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USING WELL TESTING TO CONFIRM THE SUSPECTED RESERVOIR MODEL BY SEISMIC INVESTIGATIONS

1. INTRODUCTION

The petroleum and natural gas industry can't develop without the help of the research field, respectively the seismic prospection, the well drilling and their geophysical investigations and well-testing.

The activity of seismic surveys is very complex and has the purpose to investigate the underground, in order to discover productive geological structures and various relations among the already known structures. More often, lately, there are looked for subtle traps in the areas with complicated geology, fact that requires more attention in the projection and execution of acquisition works, as well as the processing and interpretation of the gathered information.

An area intensively researched lately is the Eastern area of Romania, a very troubled area from a tectonic point of view, with many structural traps and very many faults. In this region, our company emphasised several hydrocarbon accumulations of lenticular form.

After making the seismic surveys there is the attempt to obtain, by modelling in specialized software's, a correct and clear image of the underground in the investigated area, especially at the level of the followed geological objective. After the interpretation of the obtained data by seismicity, there follows the placing and verification of the model by drilling.

2. THE ACQUISITION AND INTERPRETATION OF THE SEISMICITY

The solving of the geological problems by the seismic method starts from the gathering of the seismic information about a geological environment, seen as an undetermined system, with many unknown factors. Obtaining the information is made by a field experience,

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represented by a seismic acquisition. The result of this experience consists in a registration of primary data. These data represents in fact, the numeric image of the movement of the material particles from the underground, and under the action of some elastic waves that, in their propagation, are „charged" with the seismic message about the physical properties of the crossed environment.

An important step that follows to the field operations and that offers a final result to the geological problem is the phase of seismic information interpretation. This phase implies deciphering the beforehand registered seismic message by the acquisition of the primary data and is made of a automated processing process of the seismic data, that offer as result a time migrated seismic session, and a process of geologic interpretation of the seismic image of the underground, that offers the final outcome of the geological problem that is the depth geological section.

Still this chain of interdependent processes constitutes in a seismic system, characterised by an entrance, by a combination of parameters that define the system state and by an exit.

The seismic processing is an important phase in solving the geologic problem about a work project in a certain area. Not as far as laborious or expensive as the acquisition phase, the processing is the phase that offers a first result and that is the seismic image of the underground of the prospected area. The image offered at the processing flux conclusion, the seismic time section or the time migrated section, is a definitive image for the applied processing sequence, but it becomes truly a final result of the geological problem after the interpretation phase, when all the seismic layers emphasised are identified and given a geological age, or, after some special processing, there are determined physical characteristics of interest for the hydrocarbon accumulations.

The processing is thus an intermediate phase that receives as input data of the seismic acquisition (seismographs) and that offers its result (time migrated section) as input data for the phase of geological interpretation of the seismic data.

This whole process can be transposed in an evolution diagram (Fig. 1), where there are emphasised the phases of the interpretation of the obtained information.

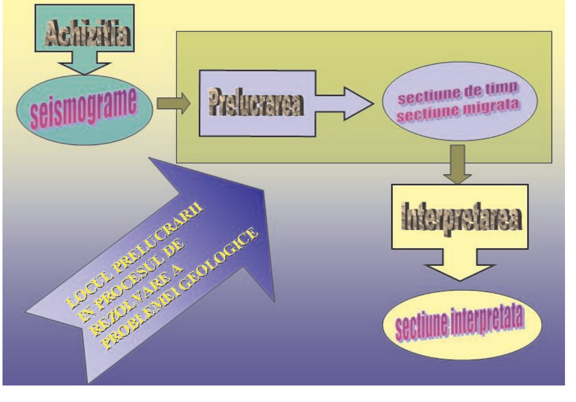

Fig. 1. Diagram of the evolution of the data interpretation from seismicity

The geo-physicians from our company interpret the obtained data with the help of a pack of integrated programs that allows the creations of a reservoir model. This software has very many options among which we remember the correlation with other wells, petro-physical modelling, facies modelling, faults analysis.

The seismic profiles registered lately in the Eastern area of Romania (Fig. 2) emphasised a major structural alignment, developed under the form of a elongated horst, delimited by major faults and characterised by a raised position and a monocline disposal of the inferior Badenian-Sarmatian stratigraphic whole.

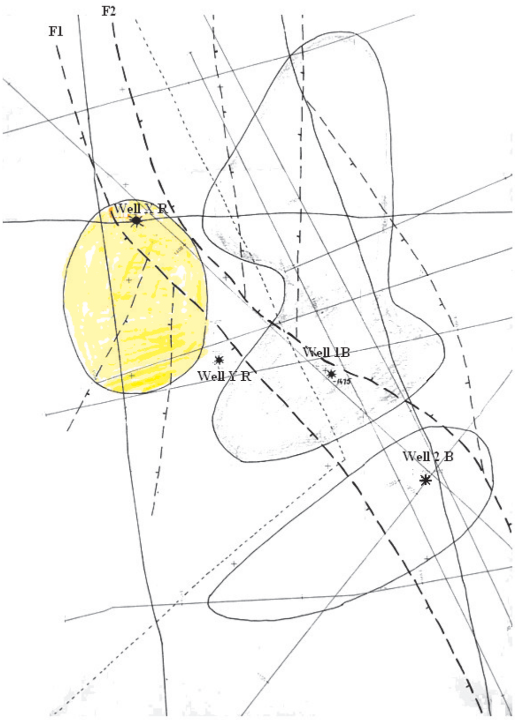

Fig. 2. Structural plan at the level of the badenian anhydrite

The seismic information, doubled partially by the geo-chemical data, reveal mainly maintaining the same conditions of structural, litologic order and of accumulation of hydrocarbon for the stratigraphic complexes of the inferior Sarmatian on an extended area at the south at the limit of the reservoir from the immediate proximity.

The seismic profiles oriented East-West, executed before 2000, but even the recently executed profiles, clearly emphasise a structural alignment, oriented North-South, in which the faults F1 – conformed and F2 – contrary, developed almost parallel, delimitates an elongated horst with regional extension. Though the faults leap indicates moderate values of 20–30 m and affects only partially the bases of the inferior Sarmatian complex, all the sandy superior collecting packs of the complex, fit the structural lift, ensuring thus the trap structural conditions. The second defining element of the trap is represented by the variable character of the litho-facies of the whole inferior Sarmatian emphasised by the standard electrical diagraphies registered in the wells drilled in the area.

According to this information there was concluded the fact that this structure is constituted in a possible mixed trap, saturated with hydrocarbons at the level of a sandy pack that seems to be extended to the East. There was considered that possible bearers of collecting hydrocarbon with reduced thicknesses of 2–3 m located in the basis of the complex.

Having as foundation the information obtained, there was estimated the approximate parameters:

– The effective saturated thickness with gas of the collector = 10 m,
– Reservoir pressure = 150 bar,
– Effective porosity = 18%,
– Saturation in gas = 70%.

The emphasised arguments related to the trap existence and of the direct seismic clues of the gas presence, led to the conclusion of the necessity to continue the exploration works of the area by passing to the next phase, of the direct testing by drilling.

The appraisal of the sands from Sarmatian, in order to state the trap conditions, to set the lithographic succession and determine the content in fluids of the crossed collectors, interpreted as possible gas-making implied executing the drilling of appraisal-prospection of the well 1 B. (Fig. 3).

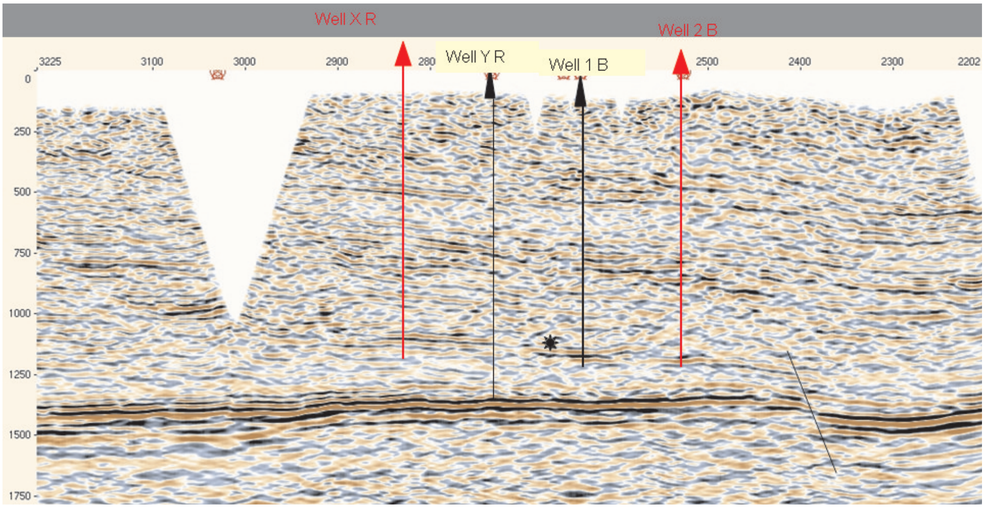

Fig. 3. Seismic section executed in the area

This well reached the depth of 1690 m and there was made only one production test in the interval 1395–1385 m. The accumulation of hydrocarbon suspected by the seismic registrations was confirmed by the production test where there was obtained a maximum debit of 200 thousands Stmc/day and the effective saturated thickness with gas of the collector was 5 m.

3. THE WELL-TESTING

The next phase constituted in making a complex well-testing job, in order to describe and evaluate the reservoir from the potential point of view. Thus there was made an isochronal test and a test of restoration of the reservoir static pressure (Fig. 4).

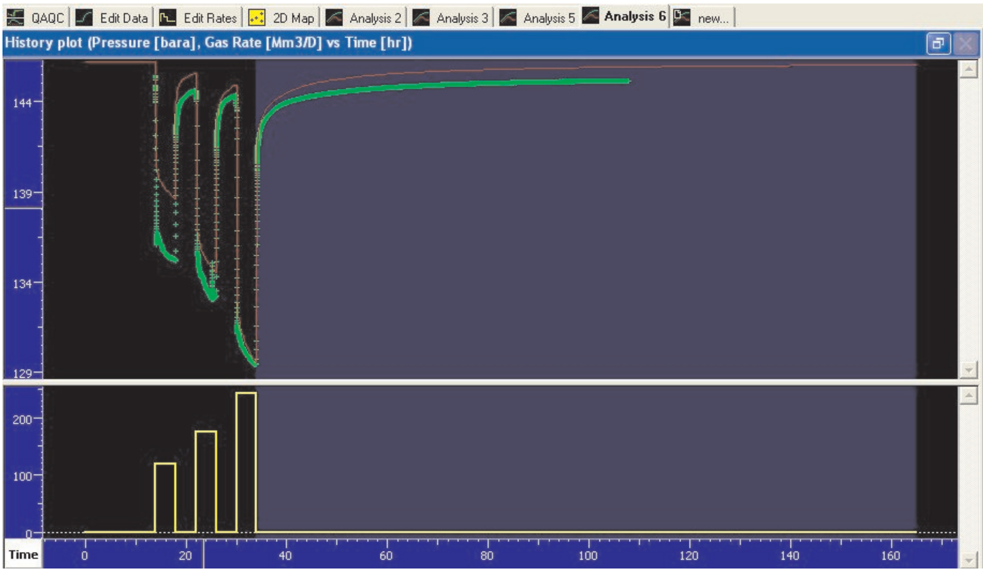

Fig. 4. Profile of the reservoir pressure during the well-testing

The isochronal test, with the time steps related to the closing period equal with the time steps related to the flow period, was made on a set of three chocks and there were registered the following results:

ϕ 8 mm, Pt/ Pc= 114/120 bar, Pd $_{rez}$ =135,18 bar, Q = 119 mii mc/day,
ϕ 10 mm, Pt/ Pc=110/119 bar, Pd $_{rez}$ =133,04 bar, Q = 175 mii mc/day,
ϕ 12 mm, Pt/ Pc=102/115 bar, Pd $_{rez}$ =129,48 bar, Q = 241 mii mc/day.

After making the well-testing job with variable flow rate the well was closed to make the build up test to see the reservoir static pressure. This test allowed the reservoir evaluation from the point of view of the hydrodynamic properties, as well as the reservoir model. Thus, after the analysis and the interpretation of the obtained data in specialized software's there was chosen the model of the homogenous reservoirs with parallel faults.

This type of reservoirs are characterised by 2 parallel faults as borders sealed or with constant pressure, located some distance away from the well, limit the reservoir extension in two opposite directions. In the other two directions the reservoir is of infinite extent. The well being at any position between the two boundaries.

At early time before the first boundary is seen, infinite system behaviour may be observed. The start of the boundary influence is proportional to the smaller of F1 (110 m) and F2 (40 m).

Two sealing faults: If the well is off-centered between the boundaries, when the influence of the closest fault influence is seen, the pressure behaviour may correspond to a well near one sealing fault. When both faults are seen a linear flow condition is established in the reservoir. If both faults are at similar distances, the intermediate behaviour may not be seen. On a log-log scale, during linear flow, the derivative curve follows a straight line of slope 0,5. In the case of a drawdown the pressure curve also follows a half unit slope but this effect is seen much later (at least one log cycle) than it is seen on the derivative.

Constant pressure boundaries: If one (or both) of the boundaries is constant pressure the pressure stabilizes and the derivative drops. If the boundary closest to the well is a sealing fault the derivative response first rises to 1 and then drops when the influence of the constant pressure boundary is felt. If the closest boundary is constant pressure, its effect will mask the response of a sealing fault farther from the well.

The pressure match should be made on the stabilization corresponding to radial flow.

The cursor should be positioned at the time when the derivative leaves the first stabilization (either upwards or downwards), the program then calculates the approximate distance to the first boundary. The distance to the second boundary is given by the time of the next significant change of level or slope on the derivative.

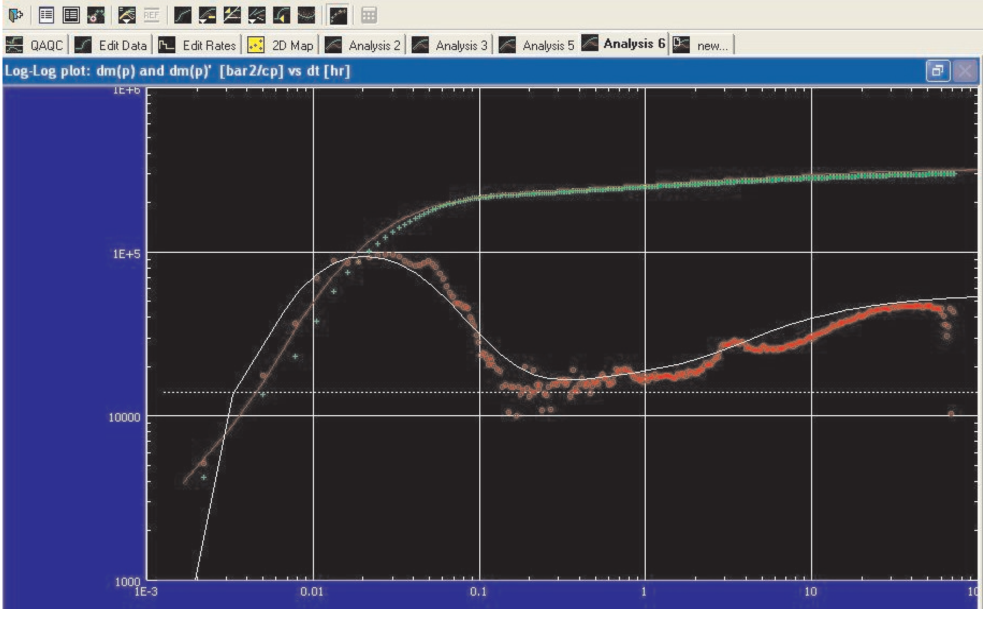

Fig. 5. Curve of pressure restoration

After the data interpretation resulted the following hydrodynamic reservoir parameters:

- reservoir static pressure: 146 bar,
- skin: 3,98,
- permeability: 116 mD,

– flow capacity (kh): 465 mD m,
– productivity index: 14,5339 Mm^3/D/bara,
– hydraulic diffusion coefficient: 7130 mD/cp,
– suplementary pressure fall: 4,66985 bar.

4. CONCLUSIONS

Making the well-testing and correlating the obtained results with the offered information by the seismic surveys allow the evaluation and description as correct as possible of an accumulation of hydrocarbon recently discovered.

The well-testing allowed obtaining some items of information about the properties of the fluids and of the porous environment, as well as about the productive potential of that specific area. According to the pressure registrations from the reservoir, there were determined the necessary parameters to the evaluation of the reservoir and to the setting up a model, by using specialized software's.

The reservoir model that was revealed from the well-testing job was identical to the reservoir model suspected by the interpretation and analysis of the seismic information. This fact allowed taking the decision to introduce it in the exploitation and development process.

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