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Radioactive elements detected in crude oil from volcanic areas

Pierwiastki radioaktywne stwierdzone w ropie naftowej z obszarów wulkanicznych

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ABSTRACT: In the geological structures containing crude oil and associated gases and located in areas where volcanic activity has been detected, radioactive substances and minerals are contained both in the structure of the reservoir waters and in the impurities related to the composition of the extracted crude oil. They are present during the extraction of crude oil and associated gases and affect human health and environmental safety. Radioactive elements have been detected in reservoir waters, in impurities associated with crude oil, and especially during the processing of drilling fluids (the separation of detritus sourced from geological strata from the used drilling fluid). Other radioactive elements were also detected in the areas polluted with oil and drilling waste. In order to determine the radioactivity level of crude oil originating from the area of volcanic activity of the Romanian Mountains, crude oil samples were collected from the oil field in a one-year analysis. The collected samples were analysed to determine their physical-chemical structure. The reservoir water associated with these samples and the minerals separated from the crude oil following their solvent extraction were also analysed. Radioactive elements were detected using X-ray spectrometry, and their chemical structures are also discussed.

Key words: oil and gas, radioactive elements, water, sediments.

STRESZCZENIE: W strukturach geologicznych zawierających ropę naftową i towarzyszący jej gaz ziemny oraz zlokalizowanych w obszarach, w których wykryto aktywność wulkaniczną, substancje i minerały radioaktywne zawarte są zarówno w strukturze wód złożowych, jak również w zanieczyszczeniach powiązanych ze składem wydobywanej ropy. Są one obecne podczas wydobycia ropy naftowej i towarzyszącego jej gazu, mając wpływ na zdrowie ludzkie i bezpieczeństwo środowiska. Pierwiastki radioaktywne wykryto nie tylko w wodach złożowych i związanych z nią zanieczyszczeniach, ale przede wszystkim podczas obróbki płuczek wiertniczych, w tym w procesie oddzielania detrytusu pochodzącego z warstw skalnych od zużytej płuczki wiertniczej. Inne pierwiastki radioaktywne wykryto także w obszarach zanieczyszczonych ropą i odpadami wiertniczymi. Dla określenia poziomu radioaktywności ropy naftowej pochodzącej z obszaru aktywności wulkanicznej w górach Rumunii, z jednego ze złóż ropnych w ciągu jednego roku pobrano próbki ropy naftowej do analiz. Pobrane próbki przeanalizowano pod kątem struktury fizykochemicznej. Przebadano także wodę złożową powiązaną z tymi próbkami oraz minerały oddzielone z ropy naftowej po ich ekstrakcji rozpuszczalnikiem. Pierwiastki radioaktywne zidentyfikowano za pomocą spektrometrii rentgenowskiej, omówiono również ich struktury chemiczne.

Słowa kluczowe: ropa i gaz, pierwiastki radioaktywne, woda, osady.

Introduction

The oil and gas industry is affected by radioactive material pollution. The radionuclides 226Ra, 228Ra, 222Rn, 210Pb, 40K were identified in the analyses performed on the reservoir waters associated with the extraction of crude oil, and especially in the sediments extracted together with useful mineral substances (Ajayi et al., 2009; Vincent-Akpu et al., 2018).

The first references to the presence of radioactive elements in the area of oil exploitation (TENORM-technically enhanced naturally occurring radioactive materials) were reported in the first exploitation of oil fields (period 1920–1930), following the reporting by Hempstead and Burton (Attallah et al., 2012; Osmanlioğlu, 2021) of radioactive emissions in some polluted areas with crude oil and drilling fluids located in oil fields in Germany, Russia and the USA.

Concerns regarding the need to protect the work and health of employees who may be exposed to TENORM radiation began in the 1970s when radium was detected in groundwater and drilling fluid muds used in the North Sea (Betti et al., 2004; Petrache et al., 2022).

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After 1985, Kolb and Wojcik were also able to determine the impact of exposure of workers and the affected environment by the pollution with radioactive substances present in the waste from oil wells (Gazineu et al., 2005; Petrache et al., 2022).

The structural analysis of some muds from a drilling in Albania led to the identification of radionuclides 228Ra, 226Ra and 222Rn (Gesell, 1975; Hamlat et al., 2001; Petrache et al., 2022).

The effects of radioactive pollution from oil and gas extractive areas in Romania have affected human health and the environment, and that is precisely why, after 2000, it was necessary to research the environment affected by oil pollution and the effects of radioactive pollutants on environmental factors (water, soil, air) (Petrache et al., 2022).

The effect of radioactive elements on the environment was determined in some oil and gas polluted areas (oil and gas refinery and treatments, etc.) (Heaton and Lambley, 1995; Vincent-Akpu et al., 2018).

In closures of the exploitation of some oil and associated gas fields, which were depolluted to the level required by Romanian legislation (through the removal of petroleum substances to the minimum acceptable threshold, without removing the radioactive minerals) (Petrache et al., 2022).

Variable concentrations of the radioactive elements 226Ra-, 40K-, and 228Ac- have been identified in oil-contaminated areas in Romania. However the detection of radioactive elements in the reservoir water and the detritus associated with the extraction of crude oil is very rarely mentioned in the Romanian specialized literature, the crude oil deposits of Romania being described by I.D. Pârcălăbescu (Petrache et al., 2022).

The International Atomic Energy Agency and the European Community have issued rules for the protection of employees in the oil industry, but without mentioning in these rules the elements of environmental protection following the abandonment of deposits or inadequate depollution (European Commission, 1997; International Atomic Energy Agency, 2003). This has led to the concept of NORM (Natural Occurrence Radioactive Substance) being introduced, defining radioactive substances produced by natural processes (Kolb and Wojcik, 1985; Jonkers et al., 1997; Kadyrzhanov et al., 2005; Kevin et al., 2007).

Oil rock radioactivity

Analyses on cores extracted from oil and gas deposits prove more or less radioactive (Osmanlioğlu, 2021). Their radioactivity depends on the content of uranium (and its products), thorium (and its products) and potassium, which are the three elements present in sufficient quantities to be taken into account (Pasocha, 1997).

Sedimentary radioactive materials originated from the mechanical fragmentation, into very small particles, of heavy radioactive materials contained in the original eruptive masses and from the deposition of radioactive materials from solutions (seas and oceans).

Radium is precipitated from solution by various types of living organisms, while uranium and potassium can be deposited in colloidal form in a reducing environment (Scot, 1998; Strand and Lysebo, 1998). According to the analyses carried out on the cores extracted from some oil and gas fields in Romania, the content of thorium and radium has been determined (Table 1). The analyses were carried out during 5 years of study and on rocks collected in the drilling conducted as part of the campaigns to detect new oil and gas fields, located in eruptive zones (the area of the Carpathian mountains). Each sample was crushed and tested with the instrument at least three times, with a maximum error of determination of 0.5%. The intensity of gamma radiation was also determined by radiochemical neutron activation analysis (RNAA) (Lysebo et al., 1996; Swan et al., 2004) (Table 2). Again, several samples were analysed with a maximum error of 0.4%.

Table 1. The radium and thorium content of several rock types

Tabela 1. Zawartość radu i toru w różnych typach skał

Rock types	Contents in Ra [g Ra/g rocks]	Contents in Th [g Th/g rocks]
Eruptive rocks		
– Granite	$3.20 \cdot 10^{-12} – 4.90 \cdot 10^{-12}$	$1.10 \cdot 10^{-5} – 3.10 \cdot 10^{-5}$
– Syenite	$2.50 \cdot 10^{-12} – 4.70 \cdot 10^{-12}$	$3.10 \cdot 10^{-6} – 3.50 \cdot 10^{-6}$
– Eruptive basaltic rock	$9.10 \cdot 10^{-13} – 1.10 \cdot 10^{-12}$	$5.10 \cdot 10^{-6} – 5.40 \cdot 10^{-6}$
Sedimentary rocks		
– Clays	$9.10 \cdot 10^{-13} – 1.70 \cdot 10^{-13}$	$1.10 \cdot 10^{-5} – 1.40 \cdot 10^{-5}$
– Chalk	$4.10 \cdot 10^{-13} – 4.40 \cdot 10^{-13}$	$1.20 \cdot 10^{-6} – 1.30 \cdot 10^{-6}$
– Oolitic limestone	$2.20 \cdot 10^{-12} – 3.20 \cdot 10^{-12}$	$1.10 \cdot 10^{-6} – 1.40 \cdot 10^{-6}$
Metamorphic rocks		
– Gneiss	$4.20 \cdot 10^{-13} – 4.50 \cdot 10^{-13}$	$1.10 \cdot 10^{-5} – 1.30 \cdot 10^{-5}$
– Mica rocks	$3.10 \cdot 10^{-13} – 3.40 \cdot 10^{-13}$	$1.50 \cdot 10^{-5} – 1.55 \cdot 10^{-5}$

Table 2. Gamma ray intensity of some rocks connected with oil and associated gas deposits

Tabela 2. Natężenie promieniowania gamma w niektórych skałach związanych ze złożami ropy naftowej i towarzyszącego jej gazu

Lithological type	Number of samples analysis	Medium radioactivity (10-12 g Ra equivalent/g rocks)
Black shales and organogenic blackish ashes	65	26.1
Clay shales, dark in colour	75	22.4
Slightly sandy clay shales	180	16.3
Marls and blackish marly shales	72	16.5
Marly and clayey shales, sandy	15	13.6
Dark sandy marls and clays	65	13.1
Grey clays and marls	17	11.4
Grey sandy clays and marls	22	9.5
Marno dark limestones	14	8.9
Marly sandstones	40	7.1
Light-coloured marly limestones	18	6.9
Sandstones	80	4.2
Limestones and dolomites (in general)	65	4.1
Limestones and light-coloured dolomites	66	3.1
Limestones and grey dolomites	77	4.1
Limestones and blackish dolomites	80	6.2
Anhydrites	5	0.5
Coals	15	0.8
Salts	90	1.4
Bentonites, volcanic tuffs	22	20.0
Marine organogenic shales	15	55.0

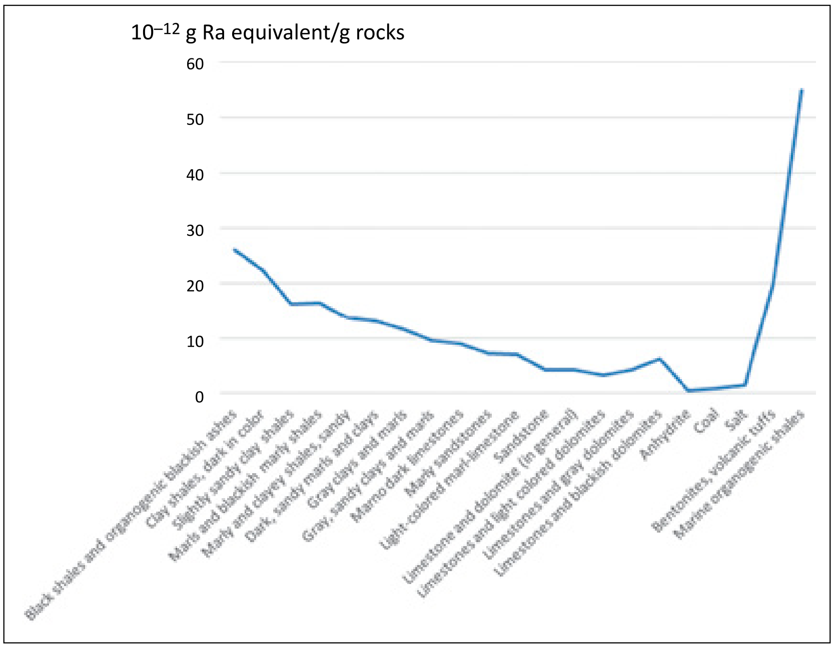

Figure 1. Average radioactivity of different lithological rock types

Rysunek 1. Średnia radioaktywność różnych typów litologicznych skał

The intensity of γ radiation allows classifiying of rocks associated with oil saturation as having low, high or abnormally high radioactivity.

The group of rocks with low radioactivity includes sandstones, sands, dolomites, salts and anhydrites. It should be noted that in the case of sandstones, the way they are cemented has very little influence on the radioactivity of the rocks.

Interstitial water also has little effect on radioactivity values, except in cases where sandstones, limestones and dolomites cannot be identified by radioactivity (in which case knowledge of the local stratigraphy is required) (White, 1992; Testa et al., 1994).

Rocks with high radioactivity are marls and clays, especially if they are highly interstratified (sandy marls, sandy clays and calcareous marls have medium and high values of radioactivity) (Testa et al., 1994). Organogenic black shales, granite, bentonite and cinerite are rocks with particularly high radioactivity.

Simultaneously, underground waters are susceptible to the formation of deposits of deliquescent salts, which indicate high values of radioactivity (Zieliński and Budahn, 2007).

It should be noted that groundwater can contain different radioactive markers.

Geological studies of the borehole have shown that the first 30 metres of depth are cosmic rays, and gamma radiation is quite significant.

Lithologically homogeneous formations (sands, limestones and dolomites) are characterised by low radioactivity. As the marl or clay content increases, so does the radioactivity, and the presence of rocks associated with volcanic activity (tuffs and bentonites) causes an increase in gamma radiation values.

The granite and crystalline basement are always highly radioactive compared to the sedimentary formations lying above these structures (Petrache et al., 2022).

Oil area analysis

Radioactive elements may appear from the exploitation of oil and gas fields in (Petrache et al., 2022):
- the detritus produced during well drilling;
- waters associated with extracted oil;
- sediments and sludges stored in crude oil, water and gas tanks and separators;
- the crusts that form in the pipelines for transporting drilling fluids and reservoir waters.

In order to study the quantity and quality of radioactive elements in the crude oil extraction areas, samples were taken from the reservoir water associated with the crude oil and from the sediments contained in the extracted petroleum fluids. The samples, taken monthly for a year (2022), were analysed and reported in accordance with the regulations in force. That is precisely why we have analysed several oil fields located in areas affected by volcanic activity, namely:
- Săcel-Săliște extraction area;
- Moinești exploitation area;
- Măgurele-Mălăesti extraction area.

The Săcel-Săliște crude oil fields are part of the Pannonian Basin, located between the Gutâi-Oaș eruptive chain and the crystalline-Mesozoic zone of the Eastern Carpathians. Over the crystalline foundation, sedimentary deposits belonging to the Jurassic, Cretaceous, Paleogene and Neogene were formed. The parent rock is represented by menilitic, disodilic schists, marls and bituminous clays. The geological series is of the lower and upper bituminous type. The reservoir rock is the Borşa sandstone of the Oligocene age. The protective rocks are the intercalations of marls and clays corresponding to the Borşa sandstone. Oil deposits are stratified, divided into blocks and tectonically shielded.

The Măgurele-Mălăești oil fields are structured in Dacian and Meotian reservoirs. The Dacian collector has a clearly highter percentage of zeolites of phyllipsit (3.17 Å), gismondin (7.28 and 3.24 Å) and chabasite (9.28 and 4.32 Å) variates compared to the Meotian collector.

The Moinești field is associated with a reservoir of the Eocene age and is rich in zeolites.

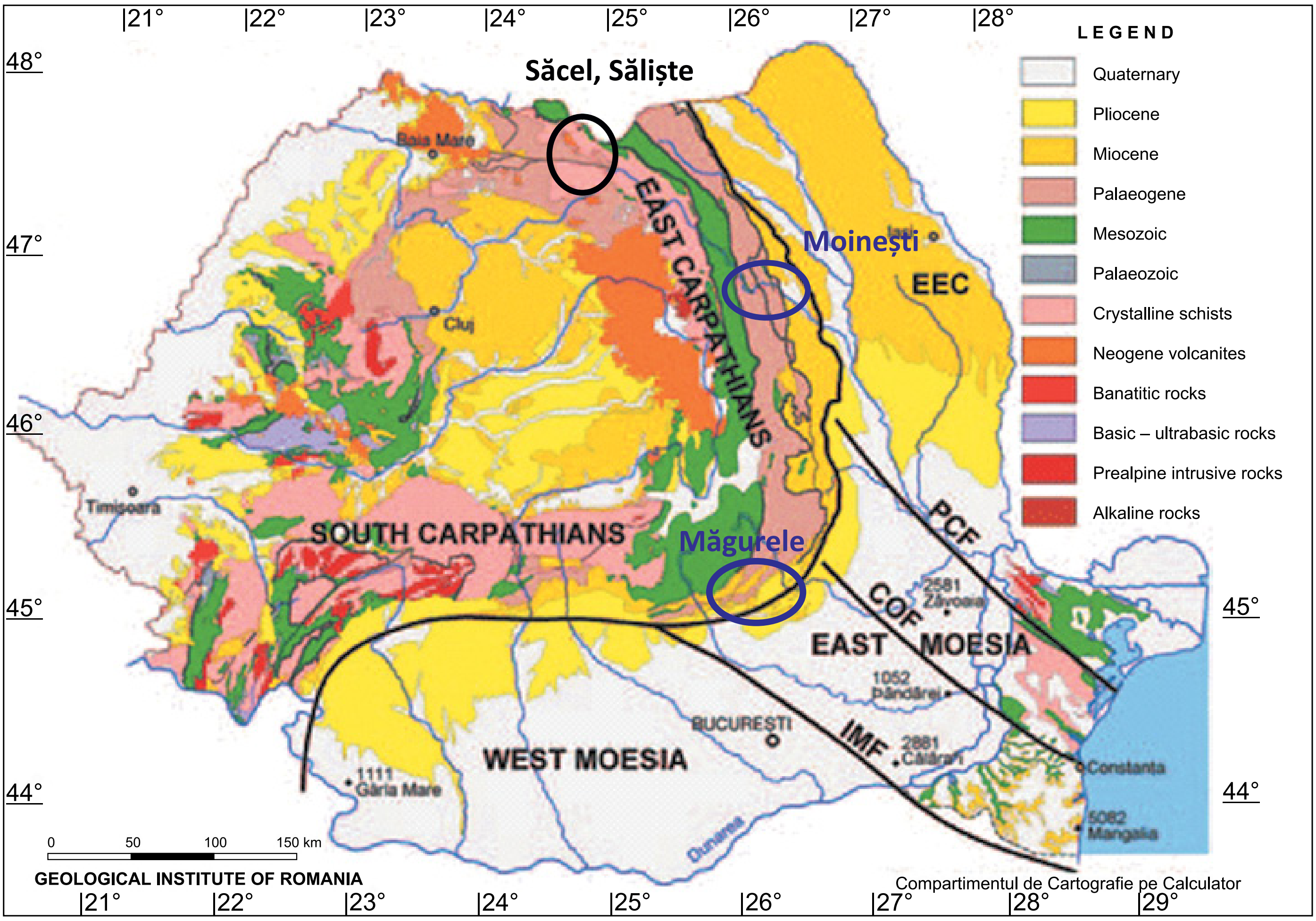

Figure 2. Schematic geological map of Romania with location of Săcel-Săliște, Măgurele, Moinești areas (Vaida and Verniers, 2005)
Rysunek 2. Schematyczna mapa geologiczna Rumunii z lokalizacją rejonów Săcel-Săliște, Măgurele i Moinești (Vaida i Verniers, 2005)

Materials and methods

For the analysis of the physico-chemical composition of the crude oil, reservoir water and associated sediments, crude oil samples were taken from the two productive geological horizons from every oil area as shown in Table 3.

Crude oils are of a very light and medium light type according to the classification of the National Agency for Mineral Resources (Petrache et al., 2022). The collected samples were analysed according to the standards listed in Table 4.

Each physicochemical analysis was repeated 5 times. The accuracy of the analytical methods was inscribed in the reference standards, with a maximum relative error of ±1.0%. Sediment samples separated from crude oil were also examined using X-rays to study their spectral aspects and chemical structure. Percentages of zeolites of phyllisite (2.96 Å), gismondine (7.70 Å) and chabasite (4.39 Å) were identified in each sample.

As radioactive elements are also present in the reservoir water associated with crude oil, their nature and content in microstructural elements were determined. The solid medium radioactivity, microstructural analysis of water and the reservoir sediments is analysed (Table 5 and Table 6).

The presence of chlorine and sulphur in the analysed waters, of radioactive chemical elements, of lanthanides, samerskite and xenotime can be attributed to the volcanic activity of the Tibles Mountaints.

Nuclear disintegration processes

In oil fields, several types of particles may result from the decay of unstable atoms and the loss of their excess energy. This energy is lost in particle forms or energy emission (ionising radiation). This paper proposes studying this radioactive decay (alpha radioactivity, beta radioactivity and gamma radioactivity).

Alpha radiation is associated with the release of energy Q and most alpha particles have energies between 4 and 6 MeV.

Table 3. Properties of oil extracted by analysis area

Tabela 3. Właściwości wydobytej ropy naftowej według analizowanych rejonów

Parameters	Density	Acid index	Waxes	Asphaltenes	Resins	Sulphur	Distillate 1–200°C
	[at 20°C]	[mg KOH/g]	[% weight]	[% weight]	[% weight]	[% weight]	[% vol]
Paleogen, Săcel	0.8253	0.1200	11.200	1.5300	17.200	0.1200	22.500
Paleogen, Săcel	0.8765	0.7100	3.500	2.3300	18.200	0.1300	21.000
Dacian, Măgurele	0.8245	0.1450	13.750	1.6850	16.330	0.1600	23.450
Meotian, Măgurele	0.8799	0.7350	3.850	2.6700	17.950	0.1700	21.380
Eocen 1, Moinești	0.8663	0.1455	10.800	1.6700	17.990	0.1200	25.600
Eocen 2, Moinești	0.8668	0.7750	3.610	2.7900	18.440	0.1700	26.800

Table 4. Oil methods of quality analysis

Tabela 4. Metody analizy jakościowej ropy naftowej

Parameters	Oil methods of analysis
Density [at 20ºC]	ISO 12185:1996(en) Crude petroleum and petroleum products – Determination of density – Oscillating U-tube method
Acid index [mg KOH/g]	ASTM D3339-21 Standard Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration
Waxes [% weight]	ASTM D5442-17(2021) Standard Test Method for A nalysis of Petroleum Waxes by Gas Chromatography
Asphaltenes [% weight]	ASTM D6560-17 Standard Test Method for Determination of Asphaltenes (Heptane Insolubles) in Crude Petroleum and Petroleum Products
Resins [% weight]	ASTM D1763-00(2021) Standard Specification for Epoxy Resins
Sulpur [% weight]	ASTM D4294-21 Standard Test Method for Sulphur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
Distillate (1–200°C) [% vol]	ASTM D86-20b Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

Table 5. Microstructural elements of formation waters

Tabela 5. Elementy mikrostrukturalne wód złożowych

Oil level [m]	Na^{+} [%]	K^{+} [%]	Ca^{2+} [%]	Mg^{2+} [%]	Cl^{-} [%]	SO_4^{2-} [%]	HCO_3^{-} [%]	Water type after V.A. Sulin
920 Paleogen, Săcel	35.4	0.33	8.77	5.23	45.22	0.0031	0.1680	chlorine-calcium
1120 Paleogen, Săcel	22.1	0.28	9.12	5.89	49.54	0.0018	0.1450	chlorine-calcium
900 Dacian, Măgurele	39.55	0.35	8.63	5.33	45.66	0.0033	0.1680	chlorine-calcium
1800 Meoțian, Măgurele	23.33	0.33	9.06	5.55	55.56	0.1798	0.0660	chlorine-calcium
1800 Eocen 1	38.33	0.27	8.72	4.99	43.21	0.1823	0.0121	chlorine-calcium
1900 Eocen 2	24.44	0.55	8.33	5.02	50.44	0.1634	0.1555	chlorine-calcium

Table 6. Spectral parameters of radioactive elements of oil sediments extracted by oil wells

Tabela 6. Parametry widmowe pierwiastków radioaktywnych z osadów pochodzących z poziomów roponośnych w odwiertach ropnych

Elements	U	Th	Pb	Rb	Sr	K	Ca	Bi	Y	Fe
Wave length λ, Å	43621.1	4019.14	3685.5	4201.8	3464.5	3446.4	3468.5	3397.2	4374.9	3406.4
920 Paleogen, Săcel, λ, Å	0.4	3.3	2.2	5.3	3.1	1.5	3.2	–	7.3	2.4
1120 Paleogen, Săcel, λ, Å	2.7	6.3	1.1	5.5	0.5	–	6.6	–	13.2	3.3
900 Dacian, Măgurele λ, Å	0.5	3.5	2.3	5.1	3.3	1.6	3.8	–	7.6	2.5
1800 Meoțian, Măgurele λ, Å	2.8	6.1	1.2	5.1	0.6	–	6.8	–	13.3	3.5
1800 Eocen 1 λ, Å	0.3	3.3	2.1	5.7	3.9	1.8	3.2	–	7.8	2.1
1900 Eocen 2 λ, Å	2.9	6.3	1.4	5.4	0.5	–	6.9	–	13.4	3.3
Elements	**Zr**	**Nb**	**Mo**	**Er**	**P**	**Ta**	**Ti**	**Ru**	**Rh**	**Ba**
Wave length λ, Å	3438.2	4058.9	3903.0	3372.7	4246.9	4574.3	4305.9	4080.6	3434.9	3501.1
920 Paleogen, Săcel λ, Å	4.6	3.3	3.0	6.7	3.1	1.4	7	3.3	0.8	2.5
1120 Paleogen, Săcel λ, Å	3.1	4.9	2.1	2.9	9.1	2.2	0.5	2.2	2.5	5.8
900 Dacian, Măgurele λ, Å	4.4	3.1	3.1	6.9	3.8	1.8	6.9	3.2	0.5	2.6
1800 Meoțian, Măgurele λ, Å	3.4	4.6	2.7	2.3	9.2	2.6	0.7	2.1	2.8	5.5
1800 Eocen 1 λ, Å	4.1	3.5	3.9	6.1	3.6	1.8	6.4	3.1	0.5	2.2
1900 Eocen 2 λ, Å	3.8	4.2	2.5	2.1	9.1	2.7	0.2	2.3	2.5	5.9

Alpha decays chemically about this equation:

$$ {}_{Z}P^{A} \rightarrow {}_{Z-2}D^{A-4} + {}_{2}He^{4} + Q_{\alpha}(Q_{\alpha} = K_{Y} = E_{\alpha} + E_{recoil} + E_{\gamma}) $$

Where P is the parent nuclide, D is the daughter nuclide, and Q is the equivalent to the total kinetic energy during the alpha particle decay process. Uranium (4n+2) and thorium (4n) are the ends of a classical series of radioactive transformation. This series has one final stable lead product. Bismuth is the stable end product of radioactive series (4n+1). Neptunium, which cannot be identified by spectral emission analysis.

Nuclear disintegration is generalised by the equation:

$$ A \text{ (mother nuclide)} \rightarrow B \text{ (daughter nuclide)} + $$
$$ + X \text{ (radiation and quanta)} + \Delta E \text{ (energy)} $$

In the nuclear disintegration equation, the energy term is disintegrated a kinetic energy of the emitted radiation and the ζ quanta. Nothing by E (total energy) is obtained by nucleus fission; we can determine this using the variation of the initial nuclide masses (in disintegration equation E is described by Eistein's relation):

$$ E = \Delta mc^2 = (m_A - m_B - m_x)\, c^2 $$

In the oil field, energy E is not only equal to the particle energy. Energy ζ quanta is emitted by disintegration and includes the energy offered to the daughter nuclide. Forms of nuclear disintegration are outlined in table 7, and in the analysis of oil fields the mother U and Th nuclides, by their α, ζ and e–, emission during the geological time $T_{1/2} > 10^9$ years. Each structure analysis has influenced the continuous transformation of matter in these systems.

The natural nuclide ${}^{87}_{37}$Rb with $T_{1/2} > 6 \cdot 10^{10}$ years amplified the spontaneous disintegration of uranium emitting β^-.

The fission within the system leads to the stable daughter nuclide ${}^{87}_{37}$Sr.

In the second nuclear natural elements ${}^{40}_{19}$K with $T_{1/2} > 1 \cdot 10^{10}$ years are parts of dual disintegration:

$$ {}^{40}_{19}\mathrm{K} \rightarrow \beta^- \rightarrow {}^{40}_{20}\mathrm{Ca} $$
$$ {}^{40}_{19}\mathrm{K} \rightarrow \beta^+ \rightarrow {}^{40}_{18}\mathrm{Ar} $$

Another element of the transformation is:

$$ {}^{91}_{41}\mathrm{Nb} \rightarrow {}^{91}_{40}\mathrm{Zr} $$
$$ {}^{94}_{41}\mathrm{Nb} \rightarrow \beta^- \rightarrow {}^{94}_{42}\mathrm{Mo} $$
$$ {}^{100}_{41}\mathrm{Nb} \rightarrow \beta^- \rightarrow {}^{100}_{42}\mathrm{Me} $$

In oil field analysis the Y-Zr couple is desintegrated in:

$$ {}^{88}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{88}_{40}\mathrm{Zr}\text{, with } T_{1/2} > 150 \text{ days} $$
$$ {}^{90}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{90}_{40}\mathrm{Zr}\text{, stable isotope} $$
$$ {}^{91}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{91}_{40}\mathrm{Zr}\text{, stable isotope} $$
$$ {}^{92}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{92}_{40}\mathrm{Zr}\text{, stable isotope} $$
$$ {}^{93}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{93}_{40}\mathrm{Zr}\text{, with } T_{1/2} > 9.5 \cdot 10^5 \text{ years} $$

The activity of potassium was intense since the spectral parameter I_t–I^f, for Table 3. This stable isotope ${}^{40}_{20}$Ca participated 90% in Dacian. Where bombarded with β^- its transformation ${}^{93}_{41}$Nb, stable isotope, with 100% participation.

The natural mixture ${}^{94}_{39}Y$ is a stable isotope with 17% participation in natural mixture.

$$ {}^{94}_{39}\mathrm{Y} \rightarrow \beta^- \rightarrow {}^{93}_{40}\mathrm{Zr} $$

Table 7. Nuclear disintegrations process
Tabela 7. Procesy rozpadu jądrowego

Forms of disintegrations	Emission products	
Spontaneous characteristic only for nuclides with $z \geq 0$	Neutrons ζ cuants	$Z_1 + Z_2 = z$ $A_1 + A_2 + v = ›$ $\frac{A}{Z}X \rightarrow \frac{A_1}{Z_1}Y_1 + \frac{A_2}{Z_2}Y_2 + nv$
α radiation characteristic for $z > 83$	nuclide ${}^{4}_{2}He^{2+}$	$\frac{A}{Z}X \rightarrow \frac{A-4}{Z-2}Y + {}^{4}_{2}He^{2+}$
β radiation, characteristic for nucleus with an excess of neutrons Characteristic for nucleus with a deficit of neutrons, for which $E \geq 1.02$ MeV	negraton ${}^{0}_{1}e^-$ pozitron ${}^{0}_{1}e^+$	$\frac{A}{Z}X \rightarrow \frac{A_y}{Z+1}Y + \beta^- + \overline{v}$
Capture of electron, characteristics for nuclei with a deficit of neutrons	characteristic Röntgen radiation of the daughter nuclide	$\frac{A}{Z}X + {}^{0}_{1}e^- \rightarrow \frac{A_y}{Z-1}Y + v$
ζ quanta emission, giving off the daughter energy after radioactive disintegration – metastable nuclides disintegration	ζ photons	$\frac{A}{Z}X \rightarrow \frac{A}{Z}X + \zeta$
Emissions of the conversion electrons characteristic for the reduced excitation levels upon the atomic nucleus <0.2 MeV	electrons and Röntgen radiation	passing of the nuclide excitations energy to the electron shell

From the scheme results 97% of Y passed to Zr ${}^{93}_{40}\mathrm{Zr}$.

$$ {}^{88}_{40}\mathrm{Zr} \to \mathrm{CE} \to {}^{86}_{39}\mathrm{Y} \to \beta^{-} \to {}^{86}_{40}\mathrm{Zr} \to \mathrm{CE} \to $$

$$ \to {}^{86}_{39}\mathrm{Y} \to \beta^{-}\, {}^{88}_{40}\mathrm{Zr} \to \mathrm{CE} \to {}^{86}_{39}\mathrm{Y} $$

Conclusions

The collection of oil field analysed in a volcanic area of Romania is full of zeolites (15 Å) and Y, Er, Ta, Ru, Rh, Mo, Nb, Ni, Rb, Sr, Zr elements are identified. In these zeolites we have detected polar and radioactive interstitial water, and there has been, in geological layers, some organic matter.

This organic matter is influenced by nuclear energy, parts of activity of volcanic activity (Tibles, Harghita Mountain) and elements detected in nuclear rocks (samarskite and xenotime).

In the polar catalytic and radioactive space, possessing polar and radioactive interstitial water, there has been, during geological time, some organic matter which, under the influence of nuclear energy has been continuously transformed, reaching the oil field stage.

In zeolite rocks molecular sieves of the montmorillonite type, tridimensionally linked, are catalysts saturated with radioactivity chemical elements and also due to the lower intensity of nuclear disintegration energy as a result of the very reduced participation of samarskite and xenotime.

Radioactive materials are found in the many processes of oil and gas field production processes. In many cases radioactive elements are detected in:

a) cleaning of downhole equipment and electric submersible pumps;
b) in detritrus of driling muds;
c) refining products and fluids used in cleaning equipment.

The presence of radioactive elements is a health risk to working people and causes environmental pollution. The nature of the risk assessment of working people divided in the physical effects (skin cancer, blood cancer or lung cancer) or white of the eye injury and sterility. A second physical effect affected descendants of the person exposed to the radiation. An incidence of this cancer is present in this study area (more than 10% increase above normal rate in Romania).

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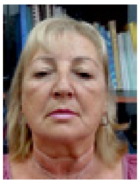

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