseni the asphalt occurrences at Derna and Brusturi (Bihor County).

The presumed strictly tectonic relationships between salt and oil occurrences, based on field data, were published in the same year that the lithographed course issued (Popescu-Voitești 1924b). It also includes a map with the areal distribution of salt masses, but also of salt springs, which can sometimes be hints of the presence of nearby petroleum. He insisted on the ancient age of the salt, '*.../older than at least the formations of the Mesozoic-Tertiary Flysch, from which it emerges.*' (p. 16). The source of the petroleum is once again considered to be a deep one.

Later (Popescu-Voitești 1930) he agrees that the source rock of petroleum can be any rock located in a sedimentary basin (*'depression or geosyncline'*), bearing finely disseminated organic matter in its mass and at temperatures and pressures high enough to trigger the *'beginning of distillation'* of that substance. In tectonically undisturbed geosynclines, hydrocarbons would retain their location into the primary reservoir, assuming that the role of tectonic movements is to trigger the migration of petroleum to secondary reservoirs, and not to favor its generation. There is therefore an author's paradigm shift in terms of the hierarchy of the determinants of the different factors controlling the petroleum genesis.

He argued that petroleum is autochthonous to the vast majority of formations in which its specific manifestations occur. The presence of finely dispersed organic matter in the rocks is considered to be decisive - without, however, discussing the nature and origins of this organic matter, an element which later proved to be essential in the genesis of oil, and generally pointing out that *'marine vegetation'* are in question - to which he adds that the influence of pressure and related temperature are essential, but warns of the existence of an upper threshold beyond which hydrocarbon destruction occurs. It is estimated on this occasion that 80% of the World's petroleum comes from deposits accumulated in domes and anticlines formed under diapiric influences.

In the Polish-Romanian bilingual publication (Popescu-Voitești 1935a), the discussion on the nature of organic matter becomes more refined, the idea of the dominance of algal material in the formation of petroleum being maintained. Details also appear when the petrography of parent and petroleum-bearing rocks is discussed. The issues of migration and reservoir emplacement remain on the familiar note of previous works. Even the case studies of some deposits considered illustrative (Săcel, Bircii in Gorj, Jibou in Sălaj, Derna, Brusturi in Bihor) remain the same as those discussed in previous works. In any case, the article was a good opportunity to contradict George Macovei on a number of issues related to the genesis of oil, on which we do not dwell.

He has kept until the last breath, his Oltenian-born soul. He also briefly mentioned the petroleum and gas seepages in his native county (Popescu-Voitești 1935b) in his work on the structure and evolution of Gorj County. About this paper he mentioned (Popescu-Voitești, 1937): *'Apart the eng. M.M. Drăghiceanu's work, of 40-50 years ago, on the geology of the Mehedinți County, it is the first scientific work of this kind which looks at the totality of the and in the understanding of all the geological and morphological evolution of a county, including all the new geological data'* (p. 31).

There are mentioned: traces of paraffin, of *'heavy black oil'* (*'rifle grease'*) and methane-rich gas predominantly in the Cărbunarea Valley, at Bircii, in the *'Tortonian'*, underlining the capacity of parent rocks of this geological age; light petroleum and methane gas in the Sarmatian deposits at Măghirești, on Blahnița, or those at Săcel-Sat; the salty, iodine-rich gas and water (Glodeni - Voitești - Bălănești, Zorlești - Sârbești) and traces of petroleum (Glodeni) confined in Meotian deposits,

while proving Munteanu-Murgoci's opinion that the petroleum from Bâlteni is also Meotian.

Voitești (1939), already at an advanced stage of his professional career, summarizes a series of conclusions concerning the genesis of petroleum in our country and the economic purposes of extraction. He takes up the origin of fatty organic substances, giving priority to organic materials of algal origin (which he considers decisive in relation to those of animal origin) subject to anaerobic fermentation, to which he adds the influences linked in particular to the pressure associated with local and regional contexts. He highlighted areas where such results were to be expected, such as the Sub-Carpathians (note the mix of geomorphological and geological-structural units) and Cretaceous-Paleogene flysch deposits, to which he added the Transylvanian basin for natural gas, stressing once again the oil-methane gas relationship in this sedimentary basin, although no evidence was provided in this direction. He rightly stresses the importance of tectonic pressures in the genesis of hydrocarbons.

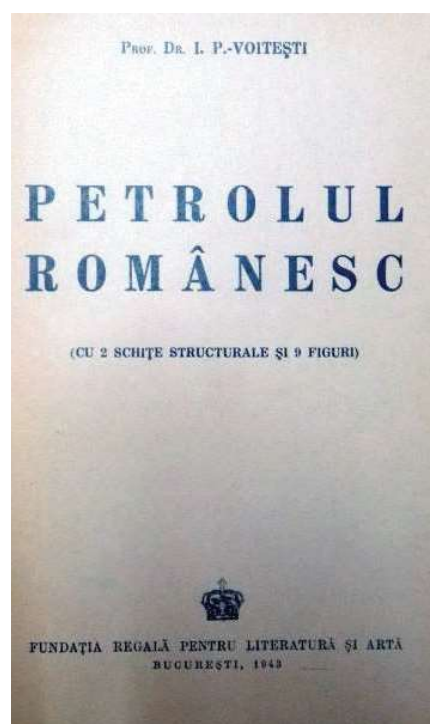


Fig. 7 – Title page of the volume *The Romanian Petroleum*, issued in 1943 (VAC personal library).

The author concludes by pointing out that until the date of publication of the article a number of formations had not been investigated for oil and gas (Pliocene from Oltenia, Eocene, Oligocene and Miocene of the Carpathian and Sub-Carpathian regions, although numerous petroleum hints were recorded in these regions and where there had been extractions based on hand-dug wells). Voitești concludes by expressing his conviction that these deposits ‘*...are sufficiently rich in oil for our industrial oil future to be assured.*’ (p. 91).

Geologist Voitești's life was not a very long one, passing away at only sixty-eight years old. Nor was his professional life any different: he was retired as soon as he reached retirement age at the University of Bucharest, which certainly added a touch of bitterness and hastened, perhaps, the early end of the scientist who would have been able to leave to posterity other writings and thoughts. As if sensing the approaching end, just a year earlier he published a book (Fig. 7) aimed both at those in the profession and at anyone who wanted to know more about *The Romanian Petroleum* (Popescu-Voitești 1943). Nothing but a synthesis of more than two decades of experience gained through field work, library studies and exchanges of ideas with a number of fellow geologists from home and abroad.

Undoubtedly, being a synthetic writing on petroleum, some of the data and formulations are repetitive, taken from other works, but also with additions related

to the progress made in petroleum geology. The book begins with an introductory chapter on natural energy resources in general, highlighting the importance of petroleum in the World's energy balance, which at the time was growing significantly both because of industrial requirements and the expanding use of internal combustion engines, such as cars. Added to this were military needs, with WWII already having broken out by the time the book issued.

The following one is dedicated to the constituent components and classification (with Romanian examples) of petroleum. Relatively extensive details can be found in the chapter devoted to bitumen, where bituminous shales of different geological ages are mentioned - especially those from Anina -, natural gas with examples from the Transylvanian basin, asphalt as a product of degradation of petroleum accumulations - exemplified by the occurrences of Matîța and Derna-Tătăruș, or the asphaltite from Judea -, paraffin such as that from the Cerăria Valley at Slănic Moldova. Scenarios are formulated for the origin of natural bitumen and different categories of crude oil, with emphasis on the '*sapropelites*', those mother-rocks for hydrocarbons, and particularly on the genesis based on organic substance, mainly algal. The genesis of parent rocks is associated with bituminous depositional facies, the occurrence of which is explained strictly tectonically, with specification of the geological ages relevant to such processes: Late Barremian, Aptian, Late Mesozoic (where it is worth noting the vicious mention of '*Dacian*' instead of Danian), Late Eocene and Early Oligocene, Late Oligocene (he argued that the Transylvanian salt was Lower Miocene), Mio-Pliocene and Pliocene/Quaternary boundary.

In terms of reservoirs, he considers dominant those involved in folded (anticlines, domes) or faulted tectonic structures, emphasizing the role of temperature and pressure. For areas such as Jibou, Derna-Tătăruș, the major role of subsurface pressure distributions is emphasized, omitting the existence of faults and fractures such as the faults that can be assumed at Jibou, which outline the horst of the north-eastern termination of the Meseș Mountains, or the large fractures that outline the eastern margin of the Pannonian basin. However, it is interesting to note that the exclusive presence of methane gas in Transylvania is due to '*too little tectonic stress*' (p. 29) and not to heat flow leading to thermal gradients unfavorable to an advanced maturation of organic matter generating petroleum, in other words a 'cold' sedimentary basin vs. a 'warm' one such as the Pannonian. It is clear that his training as a specialist in tectonics led him to seek explanations of this kind.

The truly original part of the book concerns the Romanian oilfields, a suitable opportunity for the author to review the structures of the country territory, as presented in the books and articles already published (*e.g.*, Popescu-Voitești 1921b, c, 1924c), with some names of the structural units already coined by himself. The data of interest for our country continues in the chapter devoted to the Romanian oil deposits, where the various manifestations of hydrocarbons are also recorded. It is worth noting the obvious inequality of knowledge at that time of the Romanian oilfields and gas pools. The overwhelming majority of the descriptions concern the Eastern Carpathians with the related depressions, as well as especially the Sub-

Carpathians, thus the area of the Carpathian foreland, with both its internal and external sectors in the current structural meaning (Săndulescu 1985). For the Getic Depression, the data existing at the beginning of the fifth decade of the last century are scarce and refer to some surface seepages, or to timid attempts of investigation by hand wells or the somewhat deeper Bâlteni wells, but at that time irrelevant in terms of the results obtained. The time had not yet come to consecrate the hydrocarbon fields in that area!

For the Transylvanian Depression, the author provides extremely brief data on the oil from Jibou, Turda, the vicinity of Zlatna, Ocna Sibiului, the paraffin from Cricău, as well as the '*bituminous traces*' from Parva and Parva de Ilva Mare on the eastern edge of the depression. Of course, the folded structures (mainly domes and brachy-anticlines) bearing methane gas are mentioned, where one of his disciples, the geologist Augustin Vancea (Codrea & Popescu, 2017), was to make later valuable scientific work (Vancea, 1960) during an entire professional career.

In northern Romania, in Maramureș, the seeping at Săcel - Dragomirești is mentioned, and on the eastern edge of the Pannonian basin the asphalt at Derna - Brusturi or the traces of oil at Oradea. The Pannonian area proved to be productive in the following decades (Paraschiv 1975), and the presence of petroleum there can be explained by the advanced maturation of the organic matter under influences of increased heat flow (Veliciu 1974, 1988).

A detailed analysis of them would exceed the objectives of this writing and would undoubtedly alter the curiosity of the reader eager to know on his own experience the publications of the famous scholar. On the other hand, many additions gained in terms of knowledge after the publication of Voitești's book were fortunately brought together by Paraschiv (1975) in his monographic approach to hydrocarbon deposits. Although almost half a century has passed since the publication of this monograph, it remains the reference publication because no similar other has issued, probably for the reasons explained in the introductory chapter of this work.

What is worth emphasizing is that in this section of the book we do not only find a list of fields where petroleum and gas occur, but also the author's proposals for new potentially productive or interesting areas from a scientific point of view, or plain and simply for increasing production on known structures by deepening the wells (*e.g.*, the Buștenari oilfield).

The book concludes by presenting some economic data: Romania's petroleum production and its prospects, Voitești anticipating higher oil productions in the future, which has otherwise been confirmed, Romania remaining even today a significant player in crude oil and gas production in European Union.

Concluding remarks

Starting for practical reasons at wartime, Voitești's concern with petroleum and gas fields turned into a real passion over the next quarter of century. This was also because the geologist understood the connection between the salt diapirs of the Carpathians and Sub-Carpathians and oilfields. He devoted a large part of his professional life to petroleum: he wrote and taught a university course focused on

this resource and worked hard in the field to understand the logic of hydrocarbon genesis, accumulation and distribution, at a time when the country's oil needs were constantly increasing. At that time, a number of knowledge inputs were unknown (e.g., the changes of organic matter originating from different sources into hydrocarbons or coal, the hydrocarbon traps and trapping scenarios etc.) and techniques such as those related to geophysics were still in their infancy or completely unknown. At the present stage, the petroleum and gas pools are much easier to locate based on the logic of searching for them in the field (geophysics plays an essential role) and their extraction has become more judicious through extraction regimes that allow for larger recoveries in a reservoir.

What should be emphasized is that his knowledge of petroleum fields was based on what this geologist had accumulated during his whole professional career in terms of tectonics, stratigraphy, paleogeography, facies distribution etc. The logic of the approach to hydrocarbon issues in Romania and in general can be summarized in what the author himself has repeatedly formulated. Voitești was an avowed proponent of the organic hypothesis of petroleum genesis from organic matter of algal origin finely dispersed inside the hydrocarbon source rocks (petroleum mother-rocks). This belief was probably influenced by his bright mentor Ludovic Mrazec, who held a similar view. Of course, by the time Voitești's concerns turned to petroleum, the inorganic, volcanic hypothesis had become obsolete. Ideas such as those in Grigore Cobălcescu's reception speech (1887) at the Romanian Academy were already outdated, but they still survived in the mind of some Romanian geologists such as, surprisingly, Murgoci (1926).

The genesis of petroleum and related natural gas has been assumed to have occurred at great depths, from where the hydrocarbons migrated to surface. This belief was probably acquired at a time when his wartime proposal to deepen wells on the Solonț – Stănești - Zemeș oilfield was successful, with the wells in question increasing their production. Of course, those results do not necessarily have to be related to a deep genesis of the oil, but can only be related to local traps. The genesis is associated with '*saline-bituminous concentration facies of marine geological formations*' (p. 26 in Popescu-Voitești 1943). In the genesis of hydrocarbons, he admitted regional and local tectonics as control factors, with direct palaeogeographical determinations, mentioning at the same time a series of geological ages for such processes (Barremian, Aptian, 'Senonian' etc.; once again, we remark he considered the salt in the Transylvanian basin as Early Miocene).

With a tectonic background par excellence, he placed petroleum and natural gas accumulations in a decisive relationship with the folded structures, such as anticline alignments or domes, that he considers their diapiric age to be Pliocene-Quaternary. He underlined that diapiric salt, as well as the existence of the large fractures, were decisive favorable controlling factors in the formation of petroleum and gas reservoirs by facilitating migration processes. He considers grain reservoir rocks (sandstones, sands) to be the dominant ones, accepting also the participation of limestones as reservoir rocks, but only for the ones bearing fissures or dissolution voids in which the fluids in question can accumulate. Such an estimate was based

mainly on the case of oilfields in Romania and neighboring areas, as many of the oilfields in the Middle East had not yet been discovered and developed.

As a good connoisseur of Romanian oilfields Voitești specified the importance of the judicious use of reservoir pressures (*'reservoir tension'*) in the production of reservoirs with the intelligent balance of an extraction regime in which reservoir water and gas from the gas-head accumulations are used rationally. In this context, he also mentioned artificially produced reservoir damages, mainly due to vicious casing and cementing, or accidental eruptions (already extremely rare at that time in the Romanian oilfields). For the remaining petroleum intimately linked to the sedimentary grains which cannot be recovered by free flow in boreholes, he proposed extraction through mining galleries, based on the example of Pechelbronn oil mine. However, this method has never been successfully applied in our country, excepting the case of the Sărata-Monteoru oilfield.

Before being an elite geologist, Voitești was an outstanding Romanian citizen and a patriot, who noticed what was not difficult to notice: *'.../ the known reserves constitute an asset of the State, and not of the exploiting companies, which by buying them from the State, for exploitation, seek to obtain maximum production, in minimum time and with minimum expense.'* (Popescu-Voitești 1943, p. 109). The result is the rapid drying up of the reservoirs and the appearance of real 'cemeteries of wells'.

The geologist was, however, optimistic to the end. He foresaw a future for petroleum and natural gas extraction in Romania, which history has confirmed. The extent to which Romania benefits nowadays from these natural resources is another discussion, with its lights and especially, its shadows.

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Figure captions

Fig. 1 – Professor dr. geologist Ion Popescu-Voitești
(November 18, 1876 Voiteștii din Deal – October 4, 1944 Voiteștii din Deal).

Fig. 2 – Title page of the memoir of titles of works issued in 1928 (Central University Library Cluj).

Fig. 3 - Title page of the memoir of titles of works issued in 1936 (Central University Library Iași).

Fig. 4 - Title page of Emil Severin's book on petroleum with his dedication to Ion Popescu-Voitești dated February 14, 1932 (VAC personal library).

Fig. 5 – Cross section in Solonț-Stănești and Zemeș oilfields, East Carpathians (Popescu-Voitești, 1943).

Fig. 6 - Title page of the course taught by Popescu-Voitești in 1924 at the Polytechnic of Timișoara (Central University Library Cluj).

Fig. 7 – Title page of the volume *The Romanian Petroleum*, issued in 1943 (VAC personal library).