ENVIRONMENTAL IMPACT OF SEISMIC RESEARCH WORKS FOR OIL AND GAS DEPOSITS IN THE BLACK SEA

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ABSTRACT. – Environmental impact of seismic research works for oil and gas deposits in the Black Sea. The prospecting and exploitation activity of hydrocarbon deposits in Romania has experienced a major development in the nineteenth century and has remained since a major component in achieving energy independence in our country. In 1970 the oil and gas production in Romania reached a peak of over 14.5 million tons of crude oil. Gas production reached 33 million tons of oil equivalents. After 1990 the production level fell again, because of the depletion of the existing resources and the lack of investment prevented the discovery and the development of new fields. They have led in the last few years to a decrease of the oil production level to less than 5.0 million tons of oil and of the gas production of 10,3 million oil equivalent. After 1990 the Romanian Government through THE NATIONAL AGENCY FOR MINERAL RESOURCES has decided to organize international auctions to award a series of contracts regarding exploration and participation to rates of production of specialized companies that run all the financial funds and necessary technologies for the development of hydrocarbon prospecting activities. That is why in the Black Sea, beside the oil and gas deposits leased to OMV Petrom, there were also leased 7 areas needed for research, exploration and possible exploitation of oil and gas deposits. This paper presents the effects of seismic research works on the environment, considering that these are the first that will run on the platform of the Black Sea shore.

Keywords: research, seismic, Black Sea, impact assessment

1. INTRODUCTION

The exploitation of oil and gas in the Black Sea began in 1972 when the Marine Research Institute Constanta triggered a complex recovery program of the continental shelf resources. Within the program there were studied equipments, devices, facilities and machinery specific to offshore drilling, as well as data about the marine installations in the Black Sea. In 1975 (November 9th) was launched afloat the first offshore platform Gloria that on September 16th, 1976 began offshore operations. They were held at a distance of 72mM and at a depth of 90 m.

In 1980 in the Black Sea there were found hydrocarbons [2]. There were performed over a hundred drilling and on May 7th, 1987 at 16:45 there were

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discovered more deposits, part of the two perimeters (Istria XVIII and Neptun XIX) in the area of 13880 square kilometers and currently available in OMV-Petrom lease. The deposits in operation (Lebada Est, Lebada Vest, Sinoe, Pescarus and Delta) [3] produce 32,000 boe per day, which represent 18% of Petrom's production. After 1990, due to the lack of financial resources, the Romanian State through the NATIONAL AGENCY OF MINERAL RESOURCES held several rounds of auctions, currently being leased 10 maritime areas (Table 1). Except the areas leased by STERLING RESOURCES (that started its petroleum activity in 2007) all the other companies started their petroleum activity in 2011. The petroleum activity consists in developing the following steps [4]:

a. Opening a branch of the company in Romania,
b. Signing the concession agreements,
c. Programming an exploration program and presenting it for approval to ANRM,
d. Obtaining permits for exploration of perimeters,
e. Commencement of perimeters seismic research activity,
f. Interpretation of data resulting from seismic research,
g. Starting the drilling program of producing wells,
h. Research of drilled layers and economic analysis of outlined deposits,
i. Starting exploration drilling and preparing deposits for exploration,
j. Installation of oil extraction facilities, primary processing and transportation to shore of crude oil and gas,
k. Payment to Romanian State of petroleum royalties and of related taxes.

Table 1. ***Leased perimeters in the offshore platform of the Black Sea***

Perimeter / Name	Number	Surface (sq km)	Operator
Est Rapsodia	26	**1000**	**Lukoil**
Trident	26	**1000**	**Lukoil**
Midia	4	**3500**	**Sterling Resources**
Pelican	4	**1000**	**Sterling Resources**
Luceafarul	28	**1000**	**Petro Ventures**
Muridava	24	**1000**	**Melrose Resources**
Cobalcescu	24	**1000**	**Melrose Resources**
Neptun	15	**9900**	**Petrom+Exxon**

2. MARINE DEPOSITS GEOLOGY

Interpretation of the 2D seismic data collections made in the 1980s and early 1990s in conjunction with geological information from wells drilled in the Black Sea indicate possible accumulations of hydrocarbons at about 2300-2800 m

depth. The deposits are located in the sands of the Lower Pontian and the limestone in Oligocen. Both levels are stratigraphic traps, the Oligocen being dependent of stratigraphic slope on the erosion sectioning emergence towards west, the Pontian being dependent of the wedging out of sands also of the stratigraphic slope on the emergence towards west. The quality of existing seismic data is poor. Is needed seismic research in 2D in order to better define potential deposits of hydrocarbons and research in 3D to check seabed structure.

3. ACTIVITIES DEVELOPED FOR SEISMIC RESEARCH

Seismic activity encloses the following steps:

a. Data acquisition phase: analog and digital investigations on future wells locations and sampling sedimentation test from the seabed.
b. Phase of processing and interpretation of data on land and reporting: multichannel seismic data of high resolution which are realized in an analysis center in France or England. The two phases take place rapidly (data harvesting period for 1000 sq km is of maximum 60 days and for data processing is of maximum 90 days) so that the petroleum activity to not encounter downtime.

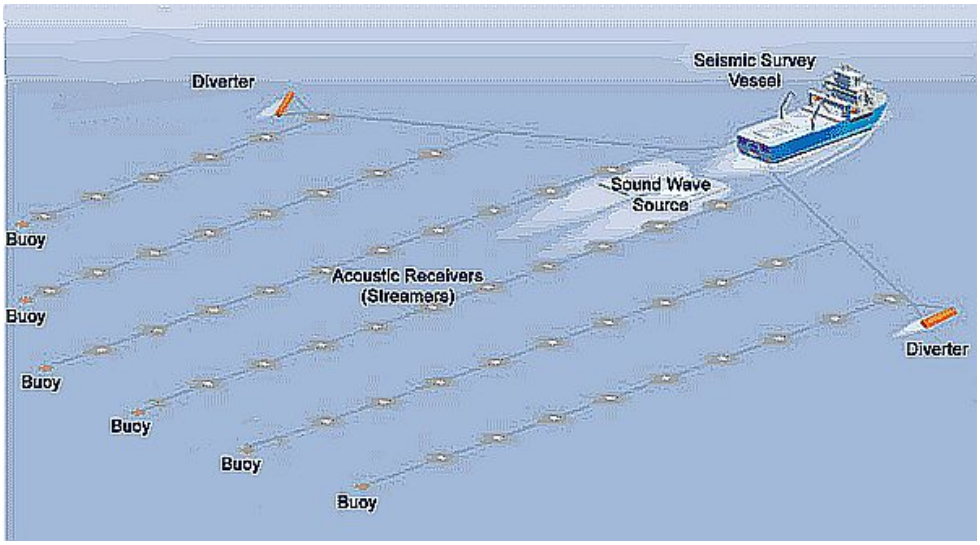

Fig. 1 ***Seismic research principles [5]***

The seismic research consists in using a special vessel that will carry out the following activities:

- Emission of seismic waves transmitted by an artificial source by shooting with air jet,
- Reception waves and especially marking reception time of these waves,

- Recording the time of reception of seismic waves and of the angle of reception,
- Processing data by analyzing the response time of seismic waves and especially of the angle of response, depending on the nature of the layer penetrated by waves,
- Delivery of data to beneficiary and correlation of geological data with seismic data.

Since each concession company will want to make their own seismic studies, environmental analysis shows that the maximum water depth is of 110 m and the projects will consist of issuing seismic waves on different lengths (depending on the equipment used) but the shoots will take place every 12,5 m, at a speed of 40,5 knots (optimum interval of reception of seismic waves). The geophysical investigation system consists of GPS and DGPS positioning equipment, sea depth control devices (with an eco-sonar) for determining any natural obstacles or man-made and located in the research area in the seabed and high-resolution seismic prospecting system consisting of an air gun battery at a pressure of 2000 psi, a receiver consisting of hydrophones mounted in line and towed by boat as well as a computer data recording.

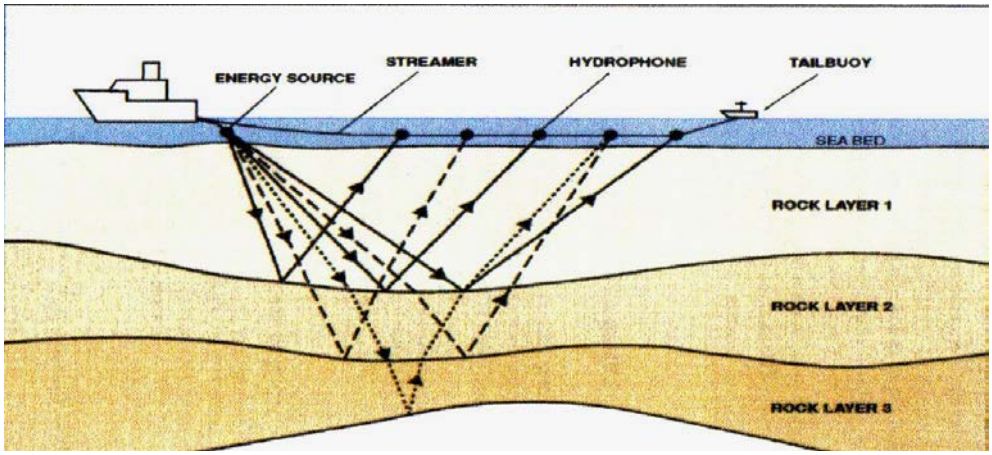

Fig. 2 ***Emission and reception of seismic waves [5]***

Seismic profiles are placed on the work surface in a grid (as a network of lines parallel and perpendicular to the geological structure), and the vessel that conducts the exploration will move along each line emitting acoustic signals at intervals of approximately 8 seconds. The acoustic signals emitted by the source diffuse into the basement from where they return as reflections caused by geological formations, which are received by hydrophones (placed on a long cable/streamer), then recorded on the computer of the ship and then processed and interpreted from the geological point of view.

The reflected acoustic signal is detected by receivers called hydrophones (hydrophone = electromagnetic powered microphone which can be used under water). Hydrophones groups are fixed on a long cable (streamer), which is towed at the stern of a vessel for seismic research. The working depth at which the streamer is towed is contained within a 5 to 7 m.

Data is recorded on the recorders on board and will be processed to obtain seismic profiles that can be interpreted by geophysicists or geologists. While seismic data strings can be produced at speeds of about 50-100 kilometric lines/day (depending on the weather conditions and considering that there are no technical problems), to interpret and process the data takes several weeks. Seismic energy source is represented by a battery consisting of more than 72 air guns towed by the ship at a depth between 4 and 6 m. The air gun is a pneumatic mechanism that generates acoustic signals by the rapid release of a volume of compressed air at different pressures (in the case of this project, of 2000 psi = 138 bar). The air expands violently causing an initial impulse that results in a series of pulses of decreasing amplitude with each oscillation. Guns used in a series have the pneumatic chamber volume between 40 and 300 $inch^3$, the total volume being of 3480 $inch^3$.

Sound frequencies are of maximum 280 Hz. The highest amount of sounds is directed vertically toward the seabed, the air-gun being designed as to achieve maximum targeting of the waves front.

4. INFORMATION REGARDING PHYSICAL AND BIOLOGICAL POLLUTANTS

Table 2 provides information on the physical pollutants generated by seismic prospecting activities to be held on site, as well as measures to eliminate / reduce pollution. After describing the technical parameters of sound waves (frequency, amplitude, spectral pressure) that have seismic sources (air guns) used on ship, it is clear that the most vulnerable organism from the perimeter site of seismic works are the three species of marine mammals living in the Black Sea – the dolphins Tursiops truncates, Phocoena phocoena and Delphinus delphis – because they emit and receive sounds in the frequency band specific to seismic sources used in acquisition. As for the seal Monachus monachus, another marine mammal from the Black sea, its' preferential habitat is the area of Capul Kaliakra (Cape of Kaliakra); so surveying will have no effect upon them. The effects of noise on marine mammals can be direct (bodily injury and/or auditory trauma, up to chronic effects and stress effects, manifested by decrease of individual viability, increased vulnerability to disease, increased potential for the impact of cumulative adverse effects, sensitivity to noise etc.) and indirect (lowering the availability of food, increasing vulnerability to predators). At the same time the sounds specific to prospects may cause trauma only in the early stages of development of benthic invertebrates and fish (eggs, larvae and juveniles) and only on a very small range. As for pelagic fish species, the physical effects of acoustic waves on fish can be

lethal only at distances less than 5 m from it. From an experimental study conducted by authors revealed a mortality of 0,018%, for the worst scenario, negligible in comparison with the mortality average rate of 10% / day.

Table 2. ***Information on physical and biological pollution generated by seismic prospecting activities on site***

Pollution type	Pollution source	Source no.	Calculated pollution caused by the activity on the target	Means of elimination/ reducing pollution
Noise	Air-gun batteries	72 guns	222 dB (re 1 Pa at 1 m), In the aquatic environment	Not exceeded the forecast work period (60 days) Audible warning before starting the activity
Atmospheric emissions	From burning fuel oil for ship movement	1	Emissions calculated for a consumption of 18 tons of fuel/day over a period of 60 days; total = 1080 tons of fuel	Not exceeded the forecast work period (60 days) Use of fuel with low content of sulfur in accordance with G.R. no. 470/2007
Waste-water	Vessel consumption (47 persons x 200 tons x 60 days)	1	564 tons	Not exceeded the forecast work period (60 days) Compliance with legislation in force regarding planned discharges.

The only clearly documented effects are the behavioral effects of fish in the area, namely the temporary removal from the area, with a reduction of fishing during the prospecting period and about five days after their termination. After this time the local stock of fish recovers gradually, quickly reaching the previous values. Plank tonic organisms of animal and vegetable origin are the only ones on whom the effects of seismic surveying noises can be fatal. It is estimated that this mortality will be lower than natural mortality, and their effects will be rapidly annihilated by the diffusion and mixing processes and dead animals will be replaced quickly due to their short life cycles.

5. CONCLUSIONS

Geophysical research works do not have major effects on the environment but on marine mammals. Therefore there will be seen the works started only if the animals are not in the area on a range of 500 m and blasting shall be done

progressively during the first 30 minutes of prospecting. Also, prospecting will be not take place at the same time in all the operating perimeters (it will be accepted only a vessel of seismic research).

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